PART 1

Sector trends and impacts

Global poultry sector trends and external drivers of structural change

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SUMMARY

The poultry sector has undergone major structural changes during the past two decades due to the introduction of modern intensive production methods, genetic improvements, improved preventive disease control and biosecurity measures, increasing income and human population, and urbanization. These changes offer tremendous opportunities for poultry producers, particularly smallholders, to improve their farm income. Evidence from case studies shows that it is difficult to see a bright future for smallholder poultry production in a rapidly changing industry structure; however, smallholders can still compete with larger producers because of savings that smaller units can achieve because of foregone or cheaper overheads, lower labour costs per unit and, possibly, more intensive supervision, leading to relatively high profit efficiencies. Smallholders also have problems in meeting high demands for food safety, traceability and compliance, because of high coordination costs and high transaction and marketing costs. Increasingly it appears that smallholders' ability to maintain their competitiveness in these types of markets is dictated by their ability to establish market trust and reputation along the marketing and distribution channels. This will require smallholders to be linked to the supply chain and to obtain certain supply chain management necessities, combining both productivity-enhancing technologies at the farm level and improved coordination in the marketing system.

Keywords: poultry sector structural changes, smallholder competitiveness, supply chain, transaction costs.

1 INTRODUCTION: CHANGES IN THE STRUCTURE OF THE POULTRY SECTOR IN DEVELOPING COUNTRIES

Over the last four decades there has been rapid growth in livestock production and a rapid change in how animal products are produced, processed, consumed and marketed. Growth in livestock production in both developed and developing countries has been led by poultry. From the 1990s to 2005, consumption of poultry meat in developing countries increased by 35 million tonnes – almost double the increase that occurred in developed countries (Table 1).

The increase in poultry meat consumption has been most evident in East and Southeast Asia and in Latin America, particularly in China and Brazil (Table 1). The share of the world's poultry meat consumed in developing countries rose from 43 to 54 percent between 1990 and 2005, which accounted for 36 percent of the large net increase in meat consumption in developing countries over this period. Further, the proportion of the world's poultry meat produced in developing countries rose from 42 to 57 percent. It is estimated that production and consumption of poultry meat in developing countries will increase by 3.6 percent and 3.5 percent, respectively, *per annum* from 2005 to 2030 because of rising incomes, diversification of diets and expanding markets, particularly in Brazil, China and India.[1]

The trends described above, and our current knowledge of smallholder involvement, raise a critical issue: for once, a sector in which the poor are heavily involved is growing. Table 2 shows that in fact pork and poultry are the prominent growth sectors of developing-country agriculture. If the poor fail to remain active in this sector, they will have missed a tremendous opportunity to improve their livelihoods. If they participate, farm income could rise dramatically; however, the conditions under which this could occur are unclear.

Although the above-mentioned issues are real, it has also been suggested that the principal reason for the exit of smallholders from livestock production in developed countries is that they are not competitive with the larger operations that benefit from both technical and allocative economies of scale embodied in genetic improvement of animals and feeds or improved organization – especially in the case of poultry and pig production where profitable adoption simply requires larger farm sizes (Narrod, 1997; Martinez, 2002; Morrison Paul *et al.*, 2004). This is a particularly difficult issue for smallholders, as it conveys a sense of inevitable economic doom propelled by irreversible technological progress. Anecdotal experience suggests that many livestock production experts do not look much beyond this explanation when assuming the inevitability of livestock industrialization in developing countries. In this paper, we try to disentangle the issues and provide empirical evidence drawing on case studies, involving household surveys, which capture various factors affecting profitability, including transaction costs and efforts to mitigate environmental externalities, for different sized producers in a number of countries.

2 GLOBAL TRENDS AFFECTING THE POULTRY SECTOR

2.1 Demand-side factors affecting the global poultry sector

Growth of the poultry industry has been both demand and supply driven. The factors that can cause the demand curve to shift outward are: (1) increases in income; (2) increases in the price of poultry substitutes such as pork or beef; (3) increases in the preference for poultry; and (4) decreases in the price of poultry complements. Factors influencing this shift are growth in population, increases in real per capita incomes, income elasticity of demand, urbanization and variations in real prices. Additionally, in many countries the population's

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1 Projections to 2030 are from the International Food Policy Research Institute's (IFPRI) International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model projections, October 2007. The IMPACT model, developed by Rosegrant *et al.* (2002), offers a methodology for projecting global and regional food demand, supply, trade, prices, income and population to 2020 and 2030.

TABLE 1

Production and per capita consumption of poultry meat by region, 1990-1992 and 2003-2005

Region	POULTRY MEAT PRODUCTION					POULTRY MEAT CONSUMPTION				
	1990-1992		2003-2005		2030 projected	1990-1992		2003-2005		2030 (projected)
	(million tonnes)	(% of world production)	(million) tonnes)	(% of world production)	(% of world production)	(million tonnes)	(% of world consumption)	(million tonnes)	(% of world consumption)	(% of world consumption)
China	4.5	10	14.2	18	23	3.3	10	10.3	16	26
India	0.4	1	1.8	2	4	0.4	1	1.7	3	3
Other East Asia	1.8	4	1.9	2	0	0.4	1	0.5	1	1
Other South Asia	0.8	2	1.8	2	1	0.3	1	0.6	1	2
Southeast Asia	1.2	3	5.2	6	7	2.1	6	4.2	6	7
Latin America	5.9	14	15.9	20	21	5.4	16	13.3	20	17
of which Brazil	2.7	6	8.5	11	10	2.3	7	6.1	9	7
West Asia and North Africa	1.5	3	2.9	4	6	2.2	7	4.4	7	7
Sub-Saharan Africa	1.3	3	1.8	2	2	0.7	2	1.2	2	4
Developing World	18.2	42	45.8	57	65	14.3	43	35.4	54	67
Developed World	25.2	58	35.1	43	35	18.8	57	29.9	46	33
World	43.5	100	80.9	100	100	33.1	100	65.3	100	100

Source: FAOSTAT accessed on October 2007. Projections to 2030 are from IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model projections, October 2007.

TABLE 2
Production growth rates in developing countries, 1975–2005

	% *per annum* (by volume)
Cereals	2.2
Fruit	3.9
Vegetables	5.1
Fish	1.6
Milk	4.0
Pork	6.0
Poultry	7.0

Note: "Fish" includes marine and freshwater fishes; "Poultry" includes chicken, duck and turkey meat.

Source: calculated from data obtained from FAOSTAT, accessed March 2007.

tastes and preferences for food products are changing, resulting in a shift away from "inferior" goods towards those considered "superior". The regions where annual income growth rates are highest, such as Africa (4.2 percent), Asia (3.5 percent) and Latin America (2.3 percent), are also those where the population growth rates are highest (between 1.2 percent and 2.2 percent) (OECD-FAO, 2007). As income increases, meat consumption tends to increase. High expenditure elasticity in poultry indicates its dominance in the diet both in the developed and the developing world (Table 3).

There is generally a positive relationship between per capita consumption of poultry products and per capita incomes. This positive relationship supports general economic theory which suggests that as incomes increase, particularly in developing countries, people will increase their consumption of high income-elastic foods. Throughout the world, this shift has traditionally involved the substitution of meat for starches. This additional meat can be produced either domestically by the reallocation of resources or imported. Figures 1a and 1b illustrate the relationship between per capita income and per capita consumption for South Asia and Latin America. The upward trends in these regions have been increasing over time.

2.2 Supply-side factors affecting the global trends of the poultry sector

Technology change in the poultry industry has been very rapid. The move from free-ranging to confined poultry operations dramatically increased the number of birds that one farmer could manage. This shift facilitated the substitution of capital for labour in animal production, and led to a significant increase in labour productivity (Narrod and Pray, 2001). Technology change in the poultry industry, led by advances in breeding that improved animal size, fecundity, growth rate and uniformity, has enabled farmers to increase output per unit of feed, produce more birds per year, improve animal disease control and decrease mortality (Narrod and Fuglie, 2000).

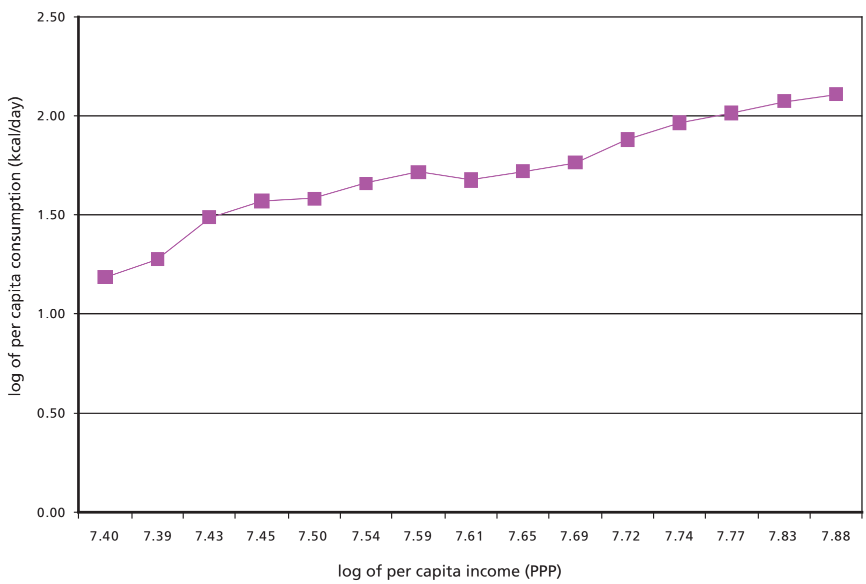
In terms of management techniques, the move to enclosed production systems in which animals of different ages are segregated and raised apart has had a positive impact

TABLE 3
Expenditure elasticities for major livestock products in developing and developed countries, 1970–1995, 2000, 2005 and projections for 2025

Region/product	Expenditure elasticities 1970–1995	Expenditure elasticities 2000	Expenditure elasticities 2005	Expenditure elasticities 2025
Developed countries				
Beef		0.18	0.10	0.01
Pork		0.24	0.14	0.02
Poultry		0.66	0.56	0.45
Milk		0.25	0.20	0.08
Eggs		0.02	-0.08	-0.19
Developing countries				
Beef	0.65	0.69	0.62	0.50
Pork	1.10	0.52	0.46	0.35
Poultry	0.27	0.72	0.77	0.66
Milk	1.36	0.60	0.48	0.37
Eggs		0.44	0.39	0.28

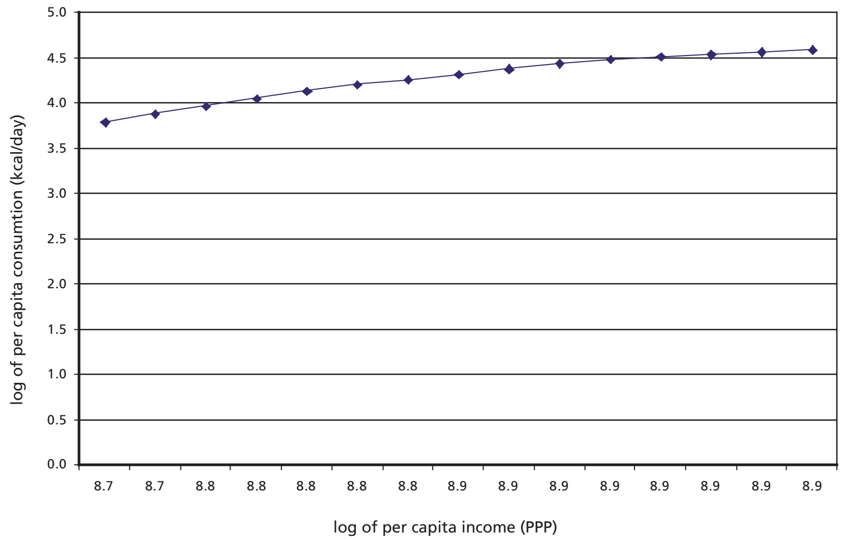
Source: Delgado *et al*. (1999) Table 8. Projections to 2005 and 2025 are from IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model projections, November 2006.

FIGURE 1A
Chicken meat consumption and income (constant 2000) for South Asia, 1990–2004



Note: PPP = Purchase price parity.

FIGURE 1B
Chicken meat consumption and income (constant 2000) for Latin America, 1990–2004



Note: PPP = Purchase price parity.

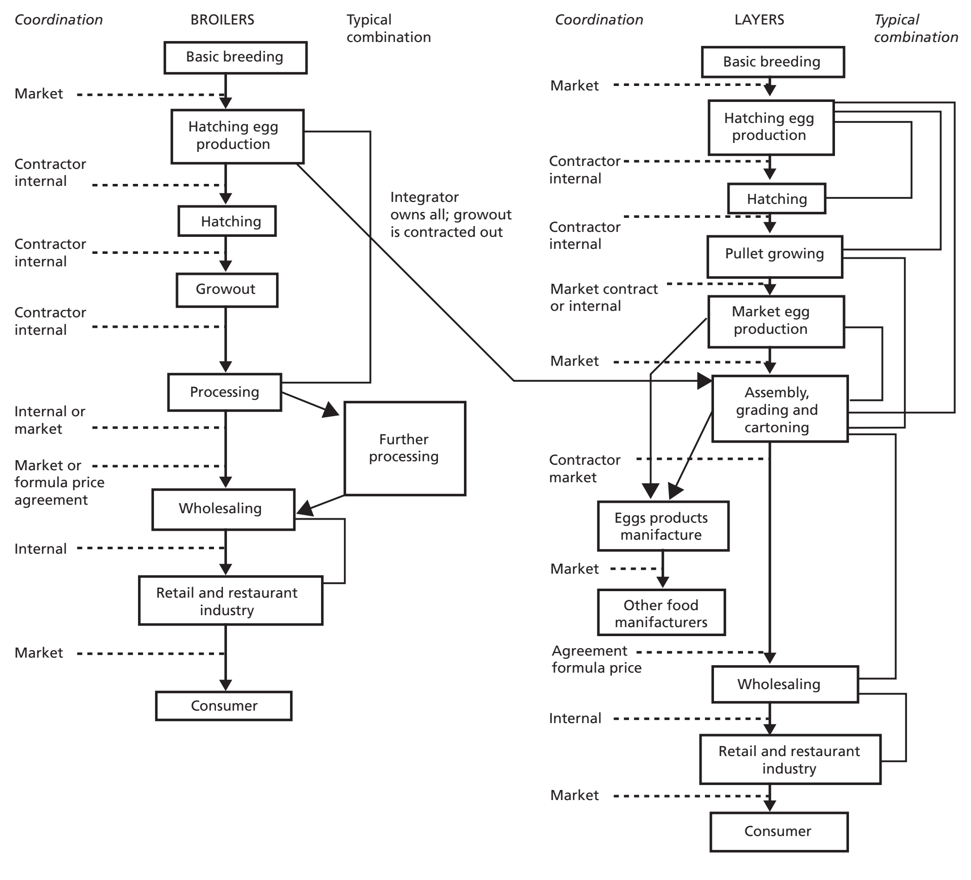
on disease control. The ability to use vaccines and pharmaceuticals to control the spread of poultry diseases helped expand the large-scale operations, allowing farmers to achieve significant economies of scale and unit-cost reductions. Further, the introduction of evaporation shed cooling in hot climates (e.g. in Thailand) has had a tremendous impact on the industrialization of the sector (Poapongsakorn *et al.*, 2003). Improvements in feed technology ensured that the improved breeds were using the ideal combination of ingredients at the least cost because of shorter production cycles and lower feed conversion ratios (from 2.0 to 1.75). The move towards increased processing of birds into a variety of convenience foods has further accelerated the growth of the poultry industry.

Concurrently, there has been a major structural change in the poultry industry throughout much of the world (Narrod, 1997; Narrod and Pray, 2001; Delgado *et al.*, 2008). Specifically, the commercial poultry industry in the developed world and in many developing countries has moved towards large-scale vertically integrated broiler operations that contract grow-out operations to smaller farmers. Today, the commercial poultry industries in most countries are moving towards such large-scale vertically integrated operations. These operations are characterized by a high level of vertical control (ownership) or coordination among suppliers of production inputs, poultry growers, poultry processors and marketers (Figure 2).

The specific degree of integration, however, varies among countries and firms. For the most part, integrated poultry operations involve most or all of the following segments: breeding flocks, hatchery, feed mill, production units, assembly of live birds or eggs, poultry slaughtering or packing plants, further processing units, delivery vehicles and distribution centres. Feed mills and further-processing segments are not always included in the integration, although they are an essential part of the production system (Henry and Rothwell, 1995). In some countries, it was the feed industry which was responsible for the initial integration of the poultry industry. In other countries, it was either the breeding company or the hatcheries which were responsible for the integration. In still other countries, integration was based on the potential market for further processing and fast food, as processors sought to add value to their business and become closer to the final customer.

The move towards vertical integration appears to mirror the stabilization of the economy and the growth of the urban market. The expansion of these large integrated operations has tended to occur in countries with developing or existing urban markets that supply the major cities. However, in some countries, integrated operations are moving closer to the

FIGURE 2
Typical integrated poultry operation



Source: adapted from Marion (1985).

source of inputs; Brazil is an example – see Camargo Barros *et al.* (2003) and Delgado *et al.* (2008). In countries where live chickens are still sold mostly in informal markets, such as India, Indonesia and Viet Nam, forward linkages are also becoming evident, particularly as these countries are faced with the highly pathogenic avian influenza (HPAI) situation and concern is growing about the poultry-to-human spread of the virus (Indonesia and Viet Nam).

Although there is a move to integrated operations in a number of developed and developing countries, for many developing countries, production practices are such that the majority of producers still maintain small flocks which are kept outdoors and are exposed to outside influences. At the same time, these small backyard producers may be interspersed with large-scale commercial operations, giving rise to highly concentrated regions of production near urban areas. Poultry products are among the most perishable, so they have to be produced in close proximity to the demand. Figures 3, 4 and 5 illustrate that in Asia, Latin America and Africa the geographical concentration of poultry operations tends to be around major cities. As can clearly be seen in Figure 3, poultry distribution patterns can be explained by the distribution of human population, i.e. where there is a dense human population then there is likely to be a dense poultry population. Growing concentrations of animals in large units near cities are associated with greater pollution and increased risk of transmission of both zoonotic and other diseases. Notably, HPAI began in areas with high poultry population density, such as China, Indonesia, Thailand and Viet Nam (Figure 3). Increasing concerns over environmental and health externalities associated with concentrated and intensive poultry production near urban areas are causing countries to rethink zoning issues.

2.3 Declining poultry prices

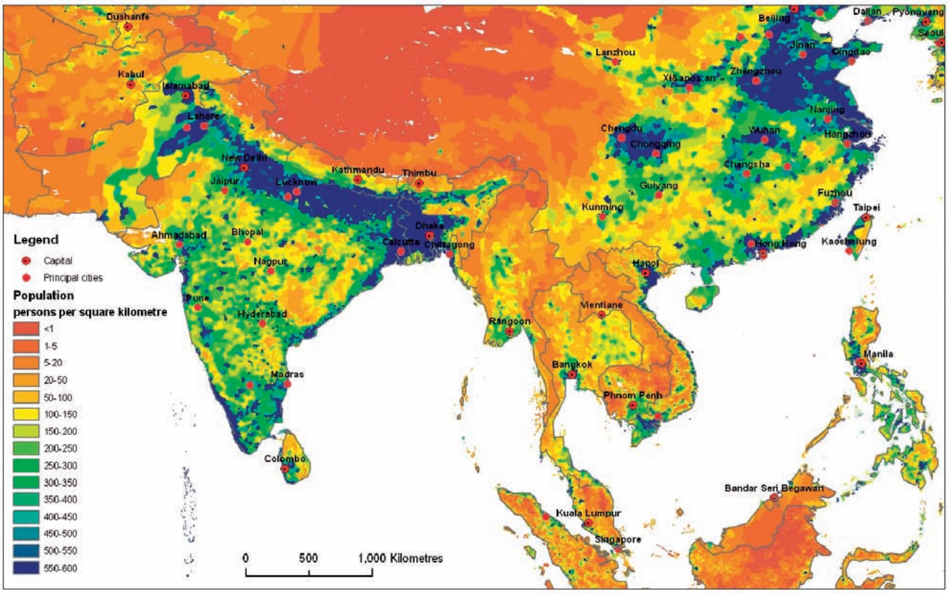
Collectively, the changes outlined above have led to a decline in world meat prices over time, particularly for poultry, as shown in Table 4. However, prices are expected to rise as a result of the rising price of maize. Between the 1980s and the 1990s, real prices of poultry declined at a rate of 3 percent per year. This decline continued, but at a slower rate. The downward trend in prices was brought about by a number of factors, such as improvements in the efficiency of production of large-scale poultry operations (Delgado *et al.*, 2003) and rapid technological progress, as in the case of the United States of America (Narrod, 1997). It is important to note that there was an increase in poultry prices between 2003 and 2004, which could be attributed to a reduction in export supplies caused by several outbreaks of H5N1 HPAI. In 2004/2005, as HPAI outbreaks were reported in some 40 countries previously not infected by the virus, poultry prices noticeably dropped – by 11 percent. Poultry prices are expected to increase over the period 2005 to 2030 at 0.2 percent per year, reflecting increasing demand in China and sub-Saharan Africa, and increasing prices of feed grains such as maize (projected to increase by 0.8 percent per year over the period 2005–2030 (Table 4), supported by the exceptional demand for maize coming from increasing biofuel production).

Consumers as a whole have benefited from the livestock industrialization process, as a result of reduction in meat prices. It is known that poultry meat and eggs contain protein and micronutrients, such as vitamins from group B, iron and zinc, which could provide an

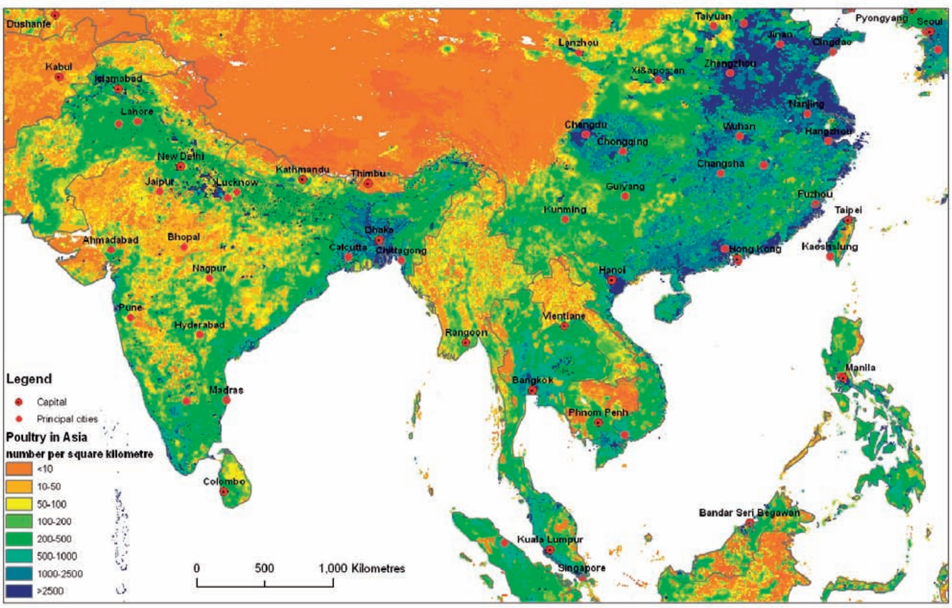
FIGURE 3

Geographical concentration of poultry operations tends to be around major cities in Asia

Human population



Poultry population

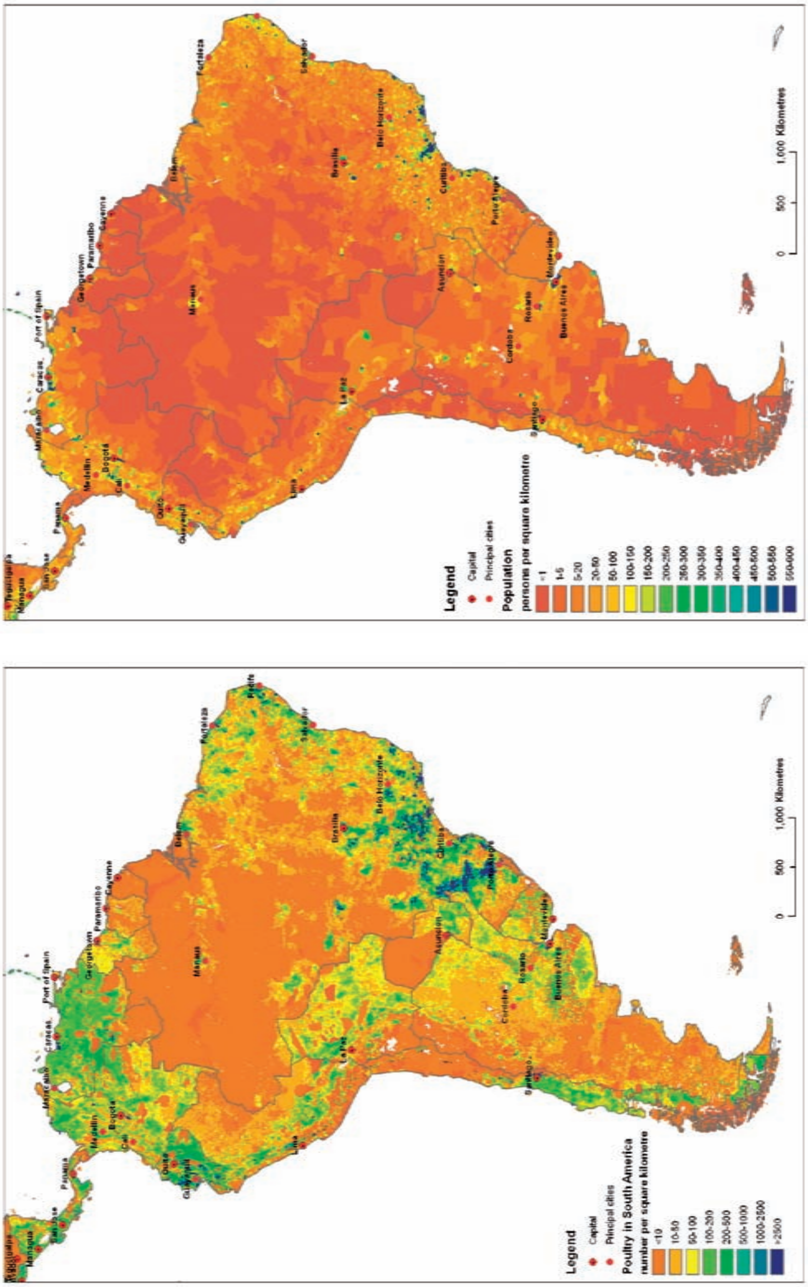


Source for human population maps: Center for International Earth Science Information Network (CIESIN), Columbia University; FAO; and Centro Internacional de Agricultura Tropical (CIAT). 2005. Gridded Population of the World: Future Estimates, 2015 (GPW2015): Population Density Grids. Palisades, NY: Socioeconomic Data and Applications Center (SEDAC), Columbia University. Available at http://sedac.ciesin.columbia.edu/gpw. (accessed on October 17, 2007). *Source for poultry population maps:* FAO Animal Production and Health Division. Gridded Livestock of the World. Available at http://www.fao.org/ag/againfo/resources/en/glw/home.html. (accessed on October 17, 2007)

FIGURE 4

Geographical concentration of poultry operations tends to be around major cities in Latin America

Human population ***Poultry population***

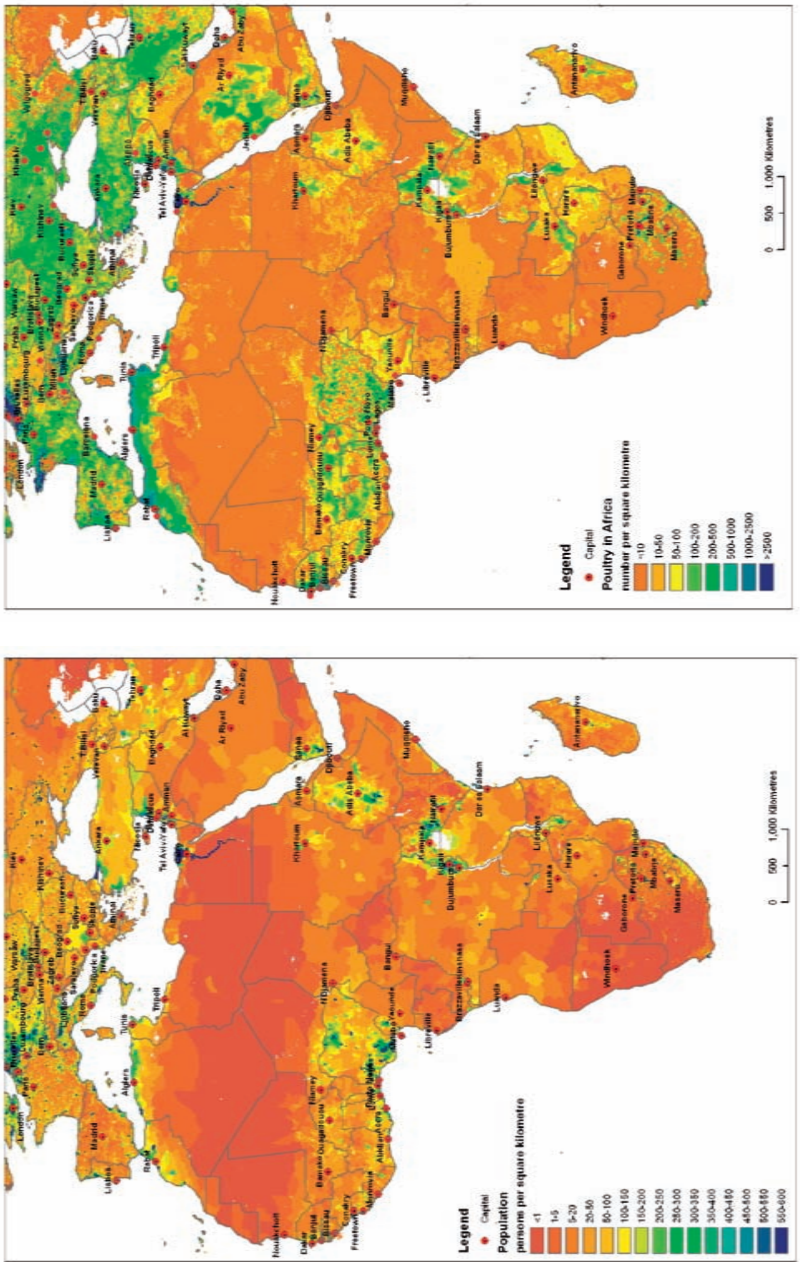


Source: See figure 3.

FIGURE 5

Geographical concentration of poultry operations tends to be around major cities in Africa

Human population ***Poultry population***



Source: See figure 3.

TABLE 4
Past trends in real prices of selected livestock products and maize

	Maize	Beef	Pork	Poultry	Milk
	Constant 2000 US$/tonne				
1980	232	5 092	3 338	1 995	2 442
1981	221	4 182	3 663	1 815	2 535
1982	172	3 805	5 056	1 629	2 259
1983	209	3 742	3 933	1 704	1 541
1984	201	3 363	3 689	1 812	1 346
1985	161	3 085	3 551	1 605	1 175
1986	123	2 937	3 820	1 759	1 282
1987	103	3 254	3 559	1 425	1 427
1988	141	3 325	2 258	1 640	2 228
1989	142	3 271	1 795	1 657	2 306
1990	134	3 145	2 720	1 482	1 587
1991	127	3 156	2 325	1 359	1 762
1992	121	2 841	1 441	1 341	1 979
1993	115	2 961	1 609	1 376	1 719
1994	119	2 583	1 377	1 360	1 707
1995	134	2 071	1 503	1 349	2 356
1996	175	1 901	2 171	1 438	2 154
1997	123	1 943	1 682	1 358	1 853
1998	105	1 789	1 042	1 440	1 799
1999	92	1 874	1 001	1 309	1 562
2000	88	1 935	1 307	1 238	1 850
2001	88	2 078	1 323	1 273	1 902
2002	95	2 018	1 000	1 175	1 349
2003	99	1 866	1 111	1 289	1 692
2004	103	2 321	1 447	1 510	2 002
2005	87	2 317	1 321	1 387	2 006
Growth rates (%)					
1980–1990	-5.3	-4.7	-2.0	-2.9	-4.2
1990–2000	-4.1	-4.7	-7.1	-1.8	1.5
1990–2005	-2.8	-2.0	-4.7	-0.4	1.6
1980–2005	-3.8	-3.1	-3.6	-1.4	-0.8
2005–2030 (projected)	0.8	0.6	0.5	0.2	-0.6

Nominal prices in US$ are deflated by the US Consumer Price Index.
Maize: US$/tonne, US #2 yellow, fob Gulf of Mexico. Source: IMF, accessed October 2007 (http://www.imf.org/external/np/res/commod/index.asp).
Beef: US$/tonne, Australia/New Zealand frozen, U.S. import price. Source: IMF, as above.
Pork: US$/tonne, USDA 5-market average hog prices. Source: IMF, as above.
Poultry: US$/tonne, USDA Avg. 12-City Broiler Price, Broiler Composite and Georgia Dock Price. Source: http://www.cattle-fax.com/data/files/poultry/prices.xls
Milk: US$/tonne, whole milk powder, fob Western Europe. After 1994, midpoint of prices reported by New Zealand Dairy Board. Sources: FAO Commodity Review and Outlook 1982-1991, FAO Commodity Market Review 1995-2000, http://future.aae.wisc.edu/data/weekly_values/by_area/1705, accessed October 2007.
Note: Projections to 2030 are from the IMPACT model projections October 2007.

important contribution to the health and nutrition of consumers. For the urban poor, the fall in prices meant an increase in their purchasing power, leading to greater economic access to poultry and other meat. Moreover, especially in the case of poor households engaged in small-scale backyard poultry raising (which is likely to be their main source of animal protein), responding to increased demand probably also leads to higher levels of home consumption (Neumann *et al.*, 2002; Barroeta, 2007).

2.4 Increased trade in poultry products further increases demand

Broiler products dominate the international poultry trade (Moore and Morgan, 2006). Table 5 shows the top five broiler importing and exporting countries or regions for 2005, along with imports and exports as a share of production. The Russian Federation dominates in terms of broiler imports, followed by Japan and the European Union. Brazil and the United States of America dominate in terms of broiler exports. China is emerging as an active broiler exporter.

Brazil has overtaken the United States of America in terms of chicken-meat exports, expanding by 21 percent from 2000 to 2005, largely due to increases in production and in demand from foreign markets (Figure 6). The United States of America's market share of chicken meat exports decreased by 7 percent over the same period, because of lower import needs in the Russian Federation. The United States Department of Agriculture predicts that there will be continued higher demand for Brazilian products because of their competitiveness and aggressive market promotion efforts by Brazilian poultry exporters in new markets (USDA/ERS, 2007). Trade in poultry meat is projected to increase at a faster rate than production and consumption (OECD–FAO 2007).

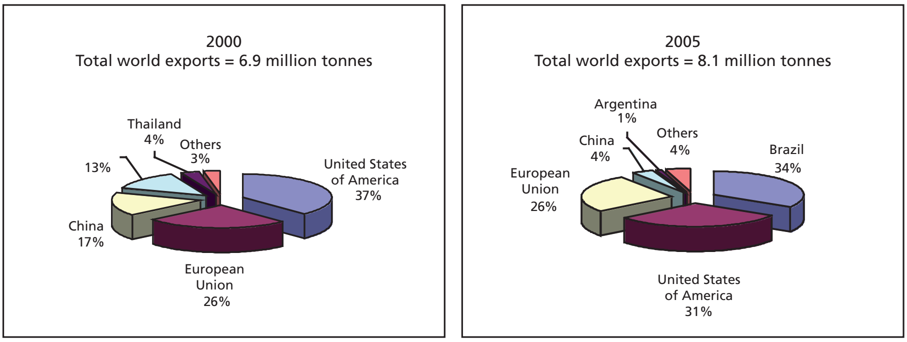
TABLE 5

Broiler imports and exports: top five countries or regions in 2005

Country/region	Imports	Exports	Production	Share of Production
		(1 000 tonnes)		(%)
Russian Federation	1 204		1 346	89
China	907		10 102	9
Saudi Arabia	451		545	83
Japan	419		1 339	31
Mexico	357		2 437	15
Brazil		2 762	8 507	32
United States of America		2 480	15 945	16
European Union		2 123	9319	23
China		296	10 102	3
Argentina		111	1 010	11

Source: FAOSTAT accessed 23 October 2007.

FIGURE 6
Changes in market share for chicken meat exports, top five exporters



Source: FAOSTAT accessed 23 October 2007.

2.5 Rise of large-scale retail outlets

The emergence of large-scale retail outlets, including supermarkets and hypermarkets, in developing countries reflects a structural change that alters the way in which meat and dairy products are assembled, inspected, processed, packaged and supplied to consumers (Costales *et al.*, in FAO, 2006). As a result, livestock markets tend to be divided between the "wet" markets for fresh and warm meat and supermarket outlets for processed, frozen, packaged and branded meat. The relative significance of each market segment is closely linked to the purchasing power of households and individuals, their demand for leisure, their preferences with respect to the form and texture of meat upon purchase, and the relative value or price premium they are willing to pay for a safer product. Wet markets are still the main output market for live broilers produced by smallholders and independent commercial producers. There are, however, no guarantees that these markets will continue to offer economic opportunities for smallholders over the longer term, even if they are relatively efficient producers, because of large fluctuations in live broiler prices, changing consumption patterns and habits, and the rapid expansion of the large-scale retail sector with its demands for product consistency and known safety.

2.6 Increased concerns over sanitary and phytosanitary (SPS) issues and food safety

Increasing international trade and globalization are also important drivers of change in the poultry sector. More precisely, they influence the relative competitiveness of producers and production systems in supplying the rising demand for poultry products, particularly in international markets (Costales *et al.*, in FAO, 2006). Increased and long-distance trade requires compliance with standards and regulations and SPS requirements to ensure food quality and safety, as well as public intervention and investment and private costs. Food control and certification systems must be of a high standard. In addition to the health and safety standards and regulations agreed by international bodies (such as the World Organisation for Animal Health, (OIE) for animal and human health measures, the Codex Alimentarius Commission for human health measures, and the International Plant Protection Convention for plant health measures), technical requirements may be imposed by retailers. These may include demands for particular meat cuts, carcass size and weight, leanness of meat, egg colour or labelling with particular information or in specified languages. Large retailers require a reliable supply of agricultural products from their suppliers (producers) with consistency in volume and in quality; hence, they vertically integrate to reduce production risk and transaction costs. Producers who become part of this integrated chain may face a change in contractual arrangements (e.g. becoming dedicated contract farmers) with increased levels of assistance and higher prices for quality products, but with increased risk if contracts are not met or the retailer closes down. This applies particularly where the farmer must specialize to satisfy volume, safety and quality requirements (see Table 6).

TABLE 6
Standards in the livestock market and implications for small-scale producers

Standards	Positive factors	Negative factors
Process standard		
Ultra-high-temperature (UHT) treatment of milk: government requirement.	Clearly specified process.	Administration costs of inspection. Investment in equipment and training may exclude smallholders.
Hazard Analysis and Critical Control Point (HACCP) systems in abattoirs: required by importers and supermarkets.	Clearly specified process.	Probably neutral for small producers.
Organic produce: standards set by certifying bodies.	Premium price. Can be carried out on a small scale (e.g. honey production in Chile). Favours labour-intensive systems	Several certifying bodies, harder to achieve in developing countries. Costs of certification. Difficult to achieve by unorganized smallholders (achievable by smallholders working in cooperatives).
Performance standards		
Salmonella levels in meat: with financial penalty for poor performance.		Standards usually set to stringent developed-country consumer requirements. No guaranteed method to meet required standards. Cost of tests may be prohibitive unless subsidized by government.
Combined standard		
Contract farming requirements for timing of activities and quality of product.	Premium price. Some support with investment and cash flow. May be supported to overcome risk, e.g. restocking after HPAI outbreaks. Technical support. Reduced risks related to variations in input and output prices.	Risk of total market loss if there is failure to produce the required quality. Not all producers meet requirements. Social stigma associated with failing to "make the grade".

Source: adapted from Costales *et al.* (in FAO, 2006).

Smallholders can find it increasingly difficult to compete with large-scale producers if they are required to make investments to meet the needs of a retailer. For smallholders to stay involved in this fast-growing segment of the market, they need to integrate into high-value chains through contract farming or other forms of institutional arrangements that have process-based food-safety systems in place and can deliver a form of branding. If smallholders choose to operate independently, it will be harder for them to remain involved over time as markets become more demanding in terms of information about the quality of the product at the time of sale and as market chains become complex.

3 CHANGING STRUCTURE OF THE INDUSTRY AND SUPPLY CHAINS ASSOCIATED WITH THE RETAILING/MARKETING OF POULTRY PRODUCTS IN DEVELOPING COUNTRIES

Under conditions of clearly specified quality and safety standards, and high risk and uncertainty in output and input markets, vertical integration is a well-known strategy to resist shocks in input and output prices, especially for small producers operating in a market subject to price instability. It is also an efficient way to provide technical assistance to the producers and to diffuse new technologies. For example, the Charoen Pokphand Group in Thailand has been promoting new housing and manure-management systems over the last six years, resulting in drastic shifts in production among its contract farmers.

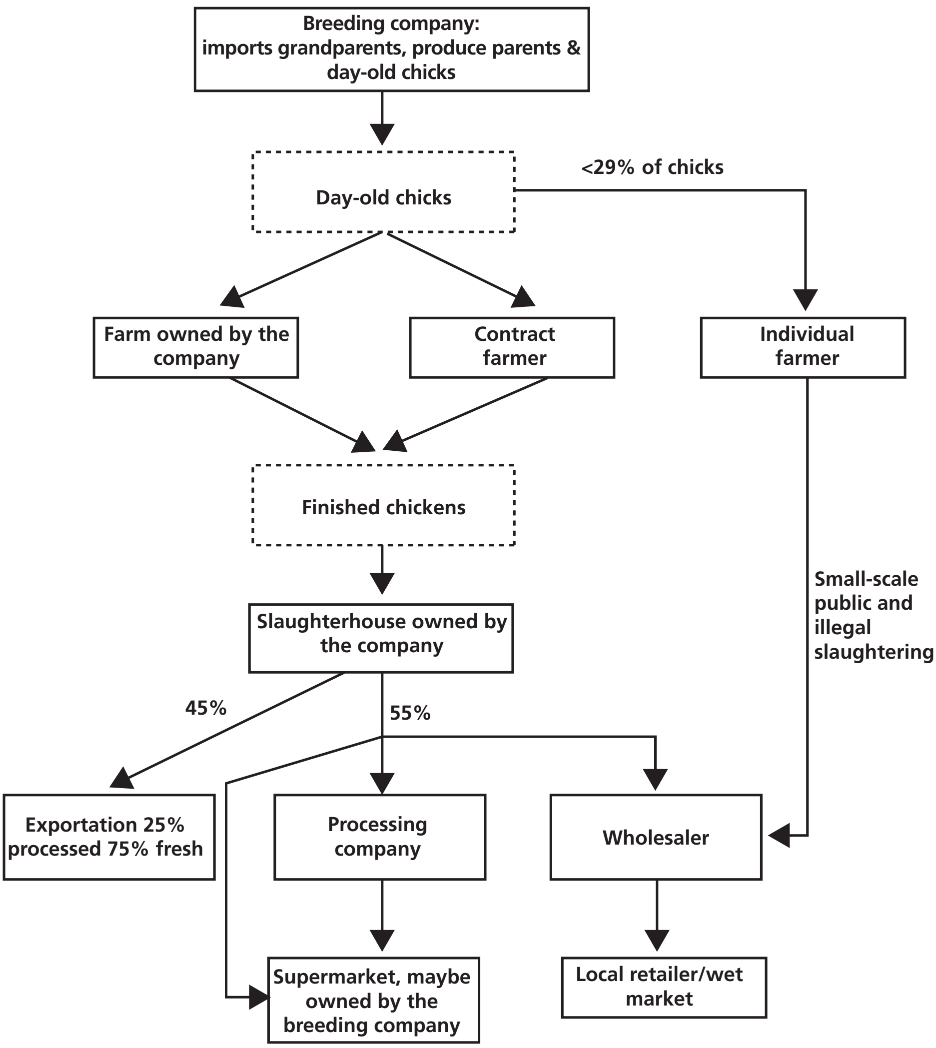
The introduction of contractual production arrangements within a framework of vertical coordination reduces transaction costs associated with information asymmetry and secures benefits from market ownership and control over product quality and safety by controlling technical inputs and processes at all levels. Large retailers and large commercial firms in developing countries are increasingly tending towards vertical coordination, although vertically coordinated chains may interact with informal markets by supplying inputs for poultry production (Figure 7).

Under production contracts, the integrators agree to supply the major inputs, such as day-old chicks (DOCs), feeds, veterinary care and medicines, and technical services. The integrators also arrange for the marketing of live broilers, which are in principle owned by them. Integrators bear all input and output price risks, and share production risks with the broiler growers. However, the growers typically do not have a share in the benefits of increasing output prices (nor do they share in losses resulting from falling output prices). Integrators operate in all aspects of production, including raising grandparent and parent flocks, rearing DOCs and milling/mixing feeds.

Conversely, the broiler producers supply the labour, land, sheds, water, electricity and management skills needed for production. They, in turn, receive a growing fee per bird based on performance indicators such as feed conversion ratio, harvest recovery and average live weight. Compensation, additional to the growing fee, is given to growers who surpass the performance standards. In the case of growers who fall below the standards, corresponding amounts per bird are subtracted from the fee.

The supply chain in Karnataka exemplifies vertically integrated broiler supply chains in India (Figure 8). All or most aspects of production (from parent stock to processing) are owned or controlled by an individual company known as the "integrator". The eggs produced from the parent-breeding farms are supplied to hatcheries, which are usually under

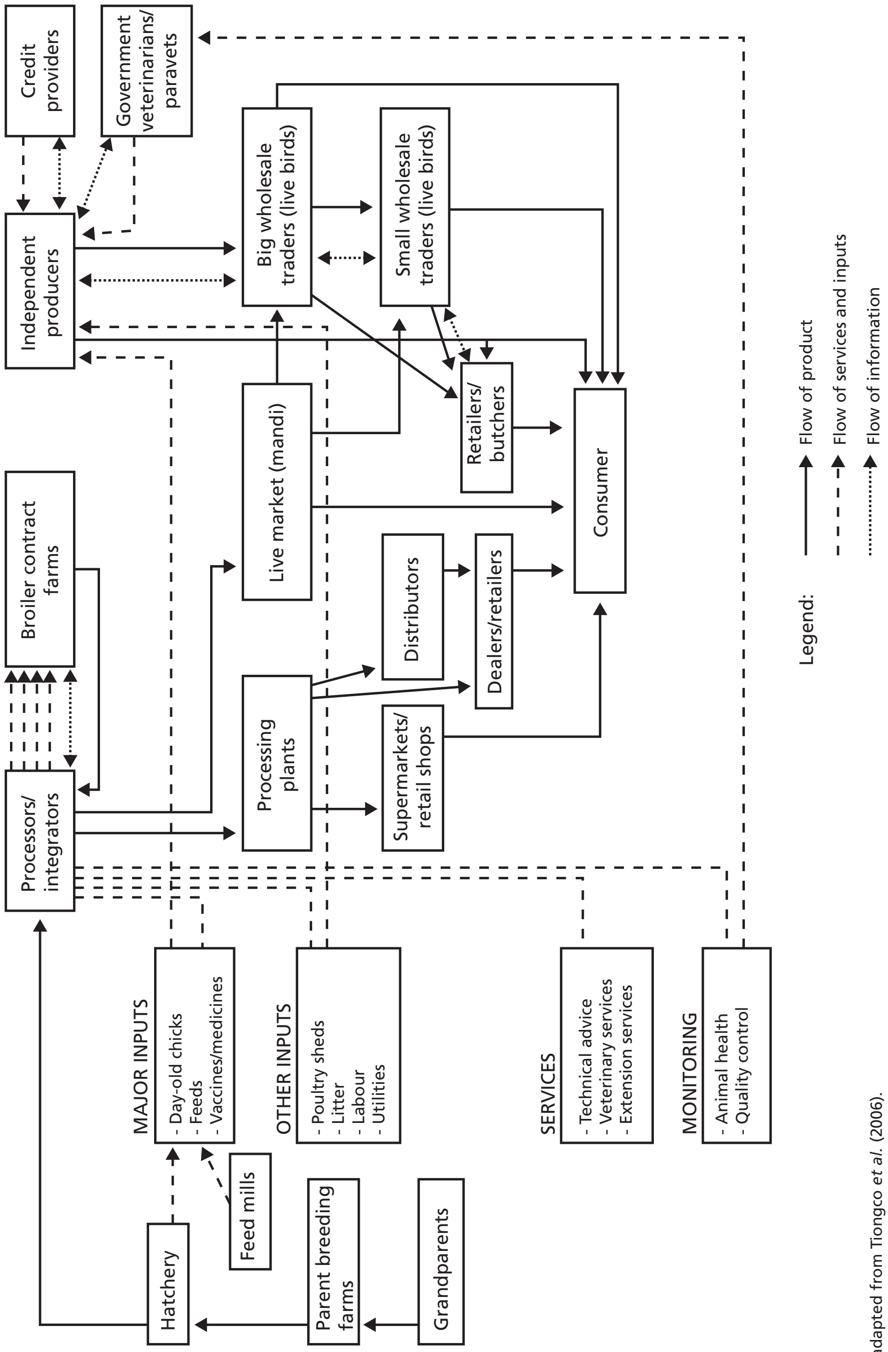
FIGURE 7
Commercial chicken supply chain in Thailand



Source: Costales *et al.* (in FAO, 2006).

contract with these big companies to produce DOCs. The DOCs are then supplied to broiler farms, which are either under contract with integrators or are independent producers of broilers. Along with DOCs, the integrators also provide the contract grower with feed, medication and technical advisors to supervise farm production. Company field representatives are assigned to visit farms on a regular basis to assist producers with their management and help them to achieve maximum performance and efficiency.

FIGURE 8
Poultry supply chain in Karnataka, India



Source: adapted from Tiongco *et al.* (2006).

Contract broiler farmers have virtually no problem marketing live birds, as the integrators arrange for the lifting of live birds from the broiler farms. The integrator, who owns the birds, will either sell the live broilers to big wholesale traders or (if they have their own processing plants) process the birds as chilled chicken to be sold to consumers.

In the case of independent broiler growers, output is sold to traders, wholesalers or retailers, or directly to consumers (if the growers have their own retail shop). Most independent farmers obtain their information on market prices from traders, intermediaries or fellow farmers, and sell broilers at the farm-gate price after negotiating with the buyer. Lack of negotiating power and lack of access to market information contribute to high transaction costs. Further, lack of facilities for collective action or other institutional arrangements makes it more difficult for smallholder producers to reduce transaction costs through economies of scale. However, overcoming these constraints is not impossible for smallholders if they have the ability and incentives to integrate into a more dynamic private-sector business.

4 EFFECT OF CHANGES ON SMALLHOLDERS' COMPETITIVENESS IN FOUR FAST-GROWING DEVELOPING COUNTRIES

4.1 Scaling-up of poultry production in Brazil, India, the Philippines and Thailand

The four country cases chosen – Brazil, India, the Philippines and Thailand – are all fast-changing developing countries where cities, population, urban incomes and consumption of livestock products have been growing rapidly since the early 1980s. Poultry is in fact one of the fastest growing segments of the agricultural sector in these four countries (Table 7). Production of poultry in these four countries has been increasing rapidly for the last 30 years, except in the case of Thailand where production has scaled down in recent years due to the avian influenza outbreaks that have hit the country periodically since 2004. Poultry production in Thailand is expected to recover as a result of improved market conditions and increases in demand for more highly-processed poultry products (overcoming depressed demand for meat in fresh from), reflecting recovery of consumer confidence in consuming poultry meat. Production is expected to increase at an annual growth rate of 2.3 percent to 2030 over the 2005 base.

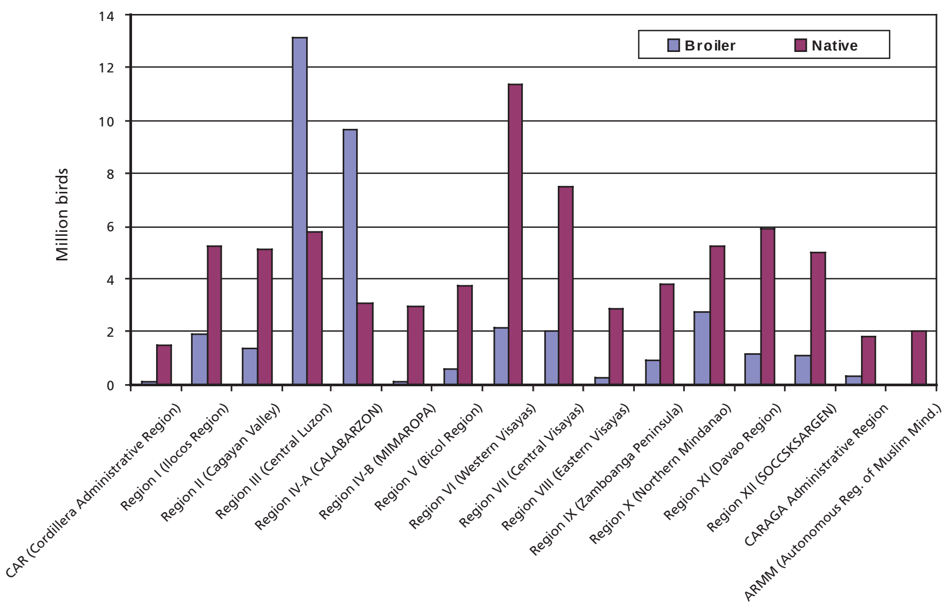
One impact of scaling-up that is occurring in the Philippines is the replacement of traditional varieties of meat animal with a few international breeds. Chicken farms in the Philippines were initially characterized by the use of native breeds. Native breeds continue to be important in the Philippines broiler market, making up about 70 percent of the total chicken population, and continue to grow at a rate of 3 percent per year. However, they are rapidly being displaced in the growing Metro Manila market and nearby cities in Regions III and IV-A (Figure 9). With a wide selection of broiler-based products (such as chicken nuggets, chicken breast sandwiches and fried drumsticks) available in fast-food establishments, an important issue for smallholders is whether they can penetrate these food-service chains. In addition, smallholders, especially those not vertically integrated with large firms, market their produce as live birds to wet markets and small retailers where food safety and quality requirements are not strictly imposed (USDA-FAS, 2006).

TABLE 7
Poultry production growth rates in Brazil, India, the Philippines and Thailand: 1975–2006 and projected to 2030

	1975–1990	1990–2006	1990–2000	2000–2006	1975–2006	2005–2030 (projected)
Brazil	10.3	8.3	9.7	6.1	9.3	2.4
India	9.1	11.3	11.8	10.5	10.2	4.5
Philippines	3.9	6.4	8.7	2.8	5.2	2.8
Thailand	5.7	3.7	6.0	-0.1	4.6	2.3

Sources: FAOSTAT accessed October 2007; rates to 2030 are taken from IFPRI's IMPACT model projections, October 2007.

FIGURE 9
Chicken inventory by region: the Philippines, 2007



Source: adapted from Costales *et al.* (2003) and Delgado *et al.* (2008); Country FAOSTAT-Philippines, accessed 24 October 2007.

As supply chains become more complex, economies of scale (cost reductions realized through expanding the scale of operations) at various stages of the production process trigger the creation of large production units. As a result of this, the number of producers rapidly diminishes even though the sector as a whole may expand. In many rapidly growing economies, the average size of operations is rapidly increasing and the numbers of livestock producers are in sharp decline. In Brazil, the estimated inventory of chickens by flock size grew significantly between 1985 and 1995-1996, as shown in Table 8. It can be observed

TABLE 8
Distribution of poultry farms by size of operation in Brazil, 1985-1996

Year	<10 000 head		>10 000 – head	
	South	Centre west	South	Centre west
1985	25%	57%	75%	42%
1996	32%	21%	68%	78%

Source: adapted from Camargo Barros *et al*. (2003). Brazilian Institute of Geography and Statistics (IBGE), Census, 1995/1996.

TABLE 9
Change in the size distribution of poultry farms in Thailand between 1988 and 2003

Flock size (birds/farm)	Number of farms (×1 000)			(% change)		
	1988	1998	2003	1988–1998	1998–2003	1988–2003
1–19	2 267	1 948	362	-14	-81	-84
20–99	946	1 146	581	21	-49	-39
100–999	27	66	68	144	3	152
1 000–9 999	9	13	14	44	8	56
10 000 and over	0.5	2	4	300	100	700
Total	3 250	3 174	1 028	-2.3	-68	-68

Sources: adapted from Poapongsakorn *et al.* (2003) citing the 1988 and 1998 Inter-censal Survey of Agriculture by the National Statistical Office and the 1993 Agricultural Survey by the National Statistical Office (National Statistics Office, 2003).

that growth in larger farms (more than 10 000 birds) happened in the centre west – states of Mato Grosso, Mato Grosso do Sul and Goiás – and also in the states of São Paulo and Minas Gerais (Camargo Barros *et al.*, 2003). In the south, the share of small farms increased by 7 percent – brought about by expansion of farms in the states of Paraná, Santa Catarina and Rio Grande do Sul (particularly farms with 5 to 10 thousand birds among which there has been significant growth).

Similarly in Thailand, only the largest category of farms grew in number (Poapongsakorn *et al.*, 2003). Table 9 shows changes in the size distribution of poultry farms in Thailand. The table depicts a situation in which smallholder farms (with less than 100 birds) still dominated in terms of numbers, although they had been declining in absolute level between 1988 and 2003. The larger-sized farms registered the largest proportional increases in number over the period covered by the table (in 2003, 43 percent of broilers produced in Thailand came from farms keeping less than 10 000 birds), indicating the increasing scale and commercialization of poultry production.

4.2 Impact of structural changes on profitability of small-scale producers – results from case studies

The main concern with regard to the forces promoting the scaling-up of livestock production in developing countries is that they might drive small-scale producers out of business altogether, and the question of whether the displacement is being accelerated by policy distortions, externalities or structural factors such as transaction costs that disproportionally affect small-scale farms. If true economies of scale resulting from technology, management or transport (for example) are driving the incentives for larger-scale poultry farming, then other things being equal, we would expect larger farms to be more profit efficient and have higher or equal unit profits compared to small farms. In such circumstances, the larger farms could eliminate competition from small farms over time by cutting their profit margins. Small farms can stay in business by using family labour valued below market price; this works well in developing countries where there are limited employment opportunities in other sectors. But as soon as employment opportunities in other sectors rise, many smallholder producers will opt out.

The results of the case studies conducted by Delgado *et al.* (2003), suggest that smallholders typically have higher profits per unit of output than have large-scale producers – as shown in the cases of India and the Philippines in Table 10. In the case of broiler producers in the Philippines, profits per unit obtained by smallholder contract farmers were higher than those obtained by large-scale contract farms. The findings from India are supported by a recent study in Karnataka, which looked at the effect of contract farming on the profitability of broiler production (Fairoze *et al.*, 2006).

In Thailand, large independent broiler farms made higher profits than medium-sized independent farms (Table 10). Fee contract farmers in the Thai broiler sample had similar per unit profits at large and small scales. In Brazil, as in the case of Thailand, small and large broiler farms have similar average profits per kg. This may reflect the fact that in the Brazilian case the majority of small and large-scale farms are contracted to vertically integrated operations. Much of the inputs are supplied by the integrator and in most cases the small and large-scale farms are using similar if not the same technology. Moreover, small-scale farms do not explicitly cost family labour, allowing them to maintain their unit profits close to large farms.

There is, however, a growing concern that smallholders might be excluded from the process of contractual arrangements, as integrators would prefer to contract with large-scale farmers so as to minimize production and transaction costs associated with searching for and screening prospective farms, negotiation of contracts, delivery of inputs and services, monitoring of growers' management on farm, and enforcing contract terms.

Tiongco *et al.* (2006) observed that an integrator's transaction costs are incurred on a per grower basis and do not depend on the size of the farm. Moreover, small farms usually require more technical assistance from the integrator per unit of output. For example, a farm visit may require the same amount of time regardless of the scale of production. It was also observed that there was no significant difference between small and large farms in terms of the growing fees paid by integrators per unit of output. Holding the growing fee per unit constant, integrators would rather contract with larger producers to lower their cost of procurement or to lower the cost of default.

TABLE 10
Average profit per unit of output of broiler live weight across farm sizes by country and by production arrangement, 2002

Country		Farm size: Smallholder <10 000 birds – Independent	Farm size: Smallholder <10 000 birds – Contract	Farm size: Large/Commercial >=10 000 birds – Independent	Farm size: Large/Commercial >=10 000 birds – Contract
India					
Average profit without family labour cost	rupees/bird	13.13	1.03	10.93	3.16
	US$/kg*	(0.11)	(0.01)	(0.09)	(0.03)
	rupees/bird	11.36		9.98	
	US$/kg*	(0.10)		(0.09)	
Average profit with family labour cost	rupees/bird	12.40	0.04	10.80	3.01
	US$/kg	(0.11)	(0.003)	(0.09)	(0.03)
	rupees/bird	10.59		9.85	
	US$/kg	(0.09)		(0.08)	
Philippines					
Average profit without family labour cost	pesos/kg	1.59	4.05	1.07	3.96
	US$/kg	(0.03)	(0.08)	(0.02)	(0.08)
Average profit with family labour cost	pesos/kg	1.34	3.98	1.06	3.95
	US$/kg	(0.03)	(0.08)	(0.02)	(0.08)
Thailand		Forward contract and independent	Per-bird wage contract	Forward contract and independent	Per-bird wage contract
Average profit	baht/ kg live weight	0.71	1.35	2.48	1.51
	US$/ kg live weight	(0.02)	(0.03)	(0.06)	(0.04)
Brazil					
Average profit	real/kg live weight	0.05		0.06	
	US$/ kg live weight	(0.02)		(0.02)	

Note: * assuming 1 bird weighs 2.4 kg live weight.
Numbers in parentheses are average profit in US$ per unit of output. The currency conversion rates used are based on 2002 foreign exchange rates: for Thailand, US$1= 42.96 baht; for India, US$1 = 48.61 rupees; and for Brazil, US$1 = 2.92 reals; for the Philippines, US$1 = 51.60 pesos.
Source: Delgado *et al*. (2008).

Smallholders will have at least a chance to compete with larger-scale producers, as they have the ability to produce at a lower per unit cost of production or at least achieve profits per unit of output that are similar to those of large-scale farmers. If smallholders are not able to sustain a rate of productivity growth equal to or greater than that of large farms under these conditions, they will have a hard time remaining in business.

TABLE 11
Mean relative profit efficiency of broiler farms across farm sizes by country, 2002

Country	Farm size (number of birds): Smallholder <10 000 birds – Independent	Smallholder <10 000 birds – Contract	Large/Commercial >=10 000 birds – Independent	Large/Commercial >=10 000 birds – Contract
Philippines	N = 30	N = 34	N = 31	N = 14
Mean efficiency (%)	35	56	45	73
	45		64	
India	N = 93		N = 42	
Mean efficiency (%)	45		85	
Brazil	N = 34		N = 195	
Mean efficiency (%)	76		86	
Thailand	Contract <5 000 N=74	Contract 5–10 000 N=51	Contract 10–20 000 N=27	Contract >20 000 N=18
Mean efficiency (%)	49	71	88	87

Source: Delgado *et al.* (2008).

In terms of relative profit efficiency, the outlook for small broiler producers is not good. Table 11 shows that large-scale producers from the four case-study countries are more profit efficient than small farms, which means that they will be able to drive their costs down and survive on smaller unit profits but bigger volumes of sales. If this is the case, it is possible that smallholders will be driven out of the market because of their small volumes of production. According to Delgado *et al.* (2008), for smallholders to survive the livestock industrialization process, the key issue is for them to have access to output markets.

Smallholders find it increasingly difficult both to meet the food safety and quality standards required in growing urban markets and in export markets and to deliver a regular supply. Small-scale producers are often left out due to their low productive capacity, remoteness and limited competitiveness compared to larger growers. Organizational challenges further impede private-sector inclusion of smallholders. Although the public sector has traditionally provided services such as extension, research, infrastructure and marketing outlets, the movement towards demand-driven agriculture limits the ability of government to fully provide the assistance needed by smallholders to enable them to gain recognition in the marketplace. Rich and Narrod (2005) suggest that close coordination of the supply chain works against the smallholder because of information asymmetry and high transaction costs, organizational constraints and regulatory failure. Smallholders tend to face high transportation costs because of their geographical location and poor infrastructure linking them to markets. Smallholders often have imperfect information regarding the needs of buyers and customers in the high-value markets for which they are producing. Further, their ability to meet public or private standards is limited – there is often a large divergence between public and private standards, and the public sector in the countries in question often has a low capacity to enforce public standards. In terms of coordination mechanisms, smallholders often have limited ability to enforce contracts and there is often a divergence in market power among the actors in the supply chain.

There are, basically, five elements that are essential to ensure smallholders' access to markets. First, producers need access to extension services or technical assistance so that they stay up to date with the specialized techniques needed to ensure the safety of high-value products. Second, they need access to good infrastructure so as to be able to manage flows between chain links quickly and efficiently so as to meet the rigid deadlines imposed by buyers and reduce transportation and distribution costs. Third, they need access to good sources of information so as to be well informed of changing market demands and to be able to integrate this information rapidly across the supply chain. Fourth, producers need to have the ability to produce products that are certifiably safe and of good quality. Certification systems need to be not only consistent but also credible, to meet buyer and customer demands. Lastly, producers need to have good mechanisms for coordination of their supplies to the markets so as to ensure the timely delivery of high-quality products. If market failures are preventing smallholders' access to these important elements, it is very possible that they will lose much of their current market access unless some sort of institutional arrangement can be made to address the problems.

5 THE FUTURE OF SMALLHOLDER POULTRY PRODUCTION IN A RAPIDLY CHANGING MARKET

Poultry production has undergone rapid changes during the past two decades as a result of the introduction of modern intensive production methods, genetic improvements, improved preventive disease control and biosecurity measures, increasing income and human population, and urbanization. The intensification of segments of the poultry sector, in proximity to areas of ever more dense human population, in conjunction with the increasing ease of transport, has led to growth or scaling-up of poultry production. In all the case-study countries, there has been a rising demand for poultry products with specific food-safety and quality attributes, probably linked to increased urbanization and income levels. The private sector in the case-study countries has taken the lead in delivering products with the desired attributes, at least to wealthier consumers patronizing high-end market outlets. Large producers in all the case-study countries have also sought a form of branding through vertical integration with small-scale retail outlets for poultry meat serving the broader urban populace.

From the findings of the case studies described above, it is difficult to see a bright future for smallholder poultry production. However, results also show that it is unlikely that smallholders will disappear soon. Smallholder producers can still compete with larger producers because of savings achieved as a result of foregone or cheaper overheads, lower labour costs per unit and, possibly, more intensive supervision, leading to relatively high profit efficiencies.

Food-safety concerns and demand for reliable timing and quality drives the concentration of supermarkets. The requirement to meet high demands for food safety, traceability and compliance often disfavours smallholders compared to larger operations in terms of supplying specific supply chains, because of high coordination costs, and high transaction and marketing costs associated with sourcing from smallholders. Increasingly, it appears that smallholders' ability to maintain their competitiveness in these types of markets is dictated by their ability to establish market trust and reputation along the marketing and distribution channels. This will require them to be linked to the supply chain and obtain certain supply chain management necessities. The fact remains that public policy targeted at achieving widespread impact on poverty by keeping smallholders involved in the growing livestock sector needs to harness the resources of the private sector, typically through the provision of incentives for contract farming. The incentives for such schemes often come in the form of tax breaks to the integrators; it will be important to factor the costs of forgone public revenue when establishing the unit costs of the schemes. The key for poverty alleviation is to ensure that the measures are beneficial to smallholder producers as well as larger farmers and integrators. Investigating the full costs and benefits of different policies aimed at encouraging contracting with smaller-scale farmers is a policy-research priority.

Aside from contract farming, there are other strategies that can facilitate a more competitive link of smallholders to changing markets. Important considerations include appropriate government policies that would provide communication and storage infrastructure facilities and cost-effective disease control methods. The HPAI crisis in East Asia severely threatens the viability of the small-scale poultry sector in the region because of its dramatic spread, and the high mortality and massive depopulation associated with outbreaks. Preventive and control measures must be pro-poor so as not to constrain the participation of smallholders.

REFERENCES

Camargo Barros, G S., Zen, S.D., Piedade Bacchi, M.R., Galvão de Miranda, S.H,. Narrod, C. & Tiongco, M. 2003. Policy, technical, and environmental determinants and implications of the scaling-up of swine, broiler, layer and milk production in Brazil. Annex V. *Final Report of IFPRI–FAO/Lead Livestock Industrialization Project: Phase II.* Washington DC, International Food Policy Research Institute.

Costales, A.C., Delgado, C., Catelo, M.A.O., Tiongco, M., Chatterjee, A., delos Reyes, A. & Narrod, C. 2003. Policy, technical, and environmental determinants and implications of the scaling-up of broiler and swine production in the Philippines. Annex I. *Final report of IFPRI–FAO Livestock Industrialization Project: Phase II.* Washington DC, International Food Policy Research Institute.

Delgado, C., Narrod, C. & Tiongco, M. 2003. Policy, technical, and environmental determinants and implications of the scaling-up of livestock production in four fast-growing developing countries: a synthesis. *Final research report of Phase II of the IFPRI–FAO/LEAD Livestock Industrialization Project.* Washington DC, International Food Policy Research Institute.

Delgado, C., Narrod C. & Tiongco, M. 2008. *Determinants and implications of the growing scale of livestock farms in four fast-growing developing countries.* IFPRI Research Report No. 157. Washington DC, International Food Policy Research Institute. (in press)

Delgado, C., Rosegrant, M. Steinfeld, H. Ehui S. & Courbois, C. 1999. *Livestock to 2020. The next food revolution.* Washington DC, International Food Policy Research Institute. (available at ftp://ftp.fao.org/docrep/nonfao/lead/x6155e/x6155e00.pdf)

Fairoze, M., Achoth, L., Rashmi, P., Tiongco, M., Delgado, C., Narrod, C. & Chengappa, P. 2006. Equitable intensification of market-oriented smallholder poultry production in India through contract farming. Annex II. *Final report of IFPRI–FAO Contract Farming of Milk and Poultry in India Project.* August 30, 2006. Washington DC, International Food Policy Research Institute.

FAO. 2006. Underneath the livestock revolution, by A. Costales, P. Gerber & H. Steinfeld. In *Livestock report 2006.* pp. 15–27. Rome. (available at www.fao.org/docrep/009/a0255e/a0255e00.htm).

FAOSTAT. *FAO statistical database.* (available at. http://faostat.fao.org/default.aspx).

Henry, R. & Rothwell. G. 1995. *The world poultry industry,*. International Finance Corporation Global Agribusiness Series. Washington DC, World Bank.

Marion, B. 1985 *The organization and performance of the US food system.* NC 117 Committee Report. Lexington, MA, USA, Lexington Books.

Martinez, S.W. 2002. *Vertical coordination of marketing systems: lessons from the poultry, egg, and pork industries.* Agricultural Research Report No. 807. Washington DC, Economic Research Service, United States Department of Agriculture.

Moore, T. & Morgan, N. 2006. *Avian influenza: trade issues.* CAST QTA2006-2, Ames, IA, USA, Council for Agricultural Science and Technology.

Morrison Paul, C., Nehring, R., Banker, D. & Somwaru, A. 2004. Scale economies and efficiency in U.S. agriculture: are traditional farms history? *Journal of Productivity Analysis,* 22(3): 185–205.

Narrod, C. 1997. Technology transfer in the poultry industry: an examination of supply factors and externalities associated with increased production. University of Pennsylvania, Philadelphia, USA. (PhD Dissertation).

Narrod, C. & Fuglie, K. 2000. Private-sector investment in livestock breeding. *Agribusiness: An International Journal,* 4(6): 457–470.

Narrod, C. & Pray, C. 2001. Technology transfer, policies, and the global livestock revolution. In *Proceedings of the International Agricultural Trade Research Consortium Symposium on Trade in Livestock Products,* held 18–19 January 2001, Auckland, New Zealand.

National Statistical Office. 2003. *Inter-censal survey of agriculture.* Bangkok, National Statistical Office.

Neumann, C., Harris, D.M. & Rogers, L.M. 2002. Contribution of animal source foods in improving diet quality and function in children in the developing world. *Nutrition Research*, 22(1): 93–220.

OECD–FAO. 2007. *Agricultural Outlook 2007–2016.* Paris/Rome. (available at http://www.oecd.org/dataoecd/6/10/38893266.pdf)

Poapongsakorn, N., NaRanong, V., Delgado, C., Narrod, C., Siriprapanukul, P., Srianant, N., Goolchai, P., Ruangchan, S., Methrsuraruk, S., Jittreekhun, T., Chalermpao, N., Tiongco, M. & Suwankiri, B. 2003. Policy, technical, and environmental determinants and implications of the scaling-up of swine, broiler, layer and milk production in Thailand. Annex IV. *Final report of IFPRI–FAO-LEAD Livestock Industrialization Project: Phase II.* Washington DC, International Food Policy Research Institute.

Rich, K.M. & Narrod, C.A. 2005. Perspectives on supply chain management of high value agriculture: the role of public-private partnerships in promoting smallholder access. Draft Working Paper.

Rosegrant, M.W., Meijer, S. & Cline, S.A. 2002. *International model for policy analysis of agricultural commodities and trade (IMPACT): model description.* Washington DC, International Food Policy Research Institute. (available at http://www.ifpri.org/themes/impact/impactmodel.pdf).

Tiongco, M., Narrod, C. & Delgado, C. 2006. *Equitable intensification of market-oriented smallholder dairy and poultry production in India through contract farming: a synthesis. Final Report of IFPRI–FAO Contract Farming of Milk and Poultry in India Project.* Washington DC, International Food Policy Research Institute.

USDA/ERS. 2007. *Brazil.* GAIN Report. USDA. Washington DC, United States Department of Agriculture.

USDA/FAS. 2006. *Philippines poultry and products.* GAIN Report. Washington DC, United States Department of Agriculture.

Scale and structures of the poultry sector and factors inducing change: intercountry differences and expected trends

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SUMMARY

Rapid growth in consumer demand for livestock products in the developing countries is being met by corresponding growth in poultry meat and egg production and consumption. Comparison of five case-study countries, India, Egypt, China, Thailand and Brazil, shows a clear association between average per capita incomes and consumption of poultry meat. In India and China only, egg consumption has grown faster. Global meat export trade is dominated by Brazil, with contributions from Thailand and China, although the latter country's imports exceed its exports. Quantities traded by India and Egypt are quite small.

Four main poultry production sectors are identified: 1, industrial and integrated; 2, commercial high biosecurity; 3, commercial low biosecurity; and 4, village or backyard. These are ranked in reverse order of scale of production, concentration of bird density, productivity per bird, contribution to total poultry meat production, market integration and adoption of formal biosecurity measures (the relative effectiveness of this biosecurity has been questioned). Sector 1 and 2 systems and poultry production are concentrated in particular limited areas of each of the case-study countries. Larger numbers of Sector 4, and possibly Sector 3, smaller-scale producers operate in all areas. Sectors 1, 2, and possibly 3, involve separation of the stages of production – breeding, growing, feed-milling, processing and distribution – allowing the benefits of increased scale and specialization. In Sector 1, the separate enterprises are vertically integrated, to reduce transaction costs and improve managerial control. The alternative of contract growing allows participation of small-scale growers and sharing of production and price risks.

Poultry breeding, feed milling and markets are seen as three drivers of change. The introduction of exotic strains and intensive breeding has led to rapid growth in productivity, particularly in India. Concentrate feed is the largest cost item. Global prices of the ingredients maize and soy meal have increased greatly this year (2007). Egypt suffers from high import dependency for both crops. India, China and Thailand, though self-sufficient in maize, are vulnerable to increasing demands and prices for feeds. Only Brazil is already a major exporter of both crops and has large areas of, as yet, underexploited cropland. Increase in poultry production and processing is linked with growth of commercial food and retailing and with globalization. Consumer preference for live-bird retailing, in Egypt and India, constrains growth of the sector.

Case-study countries differ in their comparative costs of poultry production, possibly lowest in Brazil. But prices are affected by trade, exchange-rate policies and producer support. Import duties (tariffs) imposed by importers benefit domestic producers, but raise costs for consumers and depress prices in exporting countries. Thus, tariffs on poultry meat and on feed grains affect producer prices and incentives. Devaluation of an overvalued currency has similar impacts, but (unlike tariffs) increases social welfare. The poultry industry has had relatively little direct government support. Public good and externalities associated with disease control justify government intervention. Outbreaks of highly pathogenic avian influenza (HPAI) in India, Egypt, China, Thailand and other countries (though not Brazil) have affected poultry production, consumption and trade. Policy issues arise in connection with compensation for birds culled, the use of vaccination and regulations some of which may disadvantage smallholder backyard producers.

Commercial production and consumption of poultry meat and eggs are expected to continue to expand. Possible constraints include global economic, environmental and social problems, domestic policy limitations, supplies and prices of feed grains and oilseeds, deficiencies in national infrastructure, and disease such as HPAI. Sector 4 production is likely to continue to serve a different market from that of the expanding commercial sector. The semi-commercial Sector 3 may be a transitional stage in the commercialization process and may eventually contract.

Key words: poultry, comparison, sectors

1 THE CONTRIBUTION OF POULTRY TO THE LIVESTOCK REVOLUTION

1.1 Increased production and consumption in developing countries

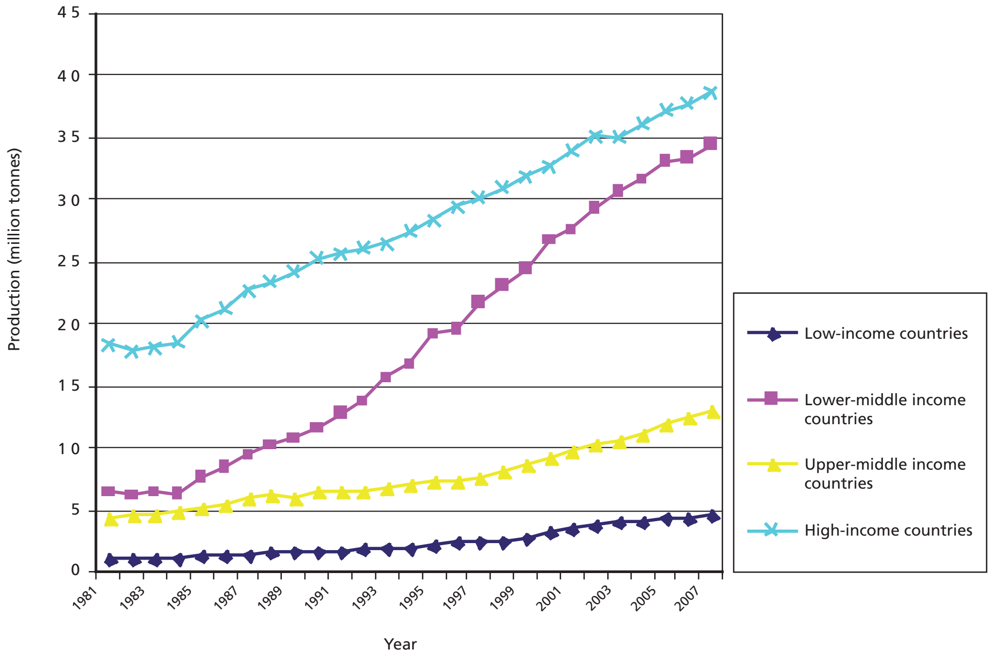
The rapid growth in developing-country demand for livestock products, known as the "livestock revolution", is being satisfied, at least in part, by rapid expansion in poultry meat production (Delgado *et al.*, 1999). The "revolution" has been fuelled by population growth, urbanization and income growth, as have the associated increases in the production and consumption of poultry meat. These changes have occurred at different rates in different countries, depending for instance on the current average per capita income levels. The World Bank classification of developing countries into low-income, lower middle-income and upper middle-income categories may be used for comparative purposes[1] (Figure 1).

The most rapid expansion, in poultry meat production, has occurred in the lower middle-income group of countries, with average annual per capita incomes of between US$876 and US$3 456. In this group, poultry meat production has grown steadily, at an annual rate of over 8 percent, and has more than quadrupled over the last 20 years. Production in the low-income group of countries, and in the upper middle-income group, started from a lower base and has grown more slowly (Figure 1).

Egg production has grown at similar rates. In the lower middle-income countries, the "volume", in tonnes, produced in 2004 was closely similar to the "volume" of poultry meat, but the value of egg production was more than double that of meat. The low-income

[1] The proportion of the total population, dwelling in urban areas, is positively associated with per capita incomes, rising from 30 percent in low-income countries to 77 percent in high-income countries. The proportion of national income derived from agriculture falls from 21.5 percent for low-income countries to 1.9 percent for high-income countries (see Annex A).

FIGURE 1
Poultry meat production 1981 to 2007



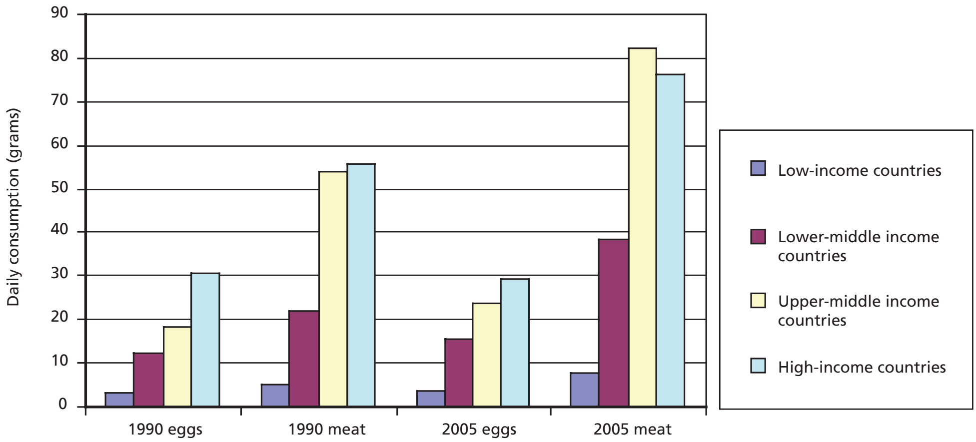
Source: FAOSTAT.

countries, as a group, produce similar quantities of poultry meat and eggs, in both volume and value terms. However, the upper middle-income countries produce a substantially lower volume and value of eggs than of poultry meat.

The impact of average per capita income on demand for poultry products is illustrated by comparing daily consumption of poultry meat and eggs in the different country-income groups, and changes over time (see Figure 2). Consumption levels of both poultry meat and eggs increased between 1990 and 2005 for all income groups except for high-income developed countries, where egg consumption fell. As average per capita incomes rose over the same period for all income groups, these changes give an indication of the impact of income growth on demand for poultry products. The decline in egg consumption in high-income countries suggests that the effect of income growth may have reached a peak and demand may be more strongly influenced by changes in consumer taste.

The contrasts in consumption of poultry meat and eggs between country-income groups in any one year are striking. Data for 2005 are presented in Table 1. These cross-country comparisons illustrate the relationship between individual incomes and consumption levels of poultry meat and eggs. It may be assumed that the average per capita consumption levels of countries with widely different average incomes provide an indication of the likely consumption behaviour of different income strata within countries. The poor, surviving on very low incomes and low levels of nutrition, can only afford to consume very small

FIGURE 2
Average daily consumption of eggs and meat per capita



Source: FAOSTAT.

TABLE 1
Mean per capita incomes and consumption of poultry meat and eggs, by country income categories, 2005

Income group	Mean gross national income per capita (US$)	Mean per capita poultry meat consumption (kg per year)	Mean per capita egg consumption (kg per year)
Low-income	585	2.81	1.30
Lower middle-income	1 923	14.04	5.70
Upper middle-income	5 634	30.06	8.64
High-income	35 264	27.80	10.71

Sources: FAOSTAT and World Bank data.

amounts of poultry meat and eggs. As incomes increase, so too does the consumption of poultry products – rapidly at first, but at a diminishing rate.

A comparison of income and consumption levels in lower middle-income countries with those in low-income countries shows that a 1 percent increase in income is associated with a more than 1 percent increase in consumption of poultry products.[2] A comparison of changes in average income and consumption levels between lower middle-income and

[2] The "income elasticity of demand", estimated as the percentage increase in quantity demanded for a 1 percent increase in income, is greater than unity over this range. The demand is said to be "elastic". It becomes less elastic as incomes rise further.

upper middle-income countries shows a smaller proportionate increase in consumption than in income. The differences in average consumption levels between high-income countries and upper middle-income countries are quite small. Indeed, consumption of poultry meat appears lower in the high-income countries. Consumption of poultry products in the upper middle- and high-income countries may be near to the desired maximum, and more expensive preferred sources of animal protein may be substituted in human diets.

1.2 The poultry industry in five case-study countries

The association between levels of income and consumption of poultry products may be illustrated by comparing the five case-study countries: India, Egypt, China, Thailand and Brazil (see Figure 3). The countries are ranked in increasing order of mean annual per capita income. While India is a low-income country, the other four are all lower middle-income countries (although Brazil is near the top of the income range). For more detailed information on the case-study countries, see Annex B.

The normal positive relationship between per capita income and consumption of poultry meat seems to apply both in the case of a very low level of consumption (India) and a very high level of consumption (Brazil). However, the pattern of egg consumption is rather different, with egg consumption in China much higher than in the other countries and more than twice as high as that of chicken meat. Egg consumption in Brazil, on the other hand, is much lower than might be expected. It appears that cultural differences affect choices regarding consumption of eggs.[3]

The relative importance of chicken and the meat of other bird species is also dependent on cultural differences. The consumption of duck is probably prevalent in irrigated areas of East Asia and Egypt, where duck rearing is a component of local farming systems.

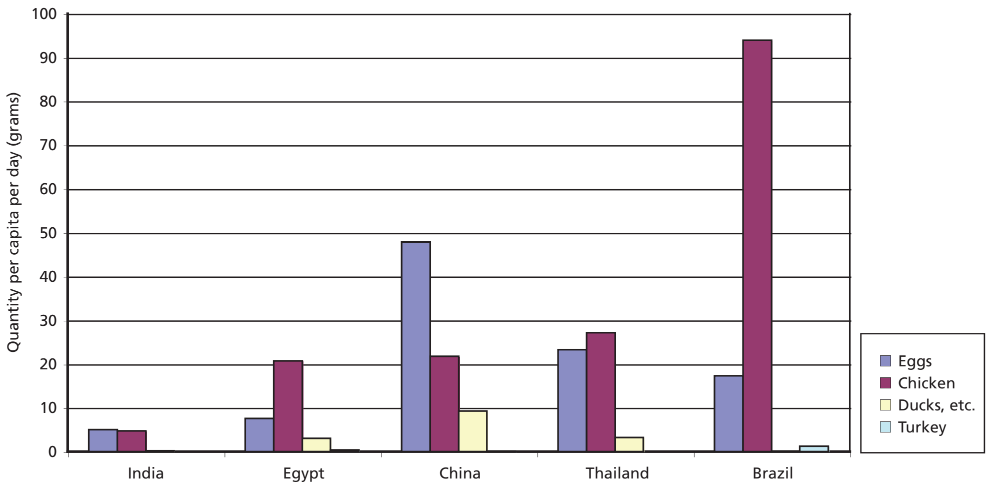
Poultry meat makes up 18.4 percent of total meat consumption in China and 46.9 percent in Brazil. Poultry meat and eggs together contribute a larger percentage of total meat, eggs and fish consumption – 30.9 percent in China and 47.4 percent in Brazil. Although the proportions might differ slightly if measured in terms of units of animal protein, it is clear that poultry make a major contribution to human nutrition in these countries.

Growth in per capita incomes in the case-study countries over the last six years has contributed to the growth in consumer demand for poultry meat. For instance, in India, incomes have grown annually by 10.5 percent while chicken-meat consumption grew by 8.4 percent. The corresponding rates in China were 13.7 percent and 2.0 percent. Thailand is exceptional in that annual income growth of 7 percent was associated with a 4.25 percent fall in poultry meat consumption. In Egypt both income and poultry-meat consumption fell over the last six years.

Three of the case-study countries, India, China and Brazil, are very large in area, human population and poultry production. Statistics for these countries, therefore, dominate those for the respective income groups – India contributing 47 percent of the aggregate production of low-income countries, and China and Brazil together accounting for over 73 percent of total lower middle-income country production.

[3] These choices will affect the development of the poultry sector, and the relative emphasis on broilers and layers. These decisions will, in turn, affect the relative availability and, inversely, the relative prices of meat and eggs.

FIGURE 3
Consumption of poultry products in the case-study countries, 2006



Source: FAOSTAT.

1.3 Poultry meat and egg production

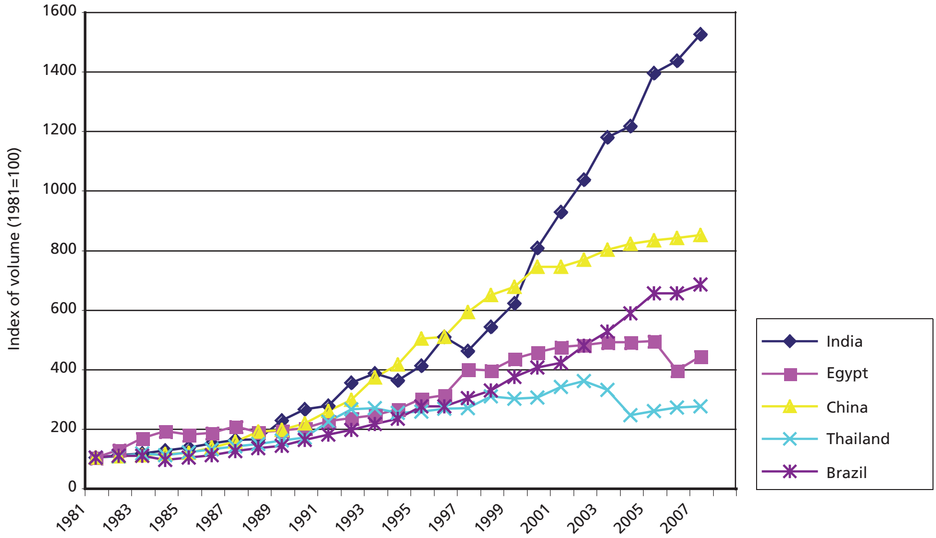
There are large differences between case-study countries in terms of the size of the poultry sector and the contribution made to global poultry-meat production. Listed in diminishing size order, the percentage contributions made to global production are as follows: China 17.5; Brazil 11.9; India 2.4; Thailand 1.3; and Egypt 0.6. A visual comparison of the relative growth rates of poultry meat production, independently from overall size, is obtained by comparing indices of growth, with 1981 as the base year set at 100 (see Figure 4).

Poultry meat production has grown most rapidly in India, at over 11 percent annually over the last quarter century. The pace appears to have accelerated in the last decade. In China production grew even more rapidly up to the mid-1990s, but the rate of growth has slowed since then, giving an overall average rate of about 9 percent. Brazilian poultry-meat production has grown steadily since 1985, at a lower rate of just below 8 percent. The slackening in growth in the last two years may be a consequence of the impact of HPAI on demand.

In Egypt, after quite rapid growth to the mid-1980s, production expanded at a slower rate until the end of the century. Since the year 2000, production appears to have stagnated; it actually fell in 2006 as a result of HPAI. Thai production grew quite rapidly until the early 1990s, then quite slowly over the next ten years. Since 2002, production has fallen as a result of HPAI outbreaks, although recovery has started.

The overall growth in production is the result of changes in three key variables: first, the inventory or number of birds in the national flock; second, "productivity" – here measured as the number of birds produced and slaughtered per head of the national flock; and third, the carcass weight. All these variables have increased over the last quarter century in most

FIGURE 4
Relative growth of poultry meat production: case-study countries



Source: FAOSTAT.

developing countries, and their relative contributions to the growth in poultry meat production may be assessed from published statistics. Results for all five case-study countries are given in Figure 5.

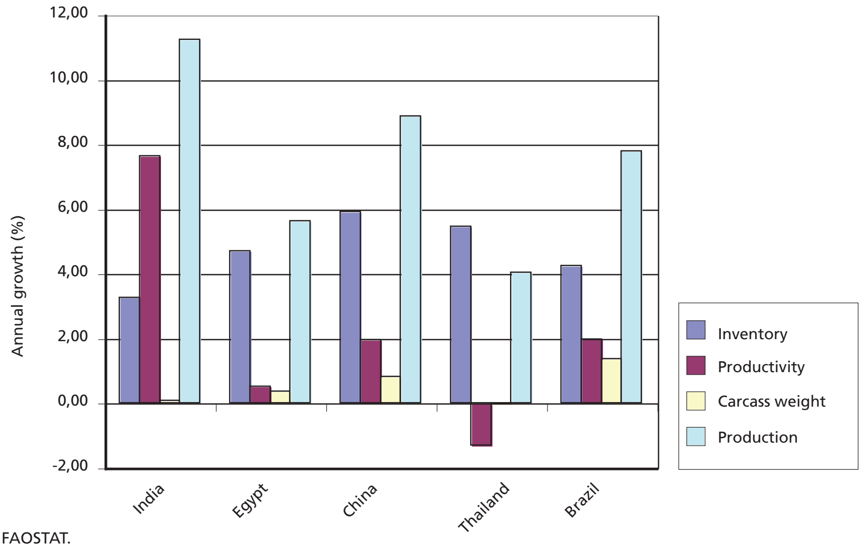
In India, the greatest gains have been made in the "productivity" measure; this is in contrast to the other four case-study countries where inventory change has contributed most to growth. This growth in productivity in India may reflect the technological change that has occurred in poultry breeding, from traditional, "desi" poultry to exotic hybrid chickens. In Thailand, the fall in productivity may be due to the large numbers of birds slaughtered for disease-control purposes and, therefore, removed from the market. The inventory of birds is not affected to the same extent, and has grown faster than total production.

Egg production has increased over the same period in all case-study countries, but less rapidly than meat production. This suggests that the overall growth of the poultry industry, in all cases, has been associated with a switch from egg production to broiler-meat production. However, there are big differences between countries with respect to the relative importance of poultry meat and eggs in volume terms. In India and China the volume of eggs produced exceeds the volume of poultry meat by 23 percent and 97 percent, respectively. In Thailand, Egypt and Brazil, the volume of egg production is less than that of poultry meat, at 65, 45 and 16 percent, respectively. For Thailand and Brazil, this may reflect the greater importance attributed to broiler production for the export market.

1.4 International trade in poultry produce

Trade in poultry products differs substantially between the five case-study countries, with Egypt and China being net importers of poultry meat, India close to self-sufficiency, and

FIGURE 5
Relative contributions to growth of meat production, 1981 to 2006



Source: FAOSTAT.

Brazil and Thailand being net exporters. Changes in poultry meat trade over the last quarter century are shown in Figure 6. However, the situation differs somewhat with respect to trade in eggs and live birds – so each country is considered in a little more detail in the following paragraphs.

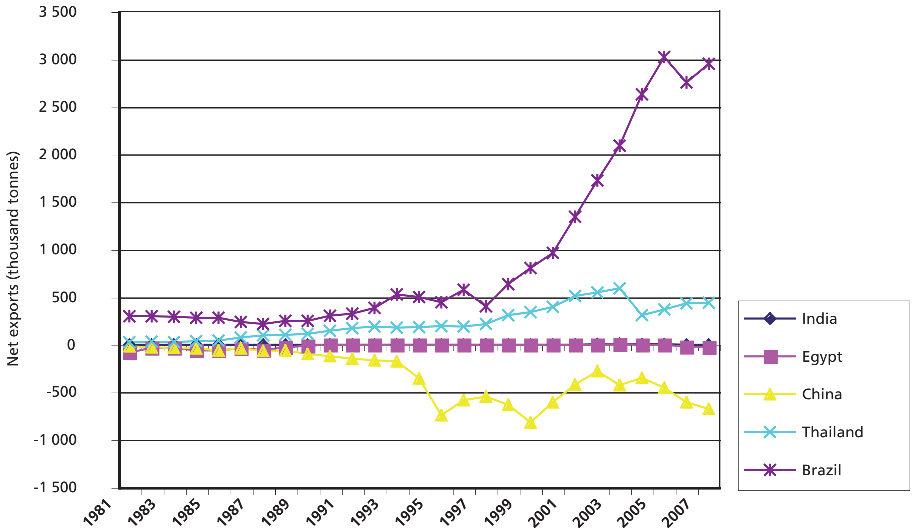
India is a net exporter of a small amount of poultry meat – a fraction of 1 percent of domestic production.[4] In this respect, it differs from the majority of low-income countries, which are net importers of poultry meat. A small amount of export revenue is earned from canned poultry meat exports. Limited costs are incurred in importing live birds. However, eggs constitute a significant net export, earning nearly 80 times the export earnings from poultry meat.

Egypt is a net importer of poultry meat and eggs, but since 2003 has been a net exporter of live birds. Quantities and values are relatively small, and poultry meat imports only represent 4.5 percent of domestic utilization.

China, despite being a significant exporter of unprocessed poultry meat on the world stage, is a net importer, attracting 15 percent of global imports and supplying 8 percent of domestic consumption from imported produce. However, poultry meat is subjected to further processing in China, and some of the products are exported. If the value of canned chicken-meat exports is added to the value of primary chicken-meat exports, then China becomes a major net exporter of poultry-meat products, in value terms. Although China is a net importer of a small number of live poultry, the value of bird exports exceeds the value of bird imports by a small margin. The volume of eggs traded is only a small percentage of total production and consumption, but the balance between imports and exports

[4] The quantity is so small that the net export graph for India cannot be distinguished from the x axis in Figure 6.

FIGURE 6
Growth in net trade for case-study countries



Source: FAOSTAT.

changes from year to year. In 2005, China switched from being a marginal net exporter to a marginal net importer. However, in value terms, exports exceeded imports.

Thailand is a much smaller East Asian country which has encouraged the growth of the poultry meat export industry. Between 1980 and 2003, exports of poultry meat grew at a rate of 15 percent annually. In 2003, Thai exports represented 7 percent of the global total. Since then, exports have fallen as a result of HPAI outbreaks and have not yet recovered to the previous level. Nonetheless, exports currently account for over 40 percent of domestic production. However, like China, Thailand is earning revenue from exports of canned meat, which currently contribute considerably more to export earning than do exports of un-canned poultry meat. This emphasis on processed exports reflects a general switch from raw or frozen poultry exports to pre-cooked and processed exports, to avoid restrictions imposed following the HPAI outbreaks. Thailand is currently a net exporter of live birds, although imports were higher in 2004 after the first HPAI outbreak. Some eggs are also exported.

Brazil has rapidly expanded poultry-meat production and exports, and now supplies around 35 percent of global exports. This places the country ahead of the United States of America, which is the other major world exporter of poultry meat. Exports account for about 28 percent of domestic production. In fact, led by Brazil, the lower middle-income countries have in the twenty-first century become the main global net exporters, while net exports from the high-income countries have dwindled to a very low level. Since the mid-1990s the upper middle-income countries have become the main net importing group.

Canned poultry meat, live birds and eggs are also exported from Brazil, but in much smaller volumes and with much smaller values than the poultry meat exports.

2 THE RELATIVE IMPORTANCE OF DIFFERENT PRODUCTION SYSTEMS

2.1 The FAO four-system classification

The rapid expansion of poultry production, in all the case-study countries and globally, has been associated with technological change and increasing scale of production units. More specifically, the development has involved a switch in emphasis from traditional small-scale production using dual-purpose indigenous breeds to intensive commercial production systems using hybrid birds specially bred either for meat or for egg production. In practice, a range of commercial and semi-commercial systems may develop – so some further categories are needed.

TABLE 2
Characteristics of four different poultry production sectors

Characteristics	Sectors			
	1. Industrial and integrated	2. Commercial: high biosecurity	3. Commercial: low biosecurity	4. Village or backyard
Biosecurity	High	Moderately high	Low	Low
Market outputs	Export and urban	Urban/rural	Live urban/rural	Rural/urban
Dependence on market for inputs	High	High	High	Low
Location	Near capital and major cities	Near capital and major cities	Smaller towns and rural areas	Everywhere: dominates in remote areas
Housing	Indoors: closed	Indoors: closed	Indoors/part-time outdoors: closed/ open	Outdoors most of the day: open
Contact with other poultry, domestic birds and wildlife	None	None	Yes	Yes
Veterinary service	Own veterinarian	Pays for veterinary service	Pays for veterinary service	Irregular, depends on government veterinary service
Source of medicine and vaccine	Market	Market	Market	Government and market
Source of technical information	Company and associates	Sellers of inputs	Sellers of inputs	Government extension service
Source of finance	Banks and company funds	Banks and company funds	Banks and private informal	Private informal and banks
Breed of poultry	Commercial	Commercial	Commercial	Native
Food security of owner	High	OK	OK	From OK to bad

Source: FAO (2004).

A set of characteristics used by FAO to distinguish between four main production sectors is presented in Table 2 (FAO, 2004). In effect, the commercial sector has been subdivided into three main categories, Sector 3 having the lowest levels of: i) scale and concentration of production; ii) intensity; iii) productivity; iv) commercialization; v) specialization; vi). market integration; and vii) formal biosecurity measures; and Sector 1 the highest. Attempts have been made to assess the distributions of poultry producers and birds between the four sectors in the case-study countries.

The four categories are better described as "sectors" than as "systems", as increasing commercialization is associated with increased segmentation of different stages in the value chain from input supply through to retail delivery of the product. The production system is, then, only one stage in the chain.

Levels of biosecurity merit further comment. Although formal biosecurity may be higher in industrial/commercial systems, the greater bird population density may increase the probability of infection and the scale of disease outbreaks that occur in these concentrated production systems (Otte *et al.*, in FAO, 2007a).

Increasing concentration of production is also associated with problems of waste disposal and soil, air and water pollution (Steinfeld *et al.*, in FAO, 2006a). Within each sector there is a great deal of variation between individual types of production system and value chains, so further discussion is needed.

2.2 Sector 4: village or backyard production

The most basic and simple backyard production system involving a few hens and a cockerel is essentially a closed system. Home-produced fertile eggs are hatched to provide replacements, birds feed by scavenging or are provided with household scraps and crop by-products; there are virtually no veterinary inputs and the remaining eggs and meat produced are consumed within the household.

Such very simple subsistence poultry production systems are probably quite rare. Producers with even slightly larger flocks, generate cash income from the sale of eggs and birds within the local community. In the five case-study countries and in most parts of the developing world, live birds and eggs are traded in open-air or "wet" markets and in retail shops, where birds are slaughtered on sale. Transactions may take place directly between producers and consumers, but traders and other market intermediaries may be involved, selling on to other sectors of the poultry industry.

Sector 4 production systems are widely distributed and exist in both rural and urban areas. In most countries, the majority of producers fall into this category, but with development of the industry a growing proportion of both meat and egg production is derived from the commercial sectors. It is estimated that today in India, only 10 to 20 percent of total poultry output is derived from "backyard" production (Landes *et al.*, 2004). Proportions may be higher in Egypt, at 22 percent of chicken meat and 30 percent of eggs, and China at over 60 percent of meat and nearly 70 percent of eggs, but are probably lower in Brazil and Thailand where the commercial sector is most developed. However, in all five case-study countries there is wide inter-regional variation in poultry population density, reflecting the localized concentration of commercial production. In areas that are less densely populated by poultry, "backyard" systems are likely to contribute a larger proportion of total poultry production.

In the village or backyard sector, production is generally based on traditional local, native breeds, producing both eggs and birds for meat. In India they are referred to as "desi" and in Egypt as "balady" poultry. Chickens are the main species kept, but in India, Egypt, China and Thailand significant numbers of ducks and other domesticated birds are kept. In China, ducks and other species make up nearly a fifth of the national poultry flock. Some are kept in mixed flocks, while others are kept separately from chickens.

Productivity of the traditional native breeds, whether measured by annual meat production per bird, feed conversion rate or eggs produced per bird, is comparatively low. For instance, in Egypt the balady chickens take two or three times as long as commercial birds to reach market weight, require almost twice as much feed per unit of weight gain, and the layers produce only two-thirds of the number of eggs per year (Taha, 2003). Nonetheless, village or backyard production can make a useful contribution to dietary protein intake and incomes of resource poor households (Acamovic *et al.*, 2005). Furthermore, given the lower opportunity costs[5] of resources and the higher market prices offered for local poultry, backyard systems are likely to yield a positive economic return, despite increasing competition from the commercial sectors.

2.3 Sector 3: low-biosecurity commercial poultry production

This sector is based on commercial production to generate cash income, but it retains some characteristics of the traditional, backyard systems, particularly in selling live birds in wet markets, to commercial intermediaries or directly to retail shops. Production units are generally intermediate in scale between backyard systems of up to 200 birds and commercial systems of over 2 000 birds. Some economies of scale may be derived in terms of scope for use of specialized equipment such as battery cages or semi-automatic feeders. Levels of biosecurity are thought to be low, in that birds are often not permanently housed, mixed flocks of chickens and waterfowl may be kept, birds are generally marketed live, and a range of different markets, un-monitored for health risks, are used for produce sales and input supplies.

Sector 3 flocks are generally devoted either to broiler meat production or to egg production. Specialized commercial hybrid chicks are generally purchased from external sources. Even where native breeds are used commercially, as in the "balady flocks" of Egypt, chicks are generally purchased from specialized hatcheries. Feeds must generally be purchased, either as premixed rations or as raw materials for home milling and mixing. Hence, the production and marketing process is segmented and the value chain may be analysed. However, for this sector in particular, there are so many alternative sources of chicks and feedstuffs and different potential market outlets, that it is difficult to establish a standard outline value chain applicable in all the case-study countries.

Sector 3 and 4 producers are not always clearly distinguished in national statistics. For instance, in China all flocks with up to 299 birds are classified as "backyard", and these account for nearly all poultry producers and around 70 percent of poultry production. Arguably, some of these should be placed in the Sector 3 category. Similarly in Egypt, Sector

[5] The opportunity cost is the amount that could be earned from the most lucrative alternative use. For many poor households the opportunity cost of labour and other limited resources may be very small.

3 and 4 producers together account for nearly the total number of producers, but account for less than a third of total production. Similar proportions apply in Thailand. In India, the smaller independent commercial producers are of regional importance in the north and east of the country and particularly around Delhi, where integrated contract production has not become established as it has in the south. Even in Brazil, where the poultry sector is heavily industrialized, it is estimated that around 40 percent of poultry meat is produced on relatively small family farms of less than 100 hectares (Camargo-Barros, in FAO, 2003).

Sector 3 poultry production may originate with backyard producers who are able to generate sufficient income and savings to escape from the poverty trap and expand into somewhat larger-scale and more intensive production systems (Otte and Upton, 2005). However, there are many other small-scale investors, retired civil servants and the like, who establish moderate-sized semi-commercial poultry units as a means of generating supplementary income. In either case, Sector 3 production units are generally independently owned, relatively small-scale, enterprises.

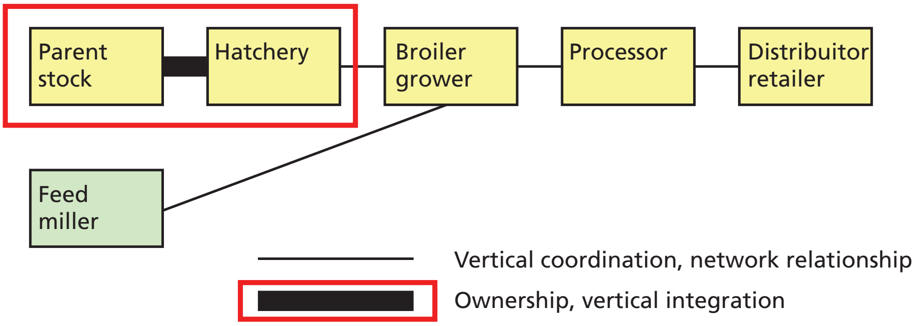
The scale of production units is subject to capital limitations. For these relatively small-scale, independent investors, not only are private investment funds scarce, but so too is access to formal credit. Market limitations arise in countries, like India and Egypt, where there is a marked consumer preference for the purchase of live birds, rather than dressed, chilled or frozen carcasses. The transport of live birds is more difficult and costly, so producers need to be located near their markets. In India, it is suggested that relatively small-scale, Sector 3, producers are at a disadvantage in facing high feed and transport costs, limited access to vaccines and veterinary services, and shortage of credit.

2.4 Sector 2: large-scale commercial, high biosecurity

This sector consists of the generally larger-scale (over 2 000 bird) commercial flocks of broilers, layers or breeding birds. Only relatively wealthy individuals or commercial joint-stock companies have the necessary investment funds or can raise sufficient credit for these larger-scale investments. Biosecurity levels are defined as high, as birds are continuously housed, strictly preventing contact with other flocks or with wildlife. Despite this, many outbreaks of HPAI appear to have started in large-scale commercial flocks (Otte *et al.*, in FAO, 2006b). Inputs are generally supplied and products marketed through formal market agencies. The production and marketing process is clearly segmented, and separate value chains for broilers and layers can be clearly identified (see Figure 7).

Figure 7 illustrates that in the non-integrated Sector 2, production of day-old chicks and feeds, broiler growing, processing and retail distribution of the final product are the responsibility of separate commercial enterprises. They are all "stakeholders" in the value chain, adding value to the product at each stage. The figure is simplified by showing a single enterprise at each stage of the chain. In practice, there may be a range of alternative partner agencies with which to transact business. Furthermore, links which are shown as "vertical coordination" might possibly be based on "arm's length market relationships", although reliance on the latter would be very risky. A similar value chain diagram could be drawn for the layer subsector, although the production cycle is longer and is subdivided into rearing and laying stages. Disposal of spent hens is another necessary activity. Eggs may be marketed without processing, although production from the larger flocks is likely to require egg packing.

FIGURE 7
Schematic diagram of a "non-integrated" broiler value chain



Source: based on Humphrey and Napier (in FAO, 2005) and PBEC (1999).

The scale and intensity of production, reflected in both the level of purchased inputs and the output per bird, is substantially higher in the commercial and industrial sectors than in backyard systems. Advantages are derived from economies of scale, providing scope for specialization and division of labour between the different stages in the production process, leading to automation of operations and labour-cost savings. These advantages add to those derived from the use of highly productive commercial hybrid chicks and improved technologies such as the evaporative cooling or air-conditioning of poultry houses.

The need for vertical coordination of all stages in the production chain, particularly in the regular supply of chicks and the transfer of birds to slaughter or markets when ready, leads to concentration of commercial poultry production in particular areas of the country, generally near major urban markets. The available statistics on poultry production in the case-study countries do not clearly distinguish between commercial (Sector 2) and industrial (Sector 1) production. However, it is clear that these two sectors together produce most of the total national supplies of poultry meat and eggs, particularly in the areas of greatest poultry population density.[6]

In India, particularly around Coimbatore, in the south, large-scale commercial, though mainly Sector 1, producers account for 75 percent of poultry meat production. The four southern states, where poultry densities and flock sizes are high, together contribute 57 percent of the nation's egg production. In the north, particularly around Delhi, non-integrated, Sector 2, producers contribute similarly large proportions of local production and consumption (Landes *et al.*, 2004; Mehta, in FAO, 2007b). In Egypt, the commercial sector is estimated to contribute 87 percent of poultry meat production and 77 percent of eggs. As there are only two major integrators in Egypt, most of this production must come from the non-integrated commercial enterprises of Sector 2 (Otte *et al.* in FAO, 2007a).

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[6] For maps showing zonal variation in poultry density within countries, see Gerber (in FAO, 2007g) or GLiPHA (2007).

In China, poultry production is heavily concentrated in the Eastern Region, around Beijing, where commercial holdings with flocks of over 2 000 birds make up just over 5 percent of the total but contribute nearly 88 percent of total broiler meat production. A similar proportion of commercial layer farms, having flocks of over 500 birds, contribute 78 percent of the eggs. The four provinces making up the Eastern Region contribute more than half the national production of eggs. Proportions of large flocks are much lower in the Central and Western Regions, and as a result, their contributions to total production of poultry meat and eggs are much smaller.

The poultry industry in Thailand and Brazil is dominated by commercial and industrial production of broilers for export and for domestic consumption. This intensive production, about half the national total, is concentrated in the Central Region of Thailand, "a small but densely populated region" (Na Ranong, in FAO, 2007c). In Brazil, the main region of intensive production is in the south (50 percent of national broiler production) and south-east (27.5 percent) (OD Consultancy, in FAO, 2007d). Intensive production is now spreading westwards to locations more accessible to the main maize and soybean growing areas. In both Thailand and Brazil, although commercial production from Sector 2 exceeds that from Sectors 3 and 4, most of the poultry production is in the hands of the industrial, integrated production systems of Sector 1.

2.5 Sector 1: industrial and integrated production

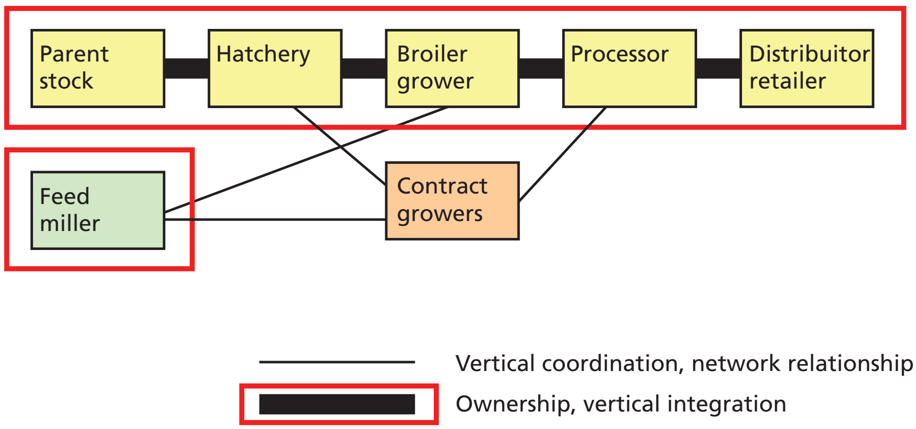
This sector consists of the largest and most industrialized enterprises in the poultry industry. The various stages in the value chain are vertically integrated into a single industrial company. The broiler-growing or egg-laying components are either fully integrated as part of the parent company, or are separate production units operating under contract to the parent company, as shown in Figure 8.

For Figure 8 it has been assumed that although the whole process, from chick breeding and hatching through to distribution and retailing is integrated in a single organization, feed milling remains as a separate business enterprise. In many instances, the feed and poultry production activities are integrated, together with "horizontal" links to other sectors such as pig production. In other cases, vertical integration is partial – from breeder down to broiler grower, or from market distributor up to broiler producer.

Vertical integration yields financial benefits by reducing the "transaction costs"[7] of exchanges at different stages of the value chain. In non-integrated poultry systems, transaction costs are likely to be high because of: first, the frequency and regularity of transactions resulting from the cyclical nature of poultry production; second, the risks of disease and market price fluctuations; and third, the investment in very specific types of assets, or "asset specificity", involved in poultry production, processing and marketing (Williamson and Masten, 1995; Dorward *et al.*, 1998). In these circumstances, the vertical integration of the different stages of the breeding, production, processing and marketing of poultry produce is a rational economic response, which should increase efficiency and reduce unit costs.

[7] These are the costs of obtaining information on the quality of the good being exchanged, negotiating a contract and enforcing the agreement.

FIGURE 8
Schematic diagram of an "integrated" broiler value chain



Source: based on Humphrey and Napier in (FAO, 2005) and PBEC (1999).

In India, substantial numbers of integrated poultry production companies have been established, particularly in the four southern states and in western India around Mumbai (Landes *et al.*, 2004). By contrast, in Egypt only one large-scale broiler farm is completely integrated (Otte *et al.*, in FAO, 2007a). Information is currently lacking on the number of large-scale integrated producers in China, but it is apparent that some operate on a very large scale. The Beijing Dafa Chia Tai Company, which claims to be the third largest in China, raises batches of 2 million broilers from their own farms and 6 million from 2 300 contract farmers.

It is estimated that 70 percent of Thai broiler-meat production is derived from the large-scale integrated poultry sector (Rushton *et al.*, 2005). A decade ago, the broiler sector was controlled by about a dozen large integrated firms (Tisdell *et al.*, 1998). In Brazil, production of broilers for export, or about 30 percent of total broiler production, is in the hands of 20 major integrated production companies associated with the main exporters' association, *Associação Brasileira dos Productores e Exportadores de Frangos* (ABEF).

3 STRUCTURE OF THE VALUE CHAIN

3.1 The introduction of commercial stock

The introduction of improved, exotic, genetic material is an important first step in the growth and development of the commercial poultry sector. Generally, the new strains are less hardy and less resistant to endemic diseases than indigenous birds. The greater productive potential cannot be attained without complementary inputs of specially compounded concentrate feeds, and improved housing, management, and veterinary care. Nonetheless, the introduction of new genetic material is the foundation on which other technological improvements are added.

Despite earlier attempts by field researchers and non-government organizations to improve the genetic potential of poultry, major advances only occurred with the introduction of exotic commercial stock. This was generally the result of private commercial activity, the importer needing sufficient capital to establish and maintain a breeding flock in a carefully controlled environment of the type required by exotic birds.

The Indian broiler industry is said to have been founded in the early 1980s by the Venkateshwara company of India in collaboration with the American poultry breeding company Cobb (now Cobb-Vantress). It is claimed that the Cobb 100 strain owned by Venkateshwara Hatcheries (VH) accounts for 60–70 percent of all broilers in India (Landes *et al.*, 2004).[8] The company distributes breeding stock and day-old chicks nationwide, and provides veterinary services to the growers. Until 1995, imports of grandparent stock were restricted to pure lines only, with the intention of protecting domestic broiler growers. This had the effect of giving VH some monopoly power. Since then, restrictions have been lifted and other integrators have been importing grandparent stock and developing their own strains. This concentration of poultry breeding activity in southern India appears to have resulted in a rapid increase in productivity per bird (Figure 5 above).

In Egypt, there are seven grandparent stock farms, largely originating from imported chicks or hatching eggs and serving over 400 commercial breeding flocks. One of the major integrated producers, the Cairo Poultry Company (CPC), is in partnership with the Hubbard chick company. However, there are a larger number of improved balady chicken type breeding farms. Egypt also exports breeding stock to other Middle Eastern and African countries. The large integrated poultry companies in China generally use improved strains originally bred in the United States of America.

The Thai company Charoen Pokphand (CP), though originally a small feed company, introduced contract broiler production in 1976 as a joint venture with the United States of America-based Arbor Acres/Avigen Company, bringing improved grandparent stock into Thailand. This is seen as the start of the livestock revolution in Thailand. CP has subsequently grown into a vertically and horizontally integrated multinational corporation, with 100 000 employees in the mid-1990s and with interests in the food, poultry and pig meat and shrimp industries. In Brazil, about 95 percent of poultry meat is produced under contract to the large integrator companies. Most of the genetic strains in use originated, or were developed, from North American foundation stock.

Three general conclusions may be reached. First, poultry breeding and chick production is now a specialized activity for large-scale producers. Many intermediate and smaller broiler and egg producers cannot afford to maintain separate flocks of specially bred parent or grandparent birds. They must purchase chicks from the specialist breeders or become contract growers. Second, many of the specialist breeders are vertically integrated with poultry processors and distributors, and commonly with feed millers, together with reliance on contract growers. Finally, there is a continuing need for imports of exotic foundation stock from the United States of America or Europe. The primary breeders in these countries still export grandparent stock to Egypt, China, Thailand and Brazil, and still have partnership arrangements with poultry breeding companies in India. In some cases these links have led to the establishment of joint ventures involving foreign direct investment.

8 The same large company supplies chicks to 85 percent of layer flocks.

3.2 Links with feed millers

The other key input for commercial and industrial broiler and egg producers is the supply of concentrate feeds. These generally account for about 60 percent of the costs of intensive poultry production, so the feed conversion ratio is an important measure of productive performance. In Figure 8, feed milling is shown as an independent commercial enterprise separate from the integrated poultry production sector, though with contractual arrangements for the supply of feeds to breeding, broiler and laying flocks. In the fully integrated poultry sector, feed milling is generally incorporated within the poultry production company. As concentrate feeds are needed for other (non-poultry) livestock enterprises, the feed milling enterprise readily forms the basis for horizontal integration into other types of productive activity.

Feed millers are, in turn, dependent on supplies of energy- and protein-rich raw materials, particularly cereals and pulses. Costs of feeds and hence of poultry production, are therefore dependent, in part, on the availability and cost of these raw materials. Maize is the main cereal used in livestock feeds in Latin America, and increasingly in Asia and the Middle East (Steinfeld *et al.*, in FAO, 2006a).

Thus, it is reported that the CP Company of Thailand prepared for the expansion of the poultry industry by first developing and persuading farmers to adopt a high-yielding maize variety, in a joint venture with DeKalb. As a result, maize yields quadrupled over the fifteen years from 1970 to 1985, leading to a big reduction in the cost of poultry production (Anon, 1997).

Coordination of feed supplies and broiler or egg production is essential to ensure productive efficiency. Different feed mixes are required at different stages of the life of a flock, and must be delivered regularly at the right time. New technologies, such as pelleting of feeds, may be needed. In these circumstances, transaction costs of feed purchases are likely to be high. Formal delivery contracts are necessary to reduce transaction costs and risks of default. However, vertical integration should bring even greater savings in transaction costs and provide greater assurance of coordinated supplies. These savings help to explain why integration appears to be the preferred option in the highly commercialized large-scale sector, and why average variable costs of production are lower for this sector.

3.3 Production, trade and use of feed crops

Availability and the relative prices of concentrate feeds, particularly maize, vary substantially between countries. Comparisons of the production, trade and feed use of maize in the case-study countries, give an indication of differences in the availability of feed grains. Although there has been a long-term upward trend in maize production in most countries, there is considerable variation from year to year, and even bigger variation in quantities traded. Nonetheless, results for a single year, 2005, illustrate the key differences between the poultry meat exporting countries that are also maize exporters, and Egypt, which is a net importer of both poultry meat and maize (see Table 3).

It may be noted that in India and Egypt feed and seed use accounts for less than half the total domestic utilization, more is used for human consumption. However, in China, Thailand and Brazil, the bulk of the crop is used for feed and seed, while relatively small proportions of the total production are exported.

Soymeal, a by-product of the soybean oil industry, is of increasing importance as a protein-rich ingredient of concentrate feeds for poultry and other intensively produced livestock. Information on production and trade in the raw material – soybeans – gives an indication of the likely availability of soymeal (see Table 4).

Clearly, Brazil has a major advantage as a poultry producer in that it produces exportable surpluses of soybeans as well as maize. Furthermore, it is reported that there are large areas of underexploited potential arable land in the Cerrado Savanna of Central West Brazil. The other four countries import most of the soybean utilized domestically (almost all in the case of Egypt).

Today, countries like India, China, Thailand and Brazil that produce more than enough maize to meet domestic requirements are at an advantage over countries like Egypt that have to import maize to me*et al*l their needs. The costs of transhipment, freight and insurance associated with imports are avoided. Nevertheless, domestic prices of feed grains and pulses in both importing and exporting countries are influenced by global markets. Over the past 12 months (to November 2007) poor harvests and growth in demand for feeds and biofuel production have led to a large increase – near 50 percent – in the price of maize on world markets (FAO, 2007e). The increase in cereal prices has influenced land allocation to other crops, so shortages and increased prices of soy products have also occurred. Hence, poultry producers in all countries are vulnerable to fluctuations in global feed prices.

Even where the main feed crops are produced domestically, delivery costs are affected by the distance from where the feed crops are produced to where the livestock are con-

TABLE 3
Maize exports, imports and usage as feed in 2005

	India	Egypt	China	Thailand	Brazil
Maize exports as a proportion of home production (%)	2.8	-	6.5	5.8	2.3
Maize imports as proportion of home utilization (%)	-	43.3	-	-	-
Feed and seed use as proportion of total utilization (%)	37	44	85	88	78

Source: FAOSTAT.

TABLE 4
Soybean exports and imports in 2005

	India	Egypt	China	Thailand	Brazil
Soybean exports as a proportion of home production (%)	-	-	-	-	72
Soybean imports as proportion of home utilization (%)	58	98	71	92	-

Source: FAOSTAT.

centrated. Thus, in India, producers in the southern states are concerned to promote local production of maize and soymeal, most of which are currently purchased from producers in central and northern India. In Brazil, integrated poultry producers are expanding into central and western Brazil, where more land is available for maize and soybean production.

3.4 Links with processors and distributors

Vertical integration takes place as a consequence of the growth of firms in the context of the process of development of the food industry and the global economy. However, there are three primary motives for vertical integration in the poultry meat sector: i) increased control of markets and marketing margins; ii) greater biosecurity and quality-control management; and iii) economies of scale in production, processing and distribution (PBEC, 1999). It follows that processing and market distribution are essential elements of the integrated value chain.

Economies of scale and the benefits of automation lead to major cost savings in the slaughter, defeathering and evisceration of broilers. A standard modern abattoir has capacity to process 6 000 to 9 000 birds per hour or up to 20 million per year. Serious losses in efficiency and economic returns can arise where slaughter plants are operated below capacity, as may occur where demand varies on a seasonal basis, when there is a serious disease outbreak, or where regular supplies of birds are too small to justify the establishment of a modern abattoir.

These risks must be set against the cost savings achieved, and the benefits of easy storage and transport for domestic distribution or export of chilled or frozen dressed carcasses. In India and Egypt, consumer preference for the purchase of live birds limits the scope for industrial processing and, because of the higher costs of transporting live birds, restricts broiler markets to the area in which the birds are produced. In the major exporting countries Brazil and Thailand, most birds for both export and domestic use are processed in industrial-type abattoirs.

From the abattoir, poultry carcasses can go for further processing into chicken parts, with or without bones, or for the manufacture of other poultry dishes. Hence, poultry processing readily links into the commercial food industry, which is growing rapidly in all the case-study countries with the spread of supermarkets, fast-food chains and other retail outlets. Exports of canned poultry meat are of increasing importance for China and Thailand, possibly in response to export bans on un-canned products following HPAI outbreaks.

Many of the large-scale integrated poultry meat producers in Thailand and China, and probably Brazil and India, have become multinational agencies in the food industry, some with their own local retail outlets. The links between integrated poultry production and the retail food sector in China are emphasised in the suggestion that local outbreaks of HPAI have accelerated the switch from wet markets to supermarkets (Evans, 2006).

For egg producers, there are fewer economies of scale in processing and marketing. Hence, although there are large enterprises that may be integrated with a feed mill, and in some cases with a hatchery, they are less commonly integrated with the processing and marketing end of the chain. Some independent operators buy day-old chicks or point-of-lay pullets, purchase feeds and sell their own eggs, while egg marketing is sometimes organized on a cooperative basis. In general, the egg industry is less concentrated than the poultry meat sector.

3.5 Contract production

Broiler growing under contract is a common feature of the integrated and semi-integrated industrialized sectors of the global poultry-meat industry. This type of contractual agreement is widely used by large integrated companies in India, China, Thailand and Brazil. Less has been written about broiler growing under contract in Egypt, possibly because there are few large fully integrated poultry producers in the country.

Although there are some local variations, the standard contract adopted usually commits the "integrator" to: i) the supply of chicks, feeds and medicines; ii) the provision of technical, managerial and veterinary support; and iii) transport for the delivery of feeds and the collection of finished broilers. The grower then provides: a) the capital invested in buildings and equipment; b) the day-to-day management; and c) electricity and water services. Under the contract, the integrator agrees, in advance, to make a flat-rate payment of a given sum per kg live weight of harvested birds, plus a bonus for improved performance, usually related to low mortality and good feed conversion ratios. In some cases, a penalty may be incurred for poor performance.

Before a contract can be agreed, the grower must meet required standards for the buildings and other facilities offered, and demonstrate his/her knowledge and experience of poultry production. The payments are based on current market prices and average levels of productivity. Similar arrangements apply in the, less common, case of egg production under contract.

The grower's contract is essentially a means of cost and risk sharing with the integrator. The grower avoids the transaction costs of organizing separate purchases of inputs and sales of products, and reduces the risks of large price fluctuations faced by an independent producer. There may be other benefits associated with the technical advice and support provided by the integrator. At the same time, there is a cost, in that independent producers generally earn larger margins per bird or per kg of meat produced. The integrator avoids the costs of establishing the necessary buildings and equipment and of day-to-day management, while excluding the risks of dealing at arm's length with independent growers. Most studies show that the overall marketing margins are lower for integrated production systems than for independent growers.

Despite the fact that many broiler producers choose to adopt contract growing for large integrator companies, and remain loyal for extended periods, doubts are raised about the fairness of the system by both contract growers and independent growers in competition with the integrated producers. It is claimed that the integrators force producer prices and margins below competitive market levels.

Where, as is often the case, there are a small number of integrators dealing with a large number of potential contract growers, the integrators are in an oligopoly situation and have a measure of market power, which may be exploited, as it is they who generally write the contracts. In India, and probably other countries, there is no formal legal basis for the contractual agreements, which makes enforcement difficult. However, broiler growers always have the option of returning to an independent status if they become dissatisfied with the terms of the current contract. Integrators have an interest in maintaining grower loyalty. The system has functioned effectively in many situations.

4 GOVERNMENT POLICIES FOR THE POULTRY SECTOR

4.1 Comparative advantage

The global distribution of poultry production, and associated patterns of trade in poultry products, is dependent in part on differences in comparative advantage or the opportunity cost of production, and in part on past and present policies affecting trade, exchange rates, markets and prices, technology development and institutions. Comparative advantage depends, in turn, on endowments of natural resources, labour and capital, and the associated productive technology.

Given that India, China and Brazil are among the largest countries in the world, with huge internal, inter-regional differences, comparisons of national average data are of limited value in assessing comparative advantage. However, there are some fairly obvious differences. Brazil, with large areas of still not fully exploited fertile land, has a particularly favourable natural resource base for producing key feed crops (see Tables 3 and 4 above). Egypt appears to be disadvantaged in this respect, and is heavily dependent on imports of feed grains and oilseeds. Relative labour scarcity is reflected in wage rates which are higher in Thailand than in China and India. All these developing countries are constrained by capital limitations, with underdeveloped communications, physical, social and institutional services. However, international movements of capital are increasing in response to economic investment opportunities.

Comparison of average broiler farm-gate prices gives an indication of relative comparative advantage, although market prices may be affected by market distortions. Estimates, of average prices per kg live weight for 2001 are as follows: India US$0.48 to $US0.84; Thailand US$0.68; and Brazil US$0.48 (Landes *et al.*, 2004). In comparison, the estimate for the United States of America is US$0.87. Production costs in China are likely to be lower than those in Thailand, as wages are lower. Market prices of commercial broilers in Egypt between 2004 and 2004 ranged from US$0.9 to US$1.2. Local "balady" chicken prices are 30 to 40 percent higher (Ibrahim *et al.*, in FAO, 2007f).

4.2 Trade policies

Policy objectives, for agriculture and the poultry sector differ among the case-study countries. India and Egypt have historically pursued import substitution policies, with the aim of achieving a measure of self-sufficiency, although both are now opening up to more foreign trade with membership of the World Trade Organization (WTO).

China has undergone major change over the last 20 years, with reductions in government intervention and central planning. There is increased reliance on market forces, which is being accelerated with WTO membership. Large trade surpluses are being earned from manufactures, and there is less concern over the agricultural trade balance. The main goals for agriculture are to achieve food security for the huge population, to improve food safety and quality, to improve farmers' incomes, and to protect the natural environment for sustainable agricultural and rural development. Brazil, as the world's largest exporter of poultry meat, and Thailand, as the fourth largest, are concerned to protect and expand their export markets. Despite these differences, all the countries have imposed quantitative controls on imports in the past and have switched to the use of tariffs under WTO rules. Both kinds of trade barrier, if effective, restrict imports and therefore raise domestic prices – benefiting domestic producers, but raising costs for consumers. In the case of feed crops, like maize and soybean, costs are increased for feed millers and poultry producers. Generally, the costs of trade barriers exceed the benefits. Tariffs are generally the preferred option, but WTO members are required to reduce tariff levels over time.

In India, quantitative import controls were applied to poultry meat, poultry preparations, eggs and egg products until April 2000, when they were replaced by tariffs of 30 percent on fresh, chilled or frozen chicken and 100 percent on processed products. Controls on imports of breeding stock and poultry feeds were lifted in 1997/98. However, an under-quota tariff on feeds of 15 percent, rising to 70 percent out of quota, was then introduced.

A ban on Egyptian imports of poultry meat introduced in the late 1980s caused domestic price rises and provided incentives for domestic producers. It was lifted in 1997, and replaced by an 80 percent tariff. Imports have remained at low levels. Further production incentives were provided by tariff-free imports of poultry feeds from July 2006.

Chinese tariffs on imports of poultry products were reduced from 20 percent to 10 percent between 2001 and 2004 as part of the trade liberalization process. Imports of poultry products provide materials for the growing processing sector from which some products are exported.

Agricultural exports from Thailand make a significant contribution to foreign-exchange earnings. Exports of agricultural and livestock products account for a large proportion of the total sector contribution to national income. However, Thailand is a net importer of some key agricultural products, including soybean and other oilseeds. In moves to promote trade liberalization, Thailand joined the ASEAN Free Trade Agreement (AFTA) and the Asia-Pacific Economic Cooperation (APEC) Group.

Tariff reforms were launched in 1994, aimed at the simplification of tariff structures and their gradual reduction over time. They were temporarily increased following Thailand's debt crisis of 1997, but now the in-quota tariff on maize and other feed crops is 20 percent. Currently, this has little effect on the maize market, as Thailand is a net exporter. However, imports of soybean are affected. The larger feed millers may benefit in being more-readily allocated low-rated tariff quota allotments. In this way the structures of the milling and poultry industries may be affected by the associated price discrimination.

Prior to the mid-1980s, Brazil like other Latin American countries pursued a policy of industrialization under protective trade barriers. Quite rapid economic growth had occurred, but this was accompanied by rapid inflation and the accumulation of a huge foreign debt. During the 1980s, measures were put in place to reduce the rate of inflation, with cuts in government spending and tighter monetary controls. Brazil joined with neighbouring countries to form MERCOSUR (*Mercado Común del Sur*) in 1991, which led to increased trade between members, but largely in capital intensive industries.

In 1994/5 the Real Economic Stabilization Plan was put in place, with effective currency devaluation and further liberalization, under the guidance of the WTO Agreement on Agriculture. Up to 2003, economic growth was slow and real wages fell under a series of domestic and international economic shocks. However, following a reform plan introduced in 2004/05, the government withdrew from agricultural markets, state enterprises were privatized and minimum support prices were eliminated. As a result, the Brazilian economy has strengthened, producing record current-account trade surpluses to which agricultural expansion has made a significant contribution.

4.3 Macroeconomic and exchange-rate policies

Government policies associated with taxation, spending, borrowing, interest rates, wage rates, the money supply and exchange rates, are together referred to as macroeconomic policies. Although they are applied to the whole economy, they can have a major impact on the development of a particular sector and trade in its products. For example, foreign exchange rates affect prices and quantities of exports and imports, and thus the prices of products and inputs. In the past, many governments have allowed their domestic currencies to become, and remain, overvalued. This situation may arise when the currency is "pegged" at a fixed rate against another currency such as the United States dollar while, as a result of changes in the global economic environment or poor macroeconomic management, rapid domestic inflation and growing foreign indebtedness, the real value of the domestic currency has fallen.

The benefits, of maintaining an overvalued exchange rate are derived in terms of cheap foreign exchange and low prices of imports, and possibly a decline in the prices of domestic produce as export quantities and revenues fall. The distortion may be maintained by the application of foreign exchange controls, together with trade quotas and tariffs, as outlined above. Losses are experienced by potential exporters faced by the artificially low domestic prices of exports. In effect they are taxed.

The main beneficiaries are thought to be urban dwellers for whom imported consumer goods and industrial raw materials are made cheaper. The situation can rarely be sustained, and macroeconomic reform strategies, usually involving currency devaluation, become necessary. Devaluation reverses the effects of an overvalued currency by raising the domestic prices for exports and imports, thereby providing incentives for domestic producers to substitute for imports and/or increase exports.

The development of the poultry sector in Brazil, Thailand and Egypt, has been affected by the international debt crises of the 1980s and 1990s. Brazil and other Latin American countries had borrowed heavily from banks in North America and elsewhere in the 1970s and early 1980s, but by 1982, debt servicing had become impossible and the problem had become a crisis. Thus, Brazil and other debtor countries were required to adopt unpopular reform policies. There followed a decade of cuts in government spending, currency depreciation associated with increasing domestic prices, and slowing economic growth. However, rising interest rates and market liberalization attracted foreign investment and poultry production started to expand.

With the introduction of the Real Economic Stabilization Plan in 1994, the Brazilian currency was changed from the cruzeiro to the real and pegged to the United States dollar. This was accompanied by trade liberalization, as outlined above. These policies stabilized the economy and brought about a consumer boom. Between 1999 and 2001 the real was devalued to about a third of its previous exchange value, leading to a major improvement in export prices, while reducing the profitability of imports. As a result there was a 20 percent expansion in the area planted to soybeans in the 2000/2001 crop year and a 35 percent increase in soybean exports (USDA, 2006). Capital inflows resumed, expansionary policies were adopted and economic growth recovered.

In the late 1990s, Thailand suffered a 40 percent devaluation of the baht which signalled the beginning of the Asian debt crisis, which spread to Malaysia, Indonesia, the

Republic of Korea and, less seriously, the Philippines. Serious capital losses experienced by foreign investors led to massive withdrawals of funds from these and other debtor countries. Interest rates rose and debtor problems were exacerbated in other countries. A further currency devaluation was needed in Brazil in 2001, while the Egyptian pound was devalued in 2002. In each case, the devaluation has raised the domestic prices of poultry products and of feed grains. The increases in poultry prices have benefited and provided incentives for domestic producers and exporters. However, rising prices of feed grains increase costs for feed millers and poultry growers. Serious problems may arise for countries like Egypt that are dependent on feed-grain imports.

4.4 Domestic support policies for the poultry industry

Public-sector investment in the development of the poultry industry has been limited in all the case-study countries. Development has been largely based on private domestic or foreign investment. Some schemes have been established to promote smallholder production and producer cooperatives in India. Poultry production has been subsidized to a limited extent by federal, state and local governments in Brazil and in Thailand. Rather more emphasis has been given to the promotion of crop production in general, and feed-grain producers may have benefited. The price of feed grains in Egypt remained low for a long period as a result of the overvalued currency.

More generally, governments are responsible for the provision of the social infrastructure of roads, telecommunications, water and electricity supplies, and other facilities. There is still much room for improvement in all developing countries. These limitations are seen as constraints to the future development of the poultry industry in all the case-study countries.

4.5 Poultry health and disease control

The maintenance of animal health and the control of livestock disease is an area where some sharing of public and private responsibility is likely to be necessary. Direct costs result from losses due to morbidity and mortality of birds, while indirect costs are incurred in the implementation of control measures.

The case for public-sector intervention in providing for specific disease control measures, such as border controls, surveillance, movement controls, quarantine services, food-safety and drug-quality control, has been argued on the basis that they yield public goods and externalities[9] (Holden, 1999, Umali *et al.*, 1992; Leonard, 1993). It is further generally agreed that where "stamping out" by compulsory slaughter is the chosen method of controlling a disease outbreak, the costs of slaughter and compensation should be met from public funds.[10]

These issues have come to the fore in recent years, with the spread of HPAI. Outbreaks of the disease, associated with a small number of human infections and deaths, have occurred in India, Egypt, China and Thailand. The disease and associated control measures

[9] Public goods are those from which no one can be excluded from the benefits and for which the cost does not depend directly on the number of beneficiaries. Hence, public goods are unlikely to be supplied adequately by private enterprise.

[10] Hitherto, no satisfactory private insurance schemes have been developed to cover these costs.

have incurred major costs, both public and private, in terms of dead or culled birds and the associated financial losses. The impacts have been greater in China and Thailand, as the outbreaks began earlier in these countries, have recurred since, and have resulted in continuing import bans on unprocessed poultry products, thus damaging these countries' major export industries.

In addition, loss of consumer confidence in the safety of eating poultry products caused a fall in demand and hence prices, which affected producers even in countries, like Brazil, where no outbreaks have occurred. However, this impact was largely temporary, as global consumer demand appears in 2007 to have recovered to its former growth path.

Governments have been forced to review their policies for control of the disease. Contingency plans have been prepared to strengthen the response if and when future outbreaks occur. Such plans include compulsory culling, with compensation as a means of "stamping out" the disease. A double "moral hazard" problem arises in determining compensation levels. If they are set too low, producers have little incentive for rapid reporting of an outbreak. If they are set too high, producers have little incentive for maintaining high biosecurity standards.

A vaccine has been developed in China and is distributed free of charge. Presumably it is intended for use in limiting the spread of outbreaks if and when they occur, rather than as a prophylactic. In Thailand, however, vaccination is banned, presumably because of its potential damaging impact on export markets. Both countries have switched most of their poultry export production to pre-cooked and processed products. This not only avoids the problem of import bans on their raw, uncooked poultry products, but also adds value to the commodity.

Other precautionary approaches aimed at limiting the risks of further outbreaks and their spread are being adopted. These include promoting improved surveillance and biosecurity, often by means of regulations that affect the structure of the industry. Regulations, such as the closure of live or wet-markets and the compulsory housing of birds, impose serious costs on smaller-scale, Sector 4 and possibly Sector 3 producers. These costs, together with a smaller capacity to cope with the costs of disease outbreaks, may drive small-scale producers out of the industry, although a small telephone survey in Thailand suggests that the majority have remained in poultry production after the trauma of the main outbreaks. These disproportionate impacts on different sectors of the poultry industry should be carefully considered by policy-makers.

5 EXPECTED TRENDS

5.1 Global expansion of the poultry industry

Commercial production and consumption of poultry meat and eggs are likely to continue to expand globally. This expansion will accompany general economic growth and industrial development, as demand for livestock products increases with growing per capita incomes and urban populations. Growth will continue at the intensive margin with increasing commercialization and industrialization of the poultry sector, and at the extensive margin as commercial poultry production spreads along with other industries.

Analysis of data for the case-study countries has shown large differences in average levels of per capita production and consumption of poultry meat and eggs, between countries and between regions within countries. These are linked, at least in part, with differences in levels of industrial development and urbanization. Intensive, large-scale commercial production is concentrated in some of the more economically advanced areas. Further intensification and integration will occur in these areas, while concurrently, commercial production may become more widely dispersed.

Expansion of the poultry industry is most rapid in low- and middle-income countries where average incomes are increasing. At low income levels, a given proportionate increase in income results in a relatively large increase in poultry meat and egg consumption.[11] As incomes increase, the impact of further growth on quantities demanded and consumed diminishes. At relatively high income levels the elasticity of demand falls to a very low level, so further increases may have little or no impact on consumption. Ultimately, in the long term, the growth in demand for poultry meat and eggs could slacken as average consumption levels approach the desired maximum. However, in global markets, this stage is quite remote, while if it occurs in individual countries, further expansion of the industry may be based upon opportunities for increasing exports.

5.2 Market and resource constraints on production

a) **Constraints on the global economy.** Growth in demand for livestock products, poultry meat and eggs is driven by growth in per capita incomes. Hence, threats to the global economy, posed by global warming, energy and mineral resource limitations, and political conflicts, could reduce the growth rate of consumer incomes and their demand for livestock products. Expansion of poultry production would have to slow, to avoid falling prices. The incidence and impacts of these constraints, on the poultry industry, are difficult to predict and depend upon the policy responses of the international community.

b) **Macroeconomic, trade, exchange rate and investment policies.** As outlined in Sections 4.2, 4.3 and 4.4, above, national economic policies can have significant impacts on income growth and distribution, and on resource and commodity prices. Policy distortions may have an adverse impact on the growth of demand for and supply of poultry products. It is widely recognized that market and trade liberalization and non-discrimination against agriculture, are desirable objectives to promote economic growth and development.

c) **Supplies and prices of feed grains and oilseeds.** General expansion of cropland is fast approaching the limit of available cultivable land, other than in Latin America. Competition for this resource with other crops and other forms of land use (e.g. for building and urban development) will increase. At the same time, demands for feed crops for other purposes, including human consumption and biofuel production, are increasing. These trends are likely to result in increasing feed prices and reduced margins for livestock producers. However, poultry have a competitive advantage over other species, as their feed conversion rate is better.[12]

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[11] The income elasticity of demand is high.

[12] The quantity of feed used per kg of poultry product is lower.

d) Deficiencies in the general transport and market infrastructure. Poor communications, limitations of the road network, lack of marketing facilities and cold chains, inadequate information and other infrastructure deficiencies limit the spread of commercial poultry production in many developing countries. Governments have a role in overcoming some of these marketing constraints, for instance by building roads and disseminating information. However, this public-sector investment is a key component of general economic development, rather than a policy aimed at promoting increased poultry production.

5.3 Disease constraints

Development of the poultry industry may suffer fluctuations due to HPAI, with outbreaks causing loss of production and loss of export markets. Reductions in demand due to human health fears appear to be short lived. However, all this depends upon maintenance of a reasonable level of disease control and the non-occurrence of a human pandemic.

Exporting countries suffer most from epidemics of transboundary diseases like HPAI. Strict SPS (sanitary and phytosanitary) standards are likely to be maintained in future, with export bans being imposed on countries where outbreaks occur. Compartmentalization and regionalization have not been generally accepted. Although freezing, storage and processing allow some flexibility in adjusting to export bans, future outbreaks and the possible endemic state of the disease may cause changes in the main poultry-trading nations.

5.4 The future of Sector 4 production

There is some debate as to whether Sector 4, backyard producers are likely to be displaced in the face of competition from the lower-priced products of the highly productive commercial sectors. However, to some extent traditional and commercial poultry producers operate in different markets for products and key inputs. As commercial production tends to develop in specific regions within each country, often in the vicinity of urban conurbations, the traditional backyard systems may still dominate in remote rural areas.

Even in peri-urban areas, where commercial poultry production is well established, backyard and commercial systems may co-exist, operating in parallel but different markets. It is widely reported, for instance in India and Egypt, that traditional, local breeds of poultry are more highly priced than commercial broilers. The opportunity cost of family labour used in backyard systems is lower than that of hired labour used in commercial systems, while purchases of feed and veterinary inputs are minimal in Sector 4 production systems.

Some form of small-scale "backyard" or "hobby" production is likely to continue in all countries. Many backyard or hobby farmers still exist in Europe, with very little impact on aggregate supplies of poultry meat and eggs, though subject to monitoring and surveillance for disease-control purposes. In poor countries, backyard production maybe supported or promoted as a means of poverty relief. However, there are dangers that disease-control measures such as the closure of open, wet markets, or the requirement that all poultry be permanently housed, impose severe costs on small-scale producers, so that they are particularly disadvantaged in comparison with the commercial sector.

5.5 The role of Sector 3 producers

A question arises as to whether Sector 3 production is a transitory phase in the commercialization of the poultry industry that will largely disappear as Sectors 1 and 2 expand, or whether it will continue to function in filling niche markets for special products, such as duck and goose meat or organic produce. The apparent small size of Sector 3 in Brazil and Thailand suggests that the former outcome is the more likely.

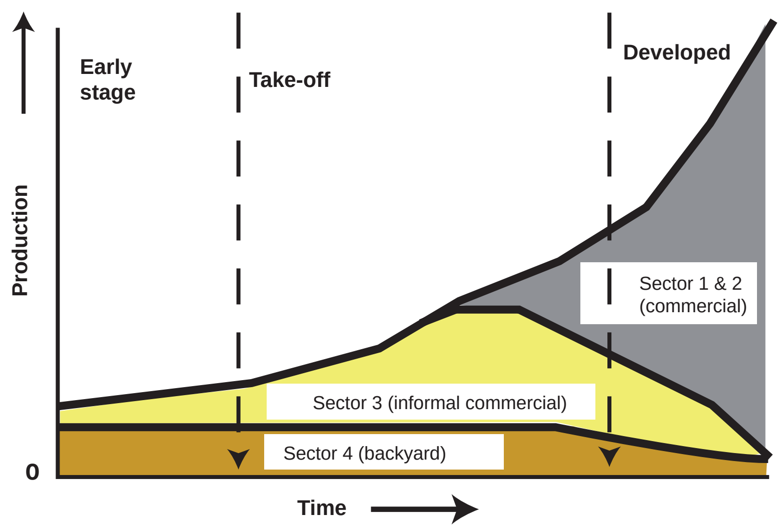
Hence the growth and commercialization of the poultry industry may be illustrated as in Figure 9 which is adapted from Rushton *et al.* (in FAO, 2006c).

Figure 9 is based on the assumption that differences between countries in the structure of the poultry industry reflect different stages in development over time. However, as already noted, development of the industry is concentrated in particular regions within countries. Hence, different regions within countries may be at different stages in the development process. For instance, while northwestern Brazil and western China may be in the "early stage", the south of Brazil and parts of eastern China have a well "developed" poultry sector.

Semi-commercial Sector 3 production may expand in the process of poultry commercialization, but eventually be displaced by larger-scale fully commercial systems. In fact, many Sector 3 producers may become contract farmers or their farms may become part of an integrated chain.

Arguably, this process of integration is required to improve overall biosecurity as contracts through the chain are strong and it is in the interests of all actors to avoid the spread of disease. Integrated systems are more likely to develop where consumer demand has shifted away from live-bird markets to those for mass-produced chilled products.

FIGURE 9
Poultry sector development



Source: adapted from Rushton *et al.* (in FAO, 2006c).

REFERENCES

Acamovic, T., Sinurat, A., Natarajan, A., Anitha, K., Chandrasekaran, D. & Shindey, D. 2005. Poultry. *In* E. Owen, A. Kitalyi, N. Jayasuriya & T. Smith, eds. *Livestock and wealth creation: improving the husbandry of animals kept by resource-poor people in developing countries.* Nottingham, UK, Nottingham University Press.

Anon. 1997. The Thai poultry industry. In, India's sleeping giant: food. *The McKinsey Quarterly*, 1997 (1).

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. & Courbois, C. 1999. *Livestock to 2020: the next food revolution.* Food, Agriculture, and the Environment Discussion Paper 28, Washington DC, Interntational Food Policy Research Institute..

Dorward, A., Kydd, J. & Poulton, C. 1998. *Smallholder cash crop production under market liberalization: a new institutional economics perspective.* Wallingford, UK, CAB International.

Evans, T. 2006. China: HPAI accelerates the switch from wet markets to supermarkets. *Poultry International,* 45(9): 12,14,16.

FAO. 2003. Livestock industrialization project: phase II – policy, technical, and environmental determinants and implications of the scaling-up of swine, broiler, layer and milk production in Brazil (Annex V), by G.S. Camargo-Barros, S. de Zen, M.R.P. Bacchi, S.H.G. de Miranda, C.A. Narrod & M.M. Tiongco. *In* C.L. Delgado, C.A. Narrod & M.M. Tiongco, eds. *Policy, technical, and environmental determinants and implications of the scaling-up of livestock production in four fast-growing developing countries: a synthesis.* Rome.

FAO. 2004. *FAO recommendations on the prevention, control and flock eradication of highly pathogenic avian influenza in Asia.* FAO Position Paper, September 2004. Rome. 59 pp.

FAO. 2005. *The value chain approach as a tool for assessing distributional impact of standards on livestock markets: guidelines for planning a programme and designing case studies,* by J. Humphrey & L. Napier. AGA/ESC Initiative on Market Exclusion. January 2005. Rome. 32 pp.

FAO. 2006a. *Livestock's long shadow: environmental issues and options*, by H. Steinfeld, P. Gerber, T. Wassenaar, V. Castel, M. Rosales & C. de Haan. Rome.

FAO. 2006b. *Evidence-based policy for controlling HPAI in poultry: bio-security revisited*, by J. Otte, D. Pfeiffer, E. Silbergeld, L. Price & T. Tiensin. Pro-poor Livestock Policy Initiative Research Report. Rome.

FAO. 2006c. *Policy choices and institutional options: how do they affect disease costs*, by J. Rushton, N. Morgan & A. McLeod. Paper presented at the Symposium for Markets and Trade Dimensions of Avian Influenza, Rome, Italy 14th November, 2006. Rome. (available at http://www.fao.org/docs/eims/upload//234376/ah671e00.pdf).

FAO. 2007a. *Industrial livestock production and global health risks*, by J. Otte, D. Roland-Holst, D. Pfeiffer, R. Soares-Magalhaes, J. Rushton, J. Graham & E. Silbergeld. PPLPI Research Report. Rome. (available at http://www.fao.org/ag/againfo/projects/en/pplpi/docarc/rep-hpai_industrialisationrisks.pdf).

FAO. 2007b. *Poultry industry in India*, by R. Mehta. Paper prepared for the conference International Conference Poultry in the Twenty-first Century: avian influenza and beyond, held 5–7 November 2007, Bangkok, Thailand. Rome.

FAO. 2007c. *Structural changes in Thailand's poultry sector and its social implications*, by V. Na Ranong, Paper prepared for the conference International Conference Poultry in the Twenty-first Century: avian influenza and beyond, held 5–7 November 2007, Bangkok, Thailand. Rome.

FAO. 2007d. *The Brazilian poultry sector: changes in the period 1995–2005*, by OD Consultancy. Paper prepared for the conference International Conference Poultry in the Twenty-first Century: avian influenza and beyond, held 5–7 November 2007, Bangkok, Thailand. Rome.

FAO. 2007e. *Food outlook – November 2007: global market analysis*. Global Information and Early Warning System (GIEWS). Rome. (available at http://www.fao.org/docrep/010/ah876e/ah876e00.htm).

FAO. 2007f. *Market impacts of HPAI outbreaks: a rapid appraisal process, Egypt,* by A.A. Ibrahim, N. Morgan, L. Albrechtsen & J. Rushton. Mimeograph. Rome.

FAO. 2007g. Maps of livestock densities, by P. Gerber. In C.L. Delgado, C.A. Narrod & M.M. Tiongco, eds. *Policy, technical, and environmental determinants and implications of the scaling-up of livestock production in four fast-growing developing countries: a synthesis*. Rome. (available at http://www.fao.org/WAIRDOCS/LEAD/X6170E/x6170e0c.htm).

FAOSTAT. *FAO Statistical Database*. (availabe at http://faostat.fao.org/default.aspx – accessed June 2007).

GLiPHA. 2007. *Global livestock production and health atlas.* Rome. FAO. (available at http://www.fao.org/ag/aga/glipha/index.jsp).

Holden, S. 1999. The economics of the delivery of veterinary services. *Rev. sci. tech. Off. Int. Epiz.* 18(2): 425–439.

Landes, M., Persaud, S. & Dyck, J. 2004. *India's poultry sector: development and prospects. Economics Research Service: Agricultural and Trade Report WRS-04-03.* Washington DC, United States Department of Agriculture.

Leonard, D. 1993. Structural reform of the veterinary profession in Africa and the new institutional economics. *Development and. Change*, 24(2): 227–267.

Otte, J. & Upton M. 2005. Poverty and livestock agriculture. *In* A. Rosati, A. Tewolde & C. Mosconi, eds. *Animal production and animal science worldwide: WAAP book of the year 2005.* Wageningen, the Netherlands, Wageningen Academic Publishers.

PBEC. 1999. *The value chain for poultry: final report.* Hong Kong, Pacific Basin Economic Council: Working Committee on Food Products.

Rushton, J., Viscarra, R., Guerne Bleich, E. & McLeod, A. 2005. Impact of avian influenza outbreaks in the poultry sectors of five South East Asian countries (Cambodia, Indonesia, Lao PDR, Thailand, Viet Nam) outbreak costs, responses and potential long term control. *World Poultry Science Journal,* 61(13): 491–514.

Taha, F.A. 2003. *The poultry sector in middle-income countries and its feed requirements.* Economics Research Service: Agricultural and Trade Report WRS-03-02, Washington D.C., United States Department of Agriculture.

Tisdell, C., Kehren, T. & Murphy, T. 1998. The pig and poultry industries in Thailand: development, trade and commerce. *Sasin Journal of Management*, 4: 1–18.

Umali, D.D., Feder, G. & de Haan, C. 1992. *The balance between public and private sector activities in the delivery of livestock services*. Discussion Paper No. 163, Washington, DC, World Bank.

USDA. 2006. Brazil's booming agriculture faces obstacles. *Amber Waves* (November 2006). Washington, D.C., United States Department of Agriculture, Economics Research Service.

Williamson, O.E. & Masten, S.E. (eds.). 1995. *Transaction cost economics.* Aldershot, UK, Edward Elgar.

World Bank data. (available at http://web.worldbank.org – accessed June 2007).

Annexes

ANNEX A

Characteristics of developing countries, by income group (2006)

Region	Low-income	Lower middle-income	Upper middle-income	High-income developed
Average GNI/capita (US$)	650	2 037	5 913	36 487
GDP growth (%)	8.0	5.7	8.9	4.3
Agriculture, value added (% of total GDP)	21.5	12.3	6.2	1.9
Urban population (% of total)	30	47	75	77
Population/km^2	82.3	79.7	19.5	29.7
Poultry/head rural population	1.2	8.2	11.4	21.7
Poultry meat production (% of world total)	5	38	14	43
Poultry meat/head/year (kg)	1.7	17.1	23.2	33.7
Poultry meat exports (% of world total)	0.1	45.4	8.8	45.7
Poultry meat imports (% of world total)	4	25	30	41

Sources: World Bank data and FAOSTAT.

ANNEX B

Characteristics of case-study countries (2006)

	India	Egypt	China	Thailand	Brazil
GNI/capita (US$)	730	1 260	1 740	2 720	3 550
GDP growth (%)	9.2	4.9	10.2	4.5	2.3
Agriculture, value added (% of total GDP)	18.3	14.9	12.6	9.9	8.1
Urban population (% of total)	29	43	40	32	84
Population/km^2	368	74	140	126	22
Poultry/head rural population	2.9	6.6	6.6	43.1	0.6
Poultry meat production (% of world total)	0.6	17.5	1.3	11.9	2.4
Egg production (% of world total)	0.4	45.0	1.1	2.5	3.9
Poultry meat/head/yr (kg)	1.8	7.3	11.3	10.0	38.7
Eggs/head/year (kg)	1.9	2.8	17.5	8.5	6.3
Poultry meat exports (% of world total)	0	0	7.2	5.4	33.9
Poultry meat imports (% of world total)	0	0.3	14.6	0.1	0
Cereal yield (tonnes/ha)	2.4	7.5	5.1	2.7	2.9
Maize production (% of world total)	2.1	1.1	19.9	0.6	5.0
Soybean production (% of world total)	2.9	0.0	7.8	0.1	23.8

Sources: World Bank data and FAOSTAT.

ANNEX C. PRODUCTIVITY OF POULTRY IN MEAT PRODUCTION

A crude, but useful, measure of productivity in the poultry-meat sector is given by the ratio of the "number of birds produced and slaughtered per year", to the "number of birds in stock, or inventory, at a single point in time". Similar "productivity ratios" may be calculated for other livestock species, as the number produced per head of the national herd or flock. Despite the omission of other valuable products such as eggs, milk and wool, these ratios provide a crude indication of productive efficiency.

Interspecies comparisons, show poultry productivity to be substantially higher than that of other domestic livestock enterprises. For instance, "productivity ratios", based on data averaged over all developing countries in 2005, are 0.2 for cattle, 0.5 for sheep and goats, 1.3 for pigs and 2.4 for poultry. (FAOSTAT, accessed 2006). Similar comparisons, using data for developed countries show higher "productivity ratios" for all species, but with the same inter-specific ranking. The high level of poultry productivity reflects both a higher reproductive rate and a faster rate of growth to maturity than those of other species. These factor together have allowed rapid genetic improvement, rapid growth of the poultry industry in many countries, rapid recovery and restocking after disease outbreaks, as well as the potential for economic gain.

National estimates of the poultry "productivity ratio" differ between countries, and have generally increased over time, as shown in the following table.

Differences between countries, in the productivity of poultry meat, may reflect differences in the relative emphasis given to egg production. In India and China, where in 1981 the ratios were rather low, there is more emphasis on egg production than there is in the other countries. However, in all the countries, except Thailand, the increase in productivity over the following 25 years is largely associated with increasing scale and commercialization of poultry production, and the introduction of specialized fast-growing broiler stock.

Thailand is a special case, in that in 1981, the average productivity ratio was already close to the levels then achieved in developed countries with largely commercial poultry sectors. The apparent decline in productivity by 2006 is largely due to the large numbers of birds lost or culled as a result of HPAI outbreaks from 2003 onwards. The very rapid growth of the productivity ratio for India, of over 7.5 percent annually over 25 years, is remarkable (see text Figure 5 and associated comments).

TABLE C1
Poultry productivity ratios for case-study countries

	India	Egypt	China	Thailand	Brazil
Productivity 1981	0.70	3.48	1.17	3.83	2.73
Productivity 2006	4.42	3.96	1.89	2.76	4.46
Average annual increase (%)	7.64	0.52	1.95	-1.30	1.98

Source: FAOSTAT.

Poultry sector in China: structural changes during the past decade and future trends

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SUMMARY

The poultry sector in China has experienced vigorous growth over the past two decades, both in terms of poultry numbers and level of output per bird. Higher levels of production are associated with the spread of intensive systems in which food conversion ratios are high. Poultry production has increased its share of China's total livestock production – growing much faster than pork production. Growth has been accompanied by great changes in the structure of production. The poultry sector is no longer dominated by hundreds of millions of smallholders keeping birds as a sideline activity. Many small farmers have given up production, especially in the economically more developed eastern provinces of the country.

Drivers of change in the poultry sector include, on the demand side, demographic changes – rising population and increased urbanization; income growth both in urban and rural areas; developments in transportation, the processing industry and retailing; rising per capita consumption; and the requirements of export markets. In rural areas, increased incomes from non-farm activities and better marketing infrastructure have reduced need for smallholders to keep poultry as a cash-generating sideline or for home consumption. On the supply side, drivers of change include technological innovation and its diffusion – feed processing has played a decisive role; and the provision of better public services, such as technical innovation, extension, disease prevention and control, quality standards and information.

For the future, it is expected that demand will continue to rise and that the intensification process will continue. Small-scale and non-commercial farmers will continue their exit from the industry. It is possible that the number of poultry farmers in China could halve by 2020. Nonetheless, poultry keeping remains an important economic option for improving the livelihoods poorer smallholders in the mountainous western parts of the country. Increasingly stringent quality and food-safety standards demanded by importing countries will favour the intensification process. Integrated operations in particular are well placed to implement reliable quality control.

Constraints to poultry sector development in China are likely to include high feed prices, particularly maize and soybean. Avian influenza and other diseases will have a major effect on the development of the sector, and may further promote intensification.

Key policy objectives for the poultry sector in China are: to provide sufficient and safe food to the consumer; to provide income and employment for farmers; and to protect the

environment and promote sustainable economic development. Requirements to promote these objectives include: improved disease control and prevention measures; land-use policies that do not unnecessarily inhibit the establishment of poultry farms; favourable investment policy and provision of loans; promotion of the sustainable use of animal waste; and improved research and extension.

Keywords: poultry, sector, China, structure

1 INTRODUCTION

This paper describes the status of the poultry sector in China. It describes the structural changes that have affected the sector particularly over the past decade. It outlines the main drivers of change both on the demand side and the supply side. It then considers future trends and describes the main challenges facing the sector. Finally, it outlines policy objectives for poultry development and the key actions needed to meet these objectives.

1.1 Case studies

The paper draws on two case studies, a broiler and a layer operation, both of which are situated in Fujian Province in the coastal area of southeastern China. The broiler enterprise, Shengnong Group, is a highly vertically integrated operation. It was set up in the mid-1980s and was the first registered private company in Fujian Province. It has now become a large enterprise with over 4 000 employees and an annual output of about 50 million broilers. Its business operations cover the whole production and marketing chain – feed processing, raising of breeding chicken, hatching, fattening of broilers, slaughtering, cutting, and meat processing. It even runs a dozen fast-food restaurants using its own products. It has an organic fertilizer plant which uses chicken waste as raw material. An electricity generating facility is under construction, which will also use chicken manure (containing rice chaff) as energy input.

The layer enterprise, Wenhua, was established during the mid-1990s. It is a family business, with a co-shareholding by two brothers and one sister. It is much smaller than the broiler enterprise, having an inventory of about 250 000 hens.

2 STRUCTURAL CHANGES IN THE PAST DECADE

2.1 Production growth

The poultry sector in China consists of several subsectors –chickens, ducks, geese, turkeys, etc. Chicken production is the predominant subsector, accounting for 70 percent of poultry meat production and over 85 percent of total egg production. Ducks and geese each account for about 15 percent of poultry meat production (MOA, 2006a).

The poultry sector has experienced vigorous growth in the past two decades, as indicated in Table 1. Poultry inventory has increased by a large margin, from 1.98 billion birds in 1985 to 5.33 billion birds in 2005 – an increase of 169 percent. Poultry output and poultry meat production have shown even greater increases – with a growth of 277 percent and 814 percent, respectively, over the same period. This is an indication of much improved poultry production efficiency. Poultry meat production increased from 1.60 million tonnes in 1985 to 7.24 million tonnes in 1995 and to 14.64 million tonnes in 2005. Egg production has also increased substantially, but at a slower pace than poultry meat production – from 5.35 million tonnes in 1985 to 16.77 million tonnes in 1995, and 28.8 million tonnes in 2005 (Table 1).

The production growth has been achieved both by expansion of bird numbers and by increased productivity. The improvement in productivity is associated with the intensification of the process of production, as industrialized operations have a better feed:meat or feed:egg conversion ratio and shorter production periods. Most of the large operations have productivity levels that are similar to those of the poultry sector in the most developed countries. This is illustrated by the two case studies described in this paper. The vertically integrated broiler enterprise, Shengnong Group, has improved its feed:meat ratio from 2.2–2.3 (feed to live weight) to 1.97–1.98 over the past decade. The fattening period has

TABLE 1
Growth of the poultry sector in China, 1985 to 2005

	Poultry inventory (billion birds)	Poultry output (billion birds)	Poultry meat production (million tonnes)	Eggs production (million tonnes)
1985	1.98		1.60	5.35
1986	1.97		1.88	5.55
1987	2.19		2.19	5.90
1988	2.49		2.74	6.96
1989	2.24		2.82	7.20
1990	2.26		3.23	7.85
1991	2.45		3.95	9.22
1992	2.60	3.19	4.54	10.20
1993	3.12	3.98	5.74	11.80
1994	3.74	5.13	7.55	14.79
1995	4.11	6.30	9.35	16.77
1996	3.79	5.63	8.33	19.65
1997	4.20	6.39	9.79	18.95
1998	4.50	6.84	10.56	20.19
1999	4.55	7.43	11.16	21.35
2000	4.64	8.10	12.08	22.43
2001	4.89	8.09	12.10	23.37
2002	4.74	8.32	12.50	24.63
2003	5.06	8.89	13.12	26.07
2004	5.16	9.07	13.51	27.24
2005	5.33	9.86	14.64	28.80

Note: Figures in 1996 were adjusted based on the first Agricultural Census conducted in early 1997.
Source: Editing Committee of China Agricultural Yearbook, China Agricultural Yearbook, China Agricultural Press, various years.

been shortened to 45 days, with live broilers weighing 4.2 kg by the time of slaughter. In the case of the layer enterprise, Wenhua, the feed/egg ratio is 2.2–2.3; hens produce about 300 eggs during a lifespan of about 550 days.

2.2 Poultry's share in the livestock sector

The poultry sector has increased its relative importance in the national livestock sector in China over the past two decades. This was especially true for the period 1985 to 1995, when poultry meat production more than quadrupled. Pork production grew much more slowly by comparison. As a result, the share of poultry in total meat production increased from about 8 percent to 18 percent, while that of pork declined from 86 percent to 70 percent (Table 2).

TABLE 2
Poultry meat production and its share in total meat production in China, 1985 to 2005

	Meat total (million tonnes)	Poultry meat (million tonnes)	Poultry meat as a proportion of total meat (%)	Pork (million tonnes)	Beef (million tonnes)	Mutton (million tonnes)
1985	19.27	1.60	8.3	16.55	0.47	0.59
1986	21.12	1.88	8.9	17.96	0.59	0.62
1987	22.16	2.19	9.9	18.35	0.79	0.72
1988	24.80	2.74	11.1	20.18	0.96	0.80
1989	26.29	2.82	10.7	21.23	1.07	0.96
1990	28.57	3.23	11.3	22.81	1.26	1.07
1991	31.45	3.95	12.6	24.52	1.54	1.18
1992	34.31	4.54	13.2	26.35	1.80	1.25
1993	38.43	5.74	14.9	28.54	2.34	1.38
1994	44.99	7.55	16.8	32.05	3.27	1.61
1995	52.60	9.35	17.8	36.48	4.15	2.02
1996	45.84	8.33	18.2	31.58	3.56	1.81
1997	52.69	9.79	18.6	35.96	4.41	2.13
1998	57.24	10.56	18.4	38.84	4.80	2.35
1999	58.21	11.16	19.2	38.91	5.05	2.51
2000	61.25	12.08	19.7	40.31	5.33	2.74
2001	63.34	12.10	19.1	41.85	5.49	2.93
2002	65.87	12.50	19.0	43.27	5.85	3.17
2003	69.33	13.12	18.9	45.19	6.30	3.57
2004	72.45	13.51	18.7	47.02	6.76	3.99
2005	77.40	14.60	18.9	50.10	7.10	4.40

Note: Figures in 1996 were adjusted based on the first Agricultural Census conducted early 1997.
Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 3
Composition of agricultural output value in China

	Total	Cropping	Forestry	Fishery	Livestock	Proportional contribution of livestock (%)
			Billion RMB			
1985	362	251	19	13	80	22
1990	766	495	33	41	197	26
1995	2 034	1 188	71	170	605	30
2000	2 492	1 387	94	271	739	30
2005	3 945	1 964	143	402	1 331	34

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

During the period 1995 to 2005, poultry meat production continued to grow – doubling within this ten year period. The growth rate was slower than that of the previous decade, and only slightly faster than the total growth of meat production. It is generally agreed that had it not been for the outbreak of avian influenza (AI) the poultry sector would have achieved greater growth in recent years.

The share of poultry meat in total meat production increased from about 8 percent in 1995 to 19 percent in 2005. The share of pork fell from 70 percent in 1995 to 65 percent in 2005.

This increased importance of the poultry sector within the livestock sector has been accompanied by a significant increase in the importance of the livestock sector within the agricultural sector. As indicated in Table 3, the share of livestock in the total value of agricultural output in China increased from 22 percent in 1985 to 30 percent in 1995 and to 34 percent in 2005. This implies that the poultry sector's significance in the overall agricultural sector has increased substantially in the last two decades.

2.3 Structural changes in the poultry sector

The overall growth of the poultry sector in China has been accompanied by great changes in the structure of production. Two decades ago, China's poultry sector was very much dominated by hundreds of millions smallholders, each with a few, or at most several dozen, chickens or ducks. Poultry raising was only a minor sideline activity for farm households. Poultry meat and eggs were luxury goods which were mostly consumed on special occasions, such as birthdays or holidays. Apart from a very few state farms around big cities, there were no large-scale commercial poultry farms.

Rapid intensification of the livestock sector has been ongoing in China since the mid-1980s. This intensification comprises two dimensions: agglomeration – the establishment of large-scale intensive industrialized operations (either integrated or not integrated); and spatial concentration. Definitions of intensive and extensive systems vary; the definitions generally applied in China for major livestock species are listed in Table 4.

The intensification process has not been the same for all animal species. Generally speaking, the poultry sector, including both broilers and layers, has experienced the fast-

TABLE 4
Criteria for defining intensive farms in China

Farm type	Criterion defining intensive farms ("scale of raising")
Pigs	Annual production of 50 or more head of pigs
Beef cattle	Annual production of 50 ore more head of cattle
Dairy cattle	With a stock of 20 or more dairy cattle
Broilers	Annual production of 2 000 or more birds
Layers	With a stock of 500 or more birds
Sheep and goats	Annual production of 30 or more sheep/goats

Source: MOA, Yearbook of Animal Husbandry, China Agriculture Press, 2006.

est intensification, followed by the pig sector. The cattle sector, including beef and dairy, intensified more slowly.

The 1996 national agricultural census provides the earliest detailed information on the production structure of poultry production in China. According to the census data, among 234 million small farmers, 104 million households (44 percent) had poultry operations in 1996 (Table 5). Of those farmers who raised poultry, 99.7 percent were small producers with a yearly production of 1 000 birds or less. Poultry produced from this huge number of small farmers accounted for about 43 percent of total poultry production. Considering the figures in more detail, 96.8 percent of the farms raising poultry operated at a scale below 50 birds; such farms provided only 27 percent of total poultry production in 1996. Large producers, with an annual output of 1 000 birds or more, accounted for only 0.3 percent of operations, but accounted for 57 percent of poultry production.

The 1996 census made no distinction between broilers and layers. This may be a reflection of the fact that the traditional system of small producers still prevailed. As a result, no separate data on the size and structure of layer production are available for 1996.

Significant changes in poultry production took place during the last decade. An increas-

TABLE 5
Structure of poultry production in China in 1996 (by size of farms)

Size of farm (number of birds)	Farms with poultry (million)	Poultry output (million birds)	Farms with poultry (%)	Poultry production (%)
<50	100.76	835.46	96.82	27.00
50–200	2.40	219.82	2.30	7.10
200–1 000	0.59	282.52	0.57	9.13
1 001–10 000	0.29	968.07	0.28	31.28
>10 000	0.03	788.55	0.03	25.48
Total	104.07	3 094.43	100	100

Source: MOA: Internal data from the 1996 national agricultural census.

TABLE 6
Changes in number of poultry farms by province in China

	1996	2005	2005 figures as proportion of 1996 (%)	Proportion of rural households (%)
China	104.068	34.612	33.3	13.7
Beijing	0.021	0.008	39.5	0.6
Tianjin	0.034	0.005	13.6	0.4
Hebei	2.893	0.361	12.5	2.5
Shanxi	1.153	0.066	5.7	1.0
Inner Mongolia	0.668	0.789	118.0	22.4
Liaoning	1.571	0.228	14.5	3.3
Jilin	1.462	0.346	23.7	9.0
Heilongjiang	1.889	0.399	21.1	8.1
Shanghai	0.267	0.003	1.0	0.3
Jiangsu	6.272	1.036	16.5	6.5
Zhejiang	2.781	0.702	25.3	5.7
Anhui	8.273	2.006	24.2	14.9
Fujian	3.740	0.738	19.7	10.8
Jiangxi	5.051	3.836	75.9	48.2
Shandong	6.596	0.443	6.7	2.2
Henan	8.371	1.194	14.3	5.9
Hubei	5.350	1.364	25.5	13.4
Hunan	8.549	4.693	54.9	31.4
Guangsong	6.636	1.330	20.0	8.6
Guangxi	5.809	3.604	62.0	36.5
Hainan	0.666	0.525	78.8	46.6
Chongqing	3.431	0.031	0.9	0.4
Sichuan	11.930	6.995	58.6	35.3
Guizhou	3.368	1.251	37.1	15.8
Yunnan	4.196	1.952	46.5	22.2
Tibet	0.009	0.027	314.5	6.6
Shaanxi	1.034	0.214	20.7	3.0
Gansu	1.357	0.086	6.3	1.9
Qinghai	0.078	0.000	0.0	0.0
Ningxia	0.214	0.084	39.1	8.9
Xinjiang	0.397	0.298	75.1	13.3

Source: calculated by the authors based on data from MOA (2006a; 2006b and, NSB (2006).

ing number of small farmers have given up their sideline poultry production. This is especially the case in the economically more developed eastern parts of the country and in the suburbs of large cities. According to data from the Ministry of Agriculture (MOA, 2006b), the total number of poultry farms had declined to 34.6 million – a fall of 67 percent from the figure in 1996. The trend was downwards in all provinces except for Inner Mongolia and Tibet. The more-developed eastern provinces and municipalities showed larger decreases in the number of poultry farms. For example, only 1 percent of the poultry farms operating in 1996 in Shanghai Municipality are still in operation in 2005. The national average is that farm households keeping poultry account for only 13.7 percent of all rural households (Table 6).

During the same period, the number of large producers and their share in poultry production increased substantially. In 1996, large-scale producers with an annual output of 10 000 birds or more had a 25 percent share of the total. In 2005, the share of large producers was over 49 percent (Table 7). The picture is similar in the layer sector. In 2005, producers with 500 layers or more accounted for only 1.9 percent of operations, but nearly 70 percent of egg production (Table 8).

The poultry sector in China is characterized by a dichotomy: large-scale integrated industrialized operations, comparable to those found in the most-developed poultry sector in North America, coexist with very small traditional backyard systems. Generally

TABLE 7
Structure of broiler production in China in 2005 (by size of farms)

Size of farm (annual output of birds)	Number of farms (million)	Broiler production (million birds)	Share of farms (%)	Share of broiler production (%)
1–2 000	34.15	1 483	98.6	23.3
2 000–10 000	0.36	1 751	1	27.5
>10 000	0.11	3 137	0.3	49.2
Total	34.62	6 371	100	100

Source: same as for Table 6.

TABLE 8
Structure of layer production in China in 2005 (by size of farms)

Size of farm (number of birds)	Number of farms (million)	Layer inventory (million birds)	Egg production (million tonnes)	Share of farms (%)	Share of layer inventory (%)	Share of egg production (%)
1–500	40.4	804.4	7.1	98.1	33.8	30.3
500–2 000	0.6	643.4	6.5	1.4	27.1	27.9
2 000–10 000	0.2	694.3	7.2	0.5	29.2	30.8
>10 000	0	236.4	2.6	0	9.9	11
Total	41.2	2 378.5	23.3	100	100	100

Source: same as for Table 6.

speaking, the market demand is mainly covered by large operations, while the backyard operations meet the consumption needs of the raisers themselves. There are practically no state-owned livestock enterprises in China nowadays. The large-scale poultry farms are all private owned.

2.4 Spatial concentration

There is very marked spatial concentration of poultry production in China. The eastern region of the country has a much higher poultry density than the central and western regions, whether compared in terms of total population density or in terms of farm numbers.

As shown in Table 8, in 1996, the 11 provinces in the eastern region of China accounted for 30 percent of farms with poultry production. The eastern region produced about 65 percent of poultry meat; it accounted for 77 percent of large poultry farms (those with an annual output of more than 1 000 birds) and 80 percent of poultry output from large farms. In contrast, the western region, with 31 percent of China's poultry farms, produced only 13 percent of poultry output. Its share of large poultry farms was even lower – only 5 percent of large poultry farms and 6 percent of poultry output produced by large farms.

TABLE 9
Spatial (by regions) structure of poultry production in China in 1996 and 2005

		Percentage of total		
		East	Central	West
1996	Farms with poultry	30.3	38.6	31.2
	Poultry output	64.6	22.6	12.9
	Farms >1 000 birds	77.0	17.6	5.3
	Output >1 000 birds	80.2	13.6	6.2
2005	Total population	38.7	31.9	27.5
	Total farm number	38.5	32.5	29.0
	Farms with broilers	15.5	40.2	44.3
	Broiler output	56.7	28.8	14.5
	Broiler farms >2 000 birds	60.1	29.8	10.1
	Broiler output >2 000 birds	66.3	24.4	9.4
	Farms with layers	19.6	31.4	49.0
	Layer farms >500 birds	60.8	30.6	8.6
	Layer inventory >500 birds	63.1	29.0	7.9
	Egg production >500 birds	60.0	31.6	8.4
	Broiler density, birds/km^2	3 707	1 675	126
	Layer density, birds/km^2	1 412	771	43

Note: the available data for 1996 are not as detailed as those for 2005, and there were no separate data on layer production for 1996.
Sources: NBS (National Bureau of Statistics of China), Statistical Yearbook of China, various years; MOA, Yearbook of Animal Husbandry in China 2006.

TABLE 10
Human and poultry population density in China by province, 2005

	Human population (million)	Poultry population (million)	Human density (persons/km²)	Poultry density (birds/km²)
China	1 308	5 985	136	623
Beijing	15	116	915	6 880
Tianjin	10	89	876	7 448
Hebei	69	289	365	1 542
Shanxi	34	14	214	90
Inner Mongolia	24	33	20	28
Liaoning	42	497	289	3 410
Jilin	27	350	145	1 868
Heilongjiang	38	179	84	395
Shanghai	18	53	2 822	8 342
Jiangsu	75	274	729	2 674
Zhejiang	49	148	481	1452
Anhui	61	335	439	2403
Fujian	35	104	291	856
Jiangxi	43	131	258	787
Shandong	92	1231	589	7 836
Henan	94	387	562	2 315
Hubei	57	107	307	577
Hunan	63	218	299	1 029
Guangsong	92	546	517	3 068
Guangxi	47	388	196	1 633
Hainan	8	49	234	1 382
Chongqing	28	43	340	527
Sichuan	82	256	168	524
Guizhou	37	26	212	151
Yunnan	45	36	116	94
Tibet	3	1	2	1
Shaanxi	37	15	181	72
Gansu	26	12	57	27
Qinghai	5	0	8	0
Ningxia	6	8	90	114
Xinjiang	20	49	12	29

Source: Calculation by authors based on data of MOA (2006b) and NSB (2006).

TABLE 11
Poultry raising size structure by inventory group (size of farm) and province in China, 2005

Inventory group	1–2 000	2 000–10 000	10 000–40 000	50 000–100 000	100 000–500 000	500 000–1 000 000	>100 000	>50 000
China	24.8	29.3	28.2	6.5	5.4	2.0	3.9	17.8
Beijing	1.0	17.8	47.5	10.2	4.1	18.2	1.2	33.7
Tianjin	0.7	11.5	61.1	16.9	7.9	1.9	0.0	26.7
Hebei	28.4	35.5	27.7	3.8	1.0	0.2	3.4	8.4
Shanxi	38.0	31.0	27.8	2.5	0.7	0.0	0.0	3.3
Inner Mongolia	46.3	40.4	13.3	0.0	0.0	0.0	0.0	0.0
Liaoning	11.0	43.3	33.7	5.5	5.2	0.7	0.5	11.9
Jilin	15.4	29.7	36.7	4.5	0.7	1.0	12.0	18.2
Heilongjiang	40.8	36.0	15.7	5.4	0.5	0.0	1.5	7.4
Shanghai	0.0	29.7	28.1	10.9	10.3	6.5	14.4	42.2
Jiangsu	13.6	38.2	25.7	5.3	3.2	0.9	13.0	22.4
Zhejiang	14.2	16.5	42.3	11.4	9.3	1.5	4.7	26.9
Anhui	43.1	18.8	25.4	6.4	4.7	0.5	1.2	12.7
Fujian	22.4	17.1	17.2	8.0	5.0	27.9	2.4	43.3
Jiangxi	53.5	28.4	11.4	5.8	0.4	0.5	0.0	6.7
Shandong	5.4	42.6	36.8	5.2	5.3	1.5	3.3	15.3
Henan	21.7	38.3	15.2	3.8	20.2	0.2	0.8	24.9
Hubei	45.5	19.2	19.9	6.0	4.0	4.2	1.2	15.3
Hunan	66.5	16.4	9.2	4.6	1.8	1.5	0.0	7.9
Guangsong	19.1	10.6	39.8	16.1	9.8	3.0	1.8	30.5
Guangxi	38.2	24.7	14.6	3.4	1.8	0.6	16.6	22.4
Hainan	43.5	17.1	13.3	8.3	10.0	5.6	2.0	26.0
Chongqing	31.8	17.3	38.5	7.5	2.4	0.0	2.5	12.5
Sichuan	70.2	10.8	11.1	4.4	3.3	0.3	0.0	8.0
Guizhou	71.0	17.9	5.5	1.6	4.0	0.0	0.0	5.6
Yunnan	50.8	14.4	17.5	12.1	5.1	0.0	0.0	17.2
Tibet	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shaanxi	65.7	17.9	14.8	0.8	0.7	0.0	0.0	1.5
Gansu	68.2	12.9	12.7	5.0	1.2	0.0	0.0	6.2
Ningxia	5.4	50.3	40.2	4.1	0.0	0.0	0.0	4.1
Xinjiang	65.7	19.4	12.8	2.1	0.0	0.0	0.0	2.1

Source: calculation by the authors based on data of MOA (2006a and 2006b).

For 2005, data are available separately for broilers and layers. The geographical patterns are similar for both types of poultry. About 39 percent of China's total population and farms (farm households) are located in the eastern region; this region accounts for a much lower proportion (15 to 20 percent) of the number of farms with poultry, but a much higher proportion (over 60 percent) of poultry output, for both broilers and layers. Measured in relation to geographical area, the poultry density in the eastern region is about 30 times as high as that in the western region, for both broilers and layers (Table 9). The central region has a density half as high as that of the eastern region.

As clearly shown in Table 10, the human and poultry population densities differ greatly among the provinces of China. Several features can be noted:

- both the human density and poultry density vary greatly across the country;
- there is a close co-relationship between human population density and poultry population density – the higher the human population density, the higher the poultry population density; and
- most of the provinces with higher poultry population density are located in economic hubs of the coastal areas, such as Beijing, Tianjin, Shanghai, Liaoning, Fujian, Shandong and Guangdong.

There is also a clear difference in the size structure of poultry production (see Table 11). Poultry production in the coastal provinces is highly concentrated in a small percentage of large operation units. For example, for the country as a whole, poultry enterprises with more than 50 000 birds account for 17.8 percent of the poultry inventory. The corresponding figures of the coastal municipalities of Beijing, Tianjin, Shanghai and the provinces of Fujian and Guangdong are much higher. The figure in Fujian Province is 43.3 percent – the highest figure for any region. This is one of the main reasons why the case studies were conducted in this province.

2.5 Marketing channels for poultry products

Due to the complexity of the various operation systems and the huge size of the country, it is not possible to prepare quantitative and valued flow charts for the whole production and marketing chain for broilers and layers in China. It is even not possible to draw charts for a single province with reasonable precision. Generally speaking, the structure of the sector is a blend of very small traditional operations, some middle-sized commercial operations, and very large and highly integrated operations. There is great variety at each level of the chain – input provision, breeding, hatching, fattening, feeding, slaughter, wholesale, retailing, consumption, and importing and exporting.

Almost all poultry operations, whether large or small, are privately owned. Both poultry enterprises surveyed for this study were established by local private investment. The integrated broiler enterprise, Shengnong Group, obtains its breeding chickens through a United States of America–China joint venture located in Beijing. The chicken variety is Avine. Shengnong gets about 40–50 thousand sets of day-old chicks delivered each month. It processes its own feed, purchasing maize, soybean cakes and other feed ingredients from different regions. It currently has 12 breeding chicken farms and 27 boiler fattening farms, scattered across several valleys within a county. In 2006, the enterprise produced about 50 million broilers, or about 55 000 tonnes of chicken meat products. Its marketing channels are as listed in Table 12.

TABLE 12
Marketing channels of Shengnong Group, 2006

Type of buyers	Type of products	Quantity of products (tonnes)
KFC, McDonald's and other chain food outlets	Cuts	16 000
Wholesale to various provinces in South China	Chickens	32 000
Food processors	Chickens and cuts	2 200
Shengnong's own processing plant	Processed and half-prepared food to supermarkets	3 000
Shengnong's own fast food restaurants	Food to end consumers	2 000
Total	-	55 200

Source: survey data obtained by the authors.

The layer enterprise, Wenhua, obtains chicks via a United States of America–China joint venture located in Shanghai. All the birds are of the Hi-line variety. Almost all the eggs produced by Wenhua are sold within the province. Of the total egg production of 3 100 tonnes, 20 percent are sold to leading supermarkets, including Wal-mart and Carrefour. Sixty percent are provided to the food-processing industry and the remaining 20 percent are sold to the local wholesale and retail markets.

Most large-scale chicken enterprises have adopted contract farming. Normally, an enterprise provides contracted farms with feed, chicks, and other services and guidance; it receives the fattened birds back for slaughtering and sale.

2.6 Product cost structure

It is difficult to compare costs between industrial and backyard operations. For backyard operations that keep a few birds –at most a dozen – it is difficult to calculate the costs for labour and other items. Even the cost for feed is difficult to estimate, as the feed structure varies significantly across the huge number of small farms; the birds are usually fed a mixture of non-commercial and commercial feed at various ratios.

As for the industrial system, it is relatively easy to obtain reliable information. As an example, the cost structure of broiler production, including slaughtering, of Shengnong Group is shown in Table 13. It clearly shows that the predominant share of costs (two-thirds of the total) is accounted for by feed.

3 MAJOR DRIVERS OF CHANGE

Many factors have contributed to changing China's poultry sector. These factors, or drivers, can be divided into two groups: "pulling" forces that affect the total demand for poultry commodities; and "pushing" forces that have direct effects on poultry production from the input side.

TABLE 13
Broiler production costs in Shengnong Group

	Yuan	%
Chicks	1.37	9.3
Feed	10.00	67.7
Animal health	0.50	3.4
Labour	0.25	1.7
Water and electricity	0.10	0.7
Transport	0.16	1.1
Depreciation	0.40	2.7
Air conditioning	0.50	3.4
Slaughtering	1.50	10.1
Total	14.78	100.0

Source: Survey results obtained by the authors.

3.1 Drivers on the demand side

Drivers on the demand side include the expansion of the total human population, changes in the urban–rural composition of the population, income growth among consumers and farmers, improvements to infrastructure, increasing per capita consumption of poultry commodities and increasing trade in poultry products.

Demographic changes

Population expansion has been the primary force driving rising demand for poultry products in China. China's total population has increased from about 1 billion in 1980 to more than 1.3 billion in 2005 (Table 14). As a result of the population-control policy, the growth rate has been reduced from 1.5 percent to 0.6 percent *per annum* over this period. The population growth was at peak in the late 1980s when there were 15 million new-born babies

TABLE 14
Population growth in China

	Total population (million)	Urban population (million)	Rural population (million)
1980	987	191	796
1985	1 059	251	808
1990	1 143	302	841
1995	1 211	352	859
2000	1 267	459	808
2005	1 308	562	745
2030*	1 500	900	600

*Projections by the State Population and Family Planning Commission (SPFP).
Source: National Bureau of Statistics of China(NBS),: Statistical Yearbook of China, various years.

per year. The figure has declined by half in recent years, but is still at nearly 8 million per year. According to authoritative projections, the total population in China will peak at 1.5 billion by 2030 (NPFP, 2007).

The size of the urban population has risen much faster than that of the total population. Urban population (including rural migrant workers) has more than doubled over the past two decades. The growth trend will continue into the future, and the urban share in the total population will reach 60 percent by 2030. This rapid urbanization process has direct implications for poultry production – more demand for livestock commodities including poultry products. This is because in China urban people consume more meat and eggs than do rural people; this can be seen from the results of household surveys. Changing consumption patterns are discussed further in the next section.

Income growth of urban and rural households

As Chinese consumers still have a relatively low level of consumption of poultry products, the effect of income on demand is large. There are a number of research reports on the income elasticity of livestock products in China. The figures produced by different studies vary widely because of differences in data and time coverage. However, all of studies show that the income elasticity of all livestock products, including poultry meat and eggs, is larger than zero. This implies that demand will rise with income growth. Estimates of the income elasticity from various studies are listed in Table 15.

Household surveys are conducted every year by the National Bureau of Statistics (NBS) in China. According to these surveys, there is a clear relationship between income level and the level of poultry consumption. A rough and simple method is used to estimate the income elasticity of poultry meat and egg consumption. Tables 16 and Table 17 show this relationship for urban households and rural households, along with the respective elasticity estimates. For urban residents, income elasticity of poultry meat consumption declines as income rises – from about 0.5 for the lower income groups to about 0.2 for the higher income groups. Income elasticity for egg consumption shows a similar trend as income

TABLE 15

Estimates of income elasticity of livestock products in China

Source	Household type	Pork	Beef and mutton	Poultry	Eggs	Dairy
Jiang (2002)		0.53	1.26	1.46	0.95	1.52
Deng (2005)	Rural	0.25	0.57	0.22	0.36	0.32
	Urban	0.32	0.49	0.48	0.26	0.49
Hsu *et al.* (2002)	Rural	0.67	0.65	0.7	0.41	0.95
	Urban	1.68	-	3.12	0.55	3.41
Hongbo *et al.* (2007)		0.77	1.34–1.38	0.9		
Gale and Kuo (2007)	Rural			0.63–0.74	0.38–0.72	
	Urban			0.25–0.78	-0.3–0.5	

TABLE 16

Income elasticity estimates for poultry meat and eggs for urban households in China, 2005

Income group	Lowest	Low	Lower middle	Middle	Upper middle	High	Highest
	10%	10%	20%	20%	20%	10%	10%
	First decile	Second decile	Second quintile	Third quintile	Fourth quintile	Ninth decile	Tenth decile
Disposable income (yuan)	3 135	4 885	6 711	9 190	12 603	17 203	28 773
Poultry meat consumption (kg)	5.5	7	8.3	9.3	10.4	11.3	11.6
Egg consumption (kg)	8.3	10.2	11	11.6	11.9	12.5	11.5
Elasticity for poultry meat		0.489	0.497	0.326	0.318	0.237	0.039
Elasticity for eggs		0.469	0.158	0.167	0.081	0.213	-2.027

Source: Calculated based on survey data of the National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 17

Income elasticity estimates for poultry meat and eggs for rural households in China, 2004

Income group	Low	Lower middle	Middle	Upper middle	High
	20%	20%	20%	20%	20%
	First quintile	Second quintile	Third quintile	Fourth quintile	Fifth quintile
Disposable income (yuan)	1 007	1 842	2 579	3 608	6 931
Poultry meat consumption (kg)	1.7	2.4	3.0	3.7	5.4
Egg consumption (kg)	2.6	3.7	4.6	5.6	7.3
Elasticity for poultry meat		0.497	0.625	0.585	0.499
Elasticity for eggs		0.852	0.389	0.372	0.609

Source: Calculated based on survey data of the National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

rises, but at a lower level; it even becomes negative for the highest income group, implying declining egg consumption with further increases in income. In fact, apart for the two lowest groups, egg consumption is almost constant across income groups. This leads to the conclusion that among urban households the low income groups will continue to demand more eggs as their incomes rise, while the higher income groups will broadly maintain their egg consumption levels as their incomes rise.

The situation for rural households is rather different. Income elasticity is in the range of 0.5 to 0.6 for both poultry meat and egg consumption, and for all income groups. This means that all the farming population will increase their demand for poultry meat and eggs significantly as income rises. The average income elasticity of urban households for poultry meat is smaller than that of rural households. However, in recent years, the income growth rate of urban residents has been much higher than that of their rural counterparts. Thus, the overall income effects on poultry consumption have been, and will continue to be, large in both urban and rural populations.

Income of urban residents has been rising at a rapid pace over the past three decades. Measured in 1978 yuan, the per capita income of urban households in 2005 is over six times higher than that of 1978 (Table 18). In other words, per capita urban incomes have doubled every ten years.

The improvement of Chinese consumers' purchasing power can also be seen from the changes in the share of food costs in total household expenditure – the so-called Engel's Coefficient. For the urban population, this coefficient declined from 58 percent in 1978 to 37 percent in 2005, which implies that Chinese consumers now have more flexibility in their consumption. If they wish, they are more able to increase expenditure on poultry products. With further improvement in income, they will consume more meat, milk and other livestock commodities, especially the low-income sections of the population whose current meat consumption level is relatively low and has more scope to increase.

Increase in income has a much greater impact on poultry meat and egg consumption than on other meats. This is because Chinese consumers generally prefer poultry products to other livestock products. As a result, given an increased income, growth in consumption of poultry meat and eggs is much larger than that of other meat, both in percentage and absolute terms.

As in the case of urban residents, the per capita income of China's rural population has also improved dramatically in the past three decades. The growth path and pace is largely the same as that for urban households (Table 19).

The impact of income growth among the agricultural population on the poultry sector is more complex than that of urban residents. The similarity is the income effect on the

TABLE 18
Changes in per capita income for urban households in China, 1978 to 2005

	Yuan per capita	Deflated index	Food share in expenditure (%)
1978	343	100	58
1980	478	127	57
1985	739	160	53
1990	1 510	198	54
1995	4 283	290	50
2000	6 280	384	39
2005	10 493	607	37

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 19
Changes in per capita income for rural households in China, 1978 to 2005

	Yuan per capita	Deflated index	Food share on expenditure (%)
1978	134	100	68
1980	191	139	62
1985	398	269	58
1990	686	311	59
1995	1 578	384	59
2000	2 253	484	49
2005	3 255	625	46

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

demand for poultry products: rapid income growth among rural households has stimulated demand for poultry products in rural households, just as has happened in urban households. However, rural households are not just consumers of poultry products. They are also producers. Increased income not only drives demand, it also directly affects the production structures of poultry sector in several ways.

First, the significance of the livestock sector for the income of farmers has declined, as the income-share earned from livestock has fallen as a proportion of farmers' total household income from 14 percent in 1990 to 9 percent in 2005 (Table 20). These figures represent the average for the whole country; in the eastern regions, the share is even lower. One important reason for traditional farmers to raise a couple of animals in the yard was that they could obtain cash income by selling the animals or their products – usually pigs, chickens or eggs. The importance of this cash-income provision has greatly declined as non-farm salary has risen dramatically. The rural population has two ways to earn non-farm salaries: either to work in township and village enterprises, or go to cities as migrant workers. According to estimations provided by different sources, the total number of rural migrants working in cities is in the range of 120 to 140 million. In this context, backyard poultry raising has lost its traditional importance as a source of cash income.

Second, rising rural income also implies higher agricultural labour costs. Raising livestock is a relatively labour intensive activity in China. Rising labour costs makes small-scale livestock raising less attractive. It needs a lot of work to raise a couple of pigs or chickens, and earnings have become ever less competitive compared to non-farm activities. Most young people in the eastern part of the country have left agriculture and found jobs in non-farm sectors in the cities.

Last but not least, as incomes have improved the rural population has become less tolerant of the environmental problems associated with in-yard livestock raising, especially the odours and flies. As a result, small backyard livestock raising has disappeared in many villages in the coastal provinces, such as Zhejiang, Jiangsu, Shandong and Guangdong. Most farmers in those regions have significantly improved their living conditions. There is still livestock raising in these provinces, but it is now more concentrated in large-scale intensive farms.

TABLE 20
Per capita net income of farmers' households in China

	Total	Non-farm salary		Livestock	
	Yuan	Yuan	%	Yuan	%
1985	398	72	18	52	13
1990	686	139	20	97	14
1995	1578	354	22	128	8
2000	2253	702	31	207	9
2005	3255	1175	36	284	9

Source: National Bureau of Statistics of China (NBS): Statistical Yearbook of China, various years.

Public infrastructure development

Dramatic improvements have taken place in China's transportation systems over the past two decades. The railway system is the major means for long distance transportation such as inter-provincial movement of goods. Not only was the length of the railway network extended by one-third between 1985 and 2005, but the quality and efficiency of the sector has been much improved. With improvement in the rail system, including increased speed and expansion of double-tracking rails, transportation capacity has been increased significantly. The railway is very important for the transportation of feed.

The improvement of the highway transportation system is even greater than that of the railway system, and it is more important for the transportation of poultry products. The road length has doubled in the last two decades. More importantly, the construction of expressways in China has shown spectacular development. China's first expressway came into operation as recently as 1990. China now boasts over 41 000 km of expressway, second only to the United States of America. The number of trucks has more than quadrupled – from 2.2 million in 1985 to 9.6 million in 2005.

At the same time, processing industries have been rapidly developed. Large-scale integrated meat processing companies have been set up nationwide, especially in the eastern part of the country. The Shennong Group Co. located in Fujian Province, for example, is the largest broiler producer and processor in South China. It is a highly integrated enterprise, which includes the whole chain of broiler production and processing – breed egg production, hatching, feed processing, fattening, slaughtering, cutting, processing, export and selling. The whole business process is equipped with modern facilities and techniques. With the most advanced facilities imported from abroad, it has an annual slaughtering capacity of 120 million birds. It provides chicken cuts to fast food restaurants such as KFC (with a share of 13 percent in KFC's total demand in China) and McDonald's; it even owns two dozen chicken meat-based fast-food restaurants. KFC opened its first restaurant in China in Beijing in 1987. Since then, it has expanded very rapidly, and now boasts over 1 400 restaurants in more than 200 large cities across the country, including Tibet. McDonald's first restaurant opened in Shencheng in southern China in 1990; it now has about 800 restaurants across the country.

Retailing facilities in China have also improved significantly during the past two decades, in particular in recent years, as supermarkets and chain stores have been booming across the country, first in the large and medium-sized cities, and now also in towns and even in villages in the economically more developed regions. One major reason for many farmers to keep backyard poultry in the past was to meet their own consumption needs. This has also lost its importance over time, as shops, weekly markets, supermarkets and other marketing facilities selling poultry products are widely developed; farmers now have easy access to a great variety of poultry commodities, from fresh meat to processed products.

Growth of per capita consumption

Per capita consumption of poultry commodities is a reflection of the combined effects of income, price, preference, physical accessibility to the commodities and other factors. The consumption of poultry products has increased continuously over the past two decades. Annual sample household surveys are conducted separately for urban and rural areas in China. Results of these surveys of poultry product consumption are shown in Table 21 and Table 22. Some important points can be noted from the tables. First, the consumption of poultry products in both urban and rural areas has risen significantly in the last two decades. Second, consumption of poultry meat has grown faster than that of any other meat for both urban and rural households. During the past decade poultry meat consumption has doubled in both sections of the population.

Comparing Table 21 and Table 22 reveals that the urban population consumes 140 percent more poultry meat and 120 percent more eggs than the rural population. This can be attributed to a number of factors, including differences in dietary preference. However, the principal and most decisive reason is the income disparity between the urban and rural populations. The average income level in urban areas is over three times of that in rural areas.

Trade in poultry products

Trade in poultry has developed in line with the general trend of agricultural trade in China (Table 23). There are several features to be noted. First, import of poultry products has increased significantly in the past decade, though there have been some variations, while export has more or less stagnated. Second, in most years, poultry export accounted for a

TABLE 21
Consumption of livestock products in urban households in China

	Pork	Beef and mutton	Poultry	Eggs	Milk
	kg per capita per year				
1985	16.7	2.0	3.2	6.8	
1990	18.5	3.3	3.4	7.3	4.6
1995	17.2	2.4	4.0	9.7	4.6
2000	15.7	3.3	5.4	11.2	9.9
2005	20.2	3.7	9.0	10.4	20.0

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

TABLE 22
Consumption of livestock products in rural households in China

	Pork	Beef and mutton	Poultry	Eggs	Milk
	kg per capita per year				
1985	10.3	0.7	1.0	2.1	
1990	10.5	0.8	1.3	2.4	
1995	10.6	0.7	1.8	3.2	0.6
2000	13.3	1.1	2.8	4.8	1.1
2005	15.7	1.4	3.7	4.7	2.1

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

relatively high percentage of China's total agricultural and food export, while poultry import made a much smaller contribution to total agricultural import. Third, China has been a net exporter of poultry products in the past decade, with an annual net surplus of some US$400 to 800 million. The poultry export is closely linked to the intensification process, as only the large-scale operations can meet the high standards required by overseas consumers, including physical and hygiene criteria. Most of the exporters are large-scale integrated enterprises with fattening, slaughtering and processing operations. China's entry into the

TABLE 23
Trade of poultry and agricultural products in China

	Agriculture total		Livestock		Poultry		Share of poultry in total	
	million US$						%	
	Import	Export	Import	Export	Import	Export	Import	Export
1995	11 207	11 324	1 479	2 831	96	781	0.85	6.90
1996	9 622	11 211	1 414	2 858	156	933	1.62	8.32
1997	8 753	11 840	1 376	2 741	145	846	1.65	7.15
1998	7 320	11 074	1 332	2 459	118	748	1.61	6.76
1999	6 940	10 479	1 859	2 247	421	820	6.07	7.82
2000	9 411	11 863	2 656	2 590	492	986	5.23	8.31
2001	9 962	11 904	2 786	2 669	453	1 064	4.55	8.93
2002	10 177	13 463	2 885	2 570	439	948	4.31	7.04
2003	16 451	15 884	3 357	2 709	478	852	2.91	5.36
2004	24 756	16 419	4 029	3 190	167	651	0.67	3.96
2005	24 576	19 689	4 227	3 604	355	915	1.44	4.65
2006	27 777	22 051	4 554	3 726	481	933	1.73	4.23

Source: MOA, complied data based on unpublished custom statistics.

World Trade Organization, which brought the import tariff for most poultry products from 20 percent in 2001 down to 10 percent in 2004 (WTO, 2001), has had no significant effect on imports.

The most important destination of poultry exports from China is Japan, which accounts for nearly 70 percent of the total export of poultry commodities. The second major destination is Hong Kong SAR, accounting for 20 percent of the total. On the import side, the United States of America used to be by far the dominant provider of poultry products to China. However, in recent years import from Brazil has grown very rapidly. Currently, the United States of America has a share of around 68 percent and Brazil has 25 percent (Table 24).

Most of the imported poultry products in China are chicken wings, other cuts and offal, which are preferred and command much higher prices than abroad. Most exports are processed poultry products, which require a lot of manual labour. This trade structure reflects the difference in consumption preferences between China and its trade partners which are usually developed economies. The average unit value for export and import of poultry products is shown in Table 24. The per-unit value of exports is almost three times of that of imports. This implies that China exports high-value processed products and imports low-priced cuts.

Most of the export of poultry products involves the coastal provinces. Shandong Province is the leading exporter of poultry commodities, accounting for about 40 percent of the national total. Guangdong Province ranks second, with a share of about 20 percent. The 11 coastal provinces, taken together as the eastern region, account for nearly 90 percent of China's total poultry export.

Overall, the poultry trade is not very significant, as both imports and exports correspond to less than five percent of domestic production. However, trade has some significance for the domestic poultry sector in some coastal areas, in particular in Shandong and Guangdong.

TABLE 24
Poultry trade in China in 2006

	Quantity (1000 tonnes)		Value (million US$)		Unit value (US$/tonne)	
	Import	Export	Import	Export	Import	Export
Total	591	392	481	933	814	2 382
United States of America	409	3	325	18	794	5 982
Brazil	143	0	119	0	834	
Argentina	28	0	25	0	915	
Chile	9	0	7	0	792	
Japan	0	206	0	645		3 129
Hong Kong SAR	0	146	0	195		1 336
Macao SAR	0	7	0	13		1 933

Source: MOA, complied data based on unpublished custom statistics.

3.2 Drivers on the input side

Drivers on the input side include those that have "pushing" effects on poultry sector development.

Technology innovation and application

Of all the factors affecting the input side of poultry production, technology is by far the most important. New breeds with higher productivity, new feeding systems, new raising facilities and new methods of poultry production management have all contributed to the improvement of poultry production efficiency, and have pushed the sector towards intensification.

Feed industry and feed production

The inception and development of the feed processing industry has played a very special and decisive role in shaping the structure of the poultry sector in China. With its virtual inception in the late 1970s, the feed industry has developed from the very ground during recent decades. Industrial feed production soared from a mere 2 million tonnes in 1980 to 103 million tonnes in 2005, including complete feeds, concentrated and premixed feeds (Table 25). The quality and the creditability of industrial feed have also gradually improved. Many poultry producers, including those in the traditional sectors, are no longer reluctant to use processed feed and have become accustomed to it. The robust development of the industrial feed sector has been the decisive factor contributing to the rising prominence of intensive poultry systems.

Geographically, the feed industry is mostly concentrated in the eastern parts of the country, in a pattern reflecting the scale structure of the poultry sector. Large poultry farms are concentrated in the coastal provinces, as discussed in the previous sections. Of the total processed feed produced in 2005, 52 percent came from the eastern zone, 30 percent from the central zone and 18 percent from the western zone. About 50 percent of the feed is produced specially for broilers or layers (MOA, 2006a).

Foreign investment and foreign ventures have played an important role in the development of the Chinese feed industry. By the end of 2005, there were 460 overseas-funded feed companies in China, mostly located in the east coast of the country (MOA, 2006a).

TABLE 25
Processed feed production in China

	Total	Complete	Concentrate	Premix
	million tonnes			
1980	2.0	2.0		
1985	15.0	15.0		
1990	31.9	31.2	0.5	0.2
1995	52.7	48.6	3.5	0.6
2000	74.1	59.1	12.5	2.5
2005	107.0	77.6	24.5	4.7

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China, various years.

Foreign investment in the Chinese feed industry has made a great contribution to the development of the industry. The foreign companies introduced the concept of animal nutrition, which was completely new in China in the early 1980s. The foreign companies have played a key role as pioneers and catalysts. Following their examples, domestic feed companies have been set up, including many private companies. By the end of 2005, there were 15 519 registered feed mills, of which only 1 114 are owned by the government or collectives. China's feed industry is still dominated by a great number of relatively small companies. In 2005, there were 128 feed companies with a production exceeding 100 000 tonnes, which together accounted for about 16 percent of the total feed production in the country. A consolidation of the sector has been underway for years, with the competition becoming increasingly fierce in recent years.

Price development

Prices of poultry products have undergone some changes over the past decades. Broiler price per kilogram has varied between 9.5 and 12.5 yuan, and that of eggs between 5.5 and 8.6 yuan (Table 26). Three major conclusions can be drawn from Table 26.

First, the price ratio between poultry products and feeds has been rather stable. The price of feed relative to that of broilers (taking the price of broilers to be 1.0) is about 0.12 in the case of maize and 0.20 in the case of chicken feed. Second, the price ratio between broilers and eggs is also very stable – close to 0.6 for most of the last decade. Third, the price ratio between chicken meat and pork has developed in a direction favouring pork. Chicken meat was more expensive than pork in 1996, but had become much cheaper than pork by 2005. The relative price of pork has increased from 0.97 in 1995 to over 1.2 in recent years. This is largely the result of changing feed efficiency. Under the traditional system, feed efficiency in chickens is lower than that in pigs, while under the intensive system, chickens are more efficient converters of feed to meat.

From the view point of production costs, the long-term price trend is more or less neutral for poultry production in China.

Public services

Public services have also played a very important role in the changing landscape of the poultry sector in China. The most important are technical innovation, technical extension, animal disease prevention and control measures, quality standards and information, marketing information, and other facilitating measures. Although the precise figures are not available, the public financial inputs for these services have probably increased by a large margin. Not only does the central government provide financial inputs, but the provincial, prefecture and county governments also make large contributions to the public service system for the poultry sector. The central government budget for agricultural support and services has almost quadrupled in the past decade, from RMB 77 billion yuan in 1995 to RMB 300 billion yuan in 2005.

One particular important area of public service for the poultry sector is AI prevention and control. Since the outbreak and public report of AI cases in early 2005, much public funding has been devoted to research work, production and free distribution of vaccine, monitoring, and compensation for farmers in the epidemic areas.

TABLE 26
Prices of products and feeds in China (1996 to 2005)

	Broiler meat	Pork	Eggs	Maize	Chicken feed
			Yuan/kg		
1996	12.65	12.28	8.60	1.57	2.32
1997	11.91	13.72	7.02	1.25	2.27
1998	11.30	11.52	6.85	1.33	2.25
1999	10.62	9.97	6.22	1.08	2.04
2000	9.97	10.10	5.26	0.96	1.84
2001	9.62	10.66	5.38	1.17	1.88
2002	9.37	10.14	5.57	1.08	1.83
2003	9.27	10.71	5.43	1.14	1.85
2004	10.38	13.76	6.53	1.36	2.14
2005	10.78	13.13	6.69	1.30	2.15
			Price ratio (broiler meat = 1)		
1996	1.00	0.97	0.68	0.12	0.18
1997	1.00	1.15	0.59	0.10	0.19
1998	1.00	1.02	0.61	0.12	0.20
1999	1.00	0.94	0.59	0.10	0.19
2000	1.00	1.01	0.53	0.10	0.18
2001	1.00	1.11	0.56	0.12	0.20
2002	1.00	1.08	0.59	0.12	0.19
2003	1.00	1.15	0.59	0.12	0.20
2004	1.00	1.33	0.63	0.13	0.21
2005	1.00	1.22	0.62	0.12	0.20

Source: MOA, unpublished survey data.

4 FUTURE TRENDS AND POLICY OPTIONS

The direction of the future development of the poultry sector in China will be decided by a number of factors. Generally speaking, all the drivers discussed above will continue to play their role more or less in the same manner and direction as in the past decade.

4.1 Demand will continue to rise

Population will continue to grow and is projected to reach 1.45 billion by 2020. This will be increase of 11 percent compared to 2005. More importantly, the population structure will continue to change as rural–urban migration continues and even speeds up. It is estimated that the urban population will reach 800–900 million, accounting for about 55–60 percent of the total population. The urban share in the total population was 43 percent in 2005. If the newly urbanized population raise their levels of poultry consumption to the average level of current urban households, this structural change alone will result in an additional 11 percent increase in poultry meat consumption and an additional 10 percent increase in egg consumption.

Income for both urban and rural residents is expected to grow at an annual rate above 5 percent. During the 28 years following the introduction of the reform policy in 1978, per capita rural income rose by 5.7 times in real terms, or at an annual growth rate of 7.0 percent. The corresponding figures for urban residents are the same. For the period 1995 to 2005, the average annual growth rate of per capita income was 5.0 percent for rural households and 7.7 percent for urban households. The projected 5 percent increase in incomes for the future seems to be realistic. This will further drive the demand for poultry commodities. Given an annual rise of 5 percent, per capita income will double in the next 15 years.

Consumption of poultry meat has doubled during the past decade. Taking all factors into consideration, it seems reasonable to expect that total poultry meat consumption will at least double in the period 2005 to 2020. Egg consumption will increase by at least 50 percent over the same period. This growth in demand implies that China should produce at least 30 million tonnes of poultry meat and 42 million tonnes of eggs in the year 2020.

4.2 Intensification process will continue

To meet the increased demand, the poultry sector in China will further expand. The growth in production will be achieved mostly within the intensive system. Further intensification of the poultry sector is inevitable.

The intensification process will continue in all three major regions in China. So far, the degree of intensification of the poultry sector in the central and western regions is lower than in the eastern region as shown in Table 27. In the eastern region, 5.2 percent of the broiler farms are large (have an output of over 2 000 birds per year); the corresponding figure in the western region is only 0.3 percent. For egg production, the situation is similar. In the coming years, more large poultry farms will be established in the western and central regions, while the existing large farms in the eastern region will further consolidate and integrate. In the mean time, an increasing number of small and non-commercial farms will

TABLE 27
Share of large operations on the total in 2005

	China	East	Central	West
	Broilers: farms with over 2 000 birds			
Share of broiler farms (%)	1.3	5.2	1.0	0.3
Share of broiler output (%)	75.2	87.8	63.7	48.6
Layers: farms with over 500 birds				
Share of layer farms (%)	1.9	4.7	1.5	0.5
Share of layer inventory (%)	66.2	76.8	57.6	42.3
Share of egg production (%)	69.7	77.9	62.4	52.8

Source: MOA, complied data based on unpublished livestock surveys.

give up their backyard poultry production. It is possible that the number of poultry farms in China will be halved by the year 2020. This trend will be particularly marked for farmers in the eastern region.

4.3 Income and trade implications

The contribution of poultry production as a proportion of total income has declined for most farmers in China. This is particularly the case for the eastern region. As shown in Table 28, only 6 percent of rural households in the eastern region still keep broilers; 10 percent keep layers. A closer look at the individual provinces within the eastern region reveals that for parts of the region only very few rural households still have poultry operations. For example, in the suburbs of Shanghai, Beijing and Tianjin, less than 1 percent of rural households are still engaged in poultry raising.

In other parts of the country, in particular in the western region, farms with poultry operations still account for a relatively high percentage of all farm households. On average, about one-fifth of the farmers in western China have broiler and layer operations (Table 28). Considering that a large number of small farmers in the western provinces of the country are still living at an income level close to poverty line, poultry production should have something to offer them. In fact, in some of the poorest areas, one of the key options to help poverty-stricken farmers is to encourage and assist them to raise poultry. This is a relatively quick and easy approach to increasing cash earnings. For farmers in remote inland areas, the intensification process in the eastern parts of the country does not pose a threat, as the local market is highly isolated by topographical barriers to inter-regional transportation.

The intensification process is favourable for international trade. As indicated in Table 29, the leading poultry exporting provinces are also those with the highest share of large poultry operations. For example, Shandong Province is by far the most important poultry exporting province in China. It accounted for over 40 percent of China's total poultry export in 2005. It also has by far the most intensified poultry production sector in the country; over one quarter of China's large broiler operations (farms with over 2 000 broilers) are located in this province. Other examples are Guangdong Province and Liaoning Province, both of which have relatively large shares of the poultry export and of large-scale broiler operations.

TABLE 28
Rural income and farmers' households with poultry production 2005, by region

	East	Central	West	China
Income (yuan/per capita)	5 123	3 029	2 356	3 255
Households with broilers (%)	6	17	21	14
Households with layers (%)	10	20	20	16

Source: National Bureau of Statistics of China (NBS), Statistical Yearbook of China 2006; MOA, complied data based on unpublished livestock surveys.

TABLE 29
Poultry export and intensification of production, 2005

Province	Poultry export	Broiler output from large operations
	% of total for China	
Shandong	41.6	25.9
Guangdong	16.0	9.8
Liaoning	9.7	9.8
Jilin	5.2	6.6
Hebei	5.0	4.6
Henan	3.0	6.7
Jiangsu	2.9	5.3
Heilongjiang	2.8	2.4
Subtotal	86.3	71.0

Source: MOA, complied data based on unpublished custom statistics.

China is competitive in the export of poultry commodities, in particular processed poultry products as a result of its cheap skilled labour forces. However, importing countries are imposing ever higher product standards, in particular sanitary standards; these standards can only be met by intensive production systems. Integrated operations, in particular, are well positioned to implement strict and reliable quality control, including proper management of animal disease prevention and eradication. The further intensification of the poultry sector will enable China to have a more favourable position in the world poultry trade. China will continue to import some poultry cuts and parts, such as wings and offal, which are very little valued in Western countries but are highly valued in China.

4.4 Rising feed prices will be a major constraint

One of the most potentially unfavourable factors for the future development of the poultry sector in China is the supply and price of feed, in particular of maize and soybean.

As shown in Table 30, production of maize in China has been steadily growing in the past decade, and reached a historic record of 145.5 million tonnes in 2006. In total, maize production grew by 30 percent between 1995 and 2006. About two-thirds of this production growth was achieved by expansion of the cropping area and one-third by yield improvement. Looking to the future, the potential to further expand the maize cropping area is very limited; the main hope for increasing production is yield improvement, which can only be achieved slowly and gradually.

Demand for maize has been increasing very rapidly in recent years, not only in the expanding livestock sector, but also in other sectors – mostly from the ethanol and other chemical-producing sectors. Rising world petroleum prices have made maize increasingly attractive as a raw material for energy and chemical production. In five whole provinces and in some counties of other provinces in central China, gasoline with 10 percent ethanol content has been available in recent years. Industries using maize as a raw material have been expanding their capacities, and can consume millions of tonnes of maize a year. One indication of increased domestic demand is that maize export from China has been declining steadily in recent years. An even clearer signal of the demand pressure is that the price of maize reached a historic high in the first half of 2007. For the first time in China's history, the price of maize exceeded the price of wheat in May 2007. Pressure on the price of maize will probably continue in the coming years.

Another important factor is the supply and price of soybean. Domestic soybean production in China has practically stagnated in recent years, in spite of all the attention given to the sector by the central government and by local governments in major producing provinces. As soybean is a low-yield crop, it is not competitive with maize and paddy rice in many production areas. As a result, the soybean sown areas cannot expand, and have in fact shrunk. As domestic production cannot meet demand, China's import of soybean has risen very rapidly. The amount of soybean imported to China has continuously broken historic records, and reached 28.3 million tonnes in 2006. China's import accounts for about 40 percent of the world's total export of soybean and by far exceeds domestic production. In 2006, 65 percent of the soybean consumed in China was imported. The trend seems set to continue into the future.

Trends in the supply and prices of feed are likely have both unfavourable and favourable impacts on the further development of the poultry sector in China. On the unfavourable side, slower growth in the production of maize and soybean, and the resulting price rises, will certainly impose pressure on production costs, increasing the need for efficiency and improved management in poultry operations. On the other hand, the poultry sector will benefit from its advantage in terms of feed conversion efficiency compared to other

TABLE 30
Production, trade and prices of maize and soybean in China

	Maize production	Soybean production	Maize export	Soybean import	Maize price	Soybean price
	million tonnes				Yuan/tonne	
1995	112.0	13.5	0.1	0.3	1 577	2 660
1996	127.5	13.2	0.2	1.1	1 482	3 208
1997	104.3	14.7	6.7	2.9	1 151	3 414
1998	133.0	15.2	4.7	3.2	1 269	3 074
1999	128.1	14.3	4.3	4.3	1 093	2 598
2000	106.0	15.4	10.5	10.4	888	2 485
2001	114.1	15.4	6.0	13.9	1 060	2 406
2002	121.3	16.5	11.7	11.3	1 033	2 418
2003	115.8	15.4	16.4	20.7	1 088	2 856
2004	130.3	17.4	2.3	20.2	1 288	3 683
2005	139.4	17.7	8.6	26.6	1 229	3 352
2006	145.5	15.3	3.1	28.3	1 431	

Source: MOA, complied data based on unpublished custom statistics.

livestock products including pork. Poultry meat and eggs will become more competitive in the consumer market relative to pork. Furthermore, rising feed costs will favour the intensification process, further enhancing the competitive edge of large-scale operations over small producers.

4.5 Avian influenza and other disease will be crucial

The shadow of AI is long on the poultry sector in China, and as such constitutes another crucial factor with far-reaching implications for the future development of the sector. During the period between February 2005 and May 2007, 18 of the 31 provinces in mainland China reported cases of AI. The first human case of H5N1 AI virus surfaced in November 2003. A man died in Beijing, and was initially thought to be a victim of severe acute respiratory system (SARS); later laboratory tests showed that it was in fact a case of AI. So far, China has reported 25 human AI cases with 16 deaths (Tao, 2007).

China has made great efforts in fighting AI. Effective vaccine has been developed, produced and provided free to poultry producers nationwide. Responses to the occurrence of the disease have been greatly improved. Strict measures have been taken to control the affected areas and compensation has been made available for farmers who have suffered losses. These efforts have achieved effective results – the number of reported cases has declined significantly since the second half of 2006. However, AI will remain one of the major challenges to China's poultry sector. The most important reason is that it is not possible to isolate the poultry flocks raised in millions of backyards from contact with migratory birds. Due to the high density of human and poultry populations and the high levels of bird migration in the eastern and central parts of the country, it is a daunting challenge to prevent and control the disease in these regions. This may be another factor favouring the intensification of the poultry sector in the eastern and central regions of China.

4.6 Policy options to promote poultry sector development and to assist farmers to adjust

The goals of agricultural policy in China have changed significantly over time. Currently, the predominant and long-term objectives of agricultural policy in China are to ensure food security for the huge population, to improve food safety and quality, to improve farmers' incomes, and to protect natural resources and the environment for sustainable agricultural and rural development. Foreign-exchange earning from agricultural products used to be an important goal, but has now almost completely lost importance in agricultural discussions given dramatic growth in the total export volume, sharp decline in the share of agricultural exports in the total, consecutive years of trade surpluses and large foreign currency reserves. Even the large agricultural trade deficits that have prevailed in recent years have not caused any noticeable concerns to Chinese policy-makers. Price stability for livestock products, another important policy goal in the past, is now given less attention. A certain degree of price movement is considered to be normal under a market system. Only when prices are abnormally high or low do policy-makers pay some attention.

Given the above-described overall agricultural policy objectives, the most significant goals for policy-makers with respect to the development strategy of the poultry sector in China can be grouped into three categories: to provide sufficient and safe poultry products to the consumers; to provide income and employment opportunities for farmers; and to protect the environment and promote sustainable economic development.

Food security has long been and still is the top priority in China's agricultural policy-making. Facing ever increasing demand as a result of expanding population, rising income and rapid industrial development on the one hand, and declining arable farmland, scarce irrigation water and worsening environmental and ecological conditions on the other, ensuring food security for the country is a daunting challenge. Grain production is the focus of attention in debates over food security. The pressure of rising demand for grains is mainly driven by the feed needs of the livestock sector. In this regard, the development of the poultry sector should play an important role, given its efficient feed:animal protein conversion ratio. The quality of agricultural products, in particular food-safety issues, has gained increasing attention from both the government and the general public. Feed additives and animal diseases have become major targets of policy measures. The outbreaks of SARS and AI have greatly increased the awareness of policy-makers with regard to animal disease prevention and control.

The issue of farmers' incomes has received increased attention from policy-makers and the general public in China, especially since the early 1990s. This has happened against the background of a rural–urban income gap that has continuously widened over the past two decades. In 2006, the national average per capita income of the rural population was only one-third that of the urban population. The need to put more effort into improving farmers' incomes is not just an economic issue, but has become a social and political issue. The state of farmers' incomes has direct consequences for rural–urban migration, the market for urban manufactured products, and social stability. Livestock production is a potential means to increase farmers' incomes, as there is much scope for expanding demand in this sector. Farmers can improve their income by enlarging the scale of their own livestock operations, but also by working for other large livestock operations. In a county of Fujian Province, the wages paid by a large integrated boiler enterprise to its workers are equivalent to 10 percent of the total income of all rural households in the county. As the intensification process unfolds, more work opportunities are created as a result of the growing market and production volume.

Awareness of the need to protect the environment has become a new element in agricultural policy-making in China. Emphasis is laid on the sustainability of natural resources and preventing environmental pollution. In the livestock sector, pollution of surface water, groundwater and soil by the waste products of pig raising has been widely recognized as a problem; the problems associated with poultry operations are believed to be much less. Efforts by some large integrated poultry enterprises to use birds' waste to produce value-added organic fertilizer, or even to generate electricity, are encouraged and supported by the government.

To promote healthy development of the poultry sector in the future in China, the following policy action areas need to be addressed:

- **Disease prevention and control measures.** This should be the top priority for government intervention in poultry-sector development. While the threat from animal disease, in particular high risk epidemics such as AI, has gained much attention in the past few years, there is a tendency for this attention to fade over time.

The general public is now very calm when faced with reports of AI cases in birds or humans. Reports of new cases no longer seem to have any effect on demand for, and consumption of, poultry products. While the reaction of the general public has become calm and reasonable, the government should not weaken efforts in the field of epidemic prevention and control. The potential danger of AI should not be underestimated. Monitoring, prevention, eradication and compensation measures should be further implemented and enhanced. The weakness in monitoring and identifying cases in the vast small-scale sector should be addressed through more intensive government support.

- **Land policy related to the establishment of new poultry farms.** China has been applying a very strict control policy with respect to changes to the use of farmland. According to the existing regulations, land in China is classified into three categories: farmland, construction land and unused land. Cropland belongs to the farmland category, and 80 percent of arable land is classified as "basic farmland". Changing land use from crop production to other purposes is very strictly controlled and must be approved by the State Council. The land used for livestock operations is not very clearly classified. According to China's Law of Land Administration, any land with buildings on it is classified as construction land. Therefore, in practice, if farmers want to build large and roofed poultry pens on cropland, they usually have to apply for permission. If the cropland is classified as "basic farmland", it is in principle impossible to obtain approval, and it is usually a lengthy and complicated process even if the cropland is not classified as "basic farmland". Policy adjustments should be made to treat the establishment of livestock farms and the associated construction differently from industrial construction. Establishment of livestock production on unused land, which is usually wasteland, should be encouraged with favourable approval procedures and support measures.
- **Investment policy and loan provision.** The establishment of new poultry operations and the enlargement of existing ones should be encouraged through preferential investment policy. Assistance with credit is needed for both large establishments and very small holdings. For smallholders, especially for the poverty-stricken farmers in the mountainous western region, the micro-credit system should be expanded and made available to as many poor farmers as possible. Governments should also adopt supportive measures to enable large private investment in the poultry sector in order to allow the necessary commercial loans to be obtained. Linked to appropriate environmental requirements, governments may provide credit guarantees to such investment.
- **Policy favouring the use of animal waste.** For those enterprises that comply with environmental standards, subsidies or taxation exemption can be made for investments in the utilization of livestock waste to produce fertilizer or energy. Such sideline activities of large livestock farms can reduce environmental pressures from livestock production and processing, and at the same time generate useful resources for other sectors.
- **Research and extension.** China has accomplished world class achievements in some areas of agricultural research, such as in hybrid and super-rice breeding. However,

in the field of livestock, China has been much less successful. One major reason is that much more attention and investment have been devoted to crop research than to livestock research. The agricultural extension system is also rather weak in China. As the educational level of Chinese farmers is still low, at about seven years on the national average, and most of Chinese farmers are small farmers or holders, it is imperative for China to have a public extension system that has wide coverage. There are a number of weaknesses in the existing system, including under-qualified staffing and insufficient funding. The system needs to be reformed and enhanced.

REFERENCES

Deng, Rong. 2005. Analysis of consumption and trade of livestock products in China. *Beijing Agricultural College Journal*, 2.

Gale, F. & Kuo, H. 2007. *Demand for food quantity and quality in China.* Washington DC, Economic Research Service, United States Department of Agriculture (available at www.ers.usda.gov/publications/err32).

Hongbo, L., Parton, K., Zhou, Z & Cox, R. 2007. *Meat consumption in the home in China: an empirical study.* Paper presented at the IATRC Symposium, Beijing 8–9 July 2007. International Agricultural Trade Research Consortium. (available at http://aede.osu.edu/programs/anderson/trade/57HongboLiu.pdf).

Hsu, H-H., Chern, W.S. & Gale, F. 2002. How will rising income affect the structure of food demand? *In* F. Gale, ed. *China's food and agriculture: issues for the 21st century.* Washington DC, Economic Research Service, United States Department of Agriculture. (available at http://www.ers.usda.gov/publications/aib775/aib775f.pdf)

Jiang, N. 2002. Determinants of consumption patterns of livestock products in China's urban and rural households. *Chinese Rural Economy,* 2.

MOA. 2006a. *Yearbook of animal husbandry in China.* Beijing. China Agriculture Press.

MOA. 2006b. *Internal report of the inventory of poultry in 2006.* Beijing.

NBS. 2006. *China statistical yearbook.* Beijing. China Statistics Press.

National Population and Family Planning Commission of China (NPFP). 2007. Family planning is a long term strategy in China. *Peoples Daily,* 16 July.

Tao, L. 2007. Soldier dies of H5N1 virus, *China Daily,* 6 June, p. 1.

WTO. 2001. *Compilation of legal instruments on China's accession to World Trade Organisation.* Beijing. Law Press of China.

Structural changes in Thailand's poultry sector and its social implications

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SUMMARY

Over the past two decades, the poultry sector in Thailand has undergone considerable structural change – moving towards greater industrialization and increased vertical integration. Up until 2004, the main driver was technology, especially the introduction of evaporative-cooling housing which can save labour costs and substantially increase poultry's growth and survival rates. One engine of the fast growth of the industry was contract farming – an arrangement which gives large integrators more flexibility in adjusting their volume of production to changes in both domestic and export demand, and which provides the contractors with contracts that are relatively lower risk and provide better returns than most of conventional agricultural activities.

During the last half decade, however, Thailand's poultry industry has been moving away from contract farming and towards vertical integration in order to ensure compliance with European importers' more stringent requirements for food safety and animal welfare. The most significant and decisive driver, however, has been highly pathogenic avian influenza (HPAI), outbreaks of which have resulted in frozen broiler meat from Thailand being banned by most importers since 2004. The ban affected Thailand's broiler export substantially in the first few years. However, most of the large companies have been able to switch their production towards precooked products.

In order to assess structural changes in the wake of HPAI outbreaks, a sample of poultry farmers first surveyed in 2002/2003 was re-surveyed. The results indicate that the great majority of these farmers have managed to stay in the poultry business. However, many contractors are only contracted on a rotating basis as a result of the decreased demand for broilers. Some are offered a duck contract, which is generally less lucrative than were typical broiler contracts in the past.

[1] The research team included Suwanna Tulyawasinphong, who also helped writing several sections of an early draft, Nipa Srianant, and Kamphol Pantakua. Dr Nipon Poapongsakorn also provided advice during the early stage of the project. We would like to thank Dr Kitti Subchooskul who spent substantial time in briefing and answering numerous questions; Mr Kukrit Areepagorn of the Thai Broiler Processing Export Association who gave us an interview and data compiled by the association, Ms Chaweewan Kampa of the Broiler Grower Association, Mr Veerabhong Pongsak, and 136 other farm owners who kindly granted us phone interviews, and Nancy Morgan of FAO for her thorough comments on the first draft of the paper. All remaining errors and omissions are, of course, the author's responsibility.

Even before the HPAI outbreak, the future of smallholders in the poultry sector looked bleak. After the outbreak they have been forced by the Thai government to upgrade their housing to a closed system, which requires substantial additional investment. Because of many stringent HPAI-combating regulations, some of their prior advantages – such as getting higher prices for chicken manure or using it to feed the fish stock in ponds beneath the chicken houses – no longer exist. While the industry may have found a way to cope with the HPAI via biosecurity and compartmentalization, many smallholders appear to be left out and continue quietly to make their exits from poultry production.

Key words: poultry, sector, Thailand, structure

1 INTRODUCTION

This paper describes the past and present status of the poultry industry in Thailand and the drivers of change in the sector. It then focuses on structural changes in Thailand's poultry sector – mainly resulting from the highly pathogenic avian influenza (HPAI) outbreaks in 2004 and after. The subsequent section considers the future of Thailand's poultry industry. The last section deals with the social implications of these structural changes – especially the impacts on smallholders.

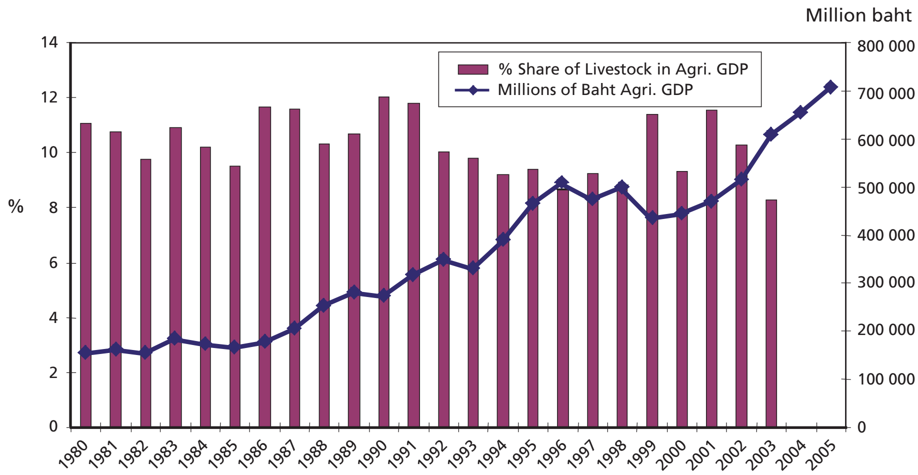
2 THE IMPORTANCE OF THE POULTRY SECTOR IN THE NATIONAL LIVESTOCK SECTOR

Livestock accounts for about 10 percent of agricultural gross domestic product (GDP) in Thailand (Figure 1). The value added by the poultry sector contributes about 3–4 percent of agricultural GDP and more than 40 percent of livestock GDP (Figure 2).

Thailand's poultry meat production in 2005 was estimated to be 950 000 tonnes or

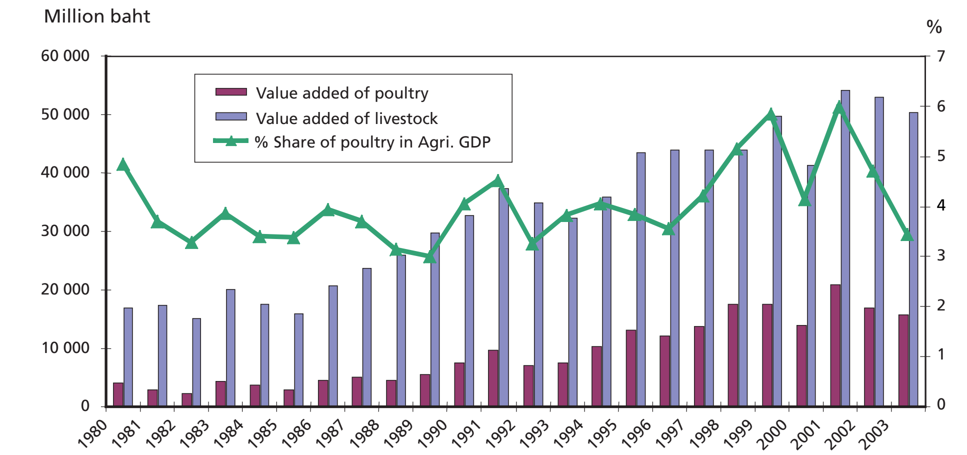
FIGURE 1

Thailand's agricultural GDP and share of livestock in agricultural GDP



Source: National Economic and Social Development Board (NESDB) National Income of Thailand; various years.

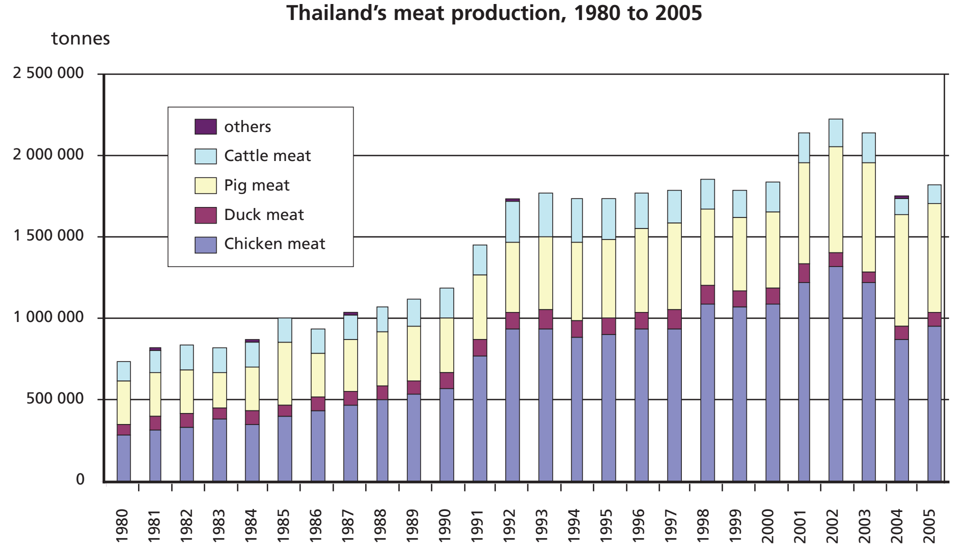
FIGURE 2
Value added by poultry and the livestock sector as a whole, and poultry's share in agricultural GDP



Source: NESDB, National Income of Thailand; various years.

approximately 52 percent of total meat production. Poultry meat ranks first among the major meat types, followed by pork (37 percent) and beef (6 percent) (Figure 3). As indicated in Table 1, during the past two decades the total production of poultry meat has increased at an annual rate of 5–6 percent, the highest growth rate of all livestock prod-

FIGURE 3
Thailand's meat production, 1980 to 2005



Source: FAOSTAT.

TABLE 1
Thailand meat production: annual growth rates

Years	Chicken (%)	Duck (%)	Pig (%)	Cattle (%)
1980–1990	6.69	2.54	3.00	2.70
1990–2000	4.59	1.03	2.52	-2.22
2000–2005	-5.07	-5.24	5.85	-9.28

Source: calculated from FAO data.

ucts. The growth rate fell only in the past few years, mainly because of the impact of HPAI from 2004 onwards.

3 STRUCTURAL CHANGES IN THE POULTRY SECTOR OVER THE PAST DECADE

Although there are a several types of poultry raised and consumed in Thailand, chicken is the most important. There are three main types of chicken in Thailand: broilers, layers and native chickens. From an economic perspective, broiler meat is the most important poultry product, both for domestic consumption and export. As in most countries, egg production from layers is mainly for domestic consumption.[2] Native chickens have been raised for several purposes; they include backyard chickens raised mainly for household consumption and small-scale trade; farm raised birds for sale in specialty markets; and, to a lesser extent, chickens raised for recreation or "sporting" purposes, including fighting cocks. This paper focuses only on broiler and layer farming, which accounts for most of the poultry production in Thailand.

About half of the country's chickens are raised in central Thailand – a relatively small but highly populated region; second in terms of poultry production is the northeastern region, which is physically the largest region of Thailand. Most of the exported chicken comes from farms in the central region.

The number of chickens in Thailand increased substantially between 1992 and 2003 (from 135 to 253 million birds). It then dropped to 180 million in 2004 following the outbreak of HPAI. The chicken stock recovered to 254 million birds in 2005 (Table 2a) but fell again to 184 million birds in 2006 (Table 2a). Total production fell drastically in 2004 and has not yet returned to the pre-HPAI levels (Table 2b).

3.1 Increasing scales of production

The poultry sector in Thailand has undergone considerable structural change in terms of the number and size of holdings over the past two decades. The underlying reason is "economy of scale" – average production cost declines with an expanding scale of production. As a result, the number of producers diminishes even though the sector as a whole may expand. The average size of commercial farms has also been increasing while the

[2] Only when they are in surplus, is a small volume (usually no more than 1–1.5 percent of the eggs produced) exported often below cost, in order to stabilize the domestic price. However, in recent years, there has been a (perhaps temporary) surge in export demand for eggs, primarily from Hong Kong SAR after they detected residuals of illegal red-pigment in Chinese eggs.

TABLE 2a
Chicken population in Thailand (number of birds)

Year	Central	Northeastern	Northern	Southern	Total
1992	82 342 344	26 335 705	15 279 767	11 217 760	135 175 576
1993	83 246 791	25 916 449	19 299 493	10 369 294	138 832 027
1994	72 163 615	24 348 503	21 603 271	11 881 709	129 997 098
1995	62 589 266	24 446 914	15 039 270	9 575 060	111 648 510
1996	69 963 645	37 506 727	23 028 677	14 080 379	144 579 428
1997	79 928 557	42 104 802	24 457 990	18 194 493	164 685 842
1998	77 224 601	38 176 754	23 841 418	16 081 873	155 324 646
1999	78 067 555	47 210 939	27 327 803	17 026 210	169 632 507
2000	98 968 145	44 958 278	27 906 485	17 508 202	189 341 110
2001	111 819 685	54 106 254	30 829 909	18 223 233	214 979 081
2002	127 411 495	56 429 660	28 677 030	16 242 141	228 760 326
2003	153 275 177	51 686 324	32 798 811	14 958 571	252 718 883
2004	89 684 664	49 542 774	28 070 941	12 440 431	179 738 810
2005	135 513 828	62 516 470	38 723 520	17 450 250	254 204 068
2006	90 689 632	59 322 572	23 776 769	10 537 779	184 326 752

Note: figures are for stock on 1 January each year.
Source: Department of Livestock Development.

TABLE 2b
Total broiler production in Thailand (number of birds)

Year	Central Plain	Northern	Northeastern	Southern	Whole country
1995	484 865 421	60 825 080	104 896 077	49 289 349	699 875 927
1996	540 673 299	54 914 702	62 988 977	59 579 799	663 242 075
1997	543 784 870	58 566 142	65 214 205	59 417 792	726 983 009
1998	614 456 148	61 676 927	76 743 327	66 898 521	819 774 923
1999	640 157 348	63 555 931	80 534 944	69 316 043	853 564 266
2000	674 289 629	64 090 285	83 115 970	69 469 091	890 964 975
2001	715 871 830	77 594 194	137 717 119	72 606 563	1 003 789 706
2002	765 954 216	79 633 916	126 315 140	70 870 879	1 042 774 151
2003	824 261 179	81 696 723	138 345 589	72 771 552	1 117 075 043
2004	492 723 422	50 834 395	87 371 052	63 430 263	694 359 132
2005	581 458 924	64 404 895	103 904 377	67 470 907	817 239 103
2006	608 406 705	67 007 326	108 575 719	65 891 723	849 881 473

Source: Department of Livestock Development (DLD) and Office of Agricultural Economics (OAE).

numbers of producers is declining. As shown in Table 3, the number of poultry farm holdings decreased by 60.7 percent between 1993 and 2003. However, the number of large farms (those that raise 10 000 birds or more) almost doubled. The number of chickens kept in farms in this category increased from 60 to 158 million birds – approximately 163 percent. The total number of chickens increased from 109 million birds in 1993 to 217 million birds in 2003.

TABLE 3
Number of holdings and chickens in 1993 and 2003

		1993		
Size of holding (number of chickens per holding)	**Number of holdings**	**Number of chickens**		
		Total	**Layers**	**Broilers**
1–19	1 681 300	373 541	145 222	228 319
20–99	863 809	863 267	368 816	494 451
100–499	53 064	1 798 003	860 693	937 310
500–999	3 861	1 693 940	768 119	925 821
1 000–9 999	13 042	45 028 706	7 343 599	37 685 107
10 000 and over	2 336	59 627 761	14 165 823	45 461 938
Total	2 617 412	109 385 218	23 652 272	85 732 946
		2003		
Size of holding (number of chickens per holding)	**Number of holdings**	**Number of chickens**		
		Total	**Layers**	**Broilers**
1–19	361 600	238 960	66 672	172 288
20–99	580 543	1 190 547	345 646	844 901
100–499	65 943	1 082 718	509 528	573 190
500–999	1 851	713 038	417 733	295 305
1 000–9 999	14 224	56 210 545	11 183 272	45 027 273
10 000 and over	4 028	158 039 328	29 337 908	128 701 420
Total	1 028 189	217 475 136	41 860 759	175 614 377
% change between 1993 and 2003	**Number of holdings**	**Number of chickens**		
		Total	**Layers**	**Broilers**
1–19	-78.5	-36.0	-54.1	-24.5
20–99	-32.8	37.9	-6.3	70.9
100–499	24.3	-39.8	-40.8	-38.8
500–999	-52.1	-57.9	-45.6	-68.1
1 000–9 999	9.1	24.8	52.3	19.5
10 000 and over	72.4	165.0	107.1	183.1
Total	-60.7	98.8	77.0	104.8

Sources: National Statistic Office. Agricultural Census 1993 and 2003.

Up until 2004, economy of scale associated with industrialization was often considered to be the primary factor driving structural change. However, economies of scale/scope are not the only drivers. The major producers (such as CP Corp.) have also adopted advanced technologies. Although smaller farms can take advantage of new technologies via contract farming or by adapting their housing technology and buying inputs that embody technological developments, the export ban imposed in the wake of the HPAI epidemic of 2004 and four further outbreaks in the past few years has drastically impeded their competitiveness.

As a result of technological changes, the broiler raising period has been substantially shortened – to around 40 days. Although this means that broiler chickens sold today are of much smaller size than in the past, the feed conversion ratio has improved substantially to around 1.75:1 or even lower.

One major aspect of broiler raising that has changed markedly during the 1990s is housing. The evaporative cooling house (or "evap house" for short) – a closed semi-automatic housing system which uses large fans and water to cool houses holding more than 10 000 chickens to 28 ˚C or less during the hot season in tropical countries such as Thailand – has contributed to the industry's cost savings. The evaporative cooling house can save labour and housing costs. More importantly, it increases growth and survival rates substantially.[3]

In the past, broiler development in Thailand was largely undertaken by the private sector, with little intervention or assistance from the Thai government.[4] However, as a result of the increasing importance of international trade in livestock – especially poultry – the Department of Livestock Development (DLD), in 1999, issued farm standards and various regulations on animal welfare to ensure compliance with the European Union's (EU) regulations and requirements. After the onset of the HPAI outbreak, the government has added measures which, in practical terms, require that all broiler farms producing birds for export are transformed into closed farms (i.e. use evaporative cooling houses). As such a transformation is quite capital intensive, the government actions, arguably, favour large-scale modernized farms.

3.2 From contract farming to vertical integration

Even after the onset of poultry industrialization, which resulted in large companies raising more chickens in their own large-scale farms, broiler production during the past two decades (up until the HPAI epidemic of 2004) relied heavily on contract farming. This system usually involves a contract in which a large (usually also vertically integrated) company provides several contractors (contracted farms) with day-old chicks and inputs (such as

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[3] The "evap houses" commonly used in Thai broiler industry are modified from those used in the United States of America. However, while the Thai "evap houses" are similar to the close-system houses in the United States of America, the main purpose of keeping the house closed is to keep the inside temperature cooler than the outside atmosphere. Initially, most evap houses in Thailand did not use full automation like those in the United States of America, partly because the labour cost in Thailand is much cheaper than in the United States of America. However, most large companies now employ full automation in order to minimize the risk of disease spread by "unnecessary" human contact.

[4] Most farmers', processors', and exporters´ organizations have been founded and almost fully funded by the companies themselves (many also have offices in the companies' buildings), partly to protect their own interests (e.g. to obtain import quota of soybean and to receive government assistance).

feeds, medicines and some other supplies) at stipulated prices, and agrees to buy the raised chickens (or eggs) usually at the guaranteed prices. Contractors, for their part, provide housing, bedding, equipment, utilities and labour, based on the company's specifications, to raise the day-old-chicks to specified weights.

One of the main reasons that companies used contract farming was that the contract gave them more flexibility in adjusting the volume of production, which sometimes needs to be varied greatly in response to seasonal and irregular changes in domestic and export demand. In such cases, the investment and adjustment costs (including the cost of having idle capacity) were borne substantially by the contractors. Nonetheless, the contractors usually agreed to this type of contract not only because they could take advantage of the embodied technology, but also because, in normal circumstances, the contracts are less risky, and provide better returns, than most other agricultural activities.

During the past decade, however, Thailand's poultry industry has been moving towards vertical integration. The main reason is to meet the ever increasing requirements, especially in the export sector, for food safety and animal welfare. About five years ago, some EU importers detected nitrofurans (a banned group of antibiotics) and dioxin in some lots of broilers imported from Thailand. Some major exporters responded to the problem by switching most of their production to in-house production so that they would have better control over all the inputs used. Animal welfare requirements imposed by most EU importers also drive such changes. The most significant driver, however, was the HPAI outbreak in 2004 along with the four subsequent outbreaks.

Since the first HPAI outbreak, most importing countries have banned frozen broiler meat from Thailand. Such bans were initially of fixed duration (e.g. subject to review after six months). However, as there have been several recurrent outbreaks, the bans have never been lifted and are expected to remain in place for the next few years. Nonetheless, the large companies that have transformed themselves through vertical integration have continued to produce for export, targeting the precooked market. By now, only smaller companies rely significantly on contract farming.

Despite increasing risks, structural change from a horizontally integrated production system to a vertically integrated industry can promote some types of production efficiency. Vertical integration provides economies of scope, ensures reliability of supply, and facilitates quality management and homogeneity of products. Vertical coordination provides an opportunity to keep control of operating and transaction costs while meeting high standards of food safety.

There has been a belief that vertical integration is motivated by tax incentives, especially when value added tax (VAT) is applied – partly because the integrators produce their own inputs and thus do not have to pay VAT on them. This belief is not true, at least in Thailand where VAT is not really collected on the basis of "value added," but as a sales tax accompanied by a tax credit for purchased inputs. In addition, agricultural produce[5] and many inputs (including grains, fishmeal, fertilizer, herbicide and insecticide) are VAT exempted.

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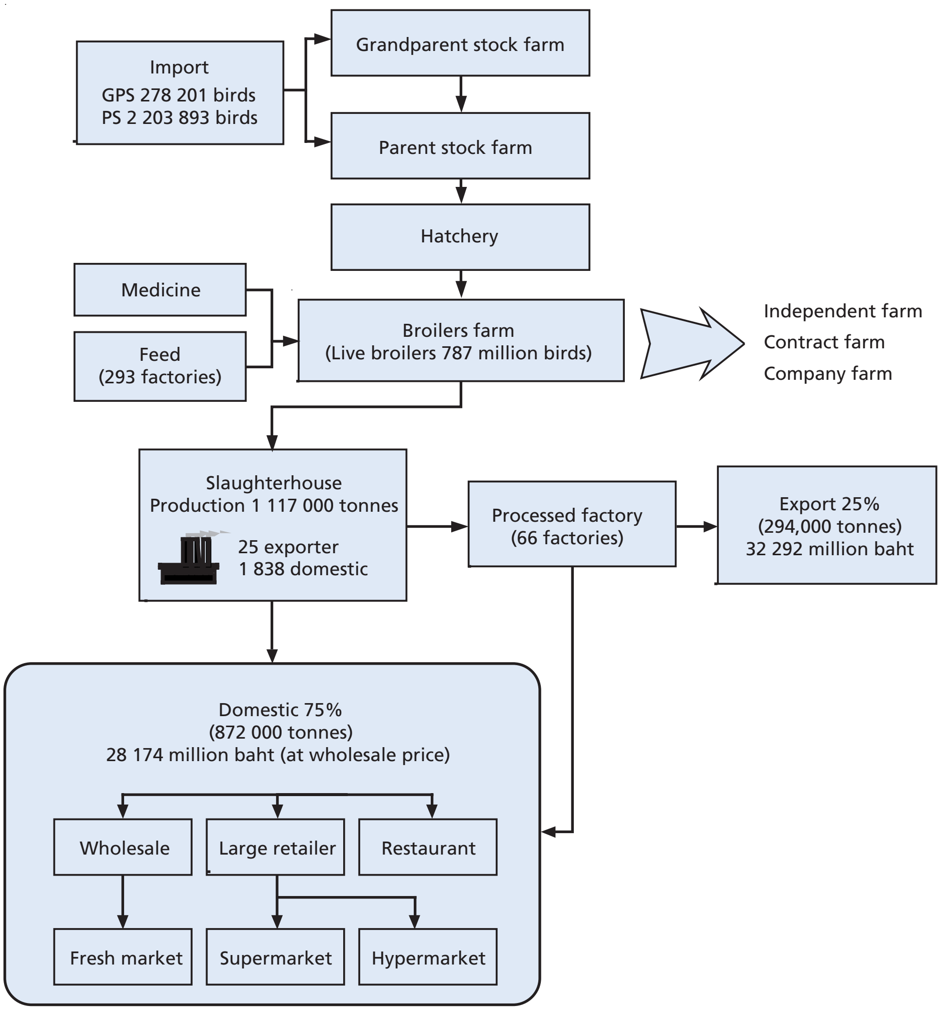
5 Except for processed, canned, and other tight-contained agricultural products. The integrators are also more likely to sell these processed or semi-processed products which are subject to full-value tax at the point of sale (and can claim very little tax credit as most of their "inputs" are raw agricultural produce which are "VAT exempted").

The reverse argument – that the integrators can obtain tax credit on other purchased inputs (such as diesel/gasoline and stationery) but small informal farms that are exempted from, or choose to not participate in, the VAT system cannot do the same – is not very relevant either. This is because those small farms (or firms) do not have to charge (and pay) VAT on their sales, and usually they pay relatively little corporate tax anyway.

At present, broiler production is located primarily in the central region of Thailand, close to the hatcheries, feed mills, and processing plants. At the top of the chain map in Figure 4, most chickens originate from parent and grandparent stock imported from the United

FIGURE 4A
Value chain map – broilers 2005

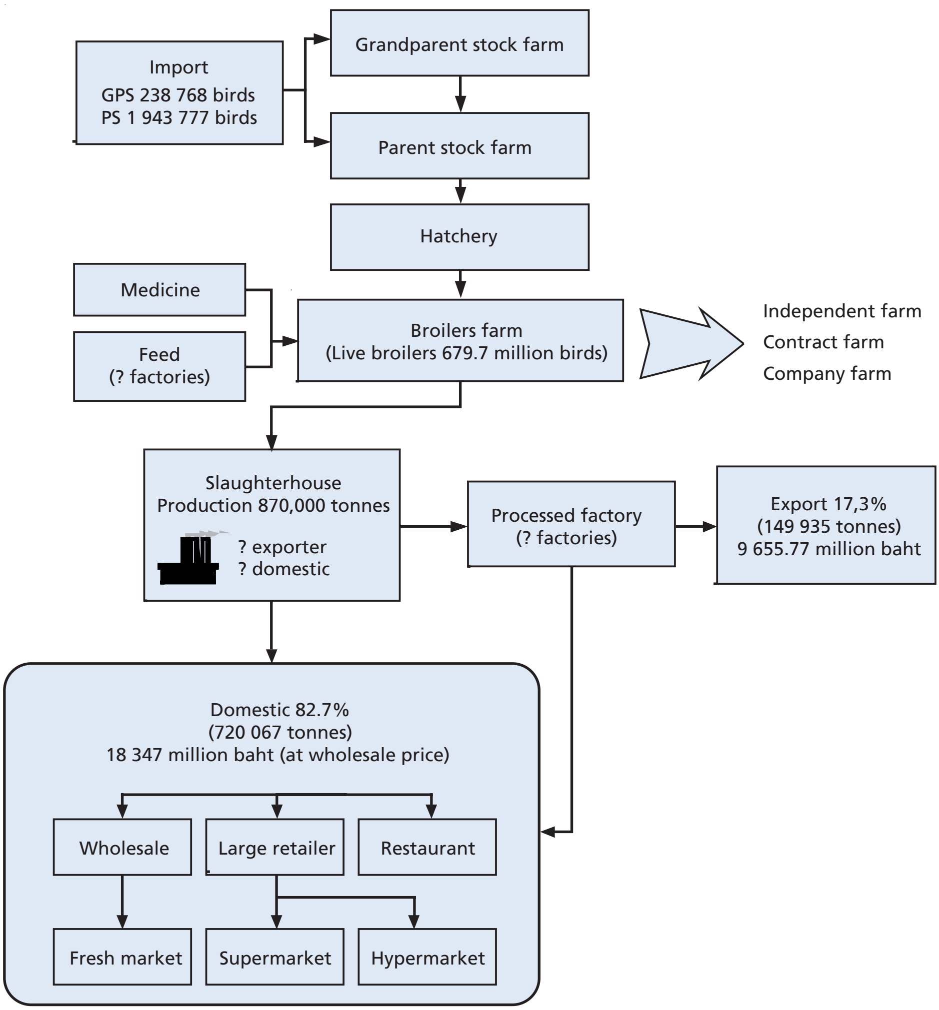


GPS = Grandparent stock, PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

States of America and the United Kingdom. Most integrators have their own hatchery – which also supplies day-old-chicks to their contractors and the independent market. Feed mills have become a part of major integrated poultry companies. Owning a feed mill is an essential part of the production flow (and cost). Some large companies also have their own animal pharmaceutical department. Having their own feed mill and pharmaceutical department can help to enhance the traceability of their inputs.

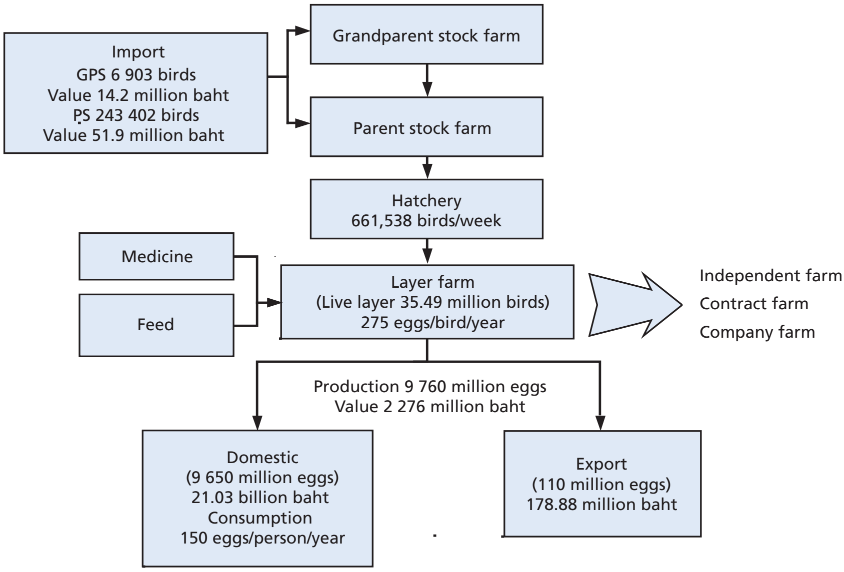
Besides in-house production on the company's farms, many integrators also rely, in part, on contract farming – although its role has lessened in the past decade, especially after the

FIGURE 4B
Value chain map – broilers 1995



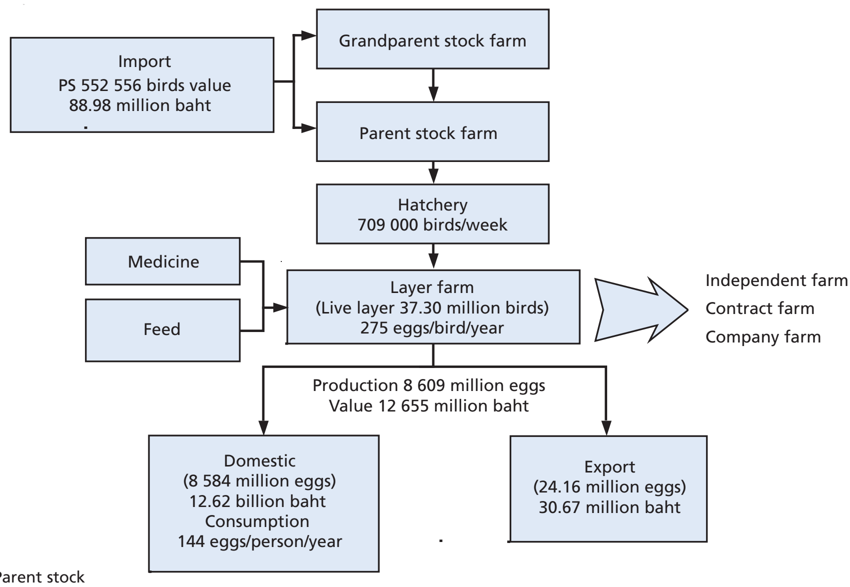
GPS = Grandparent stock, PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

FIGURE 4C
Value chain maps – layers 2005



GPS = Grandparent stock, PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

FIGURE 4D
Value chain map – layers 1995



PS = Parent stock
Source: Compiled by the author based on data from Thai Broiler Processing Exporters Association and Department of Livestock Development.

HPAI outbreak in 2004. Independent broiler farms have also decreased in number during the same period.

Like broiler farms, large integrated layer farms are concentrated mostly in the central region, although layer farms are distributed more evenly across regions. As almost all egg products are sold domestically, the industry was not, in the past, subject to such stringent requirements as the broiler industry. Although the HPAI epidemic has changed this somewhat over the past few years, structural changes are coming much more slowly to the layer industry than to the broiler industry. For example, there have been strong – and apparently quite reliable – rumours that a significant number of layer farms are using the HPAI vaccine, even though the HPAI vaccine has never been approved (in fact it has always been banned) by the Thai government.

3.3 Export

Export has been very significant for the broiler sector. Before the HPAI outbreak in 2004, as much as 40 percent of broiler production was exported annually (37 percent and 39 percent in 2002 and 2003, respectively). As not all chicken parts are exportable, the great majority of broiler chickens were raised for export purposes. The story was very different for eggs, the export of which was negligible (merely 1 to 2 percent of total production) and was mostly undertaken to stabilize the domestic price.

Between 1994 and 2003, the total quantity of broiler export almost tripled (increased by 187 percent, see Table 4). This period also witnessed a significant structural change in export. Prior to 1994, almost all exports were frozen de-boned raw chicken, as Thailand's competitive advantage stemmed from her low wage rates. The export of precooked chicken-meat products began in the early 1990s and accounted for less than 10 percent of the total in 1994. It has been increasing sharply ever since. In 2003, the share of precooked chicken in total export was almost one-third. The growth of precooked-chicken export has been even more dramatic since the HPAI outbreak of 2004. In just three years (from 2003 to 2006) the quantity of precooked chicken exported almost doubled. As Thai raw/frozen broilers are still banned by most importers, precooked chicken accounted for 97 percent of export quantity and about 98 percent of export value in 2006.

Although the structural change in export was accelerated by the HPAI outbreaks (and the possibility that HPAI could return at anytime), such a change had been expected for quite some time. As wages in Thailand are substantially higher than in neighbouring countries, and given that these neighbours include two populous countries, China and Viet Nam, it was clear that once these countries were able to comply with the importers' food-safety and animal-welfare requirements, it would only be a matter of time before Thailand faced keen competition. Therefore, some integrated companies – especially the well-known CP Group – had begun to prepare themselves for such a change for more than a decade. In addition to expanding its production base in China and Viet Nam, its shift of some production lines to precooked products has been part of an overall attempt to move towards higher value-added products in order to overcome the disadvantage of having high production costs (especially high feed prices and labour costs).

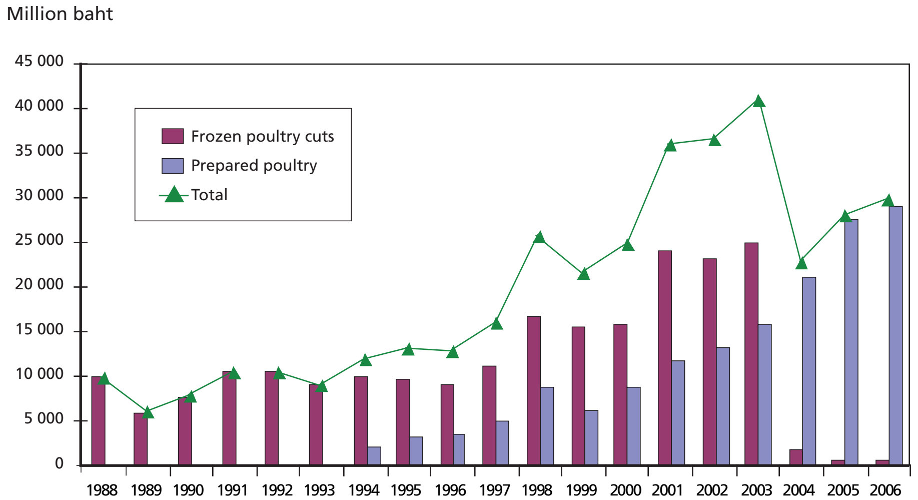
In the past decade or so, factories, processing plants, feed mills and slaughterhouses have developed their operations to meet the standards required by various importing coun-

TABLE 4
Broiler export quantities and prices, 1992 to 2006

Year	Export Quantity (tonnes)		Average export price per tonne (US$)		Price ratio (precooked: frozen)
	Frozen	Precooked	Frozen	Precooked	
1992	174 825		2 351		
1993	157 086		2 244		
1994	153 033	15 996	2 573	4 621	1.80
1995	149 935	22 124	2 598	5 628	2.17
1996	137 176	31 555	2 625	4 236	1.61
1997	150 775	41 114	2 357	3 909	1.66
1998	212 497	60 943	1 906	3 604	1.89
1999	217 720	65 074	1 853	2 403	1.30
2000	240 938	88 575	1 637	2 485	1.52
2001	309 516	116 650	1 745	2 234	1.28
2002	303 966	127 974	1 758	2 396	1.36
2003	331 045	154 464	1 804	2 446	1.36
2004	23 954	193 767	1 854	2 670	1.44
2005	4 534	263 419	3 022	2 592	0.86
2006	8 036	270 345	1 966	2 802	1.43

Source: Ministry of Commerce (the "Menucom" database) except data on precooked chicken export between 1994–1998 which are from NaRanong (in FAO, 1999) (who cited Department of Business Economics, Ministry of Commerce, and Thai Broiler Processing Export Association).

FIGURE 5
Thailand export value of poultry



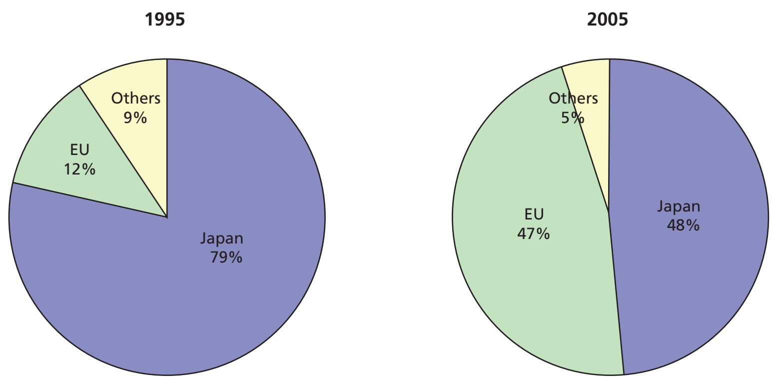
Source: The Ministry of Commerce.

tries. Some exporters have transformed their broiler export from frozen/raw to precooked/prepared products, as they realize that customers will continue to demand inexpensive, high-quality finished products. This also means products that are healthy – free from food-borne pathogens and containing minimal amounts of carcass fat – and that are tender, tasty and palatable to the consumer. Value-added marketing of such products is also an avenue for exporting companies to differentiate their most prized product offerings, while continuing to create processed products that add value and target the changing needs of the consumers, who now usually look for products that can be quickly and easily prepared in 15–30 minutes or less. The sharp growth in precooked products reflects the thinking of the industry's leaders long before the HPAI outbreak; although it was the outbreak that finally forced exporters to change their products in order to survive.

It should be noted that while the prices of precooked chicken products are usually higher than those of raw/frozen products, they are not spectacularly so. At present, the average export price of precooked chicken products is approximately 40 percent above the average export price of raw/frozen broiler, substantially lower than the price premium in the past (e.g. between 1994 and 1998 when the price premiums were as high as 60 to 120 percent, see Table 4). This premium should nonetheless suffice to keep the industry growing and provide a viable escape route in the wake of the HPAI epidemics.

Thailand's major broiler export markets in the past decade were Japan and the EU (Figure 6). In 1995, Japan accounted for 79 percent and the EU accounted for only 12 percent of total broiler meat exports. However, in the past decade Thailand's export to the EU increased substantially, partly because Thailand's export prices were more competitive. In 2005, exports to Japan and the EU accounted for 48 and 47 percent of total broiler meat exports, respectively (see details in Table 5). In the past, Japan usually bought uncooked meat in the form of boneless leg meat, boneless breast meat, and special cut-meat in sticks (Yakitori) and other made-to-order chicken meat products. Now almost all exported meat is in the form of made-to-order products, which are processed or prepared by heat (grilling,

FIGURE 6
Importing countries' shares of Thailand's broiler export



Source: The Ministry of Commerce.

TABLE 5a
Major export markets for frozen poultry (tonnes)

Countries	2001	2002	2003	2004	2005	2006 (p)	Share 2006
				tonnes			
EU	98 686	79 370	98 231	11 027	-	-	-
Germany	49 110	49 110	59 308	5 496	-	-	-
Netherlands	25 632	25 632	21 784	2 978	-	-	-
United Kingdom	20 648	20 648	15 890	1 494	-	-	-
Others							
Japan	162 131	193 919	188 101	9 706	-	-	-
Republic of Korea	26 777	32 945	41 720	2 897	-	-	-
China	12 172	10 642	21 487	603	-	-	-
Malaysia	6 612	8 176	14 082	637	-	-	-
Singapore	8 951	7 308	10 670	576	-	-	-
Hong Kong SAR	4 288	2 967	5 695	234	-	-	-
Others		3 718	8 927	457	96	2 662	100
Total	320 779	339 045	388 913	26 137	96	2 662	100
% change	30.40	5.69	14.71	-93.28	99.63	2 673	

Note: p = preliminary.
Source: Department of Customs.

steaming, boiling, etc.). Some of these products are breaded or seasoned (with salt, Japanese sauce, etc.). The EU used to import Thailand's broiler meat in the form of uncooked skinless boneless breast meat, but also switched to semi-cooked and cooked meat in made-to-order styles in the wake of HPAI outbreaks.

While Thailand is a major broiler exporter where export has been carried out without any price support or export subsidy programmes, the broiler industry is still protected by substantial import tariffs (30 percent for chilled or frozen uncooked meat and 40 percent for cooked chicken meat in 2006). This is partly because Thailand's comparative advantage has always been in processing rather than in broiler production. Without such a protection measure, it would be possible for some countries (e.g. the United States of America) to export low-value chicken parts – especially the wings and leg-quarters – to Thailand. The industry's justification for the import protection has been that export prices of wings and legs from the United States of America could be so low as to be equivalent to dumping. Moreover, as much of Thai broiler meat export consists of white breast meat for the EU market, there is potential for Thailand to have surplus of wings and legs, especially if export soars again. To date, the Thai government and the industry have tried to avoid this issue when negotiating with the United States of America.

TABLE 5b
Major export markets for prepared poultry

Countries	2001	2002	2003	2004	2005	2006 (p)	Share 2006
				tonnes			
EU	49 840	49 840	61 628	76 050	113 096	127 601	43.74
United Kingdom	20 713	28 723	32 132	42 222	69 707	82 883	28.41
Netherlands	24 450	14 956	17 676	19 093	23 818	23 680	8.12
Germany	3 908	2 995	5 862	8 915	9 751	10 806	3.70
Belgium	400	1 331	876	666	1 415	1 175	0.40
France	224	1 424	2 076	604	587	266	0.09
Others							
Japan	52 489	66 162	84 066	102 610	149 079	148 559	50.92
Singapore	7 403	4 380	4 698	5 185	5 398	7 017	2.41
Republic of Korea	3 307	2 311	1 832	5 510	3 553	2 821	0.97
Hong Kong SAR	3 495	2 672	3 484	3 329	3 493	3 380	1.16
Malaysia	7	-	34	-	-	-	-
Others	477	2 233	1 332	1 130	1 819	2 348	0.80
Total	117 018	127 598	157 074	193 814	276 438	291 726	100.00
% change	34.81	9.04	23.10	23.39	42.63	5.53	

Note: p = preliminary.
Source: Department of Customs.

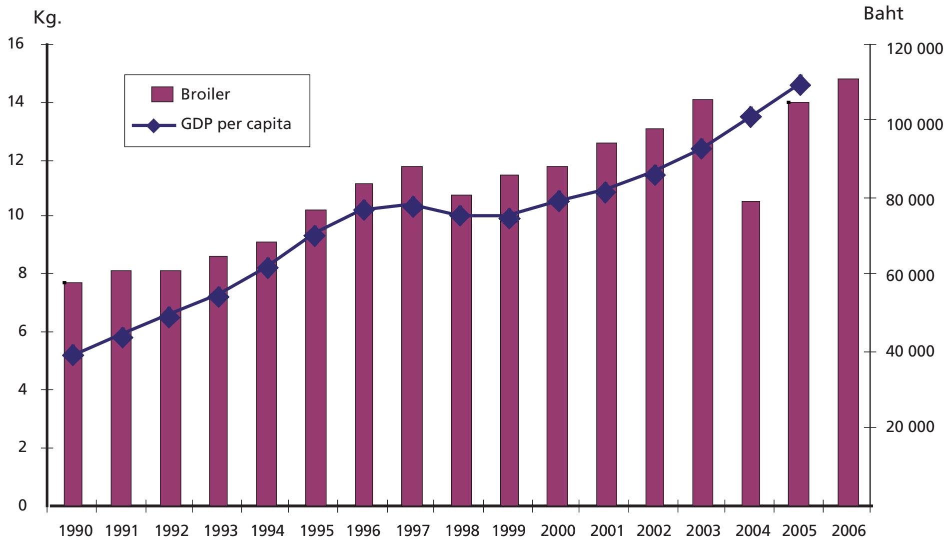
3.4 Domestic market and urbanization

Per capita broiler consumption in Thailand has grown considerably in the past decade, from 10.3 kg to 14.8 kg per year. The growth pattern is closely related to Thailand's GDP per capita (Figure 7).

Although it is natural to see an increase in protein consumption as a developing country becomes richer, one factor that makes the broiler chicken a success is that prices can be kept low. Three or four decades ago, the price of chicken meat was on par with, or sometimes even higher than, pork and fish prices. At present, chicken has become the least expensive source of animal protein in Thailand. As indicated in Figure 8, the retail price of broiler meat has been consistently lower than those of pork and beef for the past decade and a half. As a result, per capita consumption of broiler meat has continued to increase in the past decade (with a sharp drop in 2004 as a result of the HPAI epidemic) while the beef consumption has continued to decrease (Figure 9).

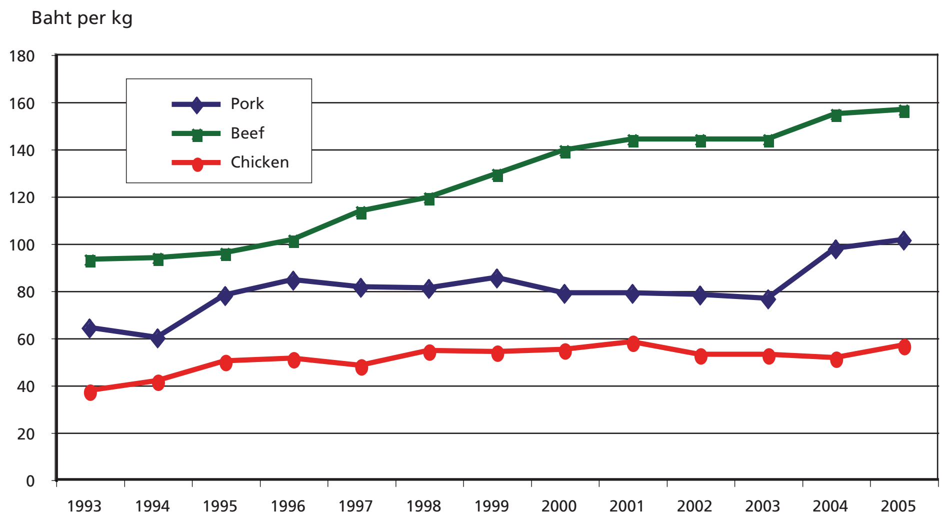
Urbanization is another factor that may have had a positive impact on poultry consumption. The increasing number of hypermarkets and convenience stores (see Table 6) as well as fast-food outlets, such as Kentucky Fried Chicken, Sizzler and Chester Grill, may help stimulate consumption growth; they introduced a stream of new products ranging from boneless and ready-to-cook products to luncheon meats, chicken nuggets and patties for

FIGURE 7
Broiler consumption and GDP per capita in Thailand, 1990 to 2006



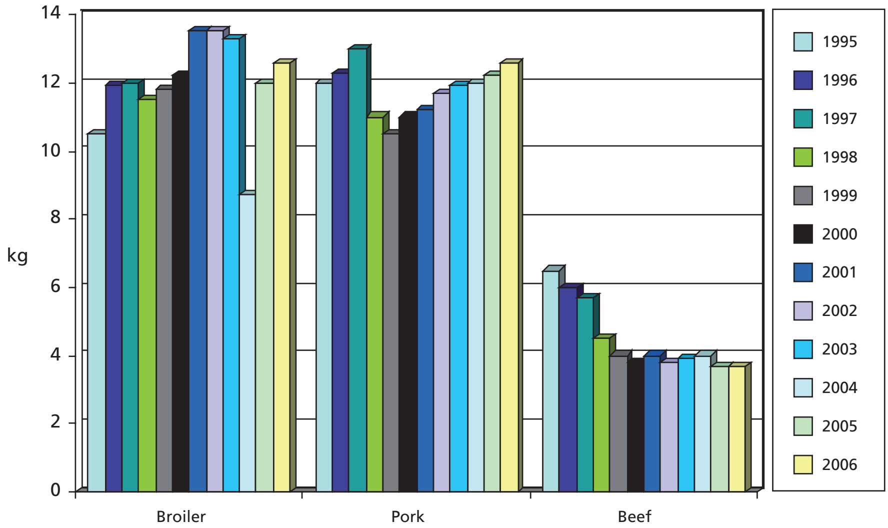
Source: Thai Broiler Processing Exporters Association and NESDB.

FIGURE 8
Retail prices of pork, beef, and chicken in Bangkok, 1993 to 2005



Source: The Ministry of Commerce.

FIGURE 9
Per capita meat consumption in Thailand, 1995 to 2006



Source: 1995–2004 Rabobank/USDA/FAO.
2005–2006 Thailand Development Research Institute (TDRI)'s estimation based on OAE's data and DLD's formulae.

restaurant use. At present, fast-food restaurants sell large quantities of chicken in many forms, including breaded chicken parts, nuggets, patties, breast filets, tenders and popcorn chicken. Many of these products are also available in the frozen food sections of hypermarkets and grocery stores. Some integrated companies, such as CP, have already established their own outlets. Chester Grill, for example, is an outlet for CP poultry products, especially

TABLE 6
Number of hypermarkets and convenience stores in Thailand

	1998	2006		
	Total	**Bangkok**	**Up-country**	**Total**
Carrefour	7	18	6	24
Tesco Lotus	13	28	28	56
Tesco Lotus Market	0	5	18	23
Lotus Express	0	212	33	245
Big C	20	23	26	49
Leader Price	0	5	0	5
Tops Supermarket	40	66	23	89
Total	80	357	134	491

Source: 1998 data from Poapongsakorn *et al.* (2002); 2006 data from Matichon Weekly, 9–16 February 2007.

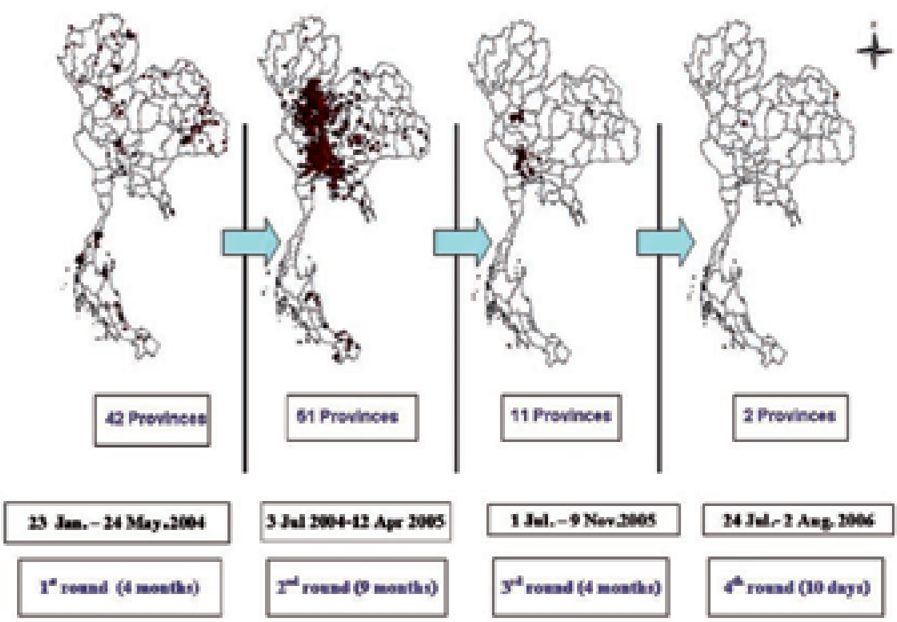
wings and legs (the parts that are not major export products). The less popular chicken parts are largely sold to the local market.

3.5 The HPAI outbreaks

Since January 2004, Thailand and other Southeast Asian countries have experienced outbreaks of H5N1 HPAI in poultry. Thailand was hit by four rounds of the outbreak between 2004 and 2006 (Figure 10) and another small round in early 2007. Since the first outbreak in January 2004, at least 25 people have caught the disease and 17 deaths have been reported (as of September 2007). Thailand rapidly applied control measures, including the killing of as many as 63 million chickens in 2004 (Table 7), disinfection, quarantine, control of animal movements and thorough surveillance (dubbed "x-ray measure" in Thailand). Checkpoints and disinfectant stations along the roads leading to slaughter houses have been increased, and officials from the DLD have been stationed at production centres to monitor the industry. A list of measures used in 2006 is shown in Box 1 below. Although HPAI control was chaotic at first, many have considered it to have been a successful undertaking. The fourth and fifth outbreaks involved only sporadic events which, in some cases, had nothing to do with the broiler or layer industry.

The "success" of the HPAI control in Thailand has, however, been accompanied by substantial costs. Besides the mass killing of poultry (65 million in 2004 alone – which

FIGURE 10
The HPAI outbreaks in Thailand 2004 to 2006



Source: Department of Livestock Development.

BOX 1

List of Thailand DLD's AI policy measures imposed in 2006

According to the DLD, the overall disease control measures implemented in 2006 were as follows:

- stamping out of animals in affected premises with 75 percent compensation (393 430 birds destroyed);
- disposal of carcasses and eggs, and infected/risk materials (e.g. litter, feed and egg flats);
- disinfection of affected premises, all infected/contaminated materials and other risk materials;
- quarantine and movement control;
- nationwide active clinical surveillance and notification for implementing disease control once a case is suspected according to the current AI case definition;
- intensive surveillance (known in Thailand as "The X-ray Campaign") for three rounds in all at-risk areas during 1–28 February, 1 June – 31 July, and 11–30 September 2006 (145 978 samples collected);
- routine sampling prior to movement (a total of 522 072 cloacal swabs were collected between January and October 2006);
- poultry restocking in the affected areas not carried out until 90 days after the completion of disinfection;
- ongoing long-term campaign of biosafety improvement;
- restructuring of free-grazing ducks production to a housed system, registration and flock identification for 7 333 987 birds of 3 109 owners;
- registration of fighting rings/arenas (2 400 holdings were listed);
- identification of fighting cocks (248 877 birds belonging to 107 163 owners were registered); and
- no AI vaccination allowed.

Source: USDA (2007).

incurred more than a billion baht of public-money compensation), some measures have affected smallholders adversely. Right after the first outbreak was formally admitted, the responsible minister and the DLD made numerous public announcements that, henceforward chickens should only be raised in closed farms. In addition, many contracted farms were also required by the integrators to upgrade their poultry housing to closed (evap-type) houses if they wanted to remain as a contractor. Many contractors – already hit hard by the epidemic – decided to call it quits (or switch to other businesses) than rather than invest further in a business with such apparently bleak prospects. In retrospect, their decisions may have been justified given that even among contractors who already had evap-type farms, many have suffered from the rationing and rotation schemes that some integrators employed after the outbreak.

TABLE 7
Number of poultry killed to curb HPAI in Thailand

Year	Number of birds killed
2004	63 000 000
2005	450 000
2006	320 000

Source: Thai Broiler Processing Exporters Association.

TABLE 8
Estimated loss of the poultry industry from HPAI in 2004

	Loss (million baht)
Hatchery farms	4 420
Feed mills	12 430
Broiler farms	27 950
Slaughter houses	28 400
Export	23 700
Total	96 900

Source: Thai Broiler Processing Exporters Association.

Thus far, there has been no systematic study to determine the impacts of the various measures on different groups of stakeholders. Our in-depth interviews with a few independent veterinarians and small farm holders have indicated a consensus belief that the DLD measures that have had the strongest negative impacts on small farms are the pressure to upgrade to closed housing, and some quarantine and movement control measures. Ironically, the first measure, while being clearly announced to the public, was not backed by corresponding changes in the rules and regulations. For example, the official poultry farm standards still allow both opened and closed housing. In practice, however, the DLD officials exercised their quarantine and movement control measures to block chicken raising in open farms. The quarantine and movement control measures were implemented under the umbrella of the Animal Epidemic Disease Control BE. 2499 (promulgated in 1959 and revised in 1999) which gives quarantine and movement control powers to the DLD authorities in the case of epidemics.

Vaccination has been one of the most controversial issues for the poultry industry in the past few years. The DLD has continued to ban AI vaccination since 2004. Its standpoint has been strongly supported by the then number-one broiler exporter (Sahafarm Co.). Another large multinational corporation (CP) – which probably uses (and may have successfully developed) AI vaccine in its operations in China and/or Viet Nam – has during the past few years proposed the use of vaccination. Although the DLD has been firm in its decision, there have been strong rumours that AI vaccine has been used in many layer farms, because their losses would be more substantial if the birds were to catch HPAI.

Since the first outbreak, Thailand's two largest export markets for chicken products, Japan and the EU, have banned imports of frozen/fresh poultry from Thailand. Initially, this ban affected the industry adversely, as at the time frozen/fresh products accounted for two-thirds of the export. The Thai Broiler Processing Exporters Association claimed that the total loss suffered by the poultry industry as a result of the HPAI outbreak in 2004 was almost 100 billion baht (US$3 billion) (see Table 8). To help poultry farmers whose birds were culled, the government provided significant compensation[6] and set aside a hardship fund of 5 000 million baht. The fund was used to provide soft loans at low interest rates to affected farmers who wanted to start new businesses. In addition, Thailand's broiler exporters took many, mostly biosecurity-related, measures to protect the industry. Contract farms were required, by both the DLD and their patrons, to upgrade their poultry housing to the closed system. Those who were unable or unwilling to comply were left with no option but to leave the poultry business.

4 THE FUTURE TREND OF THAILAND'S POULTRY SECTOR

The HPAI outbreaks have been the most important factor shaping Thailand's poultry sector in the past few years. The outbreaks have also hit smallholders very hard, resulting in many leaving the industry altogether. However, strong and devastating as it has been, HPAI is unlikely to determine the future of Thailand's poultry industry. This is because structural change is almost complete and is unlikely to be reversible.

The Thai broiler industry will continue to move towards higher levels of industrialization and more vertical integration – most large integrated firms will include food processing as a part of their operation. Further industrialization and vertical integration will make it easier for the poultry industry to comply with the foreign importers' food safety and animal welfare requirements.

The trend towards further processing of poultry (cooked and semi-cooked products) – now included as part of the operation of many integrated firms – may increase employment in the poultry sector. However, additional employment in the integrators' farms will be very limited, as many are now fully automated. Moreover, any new employment will be created at the expense of smallholders whose room to operate as self-employed broiler farmers will be increasingly curtailed.

As the sector returns to "normal" business, its future will be shaped mainly by basic drivers, such as feed supply and demand. Another significant trend may be that movement towards replacing chemical protection (antibiotics, antiseptics, or even vaccination) with biosecurity and compartmentalization will shift the industry further towards integrated industrialization.

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[6] During the first outbreaks, the government provided full compensation (at market value of healthy chickens) for the stamped-out animals. Since the second round of outbreaks (July 2004), however, the compensation has been reduced to 75 percent of the market value in order to curb moral hazard problems.

4.1 Feed supply and demand

The supply of raw materials for poultry production, particularly grain and protein, has become a key issue determining the growth – and possibly competitive strength – and future of the industry. The Thai Feed Mill Association estimates that a total of 3.52 million tonnes of maize and 1.63 million tonnes of soybean were used to feed broiler and layer chickens in 2007 (Table 9). The amount required would be much more in the future should the industry grow back to the pre-HPAI level of production – which would be easily attainable. Shortage of local feed ingredients has made the industry reliant in part on imported feeds. In addition to the feed costs, some agricultural products are under tariff quota protection. For example, while the import duty on soybean meal in quota is a mere 4 percent, the "out of quota" import duty is prohibitively high – at 119 percent. Although the tariff

TABLE 9
Estimates of poultry production and feed use, 2007

	Production (million birds)	Feed use (tonnes)	Share	
			Soybean	Maize
Broilers	811.72	3 214 411	30	62
Parent stock of broilers	10.04	506 016	25	60
Young hens	30.63	663 650	25	60
Layers	37.05	1 482 000	25	55
Parent stock of layers	0.52	20 800	25	60

Source: Thai Feed Mill Association.

TABLE 10
Feed prices

		Soybean meal (baht/kg)	
Year	Maize	Domestic	Import
1997	4.77	10.81	10.65
1998	5.02	11.25	10.50
1999	4.67	9.65	7.47
2000	4.80	9.98	9.21
2001	4.37	10.94	10.70
2002	4.68	10.47	10.16
2003	4.94	11.96	11.07
2004	5.70	13.77	14.61
2005	5.50	12.02	11.92
2006	6.18	11.03	10.53

Source: Thai Feed Mill Association.

quota has been lifted, all importers are required to buy domestic soybean proportionately to their purchase of imported soybean at a guaranteed price which is usually higher than the imported price.

As many agricultural product exporting countries, including Thailand, have been promoting biofuel production, a large proportion of grain (such as maize) and tuber (such as cassava), as well as sugarcane production, has been diverted toward gasohol and bio-diesel production – pushing the prices of animal feeds significantly upwards. Table 10 shows that the maize price has increased significantly, and the price of soybean price has also tended to rise. Although the impact of rising feed prices on the competitiveness of Thailand's poultry sector is unclear – as this worldwide phenomenon could also affect competitors – it is very plausible that the growth rate of the sector will not be as strong as in the past.

4.2 Biosecurity and compartmentalization

An important driver of vertical integration in poultry firms has been their decision to solve major safety problems, such as banned antibiotics residuals and HPAI, by using biosecurity measures. In the past, the industry relied more on chemical solutions such as vaccination, antibiotics and antiseptics, which are costly and at times leave undesirable or unacceptable residuals in the products. After the HPAI outbreaks, it was also clear that vaccination would not be acceptable to the major importers, which often require even more stringent standards than those set by the World Organisation for Animal Health (OIE). The industry's only option was, therefore, to employ biosecurity measures.

As the chicken breeds currently raised are highly susceptible to HPAI, the objective has been raise them in a closed system – an environment that minimizes contact and contamination. Most integrated broiler farms have by now introduced closed housing. Moreover, to ensure higher levels of safety, the industry, with guidance from the DLD and OIE, has moved towards a more stringent form of control – compartmentalization.

If anything, compartmentalization means more integrated, and hence larger, operations. In theory, it is possible that many (or a few) companies could share facilities within a compartment. However, as all the leading integrators already own all types of facility, it is unlikely that any would be willing to share with a competitor. Nonetheless, it is plausible that some leading integrators may provide space or service to smaller companies.

On July 13, 2006, the DLD signed an agreement with 24 major broiler and duck companies to establish 92 compartments which will cover 1 276 farms (1 250 broiler farms and 26 duck farms) and a total of 120.6 million birds per batch. The target was that by the end of 2006 at least 1 000 farms would be compartmentalized. By the end of 2006, the number of farms that had applied for compartmentalization certification had increased to 1 877 broiler farms (from 18 companies) and 899 duck farms (from 2 companies) in 40 provinces.

5 IMPLICATIONS FOR SMALLHOLDERS

Rapid industrialization and increasingly stringent trade requirements imposed by importing countries during the past decade have led to a significant increase in in-house production of broilers and layers by many integrated companies. Once these developments were underway, the future of small poultry farms was always in doubt.

For many smallholders, however, the end came much earlier than most would have expected. Most of them were hit – directly or indirectly – by the HPAI outbreaks that started in 2004. Some farms that were able to avoid the initial impact were nonetheless affected adversely by the later structural adjustment.

5.1 Smallholders and the HPAI outbreaks

In order to see how structural adjustment has affected farms of various sizes – including smallholders – the Thailand Development Research Institute (TDRI) conducted a telephone survey of broiler and layer farms that had been selected as a sample in a previous TDRI–IFPRI–FAO study in late 2002 and early 2003.

Among the broiler farms, after repeated tries, we were able to contact about half (49 percent) of the sample of 170 from the previous study. Among the respondents, 71 percent continue to operate their broiler farms (see Table 11 below). Over half operate on the same scale as they did in 2003, with about 7 percent having expanded, and another 7 percent having decreased, their farm size. Among the 29 percent who have discontinued their broiler farms, 6 (out of 24) have switched to another type of poultry farm (duck or layer) and 2 have rented their broiler farms out, presumably to other broiler operators. As such, the great majority of the farms are still in the poultry business. Among the minority who left the poultry business, 4 are still in the livestock business. Seven have switched to crop farming. Only a few have moved out of agriculture (into retail business). It should be noted that large broiler farms in our samples appeared to have been more affected, as about half of them (4 out of 9) have left the poultry industry altogether.

It is plausible that, among the half of the old sample that we were unable to contact, a greater percentage may have left the poultry business or even left the area altogether. However, one should not draw too strong an inference regarding this section of the sample, as the major cause of the low response rate is that the vast majority of the phone numbers in our record (about 85 percent) are mobile phone numbers. In the past few years, it is not unusual for an average Thai to have changed their mobile phone numbers/providers as a result of fierce competition among the mobile phone service providers.

In the case of the layer farms, we were slightly less successful in reaching our old sample – we managed to contact only 40 percent of our 2003 study sample. About two-thirds of the respondents continue in the layer business. However, most farms reportedly have fewer layers than in 2003, especially among the smaller farms. As in the case of the broiler farm sample, most respondents who have discontinued their layer business moved to into another type of livestock keeping or agriculture.

Even though most respondents are still in the poultry business, this does not mean that they have not been affected by HPAI and the government measures that have been implemented in the wake of the outbreaks. Several farmers who moved to non-broiler activities indicated that after substantial losses resulting from the HPAI outbreaks they were unable to comply with the demands of the DLD or their patron companies for further investment in upgrading their farms.

TABLE 11
What the broiler farmers from the 2003 sample do in 2007: telephone survey results

Activities in 2007	Number of farms	Proportion of respondents (%)	Proportion of 2003 sample (%)	Size				
				S	ML	MH	L	n.a.
Continue to operate the broiler farm	59	71.1	34.7	24	20	8	5	2
Raise more broilers than in 2003	6	7.2	3.5	1	1	2	1	0
Raise same number of broilers as in 2003	47	56.6	27.6	23	18	5	4	2
Raise fewer broilers than in 2003	6	7.2	3.5	0	1	1	0	0
Stopped operating the broiler farm	24	28.9	14.1	10	6	2	4	2
Switched to other poultry farming								
- Duck farm	5	6.0	2.9	2	1	1	0	1
- Layer farm	1	1.2	0.6	1	0	0	0	0
Switched to other livestock farming								
- Pig farm	2	2.4	1.2	0	2	0	0	0
- Cattle farm	1	1.2	0.6	1	0	0	0	0
- Fish farm	1	1.2	0.6	0	1	0	0	0
Rent the farm out (still as a broiler farm)	2	2.4	1.2	2*	0	0	0	0
Switched to other crops	7	8.4	4.1	1	2	1	3	0
Switched to retail business	2	2.4	1.2	2	0	0	0	0
New occupation not specified	3	3.6	1.8	1**	0	0	1	1
Total respondents	83	100.0	48.8	34	26	10	9	4
Unable to contact via telephone	86	n.a.	50.6					
Number of observations in 2003 (170 farms)	170		100.0					

Note: Small (S) = 1–5,000; Medium low (ML) = 5 001–10 000; Medium high (MH) = 10 001–20 000; Large (L) > 20 000.
* includes a case of deceased farm owner and another case of farmer who becomes a factory worker.
** includes a case that discontinue before the HPAI outbreak.
Source: Telephone survey by TDRI, March 2007.

TABLE 12
What the layer farmers from the 2003 study do in 2007: results of a telephone survey

Activities in 2007	Number of farms	Proportion of respondents (%)	Proportion of 2003 sample (%)	Size			
				S	ML	MH	L
1. Continue to operate the layer farm	26	66.7	26.8	2	6	5	13
- Raise more chickens than in 2003	5	12.8	5.2	0	0	0	5
- Raise the same number of chickens as in 2003	6	15.4	6.2	0	2	2	2
- Raise fewer chickens than in 2003	15	38.5	15.5	2	4	3	6
2. Switched to other activities	13	33.3	13.4	4	5	3	1
Egg retailer	3	7.7	3.1	2	0	0	1
Fish farm	4	10.3	4.1	0	2	2	0
Pig farm	2	5.1	2.1	0	1	1	0
Other agriculture	3	7.7	3.1	2	1	0	0
Non-agriculture	1	2.6	1.0	0	1	0	0
Total respondents	39	100.0	40.2	6	11	8	14
Unable to contact via telephone	58	n.a.	59.8				
Number of observations in 2003	97	n.a.	100.0				

Note: Small (S) = 1–5 000; Medium low (ML) = 5 001–10 000; Medium high (MH) = 10 001–20 000; Large (L) >20 000.
Source: Telephone survey by TDRI, March 2007.

5.2 The future for smallholders

Even before the HPAI outbreak in 2004, the future of smallholders in the poultry sector looked bleak. When TDRI took part in two international comparison studies sponsored by FAO and IFPRI between 2001 and 2004, the definitions (categorizations) that our team employed were larger than those used by other research teams doing studies in other Asian countries (see Tables 11, 12 and 13). Even given this categorization, we found that smallholders' competitiveness (e.g. in terms of feed-conversion ratio and the egg yield) was problematic, both for broiler and layer farmers.

Table 13 above shows results from stochastic frontier estimation based on TDRI's farm survey in 2002/2003. The results suggest that small broiler farms (with less than 5 000 and between 5 000–10 000 birds per batch) are much less efficient than larger farms (with more than 10 000 birds per batch). A similar pattern was found – although less pronounced – in case of layer farms. Given the above-described advantages of large companies/integrators and the growing trend towards vertical integration, the results shown in Table 13 come as no surprise.

If anything, the gap between large and small producers tends grow wider over time. Some of the advantages that smallholders' had in the past – such as having lower investment costs in chicken housing and sometimes getting higher prices for chicken manure or

TABLE 13

Mean relative profit efficiency of broiler and layer farms across farm sizes, 2002-2003

	Proportion of maximum profit efficiency (%)			
Farm size (number of birds) N = 170	Small <=5 000 N = 74	Medium low 5 000–10 000 N = 51	Medium high 10 001–20 000 N = 27	Large >20 000 N = 18
Broilers (contracted farms)	49	71	88	87
Farm size (number of birds) N = 97	Small <=10 000		Medium >10 000–50 000	Large >50 000
Layers	52		55	61

Source: broilers – author's re-estimation based on TDRI data (see more details in Poapongsakorn *et al.*, 2003); layers – Poapongsakorn *et al.* (2003).

using it more productively to feed fish stock in ponds beneath the chicken houses – have ceased to operate as the DLD has "requested" that they turn to closed evap-type housing to counter the HPAI epidemic. During the past few years of HPAI outbreaks, such requests/regulations have been strictly imposed on smaller farms, even though many of these farms only intend to serve the domestic market. Practices like open farming and farming over fish ponds have been deemed "risky" and forbidden in most areas. In many areas, chicken manure has become a liability rather than the valuable asset it once was.

Many smallholders (and larger farmers) who used to have a contractual arrangement with large integrators (usually known as "contract farming") were required to upgrade their poultry housing after the outbreaks. Some were unable to comply and had to stop being contractors. For those who were able to comply, many were contracted only on a rotating basis, as the demand for broilers – in both foreign and domestic markets – has not yet returned to the pre-HPAI level. Some were offered a duck contract instead of a broiler contract by their original patron. Compared with a typical broiler contract, a duck contract is generally less lucrative – partly because of the longer raising period, worse feed conversion ratio, and lower number of birds per batch. However, most contractors who were offered the duck contract accepted because otherwise they would have had to leave their housing unused. Many even considered themselves "lucky" because there were many former contractors who were not offered any contracts at all. Faced with these problems, some farm owners remodelled their chicken housing to raise pigs. Other switched to other livestock or non-livestock professions.

The above examples indicate that many smallholders have made their own adjustments during the three years since the first HPAI outbreak in 2004. A significant number of small farmers (probably more than a half of small broiler farms) have managed to keep their poultry business, even during this difficult time. Some also shifted temporarily to other livestock businesses, hoping to return to poultry farming at some point in the future. A smaller number of farmers have left the broiler and layer sectors voluntarily. It is likely that the adjustments will continue, albeit at a slow pace.

Although it is clear that many smallholders are losing their battle to stay in the poultry industry, it would be wrong to underestimate their capacity to adjust. Many have successfully done so over the past few years by switching to other livestock, other agricultural activities, or even moving out of the agricultural sector[7] – in most cases with little or no assistance from the government or other organizations.

REFERENCES

FAO. 1999. The financial crisis and the livestock sector in Thailand, by V. NaRanong *In Proceedings of the Workshop on the Implications of the Asian Economic Crisis for the Livestock Industry,* held Bangkok on 6-9 July 1999. RAP Publication 1999/29. Bangkok. (earlier version is available http://www.aphca.org/publications/files/1999_29_web.pdf)

Poapongsakorn, N., NaRanong, V. Kanto, U. & Israngkura, A. 2002. *Livestock industrialization, trade and social-health-environment issues for the Thai poultry, dairy, and swine sectors.* Monograph for IFPRI-FAO project Livestock Industrialization, Trade and Social-Health-Environment Impacts in Developing Countries. Washington DC, International Food Policy Research Institute.

Poapongsakorn, N., NaRanong, V., Delgado, C., Narrod, C., Siriprapanukul, P., Srianant, N.. Goolchai, P., Ruangchan, S., Methrsuraruk, S., Jittreekhun, T., Chalermpao, N., Tiongco, M. & Suwankiri, B. 2003. *Policy, technical, and environmental determinants and implications of the scaling-up of swine, broiler, layer and milk production in Thailand*. Monograph for Phase II of an IFPRI-FAO project Livestock Industrialization, Trade and Social-Health-Environment Impacts in Developing Countries. Washington DC, International Food Policy Research Institute.

USDA. 2005. *Thailand poultry and products annual 2005.* GAIN Report Number TH5092, September. Washington DC, Foreign Agricultural Service, United States Department of Agriculture.

USDA. 2006. *Thailand poultry and products semi annual 2006.* GAIN Report Number TH6012, January. Washington DC, Foreign Agricultural Service, United States Department of Agriculture.

USDA. 2007. *Thailand poultry and products. Updated situation for the Thailand poultry industry 2007.* GAIN Report Number TH7030, March. Washington DC, Foreign Agricultural Service, United States Department of Agriculture.

[7] As many broiler farms have switched to non-broiler professions in the past few years, it would also be wrong to conclude as some analysts have, without a good study or survey, that the broiler industry has something like 30 percent idle/surplus capacity that could be reused immediately should the demand return. Although it is likely that some surplus/idle capacity does exist, it is not a trivial job to determine the actual size of the surplus capacity.

The poultry industry in India

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SUMMARY

India's poultry industry represents a major success story. While agricultural production has been rising at the rate around 2 percent *per annum* over the past two to three decades, poultry production has been rising at the rate of around 8 percent *per annum*, with an annual turnover of US$ 7 500 million.

This paper seeks to capture the dynamics of the industry over the more recent past. Utilizing production, price and export data from the period 1995 to 2004, the study seeks to: (a) examine the trends and features of development in Indian poultry over the last ten years or so; (b) identify forces that are driving these changes; (c) predict the structure of developments in the poultry sector, over the next ten or fifteen years and trace its consequences for income, employment, public health, environmental pollution, animal wealth, etc.; and (d) shed some light on how smallholders are likely to be affected by the ongoing structural changes, i.e. whether it will seriously undermine their competitiveness, and if so what are the options available. The analysis shows a sharp jump in India's egg and poultry meat production. Poultry meat has outpaced its two major competitors – beef and veal, and buffalo meat. Another major development in Indian poultry production is the spread of integration, which is occurring very rapidly, especially in broiler production, both in southern and western parts of India.

The forces that are sustaining this growth are many. High per capita income growth and relatively low prices have played a catalytic role. A moderate shift in the consumption pattern from vegetarianism to non-vegetarianism is also helping the industry by increasing the demand for poultry products. The future outlook for Indian poultry also appears to be very favourable. The most conservative estimates predict a two- to three-fold increase in poultry production over the next ten or fifteen years. However, a worrisome feature of the accelerated growth and the ongoing structural change seems to be its potential impact on the future of small and marginal producers. While several studies on the theme have contended that vertical coordination in agricultural supply channels helps to lower the transaction costs and market risk of smallholders, it has proved difficult to support the contention in the case of poultry. Drawing on an earlier study conducted by the first author, it is shown that contract farmers earned lower profits than non-contract farmers.

In this study, we draw three alternative scenarios and trace their implications, using the OECD-FAO Agricultural Outlook AGLINK-COSIMO model. First, we assume that import of maize, the main feed ingredient, is liberalized. Second, we study the consequences of import liberalization of poultry meat and eggs. Third, we evaluate the consequences of an outbreak of avian influenza (AI).

The complete elimination of tariff on maize will not affect India's imports, because domestic prices (plus tariff) are less than world prices. A complete liberalization of imports of poultry meat could be disastrous for the domestic poultry industry – production would fall significantly; however, the consumer price would decline leading to increased consumption. The consequences of an outbreak of AI would be a significant decline in consumer price and the level of consumer demand. However, prices would revert to their normal trend within a year, and the level of consumer demand would return to normal within a year.

1 INTRODUCTION

The poultry industry in India represents a major success story. What was largely a backyard venture before the 1960s has been transformed into a vibrant agribusiness with an annual turnover of Rs 30 000 crores. Today, India is the third largest egg producer in the world (after China and the United States of America), and the nineteenth largest broiler producer. Undoubtedly, this impressive growth is a result of several factors, such as active developmental support from the state and central government, research and development support from research institutes,[1] international collaboration and private sector participation. A point worth mentioning here is that Indian poultry is self-sufficient, supported by a broad and strong genetic base in which the productivity levels[2] of broilers and layers are equal to those achieved elsewhere (e.g. in the United States of America and the European Union). Undoubtedly, these achievements are quite significant. Today, however, globalization is posing greater challenges: namely, making the industry globally competitive and viable; and fulfilling the quite enormous potential for growth that is presented by changing food habits and preferences.

In what follows, an attempt is made to describe the trends and features of development in the Indian poultry industry over the last ten years; probe the underlying factors; and predict what lies ahead, including the threats posed to smallholders. Specifically, the study seeks to:

- describe the structural changes in the poultry industry from (approximately) 1995 to 2005;
- identify and evaluate the relative importance of the drivers that have caused this structural change;
- predict future scenarios and assess possible consequences for income and employment, biosecurity and public health, environmental pollution, animal welfare, food supply and demand; and
- speculate as to how smallholders are likely to be affected by the ongoing structural changes.

The analysis is carried out based on secondary data, including reports from the Govern-

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1 Among the public sector institutions, the Indian Council for Agricultural Research is the nodal organization and includes the Indian Veterinary Research Institute, (Izatnagar), the Central Avian Research Institute (Izatnagar), and the project Directorate on Poultry, ICAR, Hyderabad. In the private sector, the Institute of Poultry Management of India (IPMI) in Pune and C & M Hatcheries Pvt. Ltd, Nasik, have been imparting practical training in poultry management. Then there are 30 veterinary colleges and over 80 agricultural colleges functioning as constituent units of 27 agricultural universities.

2 Productivity level is defined as feed conversion ratio (FCR). In this paper, productivity is generally defined as FCR unless otherwise stated.

ment of India (GOI), international agencies and the private sector, and interactions with different stakeholders including industry experts, state governments and cooperatives. The paper is organized as follows: in section 2, we begin by examining the growth of the poultry industry, including structural changes over the past ten years (approximately 1995 to 2005); in section 3 we seek to identify the main forces that lie behind this achievement; in section 4 we try to predict the future outlook, i.e. the long-term growth of the industry; three policy scenarios are also assessed using the AGLINK-COSIMO model; section 5 seeks to answer the question, what are the threats posed by large-scale industrialization of poultry to smallholders? In the final section we draw concluding observations based on our findings.

2 GROWTH AND STRUCTURAL CHANGE

Annual per capita consumption in India is only 42 eggs and 1.6 kg of poultry meat, which is below the levels recommended by the Nutritional Advisory Committee[3] – 180 eggs and 10.8 kg of poultry meat.

2.1 Recent trends in poultry production: eggs and meat

Trends in egg and poultry meat production for the period 1995-96 to 2004-2005 are shown in Table 1. For eggs and poultry meat, we report three alternative estimates of data: the first from FAO; the second from the United States Department of Agriculture (USDA); and third from the GOI. The official government data for poultry meat[4] are often alleged to be biased downwards; and hence, we are obliged to rest on FAO and USDA sources.

The data show several striking points:

- Columns (1) and (3) show a big increase in egg production. In 2004-2005, India produced 45.2 billion eggs compared to 27.1 billion eggs in 1995-1996. This represents a 66 percent increase over the ten year period. The table also shows that growth has been faster after 2000 than before.
- Columns (4) and (5) indicate a sharp increase in poultry meat production. The increase is 175 percent over the 1995 to 2005 period according to FAO data and 120 percent according to USDA data.

[3] The National Institute of Nutrition, India has recommended that a balance diet should contain 30 grams of eggs per day (i.e. 180 eggs *per annum*) and 30 gms. of meat (11 kg *per annum*).

[4] FAO and USDA were earlier taking the same data as that of GOI, but they have now revised their time-series for poultry meat from 1993 onwards. In this context, USDA (2004) mentions "assessing recent trends in Indian poultry, production and consumption are complicated by poor and conflicting data. Government and industry sources publish very little reliable data on the Indian poultry sector. Available government data consist only of periodic poultry population estimates, with the most recent estimates based on a 1992 livestock census. Government sources also report wholesale poultry prices for a few markets, but there are no official statistics on poultry consumption, marketing, processing, or feed use. The Food and Agriculture Organization of the United Nations (FAO) and the United States Department of Agriculture (USDA) publish estimates of Indian poultry supply and use, but, in the absence of supporting survey information, these estimates do not have a strong statistical foundation. Trade associations, including the Poultry Federation of India, also do not currently compile industry wide data." As the USDA and FAO figures are close, official production statistics seem to be biased downwards. The flow charts given later in this section also support the view that Indian poultry meat production is higher than the GOI official trade statistics . In addition, there is significant difference between growth rates of production (quantity) and value (constant price), based on official statistics. AMAD also relies on FAO data.

TABLE 1
Production of eggs and poultry meat in India, 1995-1996 to 2004-2005

Year	Egg production			Poultry meat (1 000 tonnes)		
	FAO estimates (1 000 tonnes)	USDA estimates (million eggs)	GOI estimates, (million eggs)	FAO estimates	USDA estimates	GOI estimates
	(1)	(2)	(3)	(4)	(5)	(6)
1995-1996	1 496	28 000	27 198	624	590	--
1996-1997	1 512	29 100	27 496	714	610	--
1997-1998	1 579	32 000	28 689	648	630	--
1998-1999	1 621	34 000	29 476	763	670	361.81
1999-2000	1 675	35 000	30 447	875	690	382.3
2000-2001	2 015		36 631	1 136	710	364.06
2001-2002	2 130		38 729	1 307	1 250	393.51
2002-2003	2 190		39 823	1 460	1 400	439.05
2003-2004	2 222		40 403	1 662	1 600	507
2004-2005	2 468		45 201	1 715		507
2005-2006	2 539					537
Growth rate (% *per annum*)*	6.18	6.24	6.18	14.0	14.09	6.50
Growth rate 1998–2004 (% *per annum*)*	8.78		8.79	18.52	22.97	4.24

*Based on regression equations.
Sources: GOI, (2006); FAOSTAT (2006) as reproduced in GOI (2006). USDA estimates are from Foreign Agricultural Service GAIN Report, India Poultry and Products Annual, various issues.

- Overall, the data suggest that poultry industry has grown at the rate of around 14 percent *per annum*.

The upward trend is even stronger in value terms (see Table 2). Both egg production and poultry meat production appear to have registered a 100 percent growth in value terms (current prices in local currencies) over the 1995 to 2005 period. Meat is the most important product in the poultry sector having a 66.7 percent share of poultry output (in value terms). There is significant difference between the growth rate of the value (at constant price) and the growth rate of the quantity of egg production. This may be due to change in the balance between desi fowl and imported fowl in the production of eggs.

2.2 The relative importance of poultry in the national livestock sector

India is one of the most important livestock-rearing countries, with a large population of cattle, buffaloes, sheep, goats and other species of livestock. The country has 1/6 of the

TABLE 2
Value of output from poultry

Year	Current prices (Rs crores)			Constant prices (1993-1994 prices)	
	Egg	Poultry meat	Total value	Egg	Meat
1995-1996	2 834	5 846	8 680	2 515	5 036
1996-1997	3 168	6 217	9 385	2 536	5 032
1997-1998	3 419	6 916	10 335	2 682	5 208
1998-1999	3 516	6 808	10 324	2 708	5 280
1999-2000	3 874	8 223	12 097	2 817	5 486
2000-2001	4 587	10 714	15 301	3 222	6 793
2001-2002	4 874	11 926	16 800	3 396	7 894
2002-2003	4 956	11 020	15 976	3 571	7 740
2003-2004	5 013	11 283	16 296	3 623	8 004
2004-2005	5 567	11 259	16 826		
Growth. rate (% *per annum*)*	8.74	11.57		5.51	7.53
Growth rate 1998–2004 (% *per annum*)*	7.62	10.55		6.55	9.77

*Based on regression equations.
Sources: GOI, national income accounts statistics, various issues.

world's cattle and about 1/2 of the world's buffalo population. India ranks sixth terms of sheep and goat population. The pig population is about 12.79 million. The improved layer bird population is around 104 million.[5]

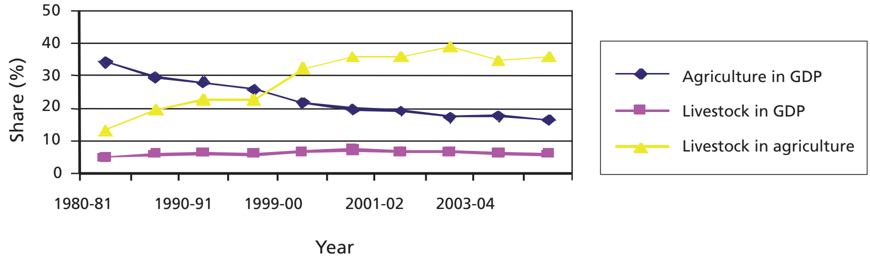
In terms of value, the share of livestock in GDP was 4.8 percent in 1980-1981, based on official GOI statistics. By 2000-2001 the share had risen to 7.33 percent; but it dropped to 6.10 percent by 2004-2005. The growing prominence of the livestock sector can also be seen if we look at trends in the relative share of this sector in the agricultural sector as a whole – 13.8 percent in 1980-1981 rising to 36.51 percent in 2004-2005, the latter figure indicating that out of every 3 rupees produced in agriculture, more than 1 rupee comes from the livestock sector. Figure 1 illustrates the changing structure of the Indian economy at large.

Compared with the rest of livestock sector, the poultry industry in India is better organized and is progressing towards modernization. What is the contribution of poultry sector to India's GDP? It has remained below 1 percent, as can be seen from Table 3.

The relative share of poultry in the national economy has remained below 1 percent, but its share in the livestock sector is continuously rising. This can be seen from Figure 2. The relative share of poultry in total livestock production has risen from 10 percent in 1996-1997 to 12 percent in 2003-2004.

[5] All India Poultry Year Book (2003–2004).

FIGURE 1
Share of agriculture and livestock in GDP (at current price in local currency)



Source: GOI, national accounts statistics, various issues.

TABLE 3
Share of poultry in GDP, 1995-2004

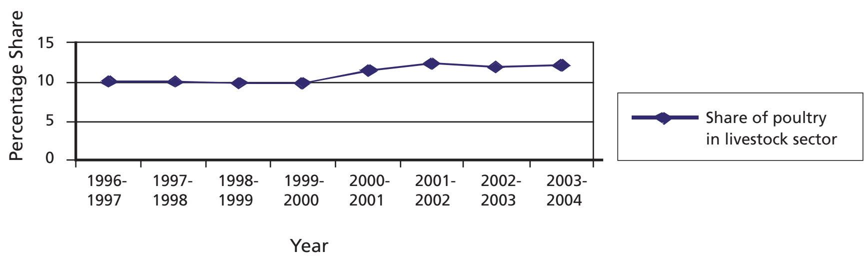
Year	Eggs*	Meat*	Total poultry (eggs + meat)*	Total GDP*	Share of poultry in GDP (%)
1995-1996	2 515	5 036	7 551	899 563	0.84
1996-1997	2 536	5 032	7 568	970 083	0.78
1997-1998	2 682	5 208	7 890	1 016 594	0.78
1998-1999	2 708	5 280	7 988	1 082 748	0.74
1999-2000	2 817	5 486	8 303	1 148 442	0.72
2000-2001	3 222	6 793	10 015	1 198 592	0.84
2001-2002	3 396	7 894	11 290	1 267 945	0.89
2002-2003	3 571	7 740	11 311	1 318 362	0.86
2003-2004	3 623	8 004	11 627	1 430 548	0.81
Growth Rate** (% *per annum*)	4.78	6.22	5.78	5.98	

*Rs crores, at 1993–1994 prices.
** Based on simple average of annual growth.
Sources: GOI, national accounts statistics, various issues.

2.3 The relative importance of poultry meat over other meats

Poultry is today the major source of meat in India. Its share in total meat consumption is 28 percent, as against 14 percent ten years ago. It has outpaced its two competitors – beef and veal, and buffalo meat (see Table 4). High mutton prices, religious restrictions on beef and pork, and the limited availability of fish outside coastal regions have all helped to make poultry meat the most preferred and most consumed meat in India. Expanding domestic production and increasing integration have pushed poultry meat prices downward and stimulated its consumption.

FIGURE 2
Share of poultry in the livestock sector in value terms



Note: calculated at 1993–1995 prices.
Source: GOI, national accounts statistics, various issues.

TABLE 4
Market shares of various meats in Indian meat production/consumption

Year	Beef and veal	Buffalo meat	Mutton/lamb	Goat meat	Pork meat	Poultry meat
			(%)			
1995	30	30	5	10	11	14
1998	29	29	5	10	10	17
2000	28	28	5	9	9	21
2001	26	26	5	9	9	25
2002	26	26	5	8	9	26
2003	25	25	5	8	9	28
2004	25	25	5	8	9	28

Sources: FAOSTAT (2006) as reproduced in GOI (2006).

2.4 Role of poultry in employment

In 1980, when the poultry sector produced 10 billion eggs and 30 million broilers, respectively, total levels of employment in the sector were not very encouraging. As the income and employment in the crop sector started to diminish, there was a big shift to the non-crop sector, which includes poultry and dairy. With demand increasing and the production level reaching 37 billion eggs and around 1 billion broilers in 1999-2000, the sector is estimated to employ around 1.6 million people (Mehta *et al.*, 2002). Whereas 80 percent of the employment is generated directly by the farms, 20 percent is generated in the provision of feed, pharmaceuticals, equipment and other services required by the poultry sector. Additionally, there may be a similar number of people who are engaged in marketing and other channels servicing the sector. By 2005, the total egg production in the country had passed 46 billion, and with higher broiler production, the estimated employment was 2.5 million (Desai, 2004). Employment statistics for 1999-2000 and 2005 are not comparable, as there are no reliable time-series data. The statistics for these two years are based on the estimates of industry experts. However, GOI provides data on employment by usual-activity status for a few sectors including livestock. Table 5 shows total numbers employed in the livestock sector for selected years. As a large number of farm households do not consider livestock to be their primary employment, much livestock-related employment may not be reflected in the data presented in Table 5.

Presently, India's per capita annual consumption is 42 eggs and 1.6 kg of poultry meat. The National Institute of Nutrition recommends that a balanced diet should contain 30 grams of eggs/day (i.e. 180 eggs *per annum*) and 30 grams of meat (11 kg *per annum*). Assume that out of this at least 9 kg would be met by poultry meat, given the constraints affecting growth of other forms of meat such as beef. Thus, the gap between the present per capita and the recommended per capita consumption is 138 eggs and 7 kg of chicken meat. How much employment can the industry generate? As and when the gap in production is bridged and the industry grows to the desired level, it can be expected to provide employment to over 9 million people (ibid.).

TABLE 5
Employment by usual activity status

	1983 (38th round)	**1987-1988 (43rd round)**	**1993-1994 (50th round)**	**1999-2000 (55th round)**
		(1 000 people)		
Agriculture	178 277 (66.32)	189 922 (63.91)	207 576 (62.52)	193 766 (57.60)
Livestock	11 973 (4.45)	12 380 (4.26)	9 789 (2.95)	8 027 (2.40)
Mining	1 730 (0.64)	2 139 (0.74)	2 684 (0.81)	2 026 (0.60)
Manufacturing	29 390 (10.93)	32 510 (11.17)	35 451 (10.68)	36 487 (10.84)
Electricity, gas, water	850 (0.32)	1 032 (0.35)	1 312 (0.40)	893 (0.27)
Construction	6 642 (2.47)	11 598 (3.99)	11 512 (3.47)	15 405 (4.58)
Trade	17 920 (6.67)	27 345 (7.34)	26 287 (7.92)	34 138 (10.32)
Transport	7 261 (2.70)	8 186 (2.81)	10 209 (3.08)	12 712 (3.78)
Services	25 563 (9.53)	28 030 (9.63)	36 709 (11.06)	32 525 (9.67)
Total employed workers	268 820	290 930	332 000	336 610

Note: figures in parentheses are percentages of the total.
Sources: Sarvekshana 35th issue, April 1988, NSS 38th round, Jan 1983-Dec 1982.
Sarvekshana Special No: Sept 90, NSS 43rd round, Jul 1987-June 1988.
Sarvekshana15th issue Vol. V No. 1&2 July-Oct 1981, NSS 32nd round.
NSS Report No.409, 50th round (July 1993-June 1994).
NSS Report No 458, 55th round (July 1999-June 2000).

2.5 Livestock and poultry populations: Government of India statistics

Growth of the poultry sector depends partly on the size of the poultry population and partly on productivity. The annual growth rate of the livestock population (excluding poultry) in India was 0.93 percent during the period 1950–1956, rising to 2.60 percent by 1977–1982. However, it recorded a negative growth rate of -0.01 percent during 1997–2003. Growth in the poultry sector was 5.22 percent in 1951–1960, fell to 0.21 percent in 1961–1966, rose to 5.79 percent in 1982–1987, and to 5.85 percent in 1997–2003 (Table 6).

The population of layers increased from 166.07 million to 215.07 million between 2000-2001 and 2005-2006, indicating a growth of 29.5 percent over five years. Production of eggs increased from 28 443 million to 43 647.7 million during the same period, indicating a growth of 53.45 percent. The number of eggs produced per hen increased

TABLE 6
Trends in livestock and poultry populations since 1951

Year	Total livestock (excluding poultry)	Poultry
	Population in millions	
1951	292.80	73.50
1956	306.60	94.80
1961	335.40	114.20
1966	344.10	115.40
1972	353.40	138.50
1977	369.00	159.20
1982	419.59	207.74
1987	445.28	275.32
1992	470.86	307.07
1997	485.39	347.61
2003	485.00	489.01
	Annual growth rate (%)	
1951-1956	0.93	5.22
1956-1961	1.81	3.79
1961-1966	0.51	0.21
1966-1972	0.55	3.72
1972-1977	0.86	2.82
1977-1982	2.60	5.47
1982-1987	1.20	5.79
1987-1992	1.12	2.21
1992-1997	0.61	2.51
1997-2003	-0.01	5.85

Sources: GOI (2006).

from 171 to 203 *per annum*, indicating a growth of 18.71 percent (Table 7). Thus, productivity growth accounted for 35 percent of the growth in egg production. However, this productivity measure does not take into account the incremental cost of inputs. If the incremental cost becomes higher than the average cost, the farmers may start another cycle of production.

Assuming that the productivity of hens is the same throughout the country, the level of development of poultry production in a given region has to be judged on the basis of number of fowls per unit of population. The national average of the number of fowls per 100 persons is 47 (Table 8). The highest density is observed in the Southern region (62 fowls per 100 persons) followed by Eastern region (44 birds per 100 persons). The North and Central regions have the lowest densities (16 and 17 fowls per person, respectively). The annual growth rate of total poultry population during the period from 1997 to 2003 was 5 percent *per annum.*

2.6 Regional variations in production: Government of India statistics

Yet another striking feature of the Indian poultry industry is the presence of significant regional variation. Figures 3 and 4 illustrate these regional variations in egg production for

TABLE 7
Growth in numbers of layers and eggs produced

Year	Type	Number of layers (million)	Number of eggs (million)	Eggs per layer (yield)
2000-2001	Desi (local)	84.08	8 825.5	104.96
	Improved	81.99	19 617.5	239.26
	Total	166.07	28 443.0	171.27
2005-2006	Desi (local)	81.28	9 083.0	111.7
	Improved	133.79	34 564.7	258.3
	Total	215.07	43 647.7	202.95

Sources: GOI (2006).

TABLE 8
Poultry population and growth across India regions

State	Number of fowls per 100 persons	Annual growth rate of poultry 1997–2003
South	62	8.9
East	43	3.3
West	23	1.5
North	16	1.2
Central	17	5.0
India	47	5.2

Sources: GOI (2006).

1997-1998 and 2005-2006. Both the Eastern and Northern regions accounted for about 13 percent of total production (the share of the Eastern region has fallen from 19.60 to 13.45 between 1997-1998 and 2005-2006) respectively. The West and the Central regions accounted for 10 percent or less of total egg production in 2005-2006.

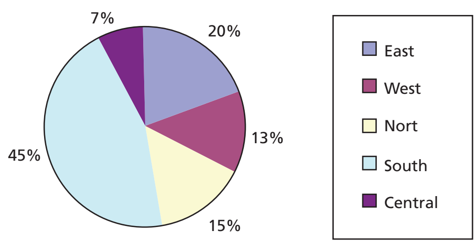
Eight states account for bulk of egg production in India – Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Tamil Nadu and West Bengal. Andhra Pradesh is the largest egg producing state, accounting for nearly 40 percent of egg production in the country. After Andhra Pradesh comes, Tamil Nadu – the share of the state in all India production increased from 11.21 percent in 1997-1998 to 13.46 percent in 2005-2006.

One district, of Tamil Nadu – Namakkal – alone accounts for more than 30 percent of total broiler production. Although, a major portion of poultry production is concentrated in clusters, this is one of the most concentrated districts in India. There are several reasons that may account for this concentration, including the presence of an egg powder plant and availability of feed mills nearby.

Per capita egg and chicken meat availability is also highest in the southern states, followed by the northern and western states, and least in the eastern and central states. The cost of production is also lowest in the southern region for both eggs and meat, largely because of: i) vertical integration in the sector; ii) lower variation in temperature in the

FIGURE 3

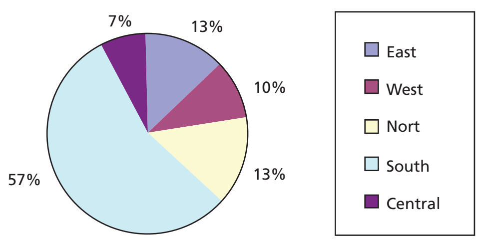
Share of various regions in egg production, 1997-1998



Source: GOI (2006).

FIGURE 4

Share of various regions in egg production, 2005-2006



Source: GOI (2006).

southern states; iii) easy availability of medicines, vaccines and veterinary services; and iv) the fact that the poultry revolution was started in the south by Dr B.R. Rao, who is commonly known as father of poultry sector in India. Though the distribution of poultry production is much greater in rural than that in urban areas, the markets are predominantly urban.

2.7 The poultry industry chain – layers

Figures 5 to 8 show flow charts for volume and value in the layer value chain for the years 2000-2001 and 2005-2006. The following points should be noted:

- The number of eggs sent for processing is calculated on the basis of information supplied by the industry. Approximately 2 percent of total egg production is reported to be sent for processing.
- Values other than exports are calculated based on the unit values derived from national income accounts statistics.
- The rural/urban division is made by applying a 60:40 ratio, again based on the opinion of industry experts.
- The number of spent layers (layers going to the live bird market after around 52 weeks) is calculated assuming a 15 percent mortality rate – information from industry sources. However, no such information was available for Desi fowls. Hence, it was difficult to work out the number entering the live bird market.
- The value of desi eggs is calculated by estimating the price to be 2.25 times that of normal eggs.

2.8 The poultry industry chain – broilers

Figures 9 to 12 show flow charts for volume and value in the broiler value chain for the years 2000-2001 and 2005-2006. The following points should be noted:

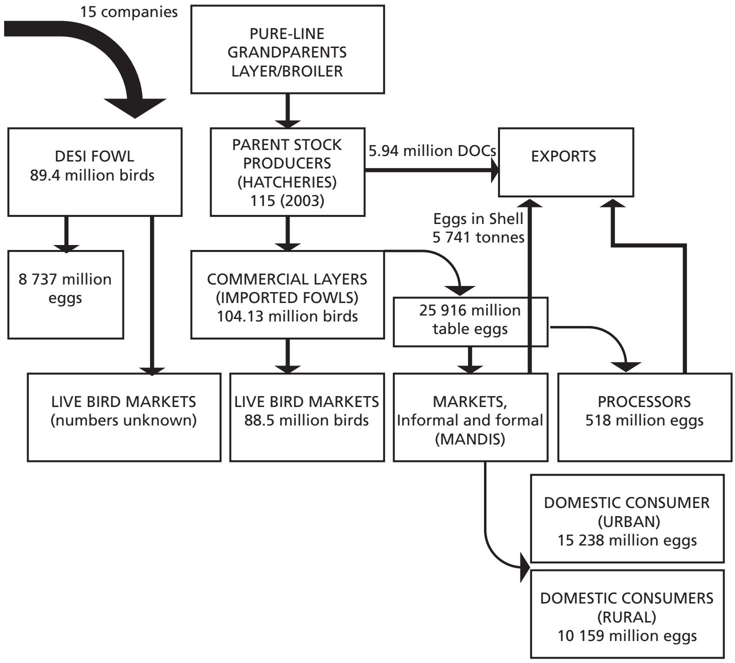
- The number of broilers going for processing is calculated on the basis of information supplied by the industry. Approximately 5 percent of total broiler production is reported to be going for processing.
- Values other than exports are taken from FAO.
- Desi fowls are generally not used for commercial poultry meat.
- Sources of other data: for broilers and chicken meat: FAOSTAT; yield: Animal Husbandry Statistics, Department of Animal Husbandry, GOI; grandparent to DOCs: 100 pullet chickens for each parent for the year 2005, and 95 pullet chickens for the year 2000.

2.9 Trade scenario

The trends in India's poultry exports for the period 1996-1997 to 2005-2006 are shown in Table 9. It can be seen that eggs and egg-based products account for 90 percent of India's poultry exports. Exports of hatching and table eggs have increased dramatically – from Rs 196 million in 1996-1997 to Rs 408 million in 2005-2006. Similarly, exports of egg powder have increased from Rs 351 million in 1996-1997 to Rs 1126 million in 2005-2006 (there was a drastic fall in exports of egg powder between 1997 and 2000 because of the ban imposed by the European Union (EU) on egg powder imports from India, but there was a

FIGURE 5

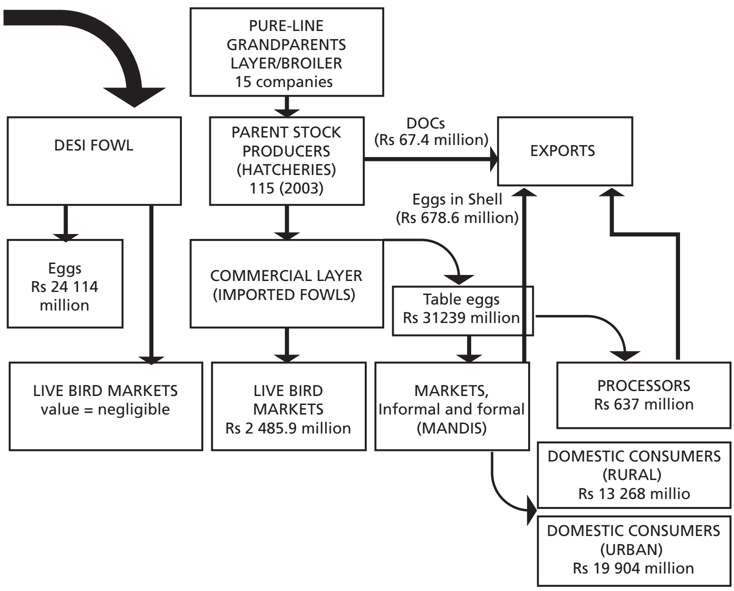
Flow chart for layers 2000-2001 – volume



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 6

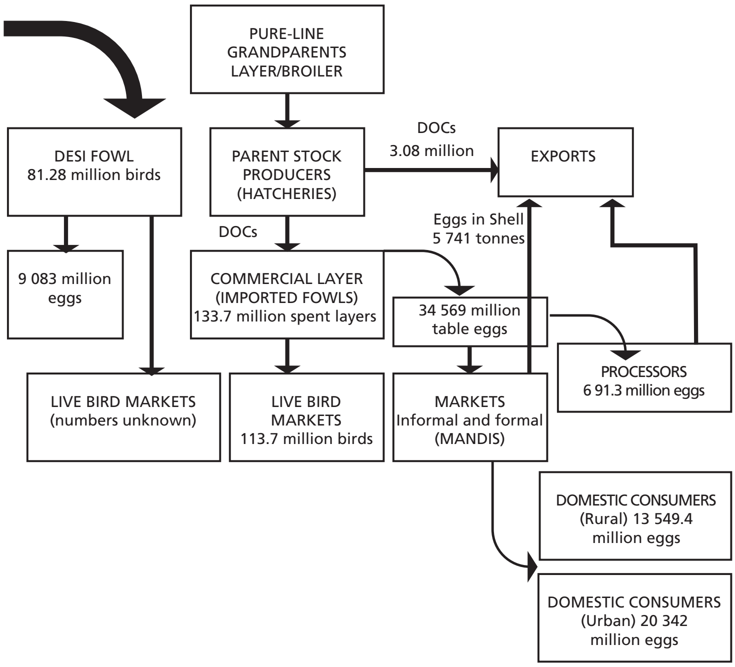
Flow chart for layers 2000-2001 – value



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 7

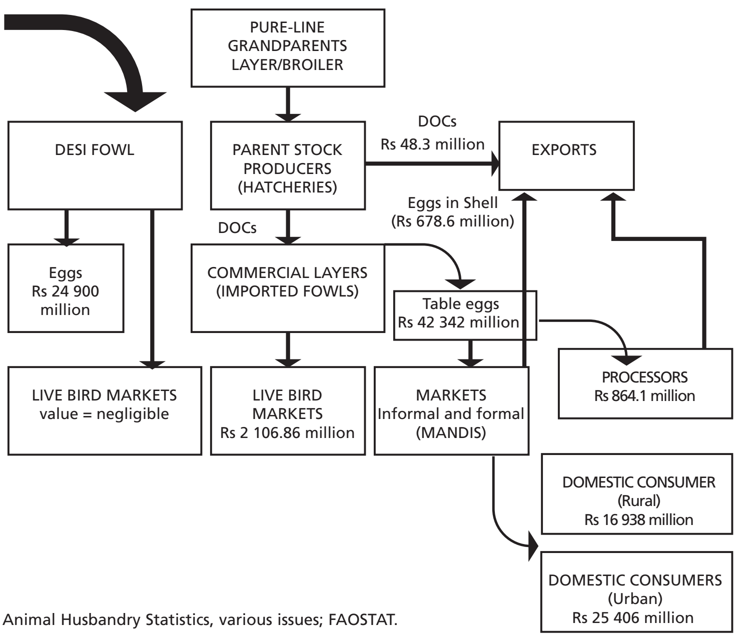
Flow chart for layers 2005-2006 – volume



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

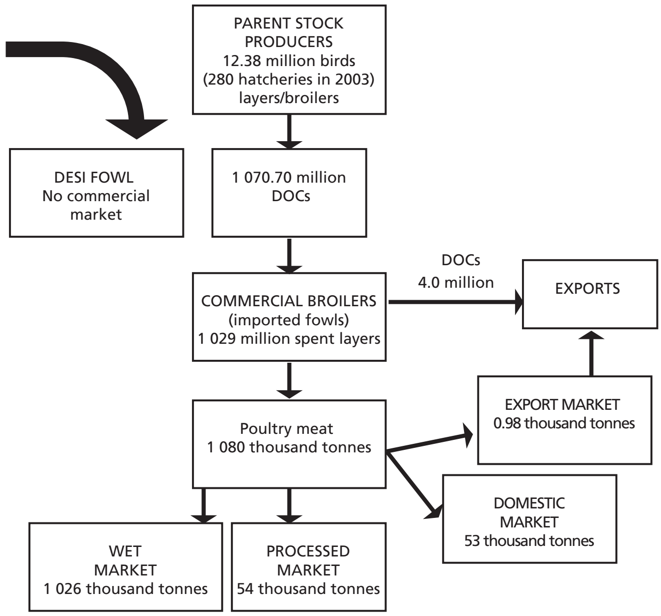
FIGURE 8

Flow chart for layers 2005-2006 – value



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 9
Flow chart for broilers 2000-2001 – volume



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

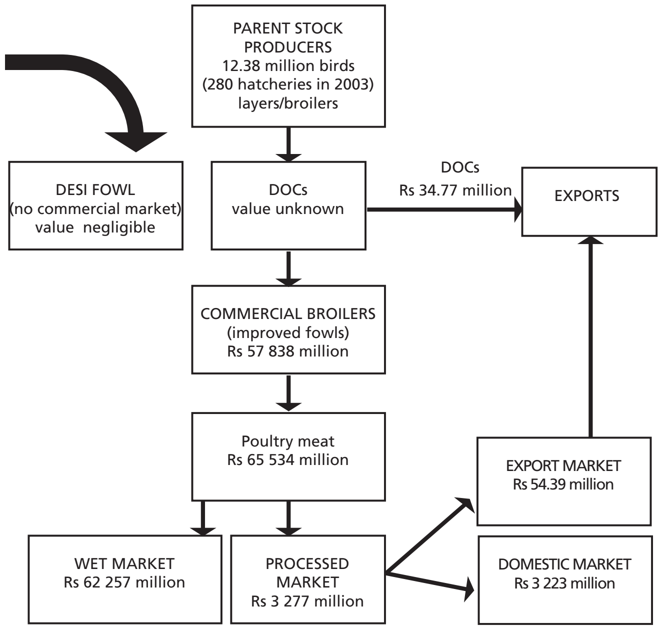
recovery from 2001 onwards). Another egg item that shows a rapid increase is "egg dried, frozen"; exports of this item have gone up from Rs 49 million in 1996-1997 to 107 million in 2005-2006. India's exports of genetic stock and feed (maize and soybean) are not very significant.

At the same time, imports of genetic stock, compound feed, maize, soybean and poultry products have been negligible, this can be attributed to several reasons. First, India's import policy restricted or banned imports of poultry genetic stock, feed and products through quantitative restrictions.[6] Although, from the early 1990s, India has sought to dismantle quantitative trade restrictions, this has so far by-passed the livestock sector except in some exceptional cases.[7] Second, the tariffs are still very high on poultry products. Third, Indians prefer fresh rather than processed poultry meat.

[6] It used to be called "negative list", which generally means that items cannot be freely imported.

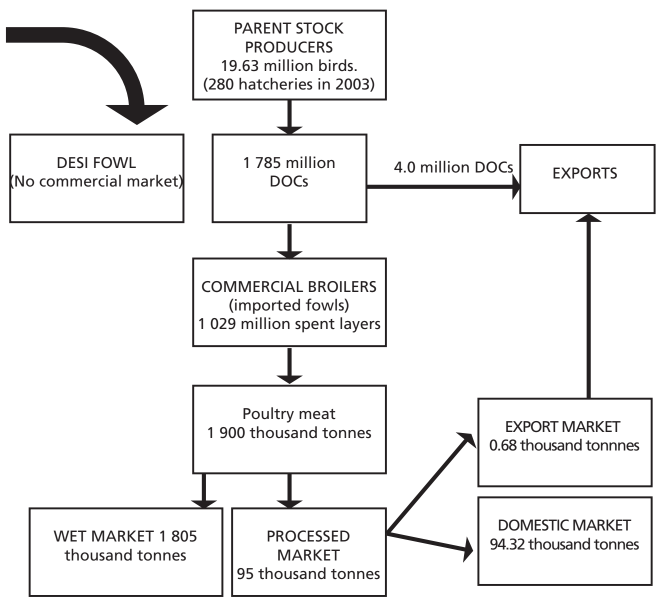
[7] For example, imports for hotels and restaurants were generally permitted. This restriction is also removed with effect from April 1, 2001, as per India's commitment to WTO (see Mehta *et al.*, 2005).

FIGURE 10
Flow chart for broilers 2000-2001 – value



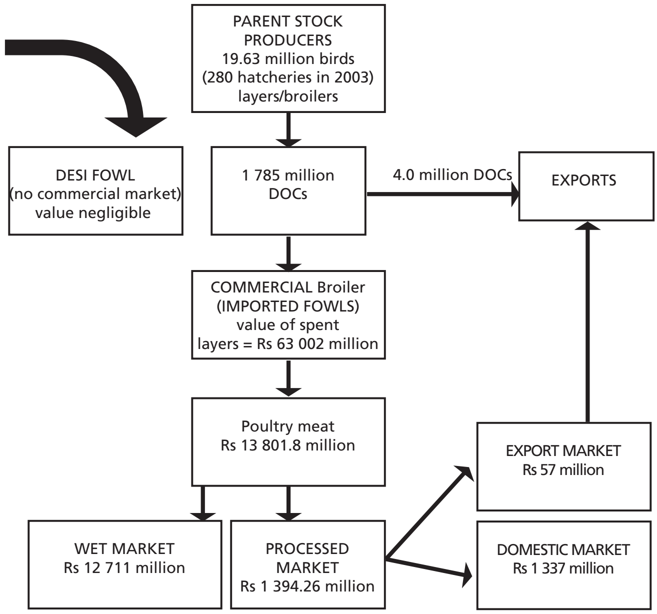
Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 11
Flow chart for broilers 2005-2006 – volume



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

FIGURE 12
Flow chart for broilers 2005-2006 – value



Sources: GOI Basic Animal Husbandry Statistics, various issues; FAOSTAT.

Main export markets

Kuwait, Oman, Saudi Arabia, the United Arab Emirates and Yemen have been major importers of India's table and hatching eggs. Similarly Germany, Austria, Japan, the Netherlands and the Republic of Korea have been the most important markets for India's egg powder. Due to a slump in sales in the EU and a decline in demand in Japan, egg powder exports declined sharply in 1998. The slump continued till 2000, after which it started to recover.

India also exports live poultry in the form of day-old chicks (DOCs). The main export markets for India's live poultry are countries of the SAARC (South Asian Association for Regional Cooperation) region (Table 10).

2.10 Structure of poultry production

Poultry farming involves breeding and raising chicks[8] for various purposes. Breeding farms hatch and raise poultry for sale to other farms. Broiler farms rear chickens for their meat, procuring day-old chicks and keeping them for around six weeks. Layer farms keep hens to produce eggs. Another category of operators, which can loosely be termed "integrators",

[8] In other countries, poultry consists of birds such as turkeys, ostrich, chickens, ducks, pigeons, geese, etc. But in India, poultry is largely confined to chickens and to some extent ducks.

TABLE 9
India's exports of poultry

Year	Live poultry		Eggs in shell		Egg powder		Egg dried and frozen		Poultry meat		Total value (Rs lakhs)
	Q	V	Q	V	Q	V	Q	V	Q	V	
1996-1997	-	630.96	4 080	1 962.4	2 407	3 519.02	461	491.12	357.42	321.99	6 925.49
1997-1998	-	125.98	2 223	3 907.1	1 955	2 927.00	1 660	1 320.97	223.80	172.21	8 453.26
1998-1999	-	324.30	6 123	3 503.62	800	1 301.88	4 457	999.00	881.02	220.58	6 349.38
1999-2000	2 725.2	256.04	3 445	3 400.00	1 057	1 064.00	1 139	705.00	159.80	158.17	5 598.21
2000-2001	4 598.0	518.46	5 741	4 021.00	1 946	2 551.00	3 548	1 536.00	109.80	123.80	8 741.26
2001-2002	4 047.0	347.75	-	5 090.02	1 774	2 353.99	8 924	5 312.90	304	142.91	13 247.57
2002-2003	4 448.0	535.21	-	4 359.68	3 365	4 324.32	12 425	6 617.06	917	524.50	16 360.78
2003-2004	3 843.0	465.58	-	7 228.36	3 238	4 989.26	6 968	5 900.71	4 575	2 419.38	21 001.29
2004-2005	2 987.0	474.96	-	5 731.23	2 246	2 873.95	3 477	6 407.39	2 733	1 536.32	17 023.85
2005-2006	594.0	99.78	-	4 079.33	7 700	11 261.30	1 500	1 068.07	667	441.76	16 950.24

Q = quantity in tonnes (for live poultry Q = number ×1 000); V = value in Rs lakhs.
Sources: All India Poultry Directory, Year Book: 2003-2004; and CMIE, India's Trade.

TABLE 10
India's country-wise exports of live poultry

Country	1995-1996		1997-1998	
	Q	V	Q	V
Fowls of the species *Gallus domesticus* - FGDD (DOC)				
Bangladesh	14.52	112.2	1.50	11.97
Nepal	0.2	3.74	0.66	2.49
South Africa	-	-	1.18	12.25
United Arab Emirates	2.48	28.87	2.14	16.32
United States of America	-	-	0.09	0.52
Sub-total	17.93	144.90	0.35	4.01
Live Poultry other than FGDD (DOC)			6.07	49.01
Bangladesh	65.57	392.64	5.89	51.37
Nepal	1.01	4.15	0.61	3.00
Oman	0.23	2.07	-	-
Saudi Arabia	0.89	8.67	0.20	1.32
Sri Lanka	2.60	24.32	1.33	14.57
United Arab Emirates	0.65	7.31	-	-
Sub-total	72.99	656.98	8.54	74.99
FGDD (excluding DOC)				
Bangladesh	0.01	0.53	-	-
Nepal	-	-	0.19	1.10
Sri Lanka	-	-	0.03	0.33
Sub-total	0.01	0.53	0.33	1.56
Live Poultry other than FGDD (non-DOC)				
Bangladesh	0.50	6.20	-	-
Nepal	0.34	4.81	0.06	0.19
Sri Lanka	0.02	1.35	0.17	1.70
United Arab Emirates	-	-	-	-
Sub-total	0.85	12.36	0.23	1.88
Total	91.78	814.45	15.07	127.44

Note: Q = number in lakhs; V = value in Rs lakhs.
Source: Animal Quarantine and Certification Service Stations Department of Animal Husbandry and Dairying, Government of India.

keep breeding stock and also operate hatcheries and commercial broiler farms. There are estimated to be roughly one lakh layer farmers and an equal number of broiler farmers.[9] About 70 percent of these are small-scale (3 000 – 10 000 birds) and medium-scale (10 000 – 50 000 birds) farmers.[10] Only 10 percent are large-scale farmers with units varying from 50 000 to 4 lakh birds.

Large farms require a good level of automation. Automation has become necessary for a number of reasons, such as hygiene and sanitation, disease prevention and, in the case of hatchery operations, to produce a greater number of chicks in a single hatch and to ensure better quality chicks. The whole organized poultry sector uses hybrid varieties of poultry and has adopted cages. The small and marginal farmers generally operate on the deep litter system.[11] In terms of technology, farmers have adopted new feeding and water systems and new management, healthcare and hygiene practices.

A distinctive feature of Indian poultry production is that it is self sufficient, supported by a very broad and strong genetic base in which the productivity level (feed conversion ratio – FCR) of broilers and layers is equal, if not superior, to those found in developed countries such as the United States of America and the European Union. India is also one of the few countries of the world, which has put into place and a sustained specific pathogen free (SPF) egg production project, which can be described as the last word in poultry technology.

There are a dozen processing units for broilers and about three units for egg processing (a further three are not producing at present). All egg-processing units, such as Balaji Foods of Venketeswara Hatcheries and SKM of Erode, have put in place the hazard analysis and critical control point (HACCP) system in their processing units.

The poultry processing industry in India is still at a nascent stage and is growing at a very slow pace. Most chickens in Thailand, Indonesia and Malaysia are processed and branded. However, in India only 2 to 3 percent of the total poultry meat is processed. The major impediments to the poultry processing are as follows:

- Indian consumers mostly prefer live and fresh chicken butchered before their eyes, which results in 95 percent of chickens being slaughtered by the retailers in a very unhygienic manner.
- a lack of cold chain facilities, exacerbated by power shortages, which makes it difficult to make frozen, freshly chilled chicken available to the consumer; and
- a lack of promotional campaigns for chicken products, as some sections of society are opposed to non-vegetarian food.

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9 See Mehta *et al*. (2002).

10 Since the 1980s, there has been a great change in both structure and size of layer and broiler farms. Particularly, broiler farms have grown rapidly both in terms of number and size. Earlier, broiler farms would raise a few hundred birds per cycle, whereas today farmers raise 10 to 15 thousand birds per week cycle (Mehta *et al*., 2002)

11 See Mehta *et al*. (2002).

2.11 Major players in the poultry industry

Venketeswara Hatcheries (VH), one of the leading names in the poultry industry in India, has played a major role in disseminating the latest techniques in poultry keeping and animal health care. It undertakes activities such as pure-line breeding, supply of grandparent and parent stock, feed manufacturing, chicken processing, egg processing, SPF production, poultry vaccine production, diagnostic services, human-resource training and production of pet foods. It is also the first Indian company selling processed chickens under the "Venky's" brand name. It supplies a number of large international fast-food companies. The product range caters to retail as well as institutional markets, and includes fresh chilled chicken, frozen chicken (whole, boneless and portions), and several economy products. Venky's Mintomein, an array of ready-to-cook products (freezer-to-fryer, microwaveable and cold cuts) has wide appeal among homemakers. Although, the company has operations in all parts of India, it is concentrated in the south and west. Despite the liberalized trade regime, the conglomerates constitute around 80 percent of the layer market and 65 percent of the broiler market.

Godrej Agrovet set up its integrated poultry business in 1999. Today, the company covers the whole spectrum of the poultry industry, from breeding, hatching and rearing of broilers to processing and marketing of its branded chicken "Godrej Real Good Chicken". It also has contract farming operations in south and west India working with 1 000 farmers.

2.12 Supporting sectors

India is almost self-sufficient as far as inputs required for producing eggs and chicken meat are concerned – the industry receives excellent support from its various input industries. They consist of a network of about 600 hatcheries, 10 000 veterinary pharmaceuticals, numerous equipment manufacturers, 130 feed mills and several education and research institutes. However, there has been insufficient production of maize, a major feed ingredient, in India during last couple of years.[12]

Hatcheries produce almost all commercial breeds of chicks that are available in North America and Europe. The annual turnover of the veterinary pharmaceutical sector is estimated to be Rs 75 000 million, indicating the presence of a vital support service to country's poultry industry. The growing veterinary infrastructure – 40 000 veterinary hospitals/ dispensaries/first aid centres – provides health care. In addition to several veterinary colleges and premier institutes, each state government extends technical and marketing support through the cooperative sector. In spite of the tremendous progress made in developing diagnostics and vaccines, serious problems still exist with respect to disease surveillance and monitoring because of lack of adequate infrastructure. India is self sufficient in all basic equipment that is required for rearing and breeding poultry. All nationalized commercial banks in the country provide facilities to invest in poultry ventures.

[12] Compound feed is not very common in India – around 30 percent of poultry feed is made up of compound feed. Maize and soybean are the major feed components used in India.

2.13 Vertical integration/contract farming

The economies of scale that have led to integrated poultry production in other countries have also begun to take hold in India. In southern and western parts of India, large-scale vertical integration is catching up especially in broiler production. Under this system, the integrator invests in the entire value chain, including:

- grandparent farms;
- parent stock farms;
- hatcheries; and
- feed mills.

Poultry farmers invest in poultry sheds and equipment on their existing land. Integrators provide:

- day-old chicks;
- feed;
- medicines/vaccines;
- training to farmers in process and cost management; and
- technical supervision.

Integrators take the broilers at around 42 days of age, and farmers are paid growing charges according to agreed rates. The farmers are given an incentive bonus if the FCR and/or mortality rate is better than the contracted level. Thus, the farmers get considerable price insurance. Moreover, the advantage is that there are no intermediaries: only integrator – farmer – wholesaler in the market. Farmers do not have to make any investments in working capital. There is also no risk to farmers from fluctuations in selling process – they get a fixed income. This arrangement has encouraged a number of small farmers to enter the poultry business in order to supplement their income with a stable return on their investment.

Poultry integrators have been expanding rapidly in the states of Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra. In Pune, in the State of Maharashtra in western Indian, a major poultry rearing area, about 6 000 poultry farmers are on contract with Venkateshwara Hatcheries, popularly known as Venky's, or with Godrej Group. Similarly, in the south, particularly in the Coimbatore area of Tamil Nadu, integrators now reportedly account for 75 percent of production and consumption. Integration has moved rather slowly in the northern and eastern parts of India.

The current status of integration is: South – 80 percent; West – 70 percent; North – 10 percent; and East – 50 percent.[13]

[13] Source: Suguna Group, personal communication. Contract farming in India is still not legal, and the poultry sector falls under state rules. The integration process was started by Venkateshwar Hatcheries in the mid-1980s in the south and the north, but it failed miserably in most areas. It was again started during mid-1990s when large numbers of small and medium farmers stopped producing chicken products. Integration started to draw on the services of some of these experienced farmers utilizing infrastructure such as shades. Integration increased in popularity in the south and then in the west. In the north, it did not become popular, probably because: i) there were significant differences in the costs of production during different seasons; ii) farmers were not ready to honour contract integrators, if market prices were high; and iii) a large number of the farmers had benefited from the green revolution in Punjab, Haryana and Western Uttar Pradesh. However, there are two or three integrators operating exclusively in the north along with some national-level integrators.

BOX 1

Suguna Poultry Farm Ltd

The Rs 1 400-crore Suguna Poultry Farm Ltd produces over 55 lakh broiler chickens through a large network of contract farmers across the country (except in the Kerala). They are marketed as live birds, dressed whole birds, and processed and branded parts. It has launched its branded eggs, "Sumegga Pro" sourced from its own high-tech layer farm in Namakkal. The farm has a capacity to produce 6 000 to 8 000 eggs a day. The company is implementing a Rs 950-crore long-term programme for setting up hatcheries and feed mills across the country. It is seeking a US$20 million (Rs 100 crore) IFC (International Finance Corporation) loan for the projects. IFC has already invested Rs 50 crore (US$11 million) as equity in Suguna Poultry Farm. Work is under way to build four hatcheries, two in Andhra Pradesh and one each in Tamil Nadu and Maharashtra. They will be completed this year (2007). Suguna has a tie-up with Ross Breeders, United Kingdom, for the supply of grandparent chicks. The company is also setting up four feed mills, two in Andhra Pradesh, and one each in Karnataka and Maharashtra. Suguna is also experimenting with contract farming in maize, the main ingredient of chicken feed, in Karnataka. It has tied up with farmers for the cultivation of 16 000 acres (6 474 hectares) of maize this season. If the experiment is found to be successful it will be replicated in all other maize-growing states in the country. Suguna, which revolutionized the way chickens are grown and marketed in India, has established itself in the market for a variety of chicken products. The Indian market is still a live-bird market, and Suguna has a very large network for retailing live birds. It caters to the high-end market, and branded restaurant chains from its high-tech processing plant Supreme Suguna Food Co. Ltd, a joint venture with Supreme Foods Co. Ltd in the Gulf. A small portion of the products are exported. Suguna is a major supplier to McDonald's in India. Suguna owns the "Sugies" brand of ready-to-cook preferred chicken parts sold through high-end retail stores. The next stage in chicken marketing would be the introduction of ready-to-eat products such as sausages and nuggets.

Source: personal communication.

Key players in integration include:

1. Venkateshwara Hatcheries
2. Suguna
3. Godrej
4. Shanti
5. Taffa
6. Arumbagh
7. Skylark

Integration has not only contributed to greater production efficiencies including lower FCR and mortality rates, but has also reduced marketing margins as a result of the increased market power of the integrator. Besides reducing production costs, the integrators have helped to cut consumer prices by cutting into the traditionally large marketing

TABLE 11
Type of vertical integration or contract farming common in the broiler industry

Broiler farmer	Integrator
Owns the broiler shed and equipment. Buys deep litter/cage material. Attends to rearing activities, such as brooding, feeding, watering (own labour or hired labour). Bears cost of electricity/fuel for brooding. Takes the manure (litter) and empty gunny (food) bags.	Supplies the following inputs: • day-old broiler chicks (owns a breeder farm and hatchery for this purpose); • broiler food required by the birds (owns a feed-mixing unit); • medicines and vaccines (buys quality medicines and supplies them to the farmers as required); and • emergency and routine veterinary services (engages qualified veterinarians for the purpose). Pays the rearing cost to the farmer to meet the cost of litter, labour, electricity, rent for buildings and equipment, and also a part of the profit. Takes back the grown broilers and arranges for their sale mostly through traders.

Sources: personal communication.

TABLE 12
Partnership activities in the layer industry

Input by the farmers	Input by the trader
Land and housing	Feed
Equipment and cages	Vaccines
Chicks	Marketing of eggs
Medicines	Transport
Labour	Consultancy
Electricity	

Sources: personal communication.

margins. The integrators have tended to establish wholesale and retail price leadership in the markets where they operate by reducing the number of intermediaries or by selling directly through their own retail outlets (e.g. in Coimbatore). In other regions, particularly in the north, traditional wholesalers still dominate the markets and marketing margins and retail prices are considerably higher than in the south. Lower retail prices have stimulated consumption, with per capita consumption in southern India reported to be 4 times the national average.

2.14 Producers' association

The National Egg Coordination Committee (NECC), which has a membership of more than 25 000 farmers, is probably the largest association of poultry farmers in the world. Its genesis goes back to 1981. Around this time, the Indian poultry industry was going through an unprecedented crisis. The intermediaries controlled trade and forced prices down. As a result, farmers were being paid less than their production costs. The scenario looked quite bleak. Over 40 percent of farmers had stopped operations because the business had become economically unviable – feed costs had more than doubled, but egg prices remained static at 35 paisa. Determined to do something, the late Dr B.V. Rao, along with a group of farmers, started a mass movement – they travelled across the country holding meetings with farmers and traders. Their objective was to unite poultry farmers from all over India, and see that they get better prices by eliminating intermediaries from the trade. Thus, NECC was born. Since then, NECC has played a significant role in the betterment of poultry farmers, and the egg industry in general, through its various programmes such as market intervention, price-support operations, egg promotion campaigns and consumer education.

The manifold activities of NECC include:

- price declaration;
- deciding a reasonable price for eggs that ensures a reasonable return for the farmer, decent margins for the intermediary and a fair price for the customer;
- monitoring the egg stock levels in different production centres;
- managing stock levels and regulating the movement of stocks from surplus to deficit regions so as to maintain a balance between demand and supply;
- market intervention through Agro Corpex India Ltd;
- organizing and uniting poultry farmers across the country;
- creating a dependable distribution network so that eggs can reach every household in every village;
- generating employment by encouraging people to take up egg farming and egg trading;
- promoting exports and develop export markets;
- making available technology and information for increased production of eggs;
- obtaining governmental support and financial aid from banks for various schemes in rural India;
- creating awareness among customers;
- undertaking egg promotion campaigns to increase the consumption of eggs;
- conducting market research, identify potential market and develop new markets; and
- preparing and submitting position papers to the government on issues affecting the poultry industry.

NECC is a completely voluntary body created by farmers, and runs on cooperative spirit. It makes no profits and subsists mainly on contributions from its members. Most of today's egg production comes from NECC members.

In the broiler sector, there is no national organization that looks after the producers' interests. No doubt, some regional organizations (e.g. the Broiler Growers' Association) have emerged and are trying to organize farmers, but the broiler marketing is largely in the hands of big traders and commission agents in mandis (wholesale markets) like Ghazipur in Delhi and Crawford market in Mumbai. In general, intermediaries are vital links between producers and consumers. The margin between the farm gate price for broilers and the price paid by the consumer is about 20 to 25 percent.

There are also efforts by a southern-based consortium of broiler producers and marketers (the National Broiler Coordination Council) to promote the consumption of poultry meat and to stabilize wholesale prices of poultry meat.

2.15 Government-supported infrastructure

Infrastructure is in place at the government level to promote the poultry industry through financing by the National Bank for Agriculture and Rural Development (NABARD). As banks and the National Cooperative Development Cooperation (NCDC) have started financing small and marginal farmers in villages, poultry insurance has also been introduced under the Indian Rural Development Programme (IRDP). The General Insurance Corporation (GIC) of India has introduced poultry insurance which covers the following:

- comprehensive cover for poultry farmers;
- epidemic poultry insurance through hatcheries; and
- poultry insurance schemes for parent stock through hatcheries.

Agriculture and Processed Food Products Export Development Authority (APEDA)

The Agriculture and Processed Food Products Export Development Authority (APEDA) came into existence in 1986 in order to promote exports of agricultural commodities and processed food products. Promotion of processed farm produce, in turn, benefits farmers through: (a) higher returns for products sold in the export market; and (b) creation of employment opportunities in rural areas through various kinds of processing activities. The main function of APEDA is to build links between Indian producers and global markets; to achieve this, APEDA seeks to identify new markets, provide better support systems for exporters and manufacturers, and introduce new products into the international market. The main activities of APEDA include the following:

- development of a database of products, markets, and services;
- publicity and dissemination of information;
- receiving official and business delegation from abroad;
- organization of product promotions abroad and arranging visits abroad for official and trade delegations;
- participation in international trade fairs in India and abroad;
- organization of buyer-seller meetings and other business interactions; and
- dissemination of information through newsletters and feedback.

APEDA also offers financial assistance under various schemes to promote agro-exports, including poultry. The following are some of the activities that are eligible for financial assistance:

- strengthening market intelligence and databases through studies and surveys;
- quality upgrading;
- development of infrastructure facilities;
- research and development; and
- upgrading of meat processing facilities.

2.16 Summing up

In short, the poultry industry has been growing at a fast pace, the number of broilers has increased ten fold and egg production has doubled. Supporting industries are also keeping pace. Above all, the growth of the poultry industry should be viewed not only in terms of the commercial success it has achieved, but also as one of the core support systems for small and marginal farmers.

3 FACTORS BEHIND THE GROWTH OF THE POULTRY INDUSTRY

3.1 Important government initiatives

In discussing policy initiatives, a clear distinction is made between the pre-reform and post-reform periods. The former refers to the period up to June 1991, when the policies were too restrictive and highly centralized. The latter refers to the period after June 1991, during which the government sought to open up the economy and integrate it with the world economy by relaxing controls and regulations especially on trade and industry.

Policies affecting the sector in the pre-reform period

Major policy initiatives sponsored by the government during this period were:

- Launching the All India Poultry Development Programme which led to a sharp increase in the number of commercial farms. As a result, poultry farming emerged as a leading component of the livestock sector. The main strategy during successive five year plans has been to increase production of eggs and poultry meat through increasing the availability of chicks and supply of inputs such as feed and health care, and making cold storage facilities available.
- Poultry farming was recognized as an important activity for poverty alleviation. Hence, the weaker sections of society, such as small and marginal farmers, and agricultural labourers were provided with help through credit facilities, subsidy and technical assistance to adopt poultry farming as a supplementary source of income.
- Establishment of a number of poultry estates in collaboration with government-initiated agencies, such as the National Cooperative Development Corporation (NCDC) and the National Bank of Agriculture and Rural Development (NABARD), state governments and non-government organizations (NGOs).
- Funding several research activities related to poultry breeding and health management. This included setting up various regional poultry breeding farms, introduction of Intensive Poultry Development Projects (IPDP), and setting up a Central Training Institute for Poultry Production and Management (CTIPPM) in Bangalore.

In its drive for self-sufficiency, the government insisted that India should have its own genetic programme, so that the requirement for DOCs can be met domestically without depending on imports of grandparents. Thanks to such efforts, India has now become more or less self-sufficient in terms of grandparents, parents and DOCs. VH group's BV-300 accounts for 85 percent of the layer market, while Vencobb accounts for around 65 percent of India's broiler market.

Again, as part of the drive to self-sufficiency, imports of all poultry products were banned or restricted through tariff and quantitative restrictions. For instance: "live poultry" (HS 02.02 and 01.15), "meat and edible offal... of the poultry, fresh, chilled or frozen" (HS

BOX 2

Central government expenditure on poultry development

Plan period	Total plan outlay (Rs million)	Expenditure on poultry (Rs million)	Expenditure on animal husbandry (Rs million)
Second plan : 1956–61	46 000.00	28.00	334.00
Third plan: 1961–66	85 765.00	46.00	770.00
Annual plan 1966–69	66 254.00	-	597.00
Fourth plan: 1969–74	157 788.00	115.00	1 542.60
Fifth plan: 1974–78	394 262.00	355.00	2 324.60
Annual plan: 1978–80	-	NA	2 087.70
Sixth plan: 1980–85	975 000.00	426.00	3 374.20
Seventh plan: 1985–90	1 800 000.00	602.00	4 767.80
Eighth plan: 1992–97	4 341 001.00	NA	11 234.80
Ninth plan: 1997–2002	8 592 000.00	NA	15 456.40
Tenth plan: 2002–2007	15 256 390.00	NA	17 450.00

Note: NA = not available.
Sources: GOI Economic Survey, various issues.

02.02), and "birds eggs in shell, preserved or cooked" where in the restricted category. All processed poultry meat preparations where subject to a duty of 35 percent. Though the duty rate was comparatively low, there were quantitative restrictions.

Policies affecting the sector in the post-reform period

As mentioned above, in June 1991 India launched a policy of economic liberalization with a view to integration into the world economy. Under the new policy regime, the government sought to simplify rules and regulations governing industry, liberalize taxation policies and relax foreign exchange regulation. Initially, the thrust of liberalization rested only on the industrial sector; the agriculture sector was not touched. In 1997, liberalization of trade in agriculture and consumer food products was initiated by shifting several of these items from the "restricted status" category to the "open general license (OGL)" category. Table 13 shows the number of items/lines placed under OGL from 1995 onwards. It can be seen that the coverage of OGL rose from less than 10 percent of all commodities in the pre-reform period to 56 percent in April 1995 and 94 percent in April 2001. In short, all the quantitative trade restrictions banning or restricting imports of agricultural commodities and consumer food items were being dismantled from 1997 onwards. From then on, tariffs would be the most important instruments in managing India's imports.

Table 14 shows how this policy reform affected the poultry sector. The table displays the tariff rates applicable to different poultry products for the years 1999 to 2005. Note that prior to 1999 all these products fell within the "restricted category". In 1999-2000, however, all were shifted to OGL, with tariff rates ranging from 15 percent ("meat, and edible offal, of the poultry of heading 01-05, fresh, chilled or frozen") to 40 percent ("live poultry, that is to say, fowls of the species *Gallus domesticus*, etc." and "sausages or similar products ... based on these products"). In 2001-2002, the rates were revised to 35 percent, with

TABLE 13
India's imports subject to quota restrictions, 1995 to 2004

Year	Percentage of commodity lines* that are free of restrictions
April 1995	56.00
April 1997	65.80
April 1998	70.20
April 2000	86.41
April 2001 onwards	94.37

* At 8 or 10-digit harmonized system level.
Sources: Mehta (1997); Mehta (1999).

a few exceptions. Thus, for items under the headings "cuts and offal, fresh or chilled; of fowls of the species *Gallus domesticus* (0207.14), "sausages and similar products, of meat, meat offal or blood; food preparations based on these products" (1601.00) and "of fowls of the species; of poultry of heading No. 01.05" (1602.32) the tariff rates were raised from the prevailing 15 percent rate to 100 percent. In 2004-2005, the rates were lowered to 30 percent, while the four items cited above continued to have a 100 percent tariff rate.

What can be said regarding the effects of trade liberalization on the poultry industry in general? It will not be easy for the industry to survive in the new environment. The domestic industry is definitely price competitive in the egg segment and to some extent in broilers. But this has to be viewed in the context of production subsidies and export subsidies prevailing in the United States of America and in European countries. The presence of such subsidies leaves India at a price disadvantage. This might lead to reckless imports, erode the country's genetic base and increase its dependence on imports.

Policies affecting feed products

The poultry industry is highly dependent on feed ingredients. Feed alone constitutes 70 percent of the costs of producing broilers and eggs. Hence, the prices of feed ingredients have a substantial effect on the costs of egg and broiler production, and thereby on its profitability.

The main feed ingredients are maize, soy, rice bran, and groundnut cake. Of these, maize is the most crucial in India – alone accounting 80 percent of the feed consumed. Hence, the availability of maize at a competitive price will determine the growth of egg and broiler production. The availability of maize depends first on domestic production and second on imports.

The domestic production of maize is, like that of all other agricultural commodities, dependent on the area under cultivation and the yield per hectare. The area under maize cultivation has remained stagnant at around 6 to 7 million hectares. Similarly, the yield per hectare is around 2 tonnes per hectare, which is one of the lowest in the world. Furthermore, its production, like all other agricultural commodities, is dependent on monsoon; and very often there has been a severe shortage of maize owing to failure of monsoon which in effect has led to high feed costs. Overall, maize production in India has remained stagnant

TABLE 14

India: Most Favoured Nation tariffs and Uruguay Round bound rates for poultry products

Harmonized system (commodity groups)		India's tariff rate[b] (%)			UR final bound rate[c] (%)
HS code[a]	HS description	1999-2000	2001-2002	2004-2005	
01.02	Live bovine animals				
0102.10	Pure-bred breeding animals	40	35	30	100
Ex 0102.10	Cows, heifers, bulls, goats, sheep, and pure line poultry stock	5	5	5	100
0102.90	Other	40	35	30	100
Ex 0102.90	Grand parent poultry stock and donkey stallions	25	25	N.A.	100
01.05	Live poultry, that is to say, fowls of the species *Gallus domesticus,* etc.				
0105.11	Fowls of the species *Gallus domesticus*; weighing not more than 185 g	40	35	30	100
0105.92	Fowls of the species *Gallus domesticus*, weighing not more than 2 000 grams; other	40	35	30	100
0105.93	Fowls of the species *Gallus domesticus*, weighing more than 2 000 grams; other	40	35	30	100
02.07	Meat, and edible offal, of the poultry of heading 01.05, fresh, chilled or frozen				
0207.11	Not cut in pieces, fresh or chilled; of fowls of the species *Gallus domesticus*	15	35	30	100
0207.12	Not cut in pieces, frozen; of fowls of the species *Gallus domesticus*	15	35	30	352
0207.13	Cuts and offal, fresh or chilled; of fowls of the species *Gallus domesticus*	15	100	100	100
0207.14	Cuts and offal, frozen; of fowls of the species *Gallus domesticus*	15	100	100	100
Ex 0207.34	Fatty livers, fresh or chilled; of ducks, geese, etc.	15	35	30	352
04.07	Birds' eggs, in shell, fresh, preserved or cooked	35	35	30	150
04.08	Birds' eggs, not in shell, and egg yolks, fresh, dried, cooked by steaming or by boiling in water, molded, frozen or otherwise preserved, whether or not containing added sugar or other sweetening matter	35	35	30	150
0408.19	Egg yolks: other	35	35	30	150
0408.91	Other than egg yolks: dried	35	35	30	150
0408.99	Other than egg yolks: other	35	35	30	150
1601.00	Sausages and similar products, of meat, meat offal or blood; food preparations based on these products	40	100	100	150

(Continued)

TABLE 14 (*Continued*)
India: Most Favoured Nation tariffs and Uruguay Round bound rates for poultry products

Harmonized system (commodity groups)		India's tariff rate[b] (%)			UR final bound rate[c] (%)
HS code[a]	**HS description**	**1999-2000**	**2001-2002**	**2004-2005**	
16.02	Other prepared or preserved meat, meat or blood				
1602.10	Homogenized preparations	40	35	30	552
1602.20	Of liver of any animal	40	35	30	150
1602.31	Of turkeys; of poultry of heading No. 01.05	40	35	30	150
1602.32	Of fowls of the species; of poultry of heading no. 01.05	40	100	100	150
1602.39	Other, of poultry of heading no. 01.05	40	35	30	150
1602.41	Of swine, hams and cuts thereof	40	35	30	552
1602.42	Of swine, shoulders and cuts thereof	40	35	30	552
1602.49	Of swine; other, including mixtures	40	35	30	150
1602.50	Of bovine animals	40	35	30	150
1602.90	Other, including preparations of blood of any animal	40	35	30	150

Notes:
a. The commodity groups defined by the Harmonized System of Indian Trade Classification (HS-ITC), in 1999/2000.
b. These rates represent the most favoured Nation (MFN) tariff rate defined as the Basic Custom duty (ad valorem) in Indian custom classification. The different types of exemptions are not taken into consideration to work out the rates.
c. The Uruguay Round Final Bound Rates. The definition of Harmonized System (HS) Codes for some items was different during the year of Uruguay Round commitments. The final bound rates are worked out after making correspondence between the custom classification (HS) of the Uruguay Round negotiation period (1992) and HS-1996.
[1] The basic custom duty of Grand Parent Poultry Stock is 25 percent instead of 35 percent.
[2] Commitments for these items were made in earlier rounds.
Sources: WTO (1995); GOI, Custom Tariff of India, various issues.

at around to 10–11 million tonnes *per annum* (see Table 15). Of this, the current consumption requirement of the poultry industry alone is 5 million tonnes. It is estimated that by the year 2020 the requirement of the poultry industry will rise to 31 million tonnes,[14] assuming that the egg production grows at the rate of 10 percent *per annum,* and broilers at the rate of 20 percent *per annum*. If these estimations hold good, there is a risk of a major imbalance between supply and demand – supply or availability falling short of demand. There are two ways to bridge the gap. One is to increase domestic production by adopting improved seeds for cultivation. The other is to import maize. To promote the former, the government has already set up a Maize Development Mission under the Technology Mission of the Government of India. The Mission is urged to intensify research and development to increase yields, oil content, etc. in order to cope with the mounting demand.

[14] Confederation of Indian Industry (CII) and McKinsey (1998).

TABLE 15
Maize availability, 2000-2001 to 2006-2007

Year	Area under cultivation (million hectares)	Production (million tonnes)	Yield (tonnes per hectare)
2000-2001	6.61	12.04	1.82
2001-2002	6.59	13.16	2.00
2002-2003	6.45	10.30	1.60
2003-2004	6.77	12.77	1.89
2004-2005	7.00	13.58	1.94
2005-2006	6.70	13.50	2.01
2006-2007	7.10	11.00	1.55

Sources: GOI, published data.

TABLE 16
Production of soybean, 1999-2000 to 2004-2005

Year	Production (million tonnes)
1999-2000	7.08
2000-2001	5.28
2001-2002	5.96
2002-2003	4.65
2003-2004	7.82
2004-2005	6.88
2005-2006	8.35

Sources: RBI (2005-06).

In 2000-2001 the government announced a tariff quota (TRQ) for maize imports. Under this regime, imports of maize up to 350 000 tonnes attract a duty rate of 15 percent, and imports above attract a duty rate of 50 percent. Soon after this announcement the maize price in the domestic market stabilized. Currently (2007-2008), the in-quota limit stands at 4 lakh tonnes with a tariff of 15 percent; above that, 50 percent duty is applied with the request from Agriculture Ministry; however, even the 15 percent duty is being waived.[15] To sum up, the domestic price of maize in the medium to long term can be expected to depend on: (i) domestic production; and (ii) the level of applied tariff. That means there will be increasing pressures on farmers to switch to high-yielding varieties and on government to reduce applied tariff on maize.

[15] As per the Finance Ministry notification, the existing policy in items falling at EXIM Code 1005 9000 [Maize (Corn), others] shall remain in abeyance till 31st December 2007. During this period, imports of this item will be allowed freely (See Custom Tariff 2007-08).

TABLE 17
Soybean demand and supply situation, 2003

	Quantity (1000 tonnes)
Total production	6 800
Imports	2.89
Stock variation	500
Export	253.1
Seed	444
Food manufacture	6 045
Waste quantity	328.5
Food	232.29

Source: FAOSTAT.

After maize, the next widely used feed is soy. The annual production of soybean is shown in Table 16. Its current demand and supply situation is given in Table 17.

It is envisaged that during the next three to four years, industry will demand an additional 2.50 million tonnes over and above the existing production. That means additional cultivation will be required to meet the additional demand.

3.2 Financial incentives

The Indian agriculture sector gets direct and indirect subsidies in the form of fertilizer, pesticides, electricity, etc. Although the poultry industry is an integral part of agriculture, and treated on a par with the rest of the livestock sector in India, it faces restrictions on its use of agricultural land, attracts higher electricity tariffs and sales tax than agriculture, pays tax on income earned from poultry farms, and is subject to different land and labour law,. It is also not getting benefits such as tax holidays which are enjoyed by a number of Indian industries. Another point worth mentioning in this context is that a large number of products are reserved for exclusive manufacture in the small-scale sector. A few years ago, the poultry feed sector fell into this category and was not subject to larger investments. The industry could not enjoy the benefits of operating on a large scale.

3.3 Foreign direct investment in the poultry sector

Foreign direct investment (FDI) has not been a significant factor in the expansion of integrated poultry operations. A large integrator operating in both the southern and western regions runs a processing facility built recently with the assistance of private investment from Saudi Arabia. Two large Asian integrators, Japfa from Indonesia and CP from Thailand, have been in the feed business in India for several years, but so far have not expanded into poultry integration. Although farms are importing breeding stock and technology from foreign breeders, there is currently almost no FDI in the broiler sector. FDI is more common in pharmaceuticals (poultry production inputs) where most companies are either multinationals or Indian joint ventures with multinationals. Most drugs or vaccines for poultry are produced by these units. The major feed companies are Indian owned.[16] According to the Reserve Bank of India, the actual inflow of FDI in the food and food-processing sector was more than US$711.4 million (Rs 3 187 crores) up to March 2004. Nearly 30 percent of FDI in this sector comes from EU countries such as the Netherlands, Germany, Italy and France.[17]

Constraints affecting the inflow of FDI in the poultry sector include:

- poor power and transport infrastructure;
- poorly defined phytosanitary measures;
- limited market for frozen poultry;
- lack of cold-chain facilities making it a difficult task to handle significant volumes of chilled or frozen products;
- competitive local prices; and
- high taxes on processed food.

A more favourable policy environment than is presently available is therefore warranted. This would include: policies for improving infrastructure facilities which will help to stabilize the price of poultry products, creating efficient marketing channels that will help producers to obtain more remunerative prices; and increasing maize production by using improved seed varieties (FAO, 2003). Landes *et al*. (2004) note that "with the expansion of the poultry industry, the country's government must address these new issues, including economic tradeoffs between poultry producers, feed producers, and consumers, potential public health concerns associated with traditional slaughter an marketing practices, and additional tariff and non-tariff policies for imports".

3.4 Veterinary health care services

In India, animal husbandry is administered at state level. During the 1970s, when the poultry industry was just picking up, the state governments provided veterinary care services to local farmers. But since the emergence of private companies in breeding, it has been these operators that have helped to sustain the growth of the poultry sector. The farmers are well aware of the need to safeguard the health of their birds. A number of hatcheries also provide animal health services to farmers. Veterinary products and diagnostic facilities are readily available to most farmers. Large farmers/integrators employ their own veterinary consultants. The danger of flock disease is relatively low in India.

Both the public and the private sectors in India produce vaccines for use in the poultry sector. Vaccines are produced by these institutions with the use of SPF eggs as mandated and laid down by British Pharmacopoeia. The private sector is more prominent in vaccine production, production of animal health care products and other drugs required by the poultry sector. The role of government is that of a facilitator and administrator of the legal framework. Organizations like NECC are engaged more in promotional activities than in production. The prices of vaccines, animal health products and food additives in India are either comparable or slightly higher than international prices. In terms of quality, they meet international standards.

[16] Economic Research Survey/USDA: Development of prospects/WRS-04-03.

[17] Government of Kerala, Virtual University for Agriculture Trade, Project by Department of Agriculture.

As mentioned above, India also has very successful breeding operations supported by research and development, biosecurity measures and strict quarantine for the breeder flocks. The breeding operations are supported by hatchery health and hygiene. The breeding flocks are subject to compulsory tests for salmonella. Disease and diagnostic laboratories are located in different regions, in addition to institutions such as the Indian Veterinary Research Institute. The private sector has set up its own sophisticated laboratories for surveillance and diagnostic services.

3.5 Food-safety standards and trade in processed foods

International trade in processed food has grown substantially during the past two decades. The main factors that have propelled its growth include rising incomes, changing food consumption habits and consumers' preferences for "ready to eat food". This rapid expansion in international trade of processed food products has in turn given rise to some new concerns regarding food safety, i.e. that food is safe and free from contaminants, toxins and diseases-causing organisms. Effective hygiene and safety controls are therefore vital to avoid the adverse consequences of food-borne diseases, food-borne injury and food spoilage.

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures sets out the basic rules for food-safety and animal and plant health standards. It allows countries to set their own standards, but it also stipulates that regulations must be based on science. They should not arbitrarily or unjustifiably discriminate between countries where identical and similar conditions prevail.

One of the problems with these standards is that these are so stringent that many countries, especially developing countries, have difficulty in implementing them. India is no exception, and is trying to harmonize its standards with those of the FAO/WHO Codex Alimentarius. However, there is a feeling in the industry that sometimes the importing countries, particularly for egg products, are using these food-safety standards in a discriminative manner (Mehta, 2005). Though, Indian standards for egg processing plants have been derived from USDA and EU regulations, many countries, including Australia, do not recognize these standards, and equivalence has not been granted by many developed countries. Similarly, the importing countries do not approve the veterinary certificates issued by competent authorities like the Export Inspection Agencies, and insist on a separate health certificate issued by the veterinary authorities. In some cases, the importing countries have their own specifications which differ from their own national standards. It is therefore evident that despite the spirit of the SPS and the Technical Barriers to Trade (TBT) agreements, these measures are being used by developed countries to hinder exports from developing countries. There is discrimination, in spite of the fact that under Article 12 of the TBT agreement there is a mention of special and differential treatment to be given to developing-country members.

The Indian poultry sector, particularly the egg processing units, has already started integrating itself into the global system in the light of the SPS and TBT agreements. All of the egg-processing units in India already operate HACCP systems.

India has also prepared and implemented its own residue-monitoring plan for egg and chicken products. The Government of India, Department of Commerce and Industries, vide order dated 19 December 2003, has authorized APEDA to operate a residue monitoring plan (RMP) (APEDA, 2006).

Objectives of the residue-monitoring plan: to establish the surveillance system, to monitor residues of drugs and pesticides in egg products exported to EU countries, to establish a system for corrective action in the event of detection of residues at a level higher than those permitted under the RMP.

Scope of the residue-monitoring plan: all egg processing units intending to process eggs for export, their affiliated feed mills, layer farms, recognized laboratories would get covered under these guidelines.

Monitoring and surveillance plan:

- Egg products exported to the EU will be sampled and tested by the nominated laboratories as provided in the plan.
- APEDA will decide on the nominated laboratories that will be responsible for the implementation of the RMP for each process.
- Procedures for obtaining the test certificate are laid down.
- The national reference laboratory will monitor the work of other nominated regional laboratories by conducting surveillance, and audit on a six-monthly basis to ascertain the criteria laid down under the RMP is followed properly.
- APEDA will assess the work carried out by the National Reference Laboratory.
- Nominated laboratories will submit bi-monthly statements of sample testing to the National Reference Laboratory as well as to APEDA.
- The report of National Reference Laboratory will be evaluated to ensure that test results submitted by the nominated laboratories on a bi-monthly basis are properly implemented and conveyed and that other control measures suggested by the National Reference Laboratories are implemented.

The RMP also:

- identifies a list of laboratories that have been approved and nominated by APEDA for sample testing;
- lays down procedures to be followed by nominated laboratories for sampling and testing of egg products for exports;
- describes the methods of sampling for checking the level of pesticide residue in egg products;
- describes the methods of sampling for checking the levels of pesticides and pharmacologically active substances in egg products;
- describes and gives a list of pesticide residue limits applicable for egg products; and
- provides a list of maximum residue limits for pharmacologically active substances.

While these regulations are certainly for export purposes, the Indian poultry sector is also looking to implement domestic standards. The quality standards that govern the food industry include: Prevention of Food Adulteration Act, 1954 (PFA); Vegetables Product Order, 1967 (VPO); Food Products Order, 1955 (FPO); Meat and Food Products Order, 1973 (MFPO); Meat and Meat Product Order, 1992 (MMPO); Agriculture Produce (Grading and Marketing) Act, 1973; Bureau of Indian Standards (BIS); Export Quality Control and Inspection Act, 1963. Good manufacturing practices (GMP), good hygiene practices (GHP), HACCP, Codex, Alimentarius and ISO 9000 are among the other certification procedures applicable to food products.

BIS has about 700 Indian standards applicable to agricultural produce and value-added products. The key issues addressed by these standards include preventing adulteration, regulating hygienic conditions, informing consumers about the product and providing product specifications.

An integrated food law, the Food safety Standards Act 2005, has come into existence, which consolidates most of the food-related laws in India to meet international standards.

3.6 Consumer demand and preferences

Patterns of poultry meat and egg consumption in India show certain peculiarities. First, the Indian poultry market remains primarily a live bird market. The consumption of chilled and frozen poultry products is very small – only 5 percent of the total production is sold in processed form; all the rest is sold alive. Second, the demand for eggs is seasonal – very low in summer compared to other seasons of the year. Eating eggs is prohibited in certain months. Further, when fish catches are high, the demand for eggs tends to be low. Thus, the demand for eggs fluctuates throughout the year, while supply is continuous. Developing storage facilities or converting eggs into egg powder would be options to address the problem. However, the demand for egg powder has so far remained low, and building up cold storage facilities to preserve eggs takes a long time. Third, cities and towns, home to 30 percent of India's population, account for 75 percent of total poultry consumption. The annual per capita egg consumption in India's major cities, such as Mumbai, Calcutta, Delhi and Chennai, is reported to be 100 or even as high as 150 or 200. In contrast, annual per capita consumption in rural areas is as low as 15 eggs. The low consumption in rural areas is due to non-availability and higher prices.

As described in Section 3, poultry meat has been gaining prominence over other meats. It has outpaced its two main competitors – beef and veal and buffalo meat. Does this represent a shift in the preference pattern of households from other meats to poultry meat, or more generally a shift from vegetarianism to non-vegetarianism? It can be speculated that high mutton prices, religious restrictions on beef and pork consumption, and the lower availability of fish in non-coastal regions may have combined to make poultry meat the preferred and most consumed meat in India. Alternatively, expanding domestic production and increasing integration may have pushed poultry meat prices downward, probably increasing its competitiveness. The shift to poultry meat may also be attributable to growing concern over red meat-borne illnesses such as bovine spongiform encephalopathy.

Data originating from periodic surveys conducted by the National Sample Survey Organization (NSSO) constitute the main source of information on preference patterns. However, the usefulness of these data is constrained by the act that they do not include poultry as a separate item – it is grouped under "meat, fish, and eggs". However, for two rounds – the 38th and 50th rounds (years 1983 and 1993-1994) – disaggregated data are available and may be used to shed light on preference patterns.

Table 18 shows the percentage of households reporting consumption of "meat, fish and eggs" at the national level during three NSS rounds. More than 42 percent of households in both urban and rural areas did not consume meat, fish and eggs in 1999-2000. Moreover, the change in preference is slow. Between 1987-1888 and 1999-2000, the proportion of people consuming any of the three items increased by 1 only percent in urban areas and by 4 percent in rural areas.

Obviously, it would be interesting to know whether there is a noticeable change within the product category "meat, fish and eggs". The NSS data tabulated from 38th (1987-1988) and 50th rounds (1993-1994) are summarized in Table 19. These data show that in rural areas, fish is preferred over eggs, while there is no special preference between fish and goat meat. The story is different in urban areas. There, eggs are preferred over fish and goat meat. The conclusion that can be drawn from this is that eggs seem to have entered the vegetarian diet of urban people but not of rural people. Note, however, that although rural people exhibit lower preference for eggs compared to urban people, the change in the preference pattern in favour of eggs is higher in rural areas than in urban areas. For instance, the percentage of households consuming eggs increased from 17 percent in 1987-1988 to 22 percent in 1992-1994.

As income increases, the proportion of income spent on food declines and the proportion spent on non-food items increases. This is known as Engel's law of demand. The economic growth in India over the past five decades and rising incomes are known to have brought significant changes in the consumption basket – a persistent decline in the per capita consumption of cereals, and a persistent increase in the per capita consumption of non-food items. Table 20 shows food expenditure figures for the years 1993-1994 to 2004 grouped into three broad categories: cereals; meat and fish and eggs; and other food.

The figures clearly show that non-food expenditure has been growing faster than food expenditure – leading to a steep decline in the share of food expenditure. Between 1991 and 2004, the share of food items in total expenditure dropped from 63.1 percent to 53.9 percent in rural areas and from 52.5 to 41.6 percent in urban areas. This shift from food to non-food is mainly due to decline in the share of cereals in total expenditure. The shares

TABLE 18

Proportion of households consuming meat, fish and eggs

Year	Rural (% of households)	Urban (% of households)
1987-1988	54.1	56.8
1993-1994	56.4	57.0
1999-2000	57.9	58.0

Sources: GOI, NSSO, All India National Consumers Surveys, various issues.

TABLE 19

Proportion of households consuming poultry products and other meat

Item	Rural (% of households)		Urban (% of households)	
	1987-1988	1993-1994	1987-1988	1993 1994
Eggs	17.1	22.0	32.7	34.9
Poultry meat	-	7.5	-	9.0
Goat meat	-	20.3	-	28.0
Fish	-	30.7	-	27.1

Sources: GOI, NSSO, All India National Consumers Surveys, various issues.

of meat, fish and eggs, and that of other food increased during the period under consideration. Thus, there is a shift from cereal to non cereal food. The share of cereals in food expenditure has declined from 38.4 percent to 32.8 percent in rural areas and from 25.3 to 24.0 percent in urban areas. The share of meat, fish and eggs rose from 5.3 percent to 6.2 percent in rural areas, and remained at around 6.4 percent in urban areas. In other words, while the expansion of the expenditure share of meat, fish and eggs is sustained in rural areas, it has remained stable in urban areas.

TABLE 20
Trends in the share of commodity groups in total expenditure

Year	Share in total consumer expenditure (%)					Share in food expenditure (%)		
	Cereals	Meat, fish and eggs	Other food	Total food	Total non-food	Cereals	Meat, fish and eggs	Other food
Rural								
1993-1994	24.5	3.3	35.3	63.2	36.8	38.8	5.3	55.9
1994-1995	24.6	3.2	33.3	61.1	38.9	40.3	5.2	54.5
1995-1996	23.5	3.2	33.6	60.4	39.6	39.0	5.3	55.7
1997	23.2	3.0	33.6	58.7	41.3	37.8	5.1	57.2
1998	23.1	3.3	34.4	60.8	39.2	38.0	5.4	56.6
1999-2000	22.4	3.3	33.7	59.4	40.6	37.6	5.6	56.8
2000-2001	20.3	3.3	32.7	56.3	43.7	35.8	6.3	57.8
2001-2002	19.2	3.4	32.9	55.5	44.5	34.3	6.1	59.6
2002	18.2	3.4	33.4	55.0	45.0	33.0	6.2	60.8
2003	19.8	3.4	32.8	54.0	46.0	33.0	6.0	61.0
2004	17.9	3.5	32.5	53.9	46.1	32.8	6.2	61.0
Urban								
1993-1994	14.3	3.4	37.0	54.7	45.3	26.6	6.3	67.1
1994-1995	14.6	3.4	35.4	53.4	46.6	27.3	6.4	66.3
1995-1996	13.3	3.2	33.6	50.7	49.9	26.5	6.4	67.1
1997	13.5	3.4	33.1	50.0	50.0	27.2	6.0	66.8
1998	13.3	3.4	33.2	49.9	50.1	26.7	6.4	66.9
1999-2000	12.5	3.4	32.4	48.3	51.7	26.0	6.4	67.6
2000-2001	11.0	3.3	29.8	44.1	55.9	25.1	6.8	68.1
2001-2002	10.5	3.3	29.8	43.6	56.4	24.3	6.5	69.2
2002	9.9	3.2	29.9	43.1	56.9	23.2	6.4	70.4
2003	10.0	2.7	29.3	42.0	58.0	23.8	6.4	70.0
2004	10.0	2.6	29.0	41.6	58.4	24.0	6.4	70.0

Sources: GOI, NSSO, All India National Consumers Surveys, various issues.

3.7 Trends in feed prices: maize and soybean

Feed, is the largest cost in broiler and egg production, constituting 70 percent of the total. The main feed ingredients are maize, soy, rice bran and groundnut cake. Maize and soy are the most widely used. Thus, the price movements of these two feed items will have a direct effect on the prices of eggs and broilers. Moreover, the future growth of the poultry industry will depend on the availability and price of maize and soy. The industry has projected that demand for maize in 2010 will be 16.65 million tonnes, and foresees a major shortfall in maize production. The poultry sector consumes about 50 percent of the total maize production – followed by human consumption, other livestock, starch and breweries. Farmers need to increase the area under maize cultivation and increase productivity to meet the demands of industry. Trends in the domestic wholesale prices of maize and soy meal are shown in Table 21.

It can be seen from the table that the prices of the two main feed ingredients have tended to rise. In the case of maize, prices have almost doubled: Rs 5 650 per tonne in 2005-2006 compared to Rs 2 756 per tonne in 1993-1994. Stagnating production and rising feed demand have tended to keep maize prices high. The situation is same in the case of soy. The prices of soy in 2005-2006 were 50 percent higher than in 1993-1994.

TABLE 21
Trends in the price of maize and soy

Item	Domestic price		Wholesale price index	
	Maize (Rs/tonne)	Soy (Rs/tonne)	Maize	Soy
1993-1994	2 756.00	6 300.00	100.00	100.00
1994-1995	3 417.00	7 119.00	123.80	113.40
1995-1996	4 079.00	8 001.00	147.60	126.80
1996-1997	4 437.00	9 135.00	161.10	144.80
1997-1998	4 106.00	8 757.00	148.50	138.80
1998-1999	4 244.00	7 812.00	154.40	124.30
1999-2000	5 347.00	6 804.00	193.60	107.50
2000-2001	4 933.00	7 623.00	178.90	121.10
2001-2002	4 740.00	8 190.00	171.50	130.00
2002-2003	5 236.00	9 639.00	189.50	153.40
2003-2004	4 988.00	9 954.00	181.20	158.40
2004-2005	5 181.00	11 844.00	187.90	187.80
2005-2006	5 650.00	9 954.00	205.00	157.50

Sources: GOI, Office Economic Advisor, Department of Industry, Index Number of Wholesale Prices; various issues.

3.8 Disease outbreaks

Avian influenza[19] has been circulating for centuries with four known outbreaks recorded in the last century. The present wave of highly pathogenic avian influenza (HPAI) commenced in Hong Kong in 1997. India, however, remained free of the disease until 2006. Between January 27 and April 18 2006 outbreaks of HPAI virus subtype H5N1 were reported in two districts (Navapur and Jalgaon) of Maharashtra and adjoining areas in Gujarat and Madhya Pradesh. In view of the global threat of HPAI and apprehensions about a human pandemic, it had been necessary to take steps to ensure preparedness for a possible outbreak.[20] Control measures included culling the entire poultry population and destruction of eggs, feeds, consumables, litter and other potentially infected material within a radius of 10 km from the location of the outbreak; restriction on the movement of poultry, poultry products and personnel to and from the affected area; and cleaning and sanitation of the infected area. More than 1 million birds and over 1.5 million eggs were destroyed. Farmers were compensated for their losses. The government carried out surveillance (clinical, virological and serological) within a radius of 15 km from the location of the outbreak. Surveillance also was undertaken throughout the country based on random sampling of observed abnormal mortality in poultry and wild migratory birds. On August 11, 2006, the government declared that India had regained its notifiable AI-free country status as per the regulations of the World Organisation for Animal Health (OIE).

When the news of the influenza spread, the price of chicken dropped from Rs 36/kg to Rs 16/kg. Mumbai and Pune, where business dropped by 40 percent, were the worst affected.[21] Production declined from 15 lakh birds to 12 lakh birds; egg production declined from 12 lakhs to 8 lakhs. Governments of other states banned imports of poultry from Maharashtra. The total estimated loss to the poultry industry is reported to be Rs 12 000 crore. Big integrators like Venketeshwara Hatcheries and Godrej Aggrovet are reported to have suffered huge losses.

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[19] Avian influenza is an infectious disease of birds caused by the type A, strain of influenza virus. The disease occurs worldwide. While all birds are thought to be susceptible to infectious virus, many wild birds carry these viruses with no apparent sign of harm. Other bird species, including domestic poultry, develop disease when infected with avian influenza. Once domestic birds are affected, avian influenza can be difficult to control, and often causes major economic impacts for poultry farmers in affected countries, as mortality rates are high and infected fowl must generally be destroyed in order to prevent disease. Indonesia suffered a direct loss of US$170 million and Thailand suffered a loss of US$1.2 billion during recent outbreaks.

[20] As a part of this preparedness, the Department of Animal Husbandry prepared an action plan. The draft plan was discussed at a meeting held with State Secretaries of Animal Husbandry chaired by the Secretary of the Department of Animal Husbandry Dairying and Fisheries in New Delhi on 26 October 2005, and thereafter circulated to the states by letter dated 16th November 2005. This document proved to be very useful in conducting the AI control operations in the States of Maharashtra, Gujarat and Madhya Pradesh. (See Appendix for details of this action plan).

[21] The wide area coverage of HPAI outbreak panicked consumers, most of whom avoided poultry meat. In a leading article, Surojit Gupta described the case of an example of poultry trader who even after buying chickens at a discount of 40 percent was sad, because after the news of the AI outbreak, sale of chicken in the wholesale market had fallen drastically.

The poultry industry initiated a media campaign on the safety of poultry meat to regain consumer confidence. In early April, the government announced a relief package for the poultry industry. The scaling down of production and increasing consumer demand meant that poultry meat prices recovered from May onwards. More and more units are getting back to production. Financial losses caused by HPAI have prompted several small poultry operators to switch to contract agreements with large poultry integrators so as to minimize price risk.

After India was declared "avian influenza free" on August 26 by the Department of Animal Husbandry and Dairying and Fisheries, the decline in poultry off-take slowed. In October, exports grew by 5.4 percent to Rs 26.5 crore. Because of the downfall in exports during the earlier months, total offtake during April to October 2006 was down by 27.7 percent at Rs 127.7 crore. Exports to all major markets have fallen, with the sharpest decline being in exports to the United Arab Emirates, Kuwait and Oman. The United Arab Emirates, which banned egg imports from India in February 2006, resumed imports on 18 January 2007.

3.9 Role of large retailers

India is at present the most attractive destination for the world's big retailers such as Wall-Mart, Woolworth, Tesco, Reliance, Bharati, Birla, Tata and Godrej. All top retailers are making a beeline for the Indian market. The latest report by AT Kearney and CII (2006) shows India, China and the Russian Federation at the top of the annual list of most attractive emerging markets for retail investments.[22] Moreover, India has retained its top position three years in a row. The Russian Federation kept its place at number two, while China moved from the fifth rank to third this year. Viet Nam and Ukraine are fourth and fifth respectively.

What is luring them all to the Indian market? The retail industry is almost untapped and undeveloped. The current total value of the Indian retail sector is estimated to be US$330 billion. Well over 95 percent of the market is currently unorganized – small family run stores. It is predicted that by 2011, the Indian retail sector will be worth US$892 billion. What is more important, especially from the point of view of global players eyeing opportunities in India, is that the fastest growth is in "modern retail" – supermarkets, department stores, hypermarkets and special shopping malls. Only 4 percent of India's total retail now falls within the "modern" or "organized" category, compared to 85 percent in the United States of America and 20 percent in China. Organized retailing in India is predicted to grow from the current $US12 billion a year to almost $US100 billion by 2011 and a dazzling $US239 billion by 2015 (IBEF, 2006).

What is driving this spectacular growth? India's vast middle class. It is estimated that 70 million Indians in a population of about 1 billion now earn a salary of US$18 000 a year,

[22] The study reports that China gained largely on the basis of its continued growth in consumer spending and retailers moving into smaller markets. It reveals that modern retail formats grew between 25 to 30 percent in India and 13 percent in both China and the Russian Federation. The study also shows how retailers now prefer to invest in tier II and III cities globally. For example, in China, Wall-mart and Tesco, are moving into smaller cities, such as Yuxi, Weifan, Nanchang and Westice. This explains the sudden spurt of retail activity in cities like Pune, Mysore and Kanpur.

a figure that is set to rise to 140 million by 2011 (BBC News, 2006). Driven by changing lifestyles and strong income growth, these people are looking for more choice as to where to spend their new-found wealth. The changing consumption pattern of Indian consumers is encouraging the big business houses to invest in this sunrise sector.

However, the road to this rapid growth in retail is not without difficulties. Lack of refrigeration and cold storage chains for perishables, poor transport links, red tape at state borders, and too many intermediaries mean that 40 percent of perishables are spoilt. Moreover, the Indian retail sector has until now been protected. Recently, restrictions on foreign investment have been eased, allowing overseas retailers to own 51 percent of outlets as long as they sell only single branded goods. For the first time, chains such as McDonald's, Marks and Spencer and The Body Shop can open and control their own operations in India. Previously, many of them worked with franchisee partners.

3.10 Food retail

Food dominates the shopping basket in India. The US$6.1 billion Indian food industry, which forms 44 percent of all fast moving consumer goods (FMCG) sales, is growing at 9 percent *per annum* and has set the growth agenda for modern trade formats. As nearly 60 percent of the average Indian grocery basket comprises non-branded items, the branded food industry is homing in on converting Indian consumers to branded food. However, the degree of supermarket penetration of the food retail market in India is still low – under 5 percent – compared to around 75 percent in Brazil, 57 percent in Argentina, 50 percent in Chile, 45 percent in Mexico, 30 percent in Kenya, 40 percent in Thailand, 60 percent in the Philippines and 25 percent in China.

Will the rise of supermarkets and hypermarkets throw small farmers out of business? Or will it give rise to bigger opportunities for small and poor farmers? There is, of course, a widespread perception in India that the growth of supermarkets will pose a threat to small farmers. This stems from the experiences of other countries. In China, for example, it is reported that producers who are certified as "green food" producers and sell to supermarkets are paid five times more than they would receive elsewhere. However, to get certified as a "green food" producer it is necessary to have production records inspected and to have the production environment sampled and checked. Supermarkets, therefore, usually sign contracts with large producers (Birthal *et al*., 2006). Similarly, in the Philippines, small producers of vegetables often found it difficult to hold on to their business links, and eventually dropped out. Supermarkets are concerned to reduce transaction costs. Reducing transaction costs requires fewer transactions, and hence greater significance is given to food quality and reliability in supply. For smallholders, these demands become an entry barrier to the supply chain.

At the same time, supermarkets open up opportunities for smallholders. They reflect the product requirements of high-income consumers, and transmit this information to farmers. In practice, however, supermarkets hardly buy directly from producers. They procure goods through commissioned agents or assemblers. Depending on the crop, and the distribution of farmers in terms of size, these consolidators or assemblers may or may not choose to work with small farmers. Smallholders may find it difficult to penetrate the system individually. The solution lies in new forms of vertical integration such as contract farming that would enable small farmers to continue to participate in the supply chain (Gulati *et al*., 2006).

4 THE FUTURE OUTLOOK

The future outlook for the Indian poultry sector appears to be bright. The most optimistic forecasts predict a two- to three-fold increase in poultry production. According to one projection, egg production is expected to reach 106 billion by 2020 (Mohanty and Rajendran, 2003). According to estimates based on a Pilot Information Survey project (Khare, 2003/2004), egg production will rise to 120 billion by 2020 and poultry meat production to 4.2 million tonnes. *Poultry vision 2010: the Indian perspective,* a study by the All India Poultry Breeders' Association forecasts that total egg production will reach 61 billion by 2010, 84 billion by 2015 and 101.8 billion by 2020; the study predicts that poultry meat production will rise to 4 million tonnes by 2010 and 8.6 million tonnes by 2020. A USDA report on Indian Poultry published in 2004 (Landes *et al*., 2004) is perhaps the most comprehensive study on Indian poultry. Using a simple economic model, the study forecast that poultry meat production and consumption would increase by 66 percent (2.3 million tonnes) by 2010; in the case of eggs, production and consumption were forecast to expand more slowly (an increase of 16.8 percent by 2010).

What, according to these studies, are the propelling forces that drive Indian poultry to these heights?

1. Today the world population is just over six billion people. By 2020, this number is expected to climb to 7.5 billion people. They are predicted to be eating 327 million tonnes of meat. Much of this growth is expected to originate in non-OECD countries. In 1997, the developing world consumed 111 million tonnes of meat; it is predicted that by 2020, the developing world will be eating 230 tonnes of meat. Poultry is expected to continue its dominance over other meats, accounting for 40 percent of the total meat eaten. India will not be an exception: the Indian population in 2020 is predicted to be around 1 350 million, and this huge population will have to be fed.
2. Because high birth rates prevailing over recent decades, a large proportion of the Indian population is relatively young – in the 20–59 year age group. People in this age group are high consumers. Thus, this factor is expected to further boost the growth of consumption in India.
3. Income levels across population segments have been growing in India. According to a National Council for Applied Economic Research (NCAER) study (reported in IBEF, 2006), the consuming class, with an annual income of US$980 (RS 45 000) or above is growing; and is expected to constitute over 80 percent of the population by 2009-2010. The increasing in income levels of the Indian population offers great growth opportunities.
4. Given the price of mutton, and fact that the availability of fish is restricted to coastal regions of the country, poultry meat has wider acceptance than any other meat.
5. There is a slow but gradual shift from vegetarianism to non-vegetarianism especially among the youth in India, implying strong growth potential for the poultry market.
6. The only constraint that will tend to restrict growth is input availability. The production of the main feed ingredients, maize and soy, has been static; until recently their

import was restricted. This scenario may change, as production may be increased through the use of high yielding varieties, and imports of maize may be liberalized.

While all these forecasts are promising for the Indian poultry sector, they are (except the USDA estimates) not based on strong economic analysis, and do not allow the impact of alternative policy parameters to be taken into consideration. The following sections, therefore, consider alternative scenarios and their possible consequences.

4.1 The OECD/FAO Agricultural Outlook, 2007-2016

The OECD/FAO *Agricultural Outlook* for 2007-2016 offers an assessment of agricultural markets covering cereals, oilseeds, sugar, meats, milk and dairy products. Using the AGLINK-COSIMO model, it presents a plausible scenario for the evolution of agricultural markets over the next decade, and provides a benchmark for the evolution of these markets. These projections are made for 20 agricultural commodities across 37 countries including India. We draw on these estimates because of the model's ability to perform alternative scenarios.

The AGLINK model began as a pilot project by OECD in 1992 for forecasting agricultural outlook. It is a recursive-dynamic partial equilibrium, supply–demand model of world agriculture developed by OECD Secretariat in close cooperation with member countries and with certain non-member countries. It covers annual supply, demand and prices for the principal agriculture commodities produced, consumed and traded in each of the countries represented in the model. The proximate goal of the model is to trace the potential impact of various trade and other economic policies on agricultural markets in the medium term. The model has, since its first application in 1992, played an important role in predicting the medium-term outlook for agriculture commodities.

The Food and Agriculture Organization of the United Nations (FAO) has long been doing agricultural projections based on its World Food Model. In 2004, FAO decided, after discussions with OECD, to collaborate in the AGLINK model, extending it to a large number of developing countries, and jointly to undertake the annual medium-term outlook exercise. The project to develop new modules has been known as the COSIMO (Commodity Simulation Model) project, and the parameters of the World Food Model were used as a basis for the development of new country models. Thus the AGLINK-COSIMO model was born – a more detailed economic model representing both OECD markets and developing-country markets for medium-term commodity projections. The model is currently composed of 10 800 equations and covers 39 countries and 19 regions. The main commodities covered by the model, and which have complete representation of supply, demand, trade and prices are: wheat, coarse grains (barley, maize, oats, sorghum, rye, other cereals), rice, oilseeds (soybeans, rapeseed, sunflower seed), vegetable oils (palm oil, oilseed oils, soybean oil, rapeseed oil, sunflower oil), milk, butter, cheese, whole milk powder, skim milk powder, fresh dairy product, other dairy product, whey powder, casein, beef and veal, pig meat, poultry meat, sheep meat, and eggs.

The projections are based on certain assumptions:

- population growth is assumed to slow to 1.08 percent *per annum* for the world as a whole;
- world oil prices are projected to remain high relative to historical levels, declining to around US$55 by 2012, then to rise slowly to just over US$60 by the outlook horizon;

- it is assumed that trade polices as agreed in the Uruguay Round agreement on agriculture will hold the entire period, and no conjectures as to the future outlook of Doha Development Agenda negotiations are incorporated;
- strong growth in the newly emerging economies such as India, China and Brazil will persist, which will support broader growth in Asia and South America – all three countries have growing presence in agriculture markets; and
- for the meat sector it is assumed that normal conditions will prevail, which is to say an absence of animal disease outbreaks and no explicit disease restrictions on production, trade or computation.

OECD-FAO Agricultural Outlook: projection of Indian poultry meat and egg production

These projections have been produced under the following assumptions or forecast values:

- real GDP is assumed to grow at the rate of 7 percent *per annum* in 2007 and 2008, and thereafter to decline to 6.6 percent in 2010 and to 4.9 percent in 2015 and 2016;
- population is assumed to grow at the rate of 1.35 present *per annum* till 2011 and then slowly fall to 1.18 percent in 2016;
- the rupee–US$ exchange rate is assumed to fall to Rs 51.6 per US$ in 2010 and, to Rs 64.8 per US$ in 2016;
- import tariff for both, poultry meat and eggs, is assumed to remain at the current level of 87 percent for poultry meat and 150 percent for eggs; and
- the price of maize, the main feed ingredient, is expected to rise to Rs 6 044.5 per tonne in 2007 to Rs 6 691.9 per tonne in 2010 and to Rs 8 320.5 per tonne in 2016.

The projections for poultry meat and eggs are shown in Table 22.

4.2 Alternative scenarios for the Indian poultry sector

Keeping the estimates shown above as a benchmark, we present three alternative scenarios and trace their implications. First, we assume that imports of poultry meat are further liberalized. Second, we study the consequences of liberalization of the import of maize, the main feed ingredient. Third, we evaluate the consequences of an outbreak of HPAI.

Scenario 1: import of poultry meat is liberalized

In the first scenario, we consider the likely impact of a complete opening up of trade in poultry meat. Currently, poultry meat imports are subject to an 87 percent tariff rate. Assuming that India removes these tariffs, imports of cheap poultry meat can be expected to invade the domestic market and compete with domestic production. What would be the magnitude of this effect?

First, for poultry meat, a tariff reduction of 87 percent can in all probability be expected to reduce the domestic price. The exact magnitude of the fall in price will depend on the response of imports to tariff cutting. As we have no information of the magnitude of this effect, the AGLINK-COSIMO model is used. The difference in the price before and after tariff reduction works out to be Rs 52 940 per thousand tonnes, which as a proportion of

TABLE 22

OECD-FAO Agricultural Outlook Projections: selected variables of Indian poultry meat

Commodity head	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Poultry Meat (1 000 tonnes)										
Consumption	2 203.7	2 338.5	2 449.5	2 595.5	2 755.6	2 870.8	3 042.3	3 144.4	3 322.7	3 428.8
Production	2 212.4	2 383.9	2 516.5	2 674.1	2 830.1	3 008.9	3 174.6	3 332.3	3 485.4	3 666.3
Exports	8.6	45.3	67.0	78.5	74.5	138.0	132.3	187.7	162.6	237.5
Imports	-	-	-	-	-	-	-	-	-	-
Producer price (Rs/tonne)	62 942.3	66 843.9	68 025.3	69 885.0	73 010.2	75 544.8	78 066.9	81 271.8	83 818.1	87 262.6
Egg (1 000 tonnes)										
Consumption	2 054.8	2 023.4	2 070.1	2 066.8	2 133.8	2 142.5	2 222.9	2 232.0	2 316.3	2 316.7
Production	2 069.4	2 038.4	2 084.6	2 081.4	2 148.4	2 157.1	2 237.4	2 246.6	2 330.9	2 331.4
Trade balance	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Producer price (Rs/tonne)	25 875.2	27 522.9	28 056.9	28 675.8	29 575.3	30 398.2	31 406.6	32 537.5	34 251.5	36 350.2

Sources: OECD Statistics.

TABLE 23
Impact of elimination of tariffs for Indian poultry: results of the AGLINK-COSIMO model

	Percentage change from the baseline solution shown in Table 22									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Consumer price	-40	-40	-39	-39	-39	-39	-38	-38	-38	-37
Per capita consumption	29	29	28	28	28	27	27	27	26	26
Producer price	-49	-49	-49	-49	-49	-49	-49	-49	-49	-49
Production	-29	-29	-29	-29	-29	-29	-29	-29	-29	-29
	Quantity (1 000 tonnes)									
Import	1 273	1 329	1 367	1 432	1 519	1 528	1 617	1 625	1 729	1 725
Net trade	-1 272	-1 365	-1 424	-1 500	-1 583	-1 656	-1 739	-1 803	-1 882	-1 952

pre-liberalization price comes to be 40 percent. This is to say, consumer price of poultry meat can be expected to fall by 40 percent as a result of tariff cutting in the first year of simulation (2007), see Table 23. This in turn can be expected to stimulate imports. Thus, India's imports of poultry meat are expected to increase from a negligible level in 2006 to 1 273 thousand tonnes in 2007 and 1 725 thousand tonnes in 2016. See Table 23 for estimates of the magnitude of the production response.

A full liberalization of imports of poultry meat could, as the figures above indicate, be disastrous to the domestic poultry industry – production would fall by 29 percent.

Scenario 2: imports of maize are further liberalized

One of the major factors that might constrain further growth of the poultry industry is as mentioned above, the availability of maize and soy at reasonable prices. Feed costs alone account for 70 percent of the cost of production of eggs and broilers; and maize and soy are the two major feed ingredients, maize being the most important. Stagnating domestic production of maize and increasing use for other purposes (such as starch) have often led to shortages of maize for feed, and consequently increases in its price.

Importing maize can mitigate domestic shortages to some extent. Until recently, maize imports were affected by a tariff-quota formula,[23] under which imports attracted a 50 percent import duty.[24] We seek to trace the potential impact of the elimination of this tariff for production of poultry meat.

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[23] In-quota imports up to 350 000 tonnes attracted a duty rate of 15 percent.

[24] Because of the rising pressure of domestic demand, maize prices were rising in the domestic market during early 2007; to mitigate this, the government temporarily relaxed the tariff quota to 4 lakh tonnes, and the 15 percent duty was withdrawn (will be in effect till 31st December 2007).

The first step in this exercise is to measure the likely impact of tariff elimination on domestic price. Surprisingly, we find from the results of applying the AGLINK-COSIMO model that the proposed tariff removal does not affect domestic price, probably because the domestic price is much lower than world price of coarse grains.

Scenario 3: Effect of an avian influenza outbreak

The consequences of an outbreak of HPAI can be manifold. First, there are direct production costs because of losses of poultry due to disease and control measures such as culling. The effects of such losses extend not only to farmers, but also to upstream and downstream sectors such as poultry traders, feed mills and breeding farms. Second, there are indirect effects resulting in demand shifts, emanating from measures adopted to contain the spread of disease, such as bans on exports/imports; consumer responses in the form of reduced consumption; and reduced levels of economic activity in sectors such as tourism, travel, transport and the hospitality industry. Finally, there are costs of prevention and control, which include costs incurred by the government for the purchase of poultry vaccines, medications and other inputs; and hiring workers for culling, clean up, etc. Governments are also faced with the need to at least partially compensate poultry owners – an important factor in persuading owners not to conceal outbreaks of contagious poultry diseases.

A total assessment of all these costs warrants far more information than what we possess at present. Therefore, we limit our assessment to the effects generated by a decline in consumption. In all principle consumption areas, i.e. nearly 40 countries from western Europe, the far East, and Africa, the outbreaks of HPAI in 2005 and early 2006 led to major consumption shocks (OECD/FAO, 2006), which translated into shifting trade flows, declines in domestic price, and supply responses in both affected and non-affected countries. Hence, to trace the potential impact of a possible outbreak of AI in India, we start by assuming that total consumption will decline by 10 percent – people will stop eating

TABLE 24
Impact of avian influenza on Indian poultry: results of AGLINK-COSIMO

	Percentage change from the baseline solution shown in Table 22									
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Consumer price	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Export	1.9	-100.0	-7.9	3.4	2.0	0.0	0.2	0.5	0.4	0.2
Import*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Per capita consumption	0.0	-6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Producer price	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Production	0.0	-0.2	-0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0

*negligible value.

poultry meat and instead shift to other meats and vegetables. Moreover, it can be assumed that imports of poultry from India will be banned. As expected, the effects are substantial in the short term (Table 24). This is based on results obtained using the AGLINK-COSIMO model. The consumer price (all India average) declines by 0.2 percent. Furthermore, exports decline by 100 percent within one year of an HPAI outbreak. Nevertheless, they will start picking up within one year. The per capita consumption declines by 7 percent in the first year of the outbreak. However, it will return to its trend within a year.

4.3 Possible consequences of rapid growth on public health and biosecurity

Disease is the main threat to any livestock industry. Diseases are mostly caused by bacteria, viruses, protozoa and fungi. Disease-causing organisms may enter farm premises via air and water, or may be are carried mechanically by human visitors or by equipment brought onto the premises in vehicles. Preventing disease entry is broadly known as "biosecurity".

In the poultry sector, one aspect of biosecurity is that farms should not be close to each other. However, the industry is now shifting towards integration, which tends to give rise to concentration of farms in a limited geographical area. Though integration may help to improve efficiency, it may pose a threat to animal health. The large-scale poultry operations of today may turn into the disease heavens of tomorrow, where even a disease of low virulence may seriously affect the entire flock. Therefore, biosecurity is one of the most formidable challenges for both the rural and commercial set-ups.

In the rural areas, animal health provision is at present insufficient to counter the high mortality rates that prevail particularly in young birds. In the commercial sector, health requirements are even more stringent and demanding given the threat posed by emerging diseases. Vaccination and medication, coupled with strict biosecurity measures, are needed to address the threat. Availability of vaccines and drugs, and their safety in terms of levels in end products for human consumption, are other issues that need to be considered. High-level surveillance is also needed to keep diseases like HPAI at bay.

4.4 Animal welfare

In the next 20 years, the poultry industry is going to be increasingly concerned about animal welfare. The cage-based system is being phased out, and those cages that are being retained will have to meet tough standards. Legislation in force sets a minimum space of 500 cm^2 for such cages. By 2012, any new cages that are added to a farm will have to provide 750 cm^2. There are also welfare issues concerning the transportation of animals. There is strong resistance to animals being transported over long distances for slaughter. The perception is that slaughter must be close to where the animals are reared. Given the extreme climatic conditions found in India, ensuring appropriate methods of transportation is an important aspect of welfare.

4.5 Environment

The commercial poultry sector not only produces eggs and meat, but also by-products such as slaughter waste, hatchery waste, poultry droppings and litter manure. The huge problem of poultry waste poses a serious threat to the environmental safety of the region. It may lead to contamination of groundwater, which has serious long-term implications. Environmental impact assessment is, therefore, another important area to be considered.

5 EFFECT ON SMALLHOLDERS

Livestock production in India, in general, is the activity of smallholders, and is extremely important for livelihoods. Poultry is, however, something of an exception it is characterized by a very wide range of operations, with livelihood and subsistence at one end of the spectrum and highly commercial operations at the other. More than 50 percent of the landless and marginal farmers at the bottom end of the smallholder spectrum supplement their livelihoods through poultry keeping. Poultry has, thus, been a core support system for subsistence farmers, providing them with supplementary income. The birds are cared for by the family, especially the women.

A worrisome feature of the introduction of poultry factory farming and its accelerated growth in India is its potential impact on small and marginal farmers. What is the prospect for these farmers in the near future? Will they benefit or will they be pushed out of business? Will they be able to participate in the fast changing environment? These are a few of the questions that concern policy-makers, and hence merit some attention here (Garces, 2002).

Compassion in World Economy Trust (CWFT), a research-based farm welfare organization that investigates the development of factory farming at an international level recently studied the effect of the rise in factory farming in southern countries. A striking finding of the study was that the introduction of industrial livestock rearing not only harms the individual small-scale farmers, but also developing countries as a whole. Because of industrial livestock rearing, these countries have become more import dependent – grains, tractors, fuel and fertilizers are required for the intensive livestock rearing. During the last decade, Asia has begun to import large amounts of grain to feed its industrially produced livestock. Machines, oil and producing units are being imported. The study reports the following example to highlight how significant family level poultry rearing is for food security: an average flock of five chickens enabled a woman in central United Republic of Tanzania to earn an additional US$38 per year, equivalent to a 9.5 percent increase in income – poultry rearing has contributed to the "greater empowerment of women by improving their financial status; and the loss of family farming to industrial farming could seriously affect women and children" (Garces, 2002).

In the Indian context, a recent study by Birthal *et al*. (2006) sought to address the issue of whether and under what conditions smallholders could benefit from such a fast-changing environment. Their main contention or key hypothesis is that vertical coordination in agricultural supply channels helps to lower the transaction costs and market risks of smallholders. "Proper market institutions are needed to reduce transaction costs, manage risks, build social capital, enable collective actions, and redress missing markets ... Unless small holders enter vertically coordinated supply chains with processors and retailers, they will have increasingly difficulty in participating in the growing high value markets." The study considered three commodities: milk, broilers and vegetables. For each, they assessed the performance of farmers under contract farming and non-contract farming.

First, they assessed the profitability of farmers under contract farming vis-à-vis those under non-contract farming. Profits of contract farmers in all three commodities were found to be higher than non-contract farmers. However, in the case of broiler production there was no statistical difference between the average profits of contract and non-contract farmers. The advantage of the contract farmers was a result of savings in production and marketing costs. Second, they found that fears that the processor/retailers may discriminate against small farmers by having a tie up with a few large farmers are misplaced. Contract farmers irrespective of the size were found to be producing at lower cost than non-contract farmers; these facts reveal that small farmers were neither being deprived of participation nor being exploited by the firm. Third, they concluded that even if markets work well, small farmers have trouble to take advantage because of poor infrastructure. This warrants provision of proper physical infrastructure that connects small farmers to markets.

That contract farming is more efficient than non-contract farming in the Indian context has been shown by another study by Ramaswami *et al*. (2006). They sought to evaluate production costs of contract growers relative to non-contract growers in Andhra Pradesh, a state in southern India. The simulated cost for contract growers is Rs 24.3 to produce a kg of bird; for the non-contract grower, it is Rs 26.22, i.e. a saving of Rs 1.9 for every kg of bird produced. If the interest cost, say 15 percent, is added, the savings of contract growers amounts to Rs 2.07. "The higher efficiency of contract grower is driven by its lower feed conversion ratio" (ibid.). To test this, they pooled the samples of contract and non-contract production, and regressed feed quantity on output, as well as output interacted with a contract dummy variable. The coefficient of interaction variable estimates the difference in FCR between the two groups of producers. The difference between the FCR was found to be statistically significant.

A recent study on Indian poultry based on a household survey of 320 farm households carried out across the states of Andhra Pradesh and Haryana has something more to say on these issues (Mehta *et al*., 2003). Specifically, the study sought to probe:

- Why do some poultry farms have higher nominal profits per unit of output than others?
- Why do some farms have higher negative environmental impact per unit of output than others? Do the negative environment externalities explain relative competitiveness?
- To what extent are these differences across farms a result of differences in transaction costs, environmental extremities, and policy subsidies, as compared to technical or allocative efficiency once these factors have been taken into account?
- What is the relative importance of each of these explanatory factors across farm sizes?

Several key points emerged from this study:

First, profitability does not differ much between small and large producers: profitability (profits per unit of output) does not differ much between small and large-scale farmers, whether layer or broiler. In other words, profitability is not significantly affected by the scale of operations. This is evident from the Tables 25 and 26.

Second, small producers expend more efforts and make more investment in pollution abatement than large producers. Due to growing awareness of the need to protect the environment, poultry farms today are increasingly required to adhere to environmental

TABLE 25
Distribution of layer units by profitability

Profitability (Rs/egg)	Small (<10 000 birds) (no. of units)	Large (>10 000 birds) (no. of units)	Total (no. of units)
-1.00–0.00	4	7	11
0.00–0.10	11	18	29
0.10–0.20	12	24	36
0.20–0.30	8	32	40
0.30–0.40	23	15	38
0.40–0.48	5	2	7
Total	63	98	161

Note: average price of output is Rs 1.19 per egg.
Source: Mehta *et al.* (2003).

TABLE 26
Distribution of broiler units by profitability

Profitability (Rs/bird)	Small (<10 000 birds) (no. of units)	Large (>10 000 birds) (no. of units)	Total (no. of units)
-0.50–0.00	2	1	3
0.00–1.00	11	2	13
1.00–2.00	8	5	13
2.00–3.00	5	7	12
3.00–5.00	10	7	17
5.00–7.00	10	4	14
7.00–11.00	19	6	25
11.00–15.00	18	3	25
15.00–20.00	10	7	17
20.00–30.00	7	4	11
30.00–53.00	9	3	12
Total	109	49	158

Source: Mehta *et al.* (2003).

regulations, particularly with regards to water purity, manure removal and carcass disposal. Conventional wisdom would have suggested that small producers would be worse offenders than large producers. When this was put to test by regressing environmental cost per unit of output[25] – with a select list of explanatory variables,[26] it was found that the scale coefficient was positive in the case of both layer and broiler production. Small-scale producers tended to spend a larger amount per unit of output in terms of pollution abatement than did large producers.

Third, profitability is determined by the price of chicks, wage rate, price of eggs/broilers, value of capital stock and FCR. The main factors that determine profitability are price of DOCs, price of labour (wage rate), price of eggs/broilers, value of capital stock and FCR – profitability is inversely related to the price of chicks, wage rate, price of feed and FCR; it is positively related to the price of eggs/broilers and value of capital stock. This emerged clearly when in the estimation of frontier profit function, the dependent variable, namely profitability, was first regressed with frontier variables: price of DOCs, wage rate, price of feeds, price of eggs/broilers, family labour per unit of output, value of capital stock per unit of output, labour housing, FCR, and a scale dummy (1 for small units and 0 for large units). The results, as expected, showed profitability to be negatively related to the price of chicks and the price of feeds, and positively related to the price of eggs.

Fourth, small farms are less efficient: though profitability does not differ much between small and large farms, their efficiency differs significantly. Small farmers are relatively inefficient; and the principle reasons for their inefficiency are high transaction costs and high pollution abatement costs. That is to say, small producers are disadvantaged compared to large producers in obtaining credit, information, marketing, transportation and storage facilities. They are also constrained to spend more on collection, drying and transporting poultry manure (pollution abatement costs) to keep poultry sheds and the surrounding environment clean. This emerged clearly when in the second step run for the frontier function, technical inefficiency (the residual terms obtained from the application of the first step) is taken as the dependent variable, and the explanatory variables are transaction costs[27] and pollution abatement costs[28]. From the estimated coefficients, one can make inferences about the direction and magnitude of the contribution of each determinant to the relative inefficiency of the farm in question. A significant positive coefficient means a positive contribution to increased inefficiency.

Fifth, contract farmers earned less profit than non-contract (independent) farmers. To check profitability of contract farms vis-à-vis non-contract farms, financial profits of sample

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[25] Environment cost is defined as the sum of the costs of controlling flies + dead bird disposal + cost of pollution payment + manure disposal cost value of manure used/consumed.

[26] Explanatory variables include: family labour, number of houses in a 500 metre radius (proxy for concentration of units), total no. of years of experience, information source, independent/contract farmers dummy, gender of decision maker, state dummy, education, and age of the decision-maker. The regression is run with an intercept dummy (ip.scale) which takes a value of 1 for small and 0 for large. If the intercept dummy has a positive value, it confirms that small producers invest a larger amount in pollution abatement than do large producers. Alternatively, if the intercept takes a negative value, then the opposite is the case.

[27] The proxy variables selected for transaction costs are: age of the decision-maker, education of decision maker, information source, and distance to output market, gender of decision maker, access to credit, primary source of income, membership of a community organization, years of experience in poultry, no. of training programs attended, and region/state characteristics.Alternatively, if the intercept takes a negative value, then the opposite is the case.

[28] Pollution abatement costs are taken as costs of controlling flies + dead bird disposal cost + cost of pollution payment + manure disposal cost + value of manure used/consumed.

TABLE 27
Average profitability of non-contract vs. contract farms

Category	Average profitability (Rs/bird)
Non-contract broiler: small	13.130
Non-contract broiler: large	10.930
Non-contract broiler: total	12.436
Contract broiler: small	1.034
Contract broiler: large	3.164
Contract broiler: total	1.615
2005-2006	8.35

Source: Indian Poultry Survey (2002).

contract farms and non-contract farms were compared. Table 27 shows the results of these calculations.

The table shows that in terms of financial profitability, non-contract farms perform better than contract farms. Average profitability in the case of non-contract farms turns out to be Rs 12.43 per bird compared with Rs 1.62 per bird for contract farms. Not only are the differences substantial, they are also statistically significant. When the comparison is drawn between small non-contract farms and small contract farms, or between large non-contract farms and large contract farms, the differences remain substantial and statistically significant, and prove the contention that non-contract farms are more profitable than contract farms.

When comparisons are drawn between small and large farms within the same category (i.e. small contract farms vs. large contract farms; or small non-contract farm vs. large non-contract farms), the differences are not sufficiently significant to state categorically that small farms are more profitable than large farms.

Sixth, differences in policy subsidies across regions/states are also found to harm the efficiency of small producers more than that of large producers. This is evident from the regression results run separately for small producers – the coefficient for regional character is statistically significant and negative. More specifically, small farms in a state such as Andhra Pradesh are more inefficient than their counterparts in Haryana, because Andhra Pradesh levies a 4 percent processing tax on poultry products in addition to taxes on poultry feed, while Haryana has no such taxes.

To sum up, studies of the effects of the livestock revolution on small farmers reveal, many striking points. First, all these studies indicate that small and marginal farmers are being pushed out of business by factory farming. Farmers in the United States of America and in Europe have already experienced the painful consequences of this process, and the same pattern is being repeated in developing countries. Second, two critical instruments that might help to break this deadlock are (a) institutional arrangements such as cooperative contract farming that tend to reduce marketing risks; and (b) provision of physical infrastructure that connects small farmers to markets. Third, some of the alleged fears that the new institutional arrangements discriminate against small farmers are not well founded. Fourth, there is no strong evidence to show that profitability differs between small and large farmers, and there is conflicting evidence with respect to profitability of contract vs. non-contract farming. Though some recent studies have come down very strongly in support of contract farming stating that profits of contract farmers are higher than non-contract farmers, strangely their data suggest the opposite conclusion, i.e. that non-contract farmers earn more profit than contract farmers. It is, thus, difficult to draw firm conclusions as to whether the profitability of contract farmers is higher than that of non-contract farmers – more research in this area is warranted.

6 CONCLUSIONS

Poultry is one of the fastest-growing segments of the agricultural sector in India, with an average growth rate of 8 to 10 percent *per annum* (production of agricultural crops has been rising at a rate of 1.5 to 2 percent *per annum*). Production levels have reached 45 billion eggs and 1.7 million tonnes of poultry meat *per annum*. India is now the world's third largest egg producer and nineteenth largest producer of broilers. Poultry production contributes around 1 percent to India's GDP. A notable feature of the Indian poultry sector is that it is self sufficient, supported by a broad and strong genetic base, with the productivity levels (FCR) of broilers/layers being equal to those achieved in developed countries. India is one of the few countries that possess the technology for producing SPF eggs. Per capita annual availability of poultry products has increased to 44 eggs and 1.76 kg of meat – still below than the recommended levels of 180 eggs and 11 kg of meat. Bridging this gap through focused research and development efforts is likely to create at least 9 to 10 million jobs, export potential and nutritional security.

Undoubtedly, the credit for this impressive growth goes to poultry farmers, poultry breeders, integrators, feed mills, and above all to pro-active government policy. The government has funded several research activities, set up a number of poultry estates in collaboration with agencies like the National Bank for Agriculture and Rural Development (NABARD), provided veterinary health care services, and made animal health and diagnostic facilities available. Disease and diagnostic laboratories are located in different regions through institutions such as the Indian Veterinary Research Institute. Population growth and sustained growth in per capita income are the other driving forces behind the accelerated growth in poultry production.

The key structural change spurring production growth has been the emergence of integrated production systems bringing about economies of scale and the sustained profit margins necessary for the expansion of the sector. Vertical integration has spread in both southern and western parts of India, while it is less developed in the north and east.

Poultry exports from India have been on the rise. However, India's poultry exports are mainly confined to table eggs and egg powder, which are growing as a result of their cost competitiveness, improving hygienic standards and logistical advantages. Poultry meat exports are negligible because of high costs, inadequate meat-processing facilities and infrastructural bottlenecks

The future of the poultry industry appears to be bright. The most optimistic predictions suggest a two- to three-fold increase in poultry production in the coming 20 years. Egg production for instance, is expected to reach 105 to 106 billion and poultry meat to 8.6 million tonnes *per annum* by the year 2020. Integration in broiler farming will spread to other regions. This is likely to reduce the price of chicken meat.

The main hurdles to future growth of poultry are: (a) availability of feed, especially maize and soy, at reasonable prices; (b) serious morbidity and mortality caused by diseases such as AI and Newcastle disease; the recent outbreak of AI in Maharashtra in February 2006 proved to be devastating for the Indian poultry sector; the fear of disease transmission led to reduced poultry consumption, depression of prices and adversely affected exports; and (c) poor infrastructure.

The future requirements for the Indian poultry industry are:

- improved biosecurity to maintain the health status of the growing number of birds in the country;
- increased productivity of feed – maize and soybean; and
- improved infrastructure.

APPENDIX I. ACTION PLAN OF THE DEPARTMENT OF ANIMAL HUSBANDRY TO CONTROL HPAI

The strategy of the government of India has been to contain the disease at sources, i.e. at the level of animal itself. This is the principle way to reduce opportunities for spread of the disease and for possible human infection. Therefore disease intelligence active animal surveillance, strengthening the early warning system in the pre-outbreak stage and total culling in prescribed radius resulting in rapid containment in the outbreak phase are critical assets to reduce such opportunities for spread of infection.

I. Pre-outbreak preparedness:

I.1: Surveillance: Need to be in a state of alertness and preparedness. Surveillance is the most important part of the strategy to control and contain HPAI. India has a poultry population of 481 million both commercial and backyard. About 60 percent of the population is in the commercial sector. It is indicated that the migratory birds play a role in the spread of the virus across countries and continents. India lies within three major internal fly ways of migratory birds. Surveillance will therefore have to include both poultry and migratory birds.

I.1.1: Poultry owner, especially commercial poultry owners including consultants, franchisees, service providers and those related to rearing of poultry are individually and collectively responsible to immediately report unusual mortality and sickness in birds to the government.

I.1.2: The state governments are advised to develop routine surveillance plans. Representative random sampling may be done.

I.1.3: A system of active and large targeted surveillance has been initiated. It includes immediate response to unusual sickness/mortality among the birds.

I.2: Sample collection, packing and Transportation: The states must ensure proper collection, packing and transportation of samples, and give particular attention to the quality and quantity of samples forwarded to the labs.

I.3: District collector has to play a central and coordinating role especially concerning aspects of quarantine closure of shops, corporation, money control, ban on sale of poultry related products, administering vaccination plan etc. Therefore the district collector should be thoroughly formalized with the action plan.

II: Steps to be taken in case of suspicion of outbreak of AI:

II.1: In case of suspicion of outbreak of AI such as receipt of any preliminary report regarding unusual sickness or above average mortality of poultry as well as wild and migratory birds at a place for any other source, the investigation officer shall visit the place immediately and ascertain the facts of the case.

II.2: The investigation officer should carry out a clinical investigation with the aim to establish the clinical situation on the farm, including ill and suspect birds. The clinical investigation must be performed on all susceptible species present on the farm, and it must begin for the most peripheral units. All this information must be reported in the epidemiological inquiry report.

II.3: If the preliminary and clinical investigations indicate that it is an unusual situation indicating surveillance of AI, then the investigating officer has to ensure that steps as indicated in the subsequent paras are taken immediately.

II.4: Collection of samples and dispatch for laboratory tests: Samples should be sent to lab immediately.

II.5: Immediate report to Director, Animal Husbandry.

II.6: Identification of alert zones.

III: Action plan in case of outbreak of NAI is confirmed:

III.1: Notification and information of outbreak: In case lab test confirmed the occurrence of Notifiable AI; HSAD Bhopal will inform the Govt. of India. The Govt. will dispatch Central Rapid Response teams of Dept of Animal Husbandry.

III.2: The International Agencies are to be notified by the Dept of Animal Husbandry.

III.3: In view of the threat of human infection for particular strain of NAI, public health aviation is to be immediately notified.

III.4: Demarcation of surveillance and infected areas and actions to be taken in these areas.

III.5: Immediate tasks to be carried out by the veterinary officer on confirmation of

(i) Quickly report the state and condition of the farm to determine the nature and scope of operations to be conducted.

(ii) Identify locations on the farm where vehicles leaving the farm can be properly washed and disinfected.

(iii) Active disinfection procedures at the point of entry/exit from the infected premises.

(iv) Ensure that vehicles are washed and disinfected internally and externally.

(v) Absolute ban on movement of poultry.

(vi) Closure of poultry and egg.

(vii) Ban on movement of farm personnel.

(viii) Destruction of birds in the infected zone of 3km radius.

REFERENCES

APEDA. 2006. *Residue monitoring plan for 2006, for drugs and pesticides for exported egg products to the European Union.* New Delhi, Agricultural and Processed Food Products Export Development Authority.

AT Kearney & CII. 2006. *Retail in India: getting organized to drive growth.* New Delhi/Mumbai. AT Kearney and Confederation of Indian Industry.

BBC News. 2006. *Countdown to India's retail revolution,* by T. Poston. (available at http://news.bbc.co.uk/1/hi/business/4662642.stm)

Bharadwaj, P.K. undated. *Poultry market – opportunities for the farmers*. Coimbature, India, Suauna Poultry Farm Ltd.

Birthal, P.S., Joshi, P.K. & Gulati, A. 2006. *Vertical coordination in high value food commodities: implications for small holders.* MTID Discussion Paper No. 85. Washington DC, International Food Policy Research Institute.

CII & Mckinsey 1998. *Food and agriculture, integrated development action (FAIDA)*, Second edition.

CMIE. 2004. *India's trade*. Mumbai, India. Centre for Monitoring Indian Economy.

Desai, A. 2004. *An overview of the Indian poultry and future scenario.* All India Poultry Year Book, Special Millennium Issue. Delhi.

FAO. 2003. *Project on livestock industrialization, trade and social-health-environment impacts in developing countries. Policy, technical, and environmental determinants and implications of the scaling-up of livestock production in four fast-growing developing countries: a synthesis. Final research report of phase II,* by C.L. Delgado, C.A. Narrod, & M.M. Tiongco. Rome.

FAO/OECD. 2006. *Impact of animal disease outbreaks on livestock markets*. Committee on Commodity Problems, Inter-government Group on Meat and Diary Products, 21st Seminar, Rome, 13-16 November.

FAOSTAT. *FAO statistical database* (available at http://faostat.fao.org/default.aspx).

Garces, L. 2002. *The livestock revolution and its impact on small holders*. *LEISA Magazine*, 18(1): 22-23.

GOI. 2006. *Basic animal husbandry statistics*. New Delhi, Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries.

GOI. *Custom tariff of India,* (various issues). New Delhi.

GOI. *Economic survey,* (various issues). New Delhi.

GOI. *National income accounts statistics*, (various issues). New Delhi, Central Statistical Organisation.

Government of Kerala. *Virtual university for agriculture trade*. Department of Agriculture, Thiruvananthapuram, India.

Gulati, A., Minot, N., Delgado, C. & Bose, S. 2007. Growth in high value agriculture in Asia and the emergence of vertical links with farmers. *In* J. Swinnen, ed. *Global supply chains, standards and the poor.* Wallingford, UK. CABI Publishing.

IBEF. 2006. *Food processing*. Gurgaon, India, India Brand Equity Foundation.

Indian Poultry Survey. 2002. New Delhi.

Khare, S.P. 2003/2004. *Estimation of production and marketing parameters of Indian poultry industry. Poultry Yearbook.* New Delhi.

Landes, M., Persuad, S. & Dyek, J. 2004. *India's poultry sector: development and prospects.* Agriculture and Trade Report, WRS 04-03. Washington DC, Market and Trade Economics Division, Economic Research Unit, United States Department. of Agriculture.

Mehta, R. 1997. Trade policy reforms, 1991–92 to 1995-96: their impact on external trade. *Economic and Political Weekly,* April: 779–784.

Mehta, R. 1999. *Tariff and non-tariff barriers of Indian economy: a profile.*New Delhi, Research and Information System for theNon-Aligned and Other Developing Countries

Mehta, R. 2005. *Non-tariff barriers affecting India's exports*. RIS Discussion Paper No. 97. New Delhi, Research and Information System for the Non-Aligned and Other Developing Countries.

Mehta, R., Nambiar, R.G. & Ray, S. 2005. WTO and poultry industry in India. *South Asian Journal*, 9 (July-September): 69–87.

Mehta, R., Nambiar, R.G., Singh, S.K., Subrahmanyam, S. & Ravi, C. 2002. *Livestock industrialization, trade and social-health-environment issues for the Indian poultry sector.* IFPRI/FAO Livestock Industialization Project, Phase II Project. Washington DC, International Food Policy Research Institute.

Mehta, R., Nambiar, R.G., Singh, S.K., Subrahmanyam, S. & Ravi. C. 2003. *Policy, technical, and environmental determinants and implications of the scaling-up of broiler and egg production in India.* IFPRI/FAO Livestock Industialization Project, Phase II Project. Washington DC, International Food Policy Research Institute.

Mohanty, S. & Rajendran, K. 2003. 2010 vision for Indian poultry. *International Journal of Poultry Science,* 2(2): 139–143.

OECD/FAO. 2007. *Agriculture outlook 2007–2016*. Paris.

OECD Statistics. (available at http://www.oecd.org/statsportal/0,3352,en_2825_293564_1_1_1_1_1,00.html).

Ramaswami, B., Birthal, P. & Joshi, P.K. 2006. *Efficiency and distribution and contract farming: the case of Indian poultry growth*. MTID Discussion Paper No.91. Washington DC, International Food Policy Research Institute.

RBI. 2005/2006. *Handbook of satistics on Indian economy*. New Delhi, Reserve Bank of India.

WTO. 1995. *Country tariff schedule of India*. Washington DC, World Trade Organization.

DEFINITIONS AND ABBREVIATIONS

Units of Conversion

1 lakh	= 100 000
1 crore	= 10 000 000
1 million	= 10 lakh
1 million	= 0.1 crore
1 billion	= 100 crore

US$1 = Rs 45.92 (2003-2004) = Rs 44.27 (2005-2006)

Indian Financial Year = April – March

AI	avian influenza
APEDA	Agriculture and Processed Food Products Export Development Authority
BIS	Bureau of Indian Standards
CII	Confederation of Indian Industry
CTIPPM	Central Training Institute for Poultry Production and Management in Bangalore
DOC	day-old chick
ERS	Economic Research Service
EU	European Union
EXIM	Export-Import Bank of India
FAO	Food and Agriculture Organization of the United States

FCR	feed conversion ratio
FDI	foreign direct investment
FMCG	fast moving consumer goods
FPO	Food Products Order, 1955
GDP	gross domestic product
GHP	good hygiene practices
GIC	General Insurance Corporation of India
GMP	good manufacturing practices
GNP	gross national product
GOI	Government of India
HACCP	hazard analysis and critical control points
HPAI	highly pathogenic avian influenza
HSAD	High solids anaerobic disegestion, main facility to develop poultry vaccine
IBEF	Indian Brand Equity Foundation
IPDP	intensive poultry development projects
IRDP	Indian Rural Development Programme
MFPO	Meat and Food Products Order, 1973
MMPO	Meat and Meat Product Order, 1992
NABARD	National Bank for Agriculture and Rural Development
NAFED	National Agricultural Co-operative Marketing Federation
NAI	notitiable form of avian influenza
NCDC	National Cooperative Development Cooperation
NECC	National Egg Coordination Committee
NGO	non-governmental organization
NPDB	National Poultry Development Board
NRL	National Reference Laboratory
NSS	National Sample Survey
NSSO	National Sample Survey Organization
OGL	open general license
OIE	World Organisation for Animal Health (Office International des Epizooties)
PFA	Prevention of Food Adulteration Act, 1954
QRs	quantitative restrictions
RMP	Residue Monitoring Plan
SAARC	South Asian Association for Regional Cooperation
SPF	specific pathogen free
SPS	sanitary and phytosanitary
TBT	technical barriers to trade
TM OPM	Technology Mission on Oilseed, Pulses and Maize
TRQ	tariff rate quota
USDA	United States Department of Agriculture
VH	Venketeswara Hatcheries
VPO	Vegetables Product Order, 1967
WHO	World Health Organization
WTO	World Trade Organization

Case study of the Egyptian poultry sector

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SUMMARY

The poultry industry is one of the main agricultural industries in Egypt, where investment in this industry is about LE18 billion. The size of the labour force is about 1.5 million permanent workers and about 1 million temporary workers. The industry contributes a large part of the country's supply of animal protein (white meats and eggs). During the last decade of the twentieth century and the early years of the twenty-first century, local poultry meat production was sufficient to cover local consumption. Local production was on average 874 000 tons during the period 2001 to 2005, compared to an average local consumption of 871 700 tons. Local egg production was 310 000 tons on average for the same period, which also covered local consumption. The poultry industry not only supplies animal protein for feeding the human population, but is also linked to other industries such as animal feed, medicine and veterinary inputs.

The value of poultry meat and egg production in 2004/2005 was about LE9.7 billion (LE7.6 billion for poultry meat and LE2.1 billion for eggs) – representing around 24.6 percent of the value of the country's animal production and around 8.8 percent of the value of agricultural production. Poultry meat contributed 20 percent of the total daily per capita consumption of animal and fish protein, which is about 30.3 grams/day. Poultry meat is popular among Egyptian consumers across all income categories, because of its low cost compared to red meat and fish. Poultry also represents an income source for many poor families who practise traditional aviculture. About 90 percent of rural households and a great number of urban households rely on aviculture as a clean and cheap source for animal protein and as a contributor to income, especially given the rising price of red meat which reached LE30–40/kg during the period after 2004/2005. Poultry keeping is considered to be one answer to the high rate of unemployment in Egypt, which stood at 11 percent of the total labour force in 2004/2005.

Poultry production differs from other animal production activities in several ways. The most important is the rate of capital circulation: while broiler chicken production requires between 50 and 60 days, the production of red meats needs 9 to 12 months. Additionally, poultry production needs relatively little capital. Poultry require about 3 kg of feed to produce 1 kg of meat – compared to the 7 kg of feed needed to produce 1 kg of red meat.

1. ECONOMIC IMPORTANCE OF POULTRY PRODUCTION IN EGYPT

1.1 The economic importance of the animal production sector in the Egyptian agricultural economy

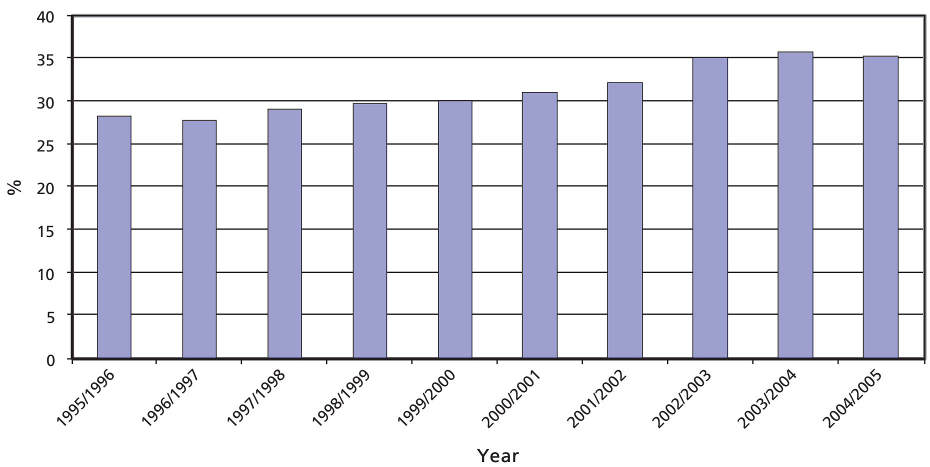
Table 1 shows that the value of animal production was LE39.3 billion in 2005, representing 35.2 percent of agricultural production; crop production represented 58.2 percent and

TABLE 1
The value of animal production relative to that of other agricultural activities, 1995/1996 to 2004/2005

Year	Plant production		Animal Production		Fish Production		Total Agricultural production	
	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%
1995/1996	33 750	67,5	14 102	28,2	2 133	4,3	49 985	100
1996/1997	38 046	67,7	15 556	27,7	2 564	4,6	56 166	100
1997/1998	40 312	65,8	17 815	29,1	3 144	5,1	61 271	100
1998/1999	40 786	64,1	18 871	29,7	3 983	6,3	63 640	100
1999/2000	43 997	63,9	20 683	30	4 207	6,1	68 887	100
2000/2001	43 852	61,2	22 126	30,9	5 686	7,9	71 664	100
2001/2002	44 744	59,9	24 003	32,1	5 993	8	74 740	100
2002/2003	48 516	57,6	29 556	35,1	6 188	7,3	84 260	100
2003/2004	55 500	57,3	34 600	35,7	6 700	6,9	96 800	100
2004/2005	65 100	58,2	39 300	35,2	7 400	6,6	111 800	100

Source: National Agricultural Income, Economic Affairs Sector (EAS) Ministry of Agricultural and Land Reclamation.

FIGURE 1
Relative importance of the value of animal production in Egyptian agriculture, 1995 to 2005



fishery production 6.6 percent. The table also shows that over the period 1995 to 2005 the value of animal production increased by 178.7 percent. Its relative importance within agriculture also increased from about 28 percent to about 35 percent over this period. Figure 1 illustrates the changes in the relative importance of animal production in Egyptian agriculture through the period from 1995/1996 to 2004/2005.

1.2 The economic importance of poultry production within the animal production sector

Table 2 shows the relative contribution of poultry meat and eggs to the value of the output of the livestock sector during period from 1995/1996 to 2004/2005.

Table 2 and Figure 2 show that in 2005 the value of poultry meat production represented 19.3 percent of the value of animal production, while eggs represented 5.3 percent. Between 1995 and 2005, the value of poultry meat production rose from LE2.3 billion to LE7.6 billion, and the value of eggs production rose from LE707 million to LE2.1 billion. The value of poultry production (meats and eggs) rose from LE3.1 billion in 1995/1996 to almost LE9.7 billion in 2004/2005. Figure 3 illustrates the relative importance of the poultry sector to total animal production in value terms; it can be seen that the share of poultry production rose from 21.6 percent in 1995/1996 to 24.6 percent in 2004/2005, reaching a maximum of 27.7 percent in 2002/2003.

Table 2 shows that the value of poultry meat production represented 78.4 percent of the total value of poultry production in 2004/2005, while egg production represented 21.6 percent. Figure 4 shows that the relative importance of poultry meat production increased from 76.8 percent of total poultry production in 1995/1996 to 78.4 percent in 2004/2005. The relative importance of egg production decreased from 23.2 percent to 21.6 percent over the same period.

Figure 4 illustrates that throughout the period 1995/1996 to 2005/2005 poultry meat represented about 80 percent of the value of poultry production, while eggs represented about 20 percent.

2 STRUCTURE OF THE POULTRY SECTOR IN EGYPT

Figure 5 illustrates the structure of the poultry sector in Egypt, which consists of two main divisions: poultry enterprises and the household poultry sector. Poultry enterprises include: broiler enterprises; table egg enterprises; rabbit enterprises; duck and turkey enterprises; broiler breeder stations; poultry grandparent enterprises; ostrich and quail enterprises; auto-slaughter enterprises; local hatching laboratories; industry hatching laboratories; and feed enterprises. Statistics related to the capacity, distribution and development of poultry enterprises are presented in the appendix to this paper.

The household poultry sector is one of the main income sources for numerous families, both in the countryside and in the cities. All types of poultry are kept – chickens, turkey, geese, ducks, rabbits and pigeons. Statistics on the household poultry sector are presented in the appendix to this paper.

TABLE 2
Value of the various components of animal production in Egypt in value terms, 1995/1996 to 2004/2005

Year	Cattle meat		Milk		Poultry meat		Table eggs		Bee honey		Wool, hair and camel hair		Manure		Total animal production	
	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%	Value (million LE)	%
1995/1996	6 426	45.6	3 426	24.3	2 346	16.6	707	5.0	75	0.5	77	0.5	1 045	7.4	14 102	100
1996/1997	7 463	48.0	3 553	22.8	2 551	16.4	705	4.5	83	0.5	77	0.5	1 124	7.2	15 556	100
1997/1998	8 038	45.1	4 685	26.3	2 757	15.5	868	4.9	84	0.5	86	0.5	1 297	7.3	17 815	100
1998/1999	8 086	42.8	5 052	26.8	2 912	15.4	879	4.7	80	0.4	95	0.5	1 767	9.4	18 871	100
1999/2000	8 494	41.1	5 383	26.0	3 315	16.0	959	4.6	87	0.4	97	0.5	2 348	11.4	20 683	100
2000/2001	8 936	40.4	6 065	27.4	3 477	15.7	1 028	4.6	90	0.4	107	0.5	2 423	11.0	22 126	100
2001/2002	9 061	37.7	6 385	26.6	4 458	18.6	1 347	5.6	97	0.4	114	0.5	2 541	10.6	24 003	100
2002/2003	11 407	38.6	7 035	23.8	6 266	21.2	1 923	6.5	99	0.3	125	0.4	2 701	9.1	29 556	100
2003/2004	12 500	36.1	9 500	27.5	6 400	18.5	2 100	6.1	100	0.3	132	0.4	3 868	11.2	34 600	100
2004/2005	15 500	39.4	9 900	25.2	7 600	19.3	2 100	5.3	109	0.3	135	0.3	3 956	10.1	39 300	100

Source: National Agricultural Income, Economic Affairs Sector (EAS).

FIGURE 2
Relative contributions of the components of animal production in value terms in Egypt in 2005

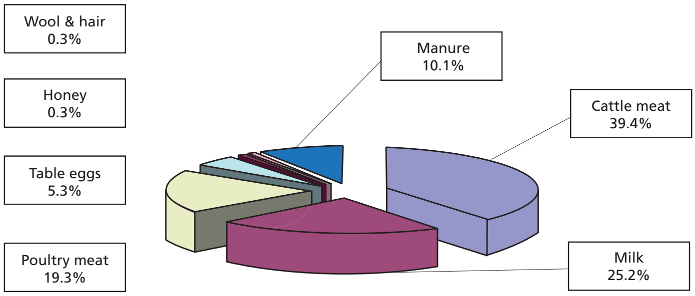


FIGURE 3
Relative importance of poultry production in value terms as a component of animal production in Egypt, 1995/1996 to 2004/2005

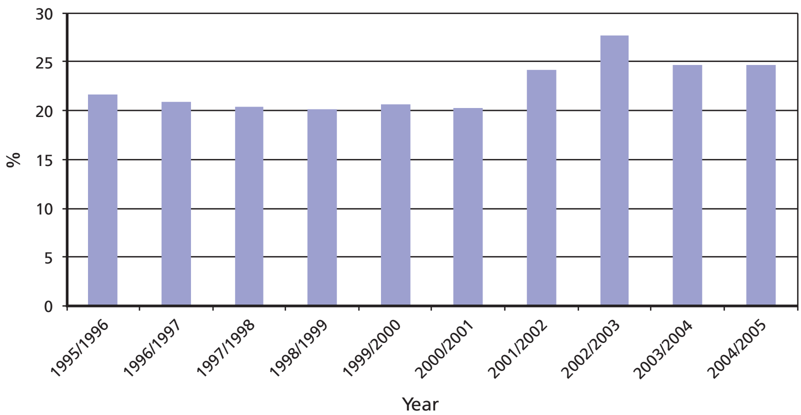


FIGURE 4
Share of meat and eggs in the value of poultry production

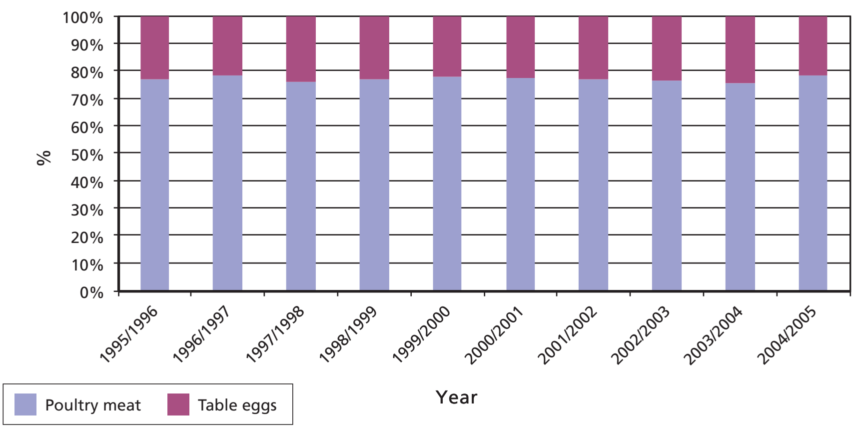
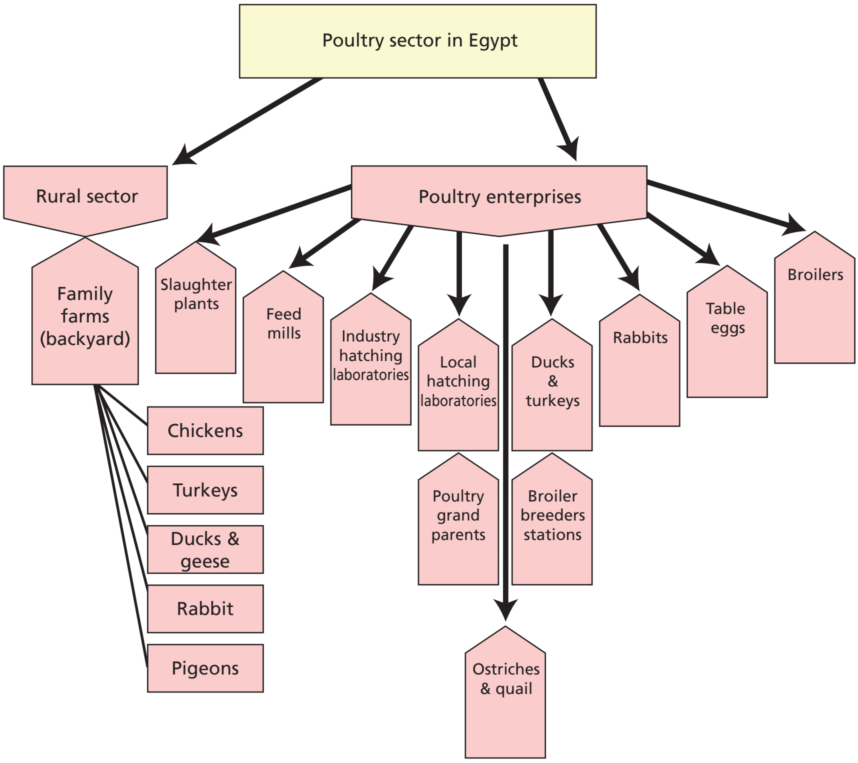


FIGURE 5
Structure of the poultry sector



3 ECONOMIC AND SOCIAL IMPACTS OF AVIAN INFLUENZA IN EGYPT

The first appearance of the disease in Egypt was in February 2006. The latest statistics (late 2007) show that the disease has caused the death of 11 people in Egypt. The total number of culled birds has reached 29 million, with an estimated value of LE463.4 million. This represents about 9.2 percent of the net annual income of the poultry sector, which was about LE5.060 billion in 2004. This means that over three months the disease caused financial losses of around LE half billion (at current exchange rate) to the poultry sector.

3.1 Economic effects

Culling of birds

Table 3 illustrates the number and value of culled birds from different classes of poultry up to 21 April 2006. It can be seen that the largest number of losses were among layers. Table 4 shows the figures for culled birds broken down by governorate.

TABLE 3
Number and value of culled poultry in Egypt up to 21 April 2006 (1 000)

	Broilers	Layers	Layer parents	Broiler parents	Grand parents	Ducks	Turkeys	Local poultry	Total
Number of culled birds (1 000)	8 182	17 737	960	1 113	28	422	60	495	28 997
Value of culled birds (1 000 LE)	108 101	239 450	32 160	61 215	NA	14 135	3 184	5 154	463 399
Total population	50 5499	18 529	317	7 966	NA	4 281	495	57 020	594 107

Source: Economic Affairs Sector (EAS), Ministry of Agriculture and Land Reclamation, 2006.

Unemployment resulting from the avian influenza outbreak

At the time of the outbreak, employment in the poultry sector was about 1.5 million permanent (full time) workers plus about one million (temporary) part time workers. As a result of the spread of the disease, about 250 000 of these workers lost their jobs – representing 10 percent of total workers in the industry on the level of the republic. Job losses were caused by the cessation of production of broiler poultry farms, as well as by the closure of feed production plants and retail and marketing operations.

Decreased demand for poultry and poultry products

Decreased demand for poultry and poultry products led to a significant decline in their prices. The poultry price index decreased by 5.5 percent, 7.9 percent and 7.0 percent, respectively, during October, November, and December 2005. This represented a serious loss for producers. The Egyptian cabinet estimated that the losses experienced by the Egyptian economy between October 2005 and February 2006 amounted to about LE3 billion.

As a result of the falling demand, poultry farmgate and consumer prices have decreased significantly – by 37 percent and 40 percent, respectively. In addition, the total marketing margins of traders have decreased by 64 percent. Consequently, the total revenue of broiler production has decreased by 28.6 percent, with a loss of 35.2 piaster per broiler; the return per Egyptian pound has decreased by 4.04 piaster. Numerous farm owners left the industry. There was also a decline in demand for inputs such as young chickens (25 percent) and concentrated feed (9.77 percent). In contrast, demand for vaccinations and drugs has increased by 11.6 percent.

The disease had both short-term and long-term effects. In the short term, it led to a 70 percent decline in poultry consumption. Demand for alternatives such as fish and red meats has, therefore, increased and their prices have risen significantly. Moreover, the significant decrease in the poultry supply led to increases in the prices of poultry and eggs when the rates of infection retreated. In the longer term, it is expected that there will be some changes to the structure of poultry industry – especially increased dependence on large-scale farms that are able to implement the required biosecurity measures. There is expected to be an increase in poultry prices, and a gap between production and demand for poultry products, which will have to be filled by imports. Moreover, it is expected that

TABLE 4
Geographical distribution of birds culled up to 21 April 2006

Governorate	Broilers	Layers	Layer parents	Broiler parents	Grand parents	Ducks	Turkeys	Local poultry	Total	Share of total (%)
Cairo	13 500	40 265	0	54 419	0	36 500	13 200	0	157 884	0.54
Gize	1 469 762	2 729 760	16 9532	597 612	0	70 212	760	0	5 037 638	17.37
Qalyubiya	1 651 626	30 472 846	0	41 700	0	24 280	15 600	0	4 776 052	16.47
Bahaira	23 041	0	6 000	0	0	11 475	0	0	40 516	0.14
Ghrabia	477 384	1 148 100	0	0	0	214 366	00	65 117	1 904 967	6.57
Sharkia	3299 790	9 452 728	779 000	385 484	28 000	8 000	5 000	0	13 958 002	48.14
Ismailia	34 000	354 820	0	0	0	0	0	0	388 820	1.34
Beni suef	4 864	0	0	0	0	0	0	0	4 864	0.02
Luxor	75 110	0	0	0	0	4 961	0	0	80 071	0.28
Aswan	22 700	0	0	0	0	0	0	0	22 700	0.08
Elminia	29 265	1 510	0	0	0	29	18 600	0	49 404	0.17
Menoufia	148 498	615 621	0	19950	0	404	2 000	00	786 473	2.71
Dakahlia	479 482	271 810	0	0	0	1 121	0	291959	1 044 372	3.61
Fayoum	21 670	6 200	5470	0	0	34 340	0	57 405	125 085	0.43
Suhag	18 588	0	0	0	0	6 100	0	00	24 688	0.09
Kafer El sheikh	55 000	5 000	0	14 000	0	1 000	0	76917	151 917	0.52
Alexandria	00	63 600	0	0	0	751	0	0	64 351	0.22
Qena	93	0	0	0	0	140	4 505	0	4 738	0.02
Damietta	353 462	4 245	0	0	0	7 980	0	3926	369 613	1.27
Assuit	4 000	0	0	0	0	0	0	0	4 000	0.01
Total	8 181 835	177 36 505	960 002	1 113 165	28 000	421 659	59 665	495 324	28 996 155	100

Source: Public Authority of Veterinary Services, 2006.

there may be a change in consumption patterns, with more consumers opting for frozen poultry products.

Financial burdens on the state

The spread of avian influenza compelled the state to compensate the owners of farms and marketing outlets. Farm owners were compensated at rate of LE5 for each culled chicken. In addition, the state spent millions of pounds to import vaccines to vaccinate the poultry flocks, and imported 2.5 million doses of drugs to treat infected humans. Moreover, the state compensated the owners of about 50 thousand licensed poultry selling shops by LE1000, which amounted to a total of LE 50 million. The state also lost huge amounts as a result of foregone revenue from taxes and customs from the poultry industry.

Reduction in revenues in sectors related to the poultry industry

The effects of avian influenza extend beyond the poultry farms to other sectors, such as the industries that provide inputs for poultry production and pack poultry meat, as well as those involved in internal and foreign trade in poultry products, and in retail and catering. It was difficult for the state to find alternative options for those involve in such businesses, because of the large financial commitments required.

Losses on uninfected farms

Uninfected farms faced losses as a result of the refusal of about 70 percent of consumers to buy poultry in the wake of the disease outbreak. Moreover, farms were unable to liquidate their production because of a lack of operating abattoirs in the affected governorates, and lack of capacity to freeze and refrigerate meat. The movement of poultry between governorates was also prohibited. Farm owners had no option but to slaughter birds randomly and sell them at low prices (LE3 per chicken). This led to losses estimated at LE266 million. The farms that couldn't market their products were obliged to pay for the ongoing maintenance of the birds (feed, labour, etc). Furthermore, on some of these farms, rates of mortality increased significantly.

3.2 Social impacts

Human health impacts

An estimated 11 people have died of avian influenza in Egypt, with about 22 infected (according to figures available in late 2007). There is a lack of awareness among citizens about how the disease spreads; this is particularly true among the rural population who live with poultry in their homes or breed poultry on their roofs. Fear of the disease has had a negative affect on tourism in Egypt.

Negative impacts on low-income consumers

The spread of avian influenza has affected a large number of low-income consumers, who depend upon poultry meat as a cheap source of animal protein. It is expected that some farms will cease production and that the prices of poultry and eggs will rise. Moreover, it is expected that prices of other protein sources such as red meats and fish will also rise.

Increases in unemployment

When poultry farms and feed factories stopped production as a result of avian influenza, thousands of workers lost their jobs. Furthermore, when about 50 thousand licensed poultry shops and an undetermined number of unlicensed poultry shops stopped operating, thousands of workers lost their jobs. In spite of a decree issued by the prime minister and the efforts of many of owners to shift towards the sale of frozen poultry or other activities, many were unable to adapt their operations because of a lack of financial capabilities and practical experience, as well reduced demand for frozen poultry products.

4 THE FUTURE OF THE POULTRY INDUSTRY IN EGYPT

4.1 Trends

A description of the crisis that hit the poultry industry in Egypt, both specialized enterprises and household flocks in rural areas, can shed some light on the future of the sector. The prices of poultry and alternative sources of animal protein were affected, as were the prices of vegetarian protein. Companies involved in marketing these products were affected.

The period from October 2005 to February 2006 saw a big fall in white poultry prices. The estimated decline was 30.14 percent, with the price of 1 kg of meat falling from LE7.3 to LE5.1 Moreover, the prices of domestic poultry also fell by an estimated 26.08 percent during the same period – from LE9.09/kg to LE6.72/kg. The prices of alternatives to poultry products recorded a significant increase. Red meat prices increased by between 0.17 to 4.83 percent. Fish prices increased by an estimated 4.45 to 20.15 percent. The state intervened in order to reduce the prices of red meats and to stabilize the local market. Prices of vegetarian protein also increased. The price of beans rose by 2.35 percent, but lentils fell by 3 percent. These are considered to be commodities used by poor families.

The shares of Cairo Poultry Company registered a decrease of 10.64 percent during the crisis period. However, the Egyptian Poultry Company registered an increase of 0.9 percent. The prices of seven companies in the milling sector registered falls of between 1.75 percent and 21.5 percent.

The process of importing grandparent poultry was affected negatively, being suspended during the period from October 2005 to February 2006. There is no doubt that this will affect the poultry industry greatly. It is expected that this cessation of imports will affect production of live birds and eggs and increase prices, particularly given the need for biosecurity and the heavy losses suffered by breeders during the outbreak. The breeders suffered from: (i) a shortage of grandparent birds, (ii) high feeding costs; and iii) lower selling prices for young chicks. Hence they need to compensate their losses in the near future. It is worth stating that the union of poultry producers has estimated the operating losses to be LE 3 billion, as an accumulative loss, which represent about 17.6 percent of the total value of investments made in the industry during the period from October 2005 to February 2006.

As a result of the changes that have affected the sector in the aftermath of the outbreak, it is expected that there may be an increase in poultry prices in local markets after the recent period of low prices. Since July 2007, prices have risen significantly – to LE10.5/kg for white poultry and LE12.5/kg for red and domestic poultry. Feed prices are increasing and farms owners are investing in veterinary services and expensive drugs.

Some breeders consider that the prices of poultry will settle at LE9–10/kg, but prices remain difficult to predict as they are subject to the volume offered in market, the volume of demand, feed prices and prices of alternative commodities. Moreover, intermediaries between farms owners and traders are playing a big role in the pricing process in the absence of a poultry bourse.

4.2 Development of slaughtering and marketing infrastructure

Loss of foreign trade, prohibition of selling and marketing live poultry in great Cairo and the governorate capitals, and reluctance of Egyptians to consume poultry products, have negatively affected the poultry industry in Egypt. About 2.5 percent of poultry farms have gone out of production. The lack of sufficient capacities of automative slaughter houses and refrigerators and large fluctuations of producer prices are considered major obstacles for the poultry industry in Egypt. There is slaughter capacity for only about 18.6 percent of the total production of broilers in Egypt with a substantial imbalance between the different Governorates (see Tables A51 and A52 in the appendix). There is a need to evaluate options for shifting the orientation of the marketing system from live to slaughtered chickens. This requires redistribution of automated abattoir capacity across governorates, as well as re-organizing production, increasing efficiency and achieving higher environmental and safety standards.

APPENDIX 1
POULTRY PRODUCTION STATISTICS

TABLE A1
Broiler production capacity, 1991 to 2005

Year	Number of farms	Number of poultry houses			Capacity (1 000 chickens)	
		Active	Non-active	Total	Total	Used
1991	13 356	7 387	11 312	18 699	46 7804	140 676
1992	13 181	8 844	9 609	18 453	465 494	161 257
1993	12 914	10 206	7 873	18 079	423 192	172 168
1994	12 609	11 567	6 138	17 705	380 890	183 079
1995	11 895	12 469	5 463	17 932	447 167	211 646
1996	11 827	13 076	5 298	18 374	458 868	237 605
1997	11 834	13 714	5 147	18 861	479 874	257 559
1998	11 394	14 626	3 951	18 577	457 282	253 671
1999	12 288	16 545	3 316	19 861	489 195	323 136
2000	12 838	17 451	3 045	20 496	508 609	342 208
2001	13 526	18 959	3 071	22 030	838 350	454 752
2002	14 519	20 566	3 159	23 725	857 376	628 144
2003	14 972	20 181	4 495	24 676	892 717	563 683
2004	15 668	20 615	5 298	25 913	922 924	505 499
2005	14 698	20 646	4 494	25 140	776 285	491 231

Source: Economic Affairs Sector (EAS) Ministry of Agriculture and Land Reclamation.

TABLE A2

Geographical distribution of broiler production capacity (1 000 birds) by size category, 2005

	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Alexandria	10 146.4	5 464	6 753	5 816	1 059.2	470.7	17 958.6	11 750.7
Behaira	11 463.44	7 618	33 500.26	20 843	2 685	1 682	47 648.7	30 143
Kafr El sheikh	2 933.5	2 120	1 7055	11 437.6	4 734	3 019.1	24 722.5	16 576.7
Dakahlia	21 190	7 666	78 516	47 284	5 716	3 135	10 5422	58 085
Damietta	10 792.205	5 754.025	14 017.87	83 66.009	2 143.1	1 068.363	26 953.175	15 188.397
Sharkia	22 119	15 063.6	90 242.75	47 088.2	11 708.3	6 369.75	124 070.05	68 521.55
Port Said	320	148	879	360	-	-	1 199	508
Ismailia	10 688	7 807	7 211	4 958	1 250	924	19 149	13 689
Suez	2 470	1 034	1 218	367.5	30	20	3 718	1 421.5
Ghrabia	14 042.79	10 438.525	63 487.64	60 552.16	9 958.08	8 691.32	87 488.51	79 682.005
Menoufia	9 701.934	5 196.85	22 366.534	8 762.7	1 332.58	678.74	33 401.048	14 638.29
Qalyoubia	8 425	5 815	75 350	59 760	8 575	4 550	92 350	70 125
Cairo	3 315	1 007.7	900	343.9	172	172	43 87	1 523.6
Lower Egypt	127 607.269	75 132.7	411 497.054	275 939.069	49 363.26	30 780.973	588 467.583	381 852.74
Giza	19 861.5	12 422	26 641	13 533	1 085	785	47 587.5	26 740
Beni Suef	2 199	1 599	5 829	2 921	1 883	1 883	9 911	6 403
Fayoum	4 948.8	2 919	10 198.75	7 013.6	1 276	1 276	16 423.55	1 1208.6
Menia	9 794	5 970	3 4712	19 531	6 526	2 955	51 032	28 456
Middle Egypt	36803.3	22 910	77 380.75	42 998.6	10 770	6 899	124 954.05	72 807.6
Assuit	875	455	5 126	2 624	667	378	6 668	3 457
Suhag	3 413	1 450.4	4 283	1 099	567	567	8 263	3 116.4
Qena	1 344	862.415	244	87.8	331	331	1 919	1 281.215
Luxor	-	-	-	-	1 230.898	902.907	1 230.898	902.907
Aswan	-	-	472	144.402	641.432	641.472	1 113.432	785.874

(Continued)

TABLE A2
(Continued)

	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Upper Egypt	5 632	2 767.815	10 125	3 955.202	3 437.33	2 820.379	19 194.33	9 543.396
Matruh	1 876.416	351	3 842.38	844.884	123.408	11.516	5 842.204	1 207.4
Noubaria	2 1943.7	16 419.5	5 908.6	6 697.8	975.6	864.6	28 827.9	23 981.9
North Sinai	105	31.3	5 253	846.5	876	402	6 234	1 279.8
Sinai South	-	-	315	28.4	-	-	315	28.4
New Valley	1 000	225	700	171	52	8	1 752	404
Red Sea	420	-	210	105	67.5	20.5	697.5	125.5
New and desert Land	25 345.116	17 026.8	16 228.98	8 693.584	2 094.508	1 306.616	43 668.604	2 7027
Grand Total	195 387.685	117 837.315	515 231.784	331 586.455	65 665.098	41 806.968	776 284.567	491 230.74

Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A3

Geographical distribution of broiler production capacity (tonne) by size category, 2005

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Alexandria	15 219.600	8 196.000	10 129.500	8 724.000	1 588.800	706.050	26 937.900	17 626.050
Behaira	17 195.160	11 427.000	50 250.390	31 264.500	4 027.500	2523.000	71 473.050	45 214.500
Kafr El sheikh	4 400.250	3 180.000	25 582.500	17 156.400	7 101.000	4528.650	37 083.750	24 865.050
Dakahlia	31 785.000	11 499.000	117 774.000	70 926.000	8 574.000	4702.500	158 133.000	87 127.500
Damietta	16 188.308	8 631.038	21 026.805	12 549.014	3 214.650	1602.545	40 429.763	22 782.597
Sharkia	33 178.500	22 595.400	135 364.125	70 632.300	17 562.450	9 554.625	186 105.075	102 782.325
Port Said	480.000	222.000	1 318.500	540.000	-	-	1 798.500	762.000
Ismailia	16 032.000	11 710.500	10 816.500	7 437.000	1 875.000	1 386.000	28 723.500	20 533.500
Suez	3 705.000	1 551.000	1 827.000	551.250	45.000	30.000	5 577.000	2 132.250
Ghrabia	21 064.185	15 657.788	95 231.460	90 828.240	14 937.120	13 036.980	131 232.765	119 523.008
Menoufia	14 552.901	7 795.275	33 549.801	13 144.050	1 998.870	1 018.110	50 101.572	21 957.435
Qalyoubia	12 637.500	8 722.500	113 025.000	89 640.000	12 862.500	6 825.000	138 525.000	105 187.500
Cairo	4 972.500	1 511.550	1 350.000	515.850	258.000	258.000	6 580.500	2 285.400
Lower Egypt	191 410.904	112 699.051	617 245.581	413 908.604	74 044.890	46 171.460	882 701.375	572 779.115
Giza	29 792.250	18 633.000	39 961.500	20 299.500	1 627.500	1177.500	71 381.250	40 110.000
Beni Suef	3 298.500	2 398.500	8 743.500	4 381.500	2 824.500	2 824.500	14 866.500	9 604.500
Fayoum	7 423.200	4 378.500	15 298.125	10 520.400	1914.000	1 914.000	24 635.325	16 812.900
Menia	14 691.000	8 955.000	52 068.000	29 296.500	9 789.000	4 432.500	76 548.000	42 684.000
Middle Egypt	55 204.950	34 365.000	116 071.125	64 497.900	16 155.000	10 348.500	187 431.075	109 211.400
Assuit	1 312.500	682.500	7 689.000	3 936.000	1 000.500	567.000	10 002.000	5 185.500
Suhag	5 119.500	2 175.600	6 424.500	1 648.500	850.500	850.500	12 394.500	4 674.600
Qena	2 016.000	1 293.623	366.000	131.700	496.500	496.500	2 878.500	1 921.823
Luxor	-	-	-	-	1 846.347	1 354.361	1 846.347	1 354.361
Aswan	-	-	708.000	216.603	962.148	962.208	1 670.148	1 178.811

(Continued)

TABLE A3
(Continued)

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Upper Egypt	8 448.000	4 151.723	15 187.500	5 932.803	5 155.995	4 230.569	28 791.495	1 4315.095
Matruh	2 814.624	526.500	5 763.570	1 267.326	185.112	17.274	8 763.306	1811.100
Noubaria	32 915.550	24 629.250	8 862.900	10 046.700	1 463.400	1 296.900	43 241.850	35 972.850
North Sinai	157.500	46.950	7 879.500	1 269.750	1 314.000	603.000	9 351.000	1 919.700
Sinai South	-	-	472.500	42.600	-	-	472.500	42.600
New Valley	1 500.000	337.500	1 050.000	256.500	78.000	12.000	2 628.000	606.000
Red Sea	630.000	-	315.000	157.500	101.250	30.750	1 046.250	188.250
New and desert Land	38 017.674	25 540.200	24 343.470	13 040.376	3 141.762	1 959.924	65 502.906	40 540.500
Grand Total	293 081.528	176 755.974	772 847.676	497 379.683	98 497.647	62 710.453	1 164 426.851	736 846.110

Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A4
Change rate of farm numbers, total capacity and used capacity for broiler chickens during the period 1991 to 2005

	Average	Regression coefficient	Change rate (%)
Number of farms	13 167.933	177.19	1.346
Total capacity	328 420.93	33 075.97	10.071
Used capacity	591 068.47	372 85.24	6.308

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A5
Distribution of broiler production capacity according to the size of the enterprise, 2005

	Enterprise scale	Large	Medium	Small	Total
Total capacity	Number of broilers (1 000)	195 387.685	515 231.784	65 665.100	776 284.57
	Capacity (tonne)	293 081.528	772 847.676	98 497.65	1 164 426.9
	Share of capacity (%)	25.17	66.37	8.46	100.00
Used capacity	Number of broilers (1 000)	117 837.315	331 586.455	41 806.97	491 230.74
	Capacity (tonne)	176 755.974	497 379.683	62 710.45	736 846.11
	Share of capacity (%)	23.99	67.50	8.51	100.00
Unused capacity	Number of broilers (1 000)	77 550.37	183 645.329	23 858.13	285 053.83
	Capacity (tonne)	116 325.554	275 467.993	35 787.19	427 580.74
	Share of capacity (%)	27.21	64.42	8.37	100.00

Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

FIGURE A1
Total and used broiler production capacity according to scale of the enterprise

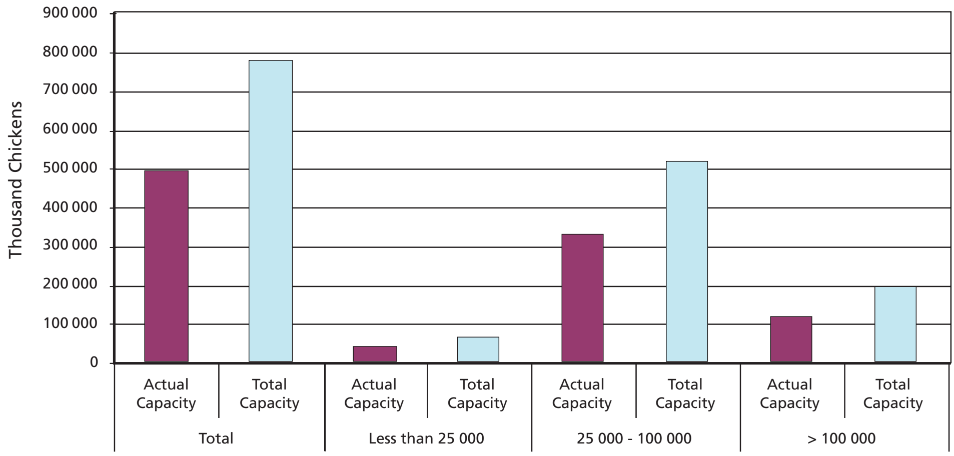


TABLE A6
Distribution of broiler chicken enterprises* according to management sector, 2005

Sector	Active enterprises			Non-active enterprises	
	Number of enterprises	Total capacity (1 000)	Used capacity (1 000)	Number of enterprises	Total capacity (1 000)
Private	871	140 623.779	96 652.65	136	20 725.656
Governmental	27	9 276.65	6 292.015	7	4 570
Cooperative	12	1 876.6	1 359.15	1	200
Investment	12	1 5815	13 595	2	1 800
Public works	2	500	108	-	-

* Enterprises of 100 000 or more birds.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A7

The geographical distribution of broiler chicken enterprises and houses, 2005

Governorate	Number of enterprises	Number of poultry houses		
		Active	Not active	Total
Alexandria	192	385	56	441
Behairah	721	1 408	321	1 729
Kafr El sheikh	455	650	73	723
Dakahlia	1 988	3 400	381	3 781
Damietta	324	727	176	903
Sharkia	2 962	3 334	750	4 084
Port Said	17	30	9	39
Ismailia	223	403	83	486
Suez	44	66	24	90
Ghrabia	1 787	2640	188	2 828
Menoufia	638	808	220	1 028
Qalyoubia	2 579	2 886	516	3 402
Cairo	35	52	46	98
Lower Egypt Total	11 965	16 789	2 843	19 632
Giza	698	1 102	529	1 631
Beni Suef	145	251	83	334
Fayoum	275	510	87	597
Menia	864	897	350	1 247
Middle Egypt Total	1 982	2 760	1049	3 809
Assuit	133	199	89	288
Suhag	129	147	280	427
Qena	8	24	8	32
Luxor	-	-	-	-
Aswan	11	15	32	47
Upper Egypt Total	281	385	409	794
Matruh	92	88	63	151
Noubaria	230	498	16	514
North Sinai	125	84	61	145
Sinai South	6	4	8	12
New Valley	12	35	28	63
Red Sea	5	3	17	20
New and Desert Land Total	470	712	193	905
Grand Total	14 698	20 646	4 494	25 140

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A8

Geographical distribution of broiler production capacity* of by size of the enterprise, 2005

Governorate		Large enterprises		Medium enterprises		Small enterprises		Total	
		Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity	Total capacity	Used capacity
Lower Egypt	No.	127 607.27	75 132.70	411 497.10	275 939.10	49 363.26	30 780.97	588 467.60	381 852.70
	%	65.31	63.76	79.87	83.22	75.17	73.63	75.81	77.73
Middle Egypt	No.	36 803.30	22 910.00	77 380.75	42 998.60	10 770.00	6 899.00	124 954.10	72 807.60
	%	18.84	19.44	15.02	12.97	16.40	16.50	16.10	14.82
Upper Egypt	No.	5 632.00	2 767.82	10 125.00	3 955.20	3 437.33	2 820.38	19 194.33	9 543.40
	%	2.88	2.35	1.97	1.19	5.23	6.75	2.47	1.94
New and Desert Land	No.	25 345.12	17 026.80	16 228.98	8 693.58	2 094.51	1 306.62	43 668.60	27 027.00
	%	12.97	14.45	3.15	2.62	3.19	3.13	5.63	5.50
Grand Total	No.	195 387.69	117 837.30	515 231.80	331 586.50	65 665.10	41 806.97	776 284.60	491 230.70
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*Number of broilers ×1 000

Note: Large: ≥ 100 000; Medium: 25 000–99 999; Small < 25 000.

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A9

Production capacity for layer chickens, 1991 to 2005

Year	Number of farms	Poultry houses			Total capacity (1 000)		Used capacity (1 000)	
		Active	Not active	Total	Chickens	Eggs	Chickens	Eggs
1991	?	642	2 191	2 833	29 116	6 454 874	12 931	2 453 911
1992	1 366	616	1 843	2 459	26 070	5 716 641	12 991	2 663 505
1993	1 635	1 023	1 948	2 971	22 961	5 307 019	12 487	2 557 034
1994	1 905	1 429	2 054	3 483	19 851	4 897 397	11 983	2 450 562
1995	1 445	1 227	1 457	2 684	22 324	4 956 175	12 507	2 457 072
1996	1 469	1 336	1 492	2 828	29 046	5 296 798	16 337	2 448 090
1997	1 340	1 374	1 375	2 749	22 365	5 648 732	14 543	2 551 622
1998	1 327	1 512	1 164	2 676	21 239	5 392 368	14 836	2 4433 032
1999	1 387	1 978	896	2 874	22 307	5 641 472	14 998	2 554 503
2000	1 331	2 057	860	2 917	22 285	5 658 035	15 499	2 944 410
2001	1 414	2 350	794	3 144	25 148	7 933 264	18 957	3 240 018
2002	1 361	2 273	677	2 950	24 737	7 802 900	19 412	5 117 889
2003	1 350	2 200	904	3 104	24 285	7 652 660	18 090	4 834 687
2004	1 461	2 415	978	3 393	28 256	8 922 352	18 529	4 015 516
2005	1 728	3 130	1 195	4 325	32 666	7 866 840	20 670	4 376 790

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A10
Geographical distribution of table egg enterprises, 2005

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Layer chickens (1 000)	Million eggs	Layer chickens (1 000)	Million eggs	Layer chickens (1 000)	Million eggs	Layer chickens (1 000)	Million eggs
Alexandria	309	73	634.92	163.16	100.52	25.62	1 044.44	261.78
Behairah	597	142	474.69	82.1	637	125.4	1 708.69	349.5
Kafr El sheikh	2 33.5	52	4.1	1	7.1	1.74	244.7	54.74
Dakahlia	1 020	248	752	185.9	21.4	5.23	1 793.4	439.13
Damietta	210	52.7	56	13.59	-	-	266	66.29
Sharkia	4 461	1 076.5	3 980	952.5	364.7	80.74	8 805.7	2 109.74
Port Said	-	-	29.97	5.2	-	-	29.97	5.2
Ismailia	230	57.5	163	40.75	26	6.5	419	104.75
Suez	75	15	34	8.64	7	1.05	116	24.69
Ghrabia	643	206.12	696.9	203.06	74.36	22.59	1 414.26	431.77
Menoufia	373.2	98.9	966.95	240.18	47	11.81	1 387.15	350.89
Qalyoubia	1 542	353	1 254.2	265.7	833	174.3	3 629.2	793
Cairo	467	115.8	246.8	58.78	3.5	0.91	717.3	175.49
Lower Egypt	10 160.7	2 490.52	9 293.53	2 220.56	2 121.58	455.89	21 575.81	5 166.97
Giza	5 258.3	1 303.65	1 832.6	451.1	18.3	4.51	7 109.2	1 759.26
Beni Suef	135	30	-	-	-	-	135	30
Fayoum	285	48	87.5	19.9	1.1	0.2	373.6	68.1
Menia	292	86	80	24	49.99	5	421.99	115
Middle Egypt	5 970.3	1 467.65	2 000.1	495	6 939	9.71	803 979	197 236
Assuit	144	26	28.67	4.76	950	170	1 122.67	200.76
Suhag	327	60	-	-	167	49	494	109
Qena	135	30	20	6.3	-	-	155	36.3
Luxor	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	97	14.55	97	14.55
Upper Egypt	606	116	4 867	11.06	1 214	233.55	1 868.67	360.61
Matruh	-	-	-	-	-	-	-	-
Noubaria	880	281.6	139.6	37.6	41.3	10.7	1 060.9	329.9
North Sinai	-	-	10	2	-	-	10	2
Sinai South	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-
Red Sea	-	-	111	35	-	-	111	35
New and Desert Land	880	281.6	260.6	74.6	41.3	10.7	1 181.9	366.9
Grand Total	17 617	4 355.77	11 602.9	2 801.22	3 446.27	709 85	32 666.17	7 866.84

Large: > 15 million eggs; Medium: 1million – 15 million eggs; Small: less than 1 million eggs.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A11
Change rate of poultry house numbers and production capacity for layer chickens, 1992 to 2005

	Average	Regression coefficient	Change rate (%)
Poultry house numbers	1 780.00	153.49	8.623
Total capacity (1 000 eggs)	6 335 189.50	276 714.36	4.368
Total capacity (1 000 layers	24 538.57	400.28	1.631
Used capacity (1 000 eggs)	4 760 337.86	135 512.80	2.847
Used capacity (1 000 layers)	15 845.64	627.94	3.963

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A12
Distribution of layer production capacity according to the size of the enterprise, 2005

	Enterprise scale	Large enterprises	Medium enterprises	Small enterprises	Total
Total capacity	Number of layers (1 000)	17 617	1 160.9	3 446.3	22 224.2
	Capacity (million eggs)	4 355.77	2 801.22	709.85	7 866.84
	Share of capacity (%)	55.369	35.608	9.023	100.000
Used capacity	Number of layers (1 000)	11 268	7 049	2 353	20 670
	Capacity (million eggs)	2 562.63	1 373	440.8	4 376.43
	Share of capacity (%)	58.555	31.373	10.072	100.000

Large: > 15 million eggs; Medium: 1 million – 15 million eggs; Small: less than 1 million eggs.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

FIGURE A2
Egg production capacity according to size of enterprise

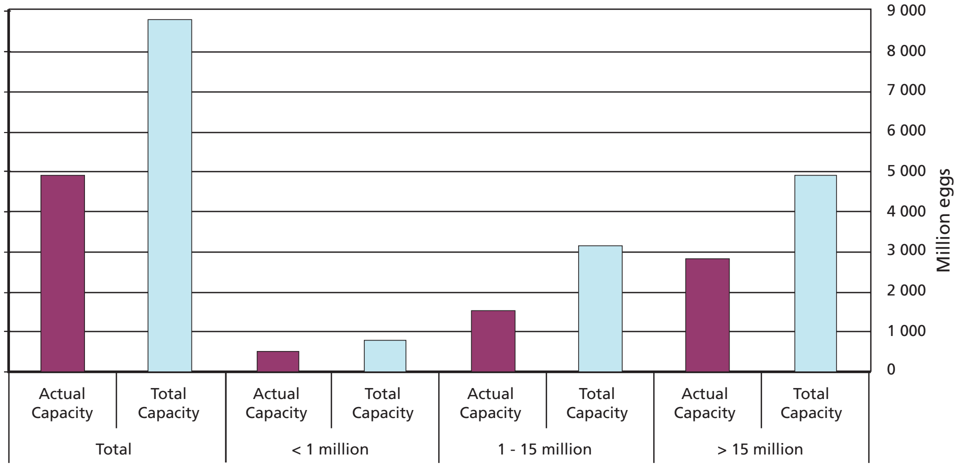


TABLE A13
Distribution of layer production capacity according to the size of the enterprise, 2005

Sector	Number of enterprises	Total capacity		Used capacity	
		Thousand layers	Million eggs	Thousand layers	Million eggs
Private	75	8 877.8	2 482.7	6862.9	1 530.70
Governmental	18	2 161	529.94	1 689 66	419.71
Cooperative	5	554.2	138.85	530.23	94.49
Investment	16	2774	663.2	2185	517.73

*Enterprises of 15 million eggs or more.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A14

The geographical distribution of layer chicken enterprises and houses, 2005

Governorate	Number enterprises		Number of poultry houses					
			Active		Not active		Total	
	Total	Large enterprises*	Total	Large enterprises*	Total	Large enterprises*	Total	Large enterprises*
Alexandria	93	3	111	13	49	-	160	13
Behaira	45	6	63	30	52	5	115	35
Kafr El sheikh	7	1	5	4	17	-	22	4
Dakahlia	68	9	131	47	73	-	204	47
Damietta	6	2	22	11	2	-	24	11
Sharkia	639	21	901	203	393	45	1 294	248
Port Said	1	-	7	-	-	-	7	-
Ismailia	21	2	23	8	23	-	46	8
Suez	8	1	8	3	3	-	11	3
Ghrabia	110	4	216	29	41	3	257	32
Menoufia	85	4	163	16	90	2	253	18
Qalyoubia	367	14	578	64	77	-	655	64
Cairo	26	4	50	12	16	-	66	12
Total for Lower Egypt	1 476	71	2 278	440	836	55	3 114	495
Giza	182	28	346	153	300	48	646	201
Beni Suef	1	1	6	6	-	-	6	6
Fayoum	7	1	22	6	8	2	30	8
Menia	6	2	23	7	7	-	30	7
Total for Middle Egypt	196	32	397	172	315	50	712	222
Assuit	4	1	184	6	7	-	191	6
Suhag	3	3	209	12	4	4	213	16
Qena	4	2	7	6	5	-	12	6
Luxor	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-
Total for Upper Egypt	11	6	400	24	16	4	416	28
Matruh	-	-	-	-	-	-	-	-
Noubaria	37	5	54	26	19	-	73	26
North Sinai	2	-	-	-	2	-	2	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-
Red Sea	6	-	1	-	7	-	8	-
Total for New and Desert Land	45	5	55	26	28	-	83	26
Grand Total	1 728	114	3 130	662	1 195	109	4 325	771

*Large enterprises: 15 million or more eggs per year.

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A15

Geographical distribution of layer production capacity of by size of enterprise, 2005

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs
Alexandria	291.1	69	475.8	118.14	36.65	9.14	803.55	196.28
Behairah	411	104.4	185.5	26.79	54.3	10.86	650.8	142.05
Kafr El sheikh	67.5	14.37	4	0.9	-	-	71.5	15.27
Dakahlia	786	179.7	322	66.3	4.4	1.6	1 112.4	247.6
Damietta	196	47.04	32.65	7.84	-	-	228.65	54.88
Sharkia	2 620	587.9	2592	500.2	216.6	44.94	5 428.6	1 133.04
Port said	-	-	28.4	3.8	-	-	28.4	3.8
Ismailia	187	37.4	89	18.25	1	0.25	277	55.9
Suez	48	10.7	23.5	4.89	2	0.23	73.5	15.82
Ghrabia	258	142.3	652.4	115.2	43.2	7.89	953.6	265.39
Menoufia	294.53	61.67	404.47	69.77	22.12	3.26	721.12	134.7
Qalyoubia	1458	338.5	1 028.5	213.9	770.5	162	3257	714.4
Cairo	304.7	77.4	167.9	43.27	3.25	0.82	475.85	121.49
Total for Lower Egypt	6 921.83	1 670.38	6 006.12	1 189.25	1 154.02	240.99	14 081.97	3 100.62
Giza	2 673.2	536.8	739.1	119.1	18.05	2.66	3 430.35	658.56
Beni Suef	117.6	33.7	-	-	-	-	117.6	33.7
Fayoum	135	31.7	86.5	18.8	-	-	221.5	50.5
Menia	157.5	44	80	22	49.99	5	287.49	71
Total for Middle Egypt	3 083.3	646.2	905.6	159.9	68.04	7.66	4 056.94	813.76

(continued)

TABLE A15
(Continued)

Governorate	Large enterprises		Medium enterprises		Small enterprises		Total	
	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs	Layers (1 000)	Million eggs
Assuit	72	20.73	5.5	1	850	150	927.5	171.73
Suhag	255	57	-	-	170	24.5	425	81.5
Qena	143.66	34.8	2.68	0.7	-	-	146.34	35.5
Luxor	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	97	14.55	97	14.55
Total for Upper Egypt	470.66	112.53	8.18	1.7	1 117	189.05	1 595.84	303.28
Matruh	-	-	-	-	-	-	-	-
Noubaria	792	133.52	100.2	16.01	13.9	3.1	906.1	152.63
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-
Red Sea	-	-	29	6.5	-	-	29	6.5
Total for New and Desert Land	792	133.52	129.2	22.51	13.9	3.1	935.1	159.13
Grand Total	11 267.79	2 562.63	7 049.1	1 373.36	2 352.96	440.8	20 669.85	4 376.79

Large: > 15 million eggs; Medium: 1 million – 15 million eggs; Small: less than 1 million eggs.
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation

TABLE A16
Capacity for production of broiler breeders parents, 1991 to 2005

Year	Number of farms	Number of poultry houses			Total capacity (1 000)		Used capacity (1 000)	
		Active	Not active	Total	Chickens	Eggs	Chickens	Eggs
1991	10	52	10	62	3 348	647 821	3 071	472 118
1992	18	116	13	129	4 605	605 894	4 211	407 277
1993	62	411	20	431	4 635	569 149	4 115	217 167
1994	100	705	27	732	4 664	532 403	4 018	27 057
1995	231	1 536	88	1 624	5 815	672 891	5 034	491 632
1996	269	1 759	106	1 865	6 152	600 258	5 132	523 718
1997	239	1 323	224	1 547	6 351	857 239	5 662	481 153
1998	327	1 791	402	2 193	7 519	1 002 826	5 926	431 933
1999	335	2 022	198	2 220	8 122	1 099 707	7 316	580 319
2000	292	1 901	224	2 125	7 571	1 018 080	6 298	504 332
2001	378	2 097	147	2 244	7 969	1 275 394	7 232	661 448
2002	408	2 224	172	2 396	8 826	1 412 160	7 946	906 732
2003	406	2 122	259	2 381	9 736	1 557 760	7 722	847 885
2004	365	1 948	240	2 188	9 655	1 544 800	7 966	963 150
2005	435	2 189	169	2 358	9 793	1 552 315	8 369	942 022

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A17
Change rate of farm numbers and capacity for broiler breeder parent production, 1992 to 2005

	Average	Regression coefficient	Rate of change (%)
Number of farms	258.3	30.69	11.88
Number of poultry houses	1 479.73	154.46	10.44
Total capacity (1 000 eggs)	996 579.8	83 259.28	8.35
Total capacity (1 000 layers)	6 984.1	459.44	6.58
Used capacity (1 000 eggs)	563 862.9	49 523.92	8.8
Actual Capacity 1 000 layers)	6 001.2	371.23	6.19

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A18
Capacity for production of layer parent stock, 1991 to 2005

Year	Number of farms	Number of poultry houses			Total capacity (1 000)		Used capacity (1 000)	
		Active	Not active	Total	Chickens	Eggs	Chickens	Eggs
1991	30	95	53	148	1 039	164 602	545	76 333
1992	28	67	71	138	9 41	143 440	480	64 247
1993	21	64	39	103	6 19	95 118	342	45 664
1994	13	61	6	67	2 97	46 795	204	27 080
1995	19	97	9	106	379	55 048	347	44 792
1996	26	109	20	129	510	82 568	284	44 910
1997	30	130	16	146	759	127 418	410	41 992
1998	19	60	17	77	277	46 612	192	22 185
1999	23	70	33	103	687	115 312	324	42 070
2000	20	66	44	110	651	109 324	279	29 840
2001	21	57	45	102	619	104 573	244	24 347
2002	22	51	61	112	714	142 800	261	37 059
2003	22	47	69	116	736	147 200	277	34 701
2004	29	82	59	141	758	151 520	317	45 307
2005	42	112	45	157	543	99 606	340	41 646

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A19
Change rate of farm numbers and capacity for layer parent stock production, 1992 to 2005

	Average	Regression coefficient	Change rate (%)
Number of farms	24.33	0.42	1.73
Number of poultry houses	77.87	-0.65	-0.83
Total capacity (1 000 eggs)	108 795.73	1 528.28	-1.40
Total capacity (1 000 layers)	635.27	-4.90	-0.78
Used capacity (1 000 eggs)	41 478.2	-1 652.66	-3.98
Used capacity (1 000 layers)	323.07	-10.41	-3.22

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A20
Geographical distribution of chicken grandparent enterprises

Governorate	Number of enterprises	Number of poultry houses			Total capacity (million eggs)	Used capacity (million eggs)
		Active	Not active	Total		
Behaira	1	12	-	12	5.2	2.3
Middle Egypt	-	-	-	-	-	-
Upper Egypt	-	-	-	-	-	-
New and Desert Land	-	-	-	-	-	-
Total	1	12	-	12	5.2	2.3

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A21
Rabbit, duck and turkey production, 2001 to 2005

Year	Rabbit		Ducks		Turkey	
	Production	Index	Production	Index	Production	Index
2001	2 230 947	100.00	3 901 424	100.00	371 392	100.00
2002	2 480 597	111.19	4 602 444	117.97	626 804	168.77
2003	2 321 922	104.08	4 852 762	124.38	535 559	144.20
2004	2 910 725	130.47	5 047 419	129.37	610 331	164.34
2005	2 430 372	108.94	5 747 526	147.32	602 473	162.22

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A22
The geographical distribution of rabbit production capacity, 2005

Governorate	Total capacity		Used capacity		Unused capacity (parents)
	Number of parents	Number of offspring	Number of parents	Number of rabbits	
Alexandria	1 550	69 750	900	30 100	650
Behairah	9 805	357 050	8 990	233 195	815
Kafr El sheikh	700	30 500	234	9 850	466
Dakahlia	448	19 715	402	13 660	46
Damietta	498	19 920	425	14 875	73
Sharkia	1 2130	515 500	11 655	284 200	475
Port said	1 694	438 560	684	29 430	1 010
Ismailia	697	34 850	376	15 040	321
Suez	1 265	49 550	895	31 656	370
Ghrabia	770	36 376	250	8 734	520
Menoufia	100	4 800	40	1 200	60
Qalyoubia	9 819	490 950	8 280	163 300	1 539
Cairo	5 745	286 855	4 255	164 845	1 490
Lower Egypt	45 221	1 838 876	37 386	715 885	7 835
Giza	12 649	414 370	895	24 250	11 754
Beni Suef	11 137	156 427	8 060	162 232	3 077
Fayoum	1 146	47 826	1 001	38 151	145
Menia	9 060	434 880	8 747	305 245	313
Middle Egypt	33 992	1 053 503	18 703	529 878	15 289
Assuit	30 350	1 212 800	25 120	1 005 400	5 230
Suhag	-	-	-	-	-
Qena	500	25 000	424	19 080	76
Luxor	900	42 300	860	38 700	40
Aswan	11 648	66 212	11 203	48 412	445
Upper Egypt	43 398	1 346 312	37 607	1 111 592	5 791
Matruh	-	-	-	-	-
Noubaria	2 495	92 200	2 265	72 535	230
North Sinai	-	-	-	-	-
Sinai South	-	-	-	-	-
New Valley	350	14 800	130	482	220
Red Sea	-	-	-	-	-
New and Desert Land	2 845	107 000	2 395	73 017	450
Grand Total	125 456	4 345 691	96 091	2 430 372	29 365

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A23
Distribution of rabbit breeder enterprises* by management sector 2005

Sector	Active enterprises			Non-active enterprises	
	No. of enterprises	Total capacity	Used capacity	No. of enterprises	Total capacity
Private	93	1 487 266	560 581	58	291 732
Governmental	23	59 0175	340 274	20	47 776
Cooperative	3	7 200	262	1	2 592
Public business	-	-	-	1	8 950

*More than 10 parents
Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A24
Geographical distribution of duck enterprises and capacity 2005

Governorate	Number of enterprises	Number of poultry houses			Capacity			
		Active	Not active	Total	Total capacity (number)	Used capacity (number)	Unused capacity (number)	Live weight of used capacity (tonnes)
Alexandria	3	6	2	8	25 500	6 108	19 392	15
Behairah	47	77	20	97	1 238 200	871 600	366 600	2 179
Kafr El sheikh	3	5	10	15	35 100	14 500	20 600	36
Dakahlia	16	18	-	18	128 880	59 235	69 645	148
Damietta	-	-	-	-	-	-	-	-
Sharkia	69	60	29	89	1 047 800	653 575	394 225	1 634
Port said	-	-	-	-	-	-	-	-
Ismailia	20	31	-	31	296 220	245 000	51 220	613
Suez	8	9	1	10	29 500	5 600	23 900	14
Ghrabia	117	114	18	132	1 154 190	896 400	257 790	2 241
Menoufia	3	-	3	3	20 740	-	20 740	-
Qalyoubia	193	242	36	278	3 336 000	1 727 000	1 609 000	4 318
Cairo	12	9	7	16	62 800	35 950	26 850	90
Lower Egypt	491	571	126	697	7 374 930	4 514 968	2 859 962	11 287
Giza	41	32	48	80	906 600	636 772	269 828	1 592
Beni Suef	18	21	16	37	430 000	119 900	310 100	300
Fayoum	6	7	4	11	62 600	22 100	40 500	55
Menia	8	5	3	8	26 400	10 900	15 500	27
Middle Egypt	73	65	71	136	1 425 600	789 672	635 928	1 974
Assuit	-	-	-	-	-	-	-	-
Suhag	6	5	9	14	31 820	17 230	14 590	43
Qena	6	5	4	9	82 800	59 000	23 800	148
Luxor	-	-	-	-	-	-	-	-
Aswan	6	8	5	13	32 750	1 155	31 595	3
Upper Egypt	18	18	18	36	147 370	77 385	69 985	193
Matruh	-	-	-	-	-	-	-	-
Noubaria	16	25	-	25	372 900	339 201	33 699	848
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	1	4	4	8	200 000	10 000	190 000	25
Red Sea	2	3	-	3	20 500	16 300	4 200	41
New and desert Land	19	32	4	36	593 400	365 501	227 899	914
Grand Total	601	686	219	905	9 541 300	5 747 526	3 793 774	14 369

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A25
Distribution of duck production enterprises according to management system, 2005

	Active enterprises			Non-active enterprises	
	No. of projects	Total capacity	Used capacity	No. of projects	Total capacity
Private sector	432	6 674 860	4 580 861	104	1 431 140
Governmental sector	37	892 150	709 893	19	247 650
Cooperative sector	7	269 500	451 772	1	16 000
Public business sector	1	10 000	5 000	-	-

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A26
The geographical distribution of Turkey enterprises and capacity 2005

Governorate	Number of enterprises	Number of poultry houses			Capacity			
		Active	Not active	Total	Total capacity (birds)	Used capacity (birds)	Unused capacity (birds)	Live weight of used capacity (tonnes)
Alexandria	-	-	-	-	-	-	-	-
Behairah	12	7	7	14	37 000	18 500	18 500	129.50
Kafr El sheikh	1	8	14	22	9 000	1 500	7 500	10.50
Dakahlia	3	2	1	3	4 300	1 050	3 250	7.35
Damietta	-	-	-	-	-	-	-	-
Sharkia	3	6	-	6	22 200	14 000	8 200	98.00
Port said	1	-	1	1	1 260	-	1 260	-
Ismailia	5	5	5	10	60 000	23 000	37 000	161.00
Suez	3	2	1	3	2 500	575	1 925	4.03
Ghrabia	6	7	3	10	123 432	72 000	51 432	504.00
Menoufia	3	2	3	5	27 500	600	26 900	4.20
Qalyoubia	6	3	4	7	175 000	3 600	171 400	25.20
Cairo	9	23	5	28	148 680	100 500	48 180	703.50
Lower Egypt	52	65	44	109	610 872	235 325	375 547	1 647.28
Giza	16	27	26	53	476 950	202 970	273 980	1 420.79
Beni Suef	6	6	11	17	118 000	43 600	74 400	305.20
Fayoum	4	9	-	9	30 700	27 400	3 300	191.80
Menia	17	17	2	19	27 750	19 108	8 642	133.76
Middle Egypt	43	59	39	98	653 400	293 078	360 322	2 051.55
Assuit	-	-	-	-	-	-	-	-
Suhag	-	-	-	-	-	-	-	-
Qena	3	2	2	4	39 000	31 800	7 200	222.60
Luxor	-	-	-	-	-	-	-	-
Aswan	6	7	2	9	4 760	3 000	1 760	21.00
Upper Egypt	9	9	4	13	43 760	34 800	8 960	243.60
Matruh	-	-	-	-	-	-	-	-
Noubaria	4	8	-	8	26 000	23 270	2 730	162.89
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	1	2	-	2	15 000	10 000	5 000	70.00
Red Sea	1	4	-	4	10 000	6 000	4 000	42.00
New and Desert Land	6	14	-	14	51 000	39 270	11 730	274.89
Grand Total	110	147	87	234	1 359 032	602 473	756 559	4 217.31

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A27
Distribution of turkey enterprises by management sector, 2005

Sector	Active enterprises			Non-active enterprises	
	Number of enterprises	Full capacity	Used capacity	Number of projects	Full capacity
Private	57	960 830	495 403	24	232 042
Governmental	18	100 410	71 070	7	14 350
Cooperative	1	19 200	16 000	-	-
Investment	2	30 000	18 000	-	-
Public business	1	2 200	2 000	-	-

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A28

Geographical distribution of ostrich enterprises and capacity 2005

Governorate	Number of enterprises	Total capacity		Used capacity			Unused capacity		
		Females	Males	Females	Males	Number of fattened birds	Number of enterprises	Females	Males
Behira	3	50	16	15	7	120	-	-	-
Dakahlia	1	340	160	102	48	50	-	-	-
Suez	2	37	3	11	2	21	-	-	-
Cairo	5	292	83	27	4	116	3	230	67
Lower Egypt	11	719	262	155	61	307	3	230	67
Middle Egypt	-	-	-	-	-	-	-	-	-
Upper Egypt	-	-	-	-	-	-	-	-	-
Matruh	1	66	34	17	17	53	-	-	-
Noubaria	1	448	224	400	200	1 700	-	-	-
Red Sea	1	400	100	10	40	50	-	-	-
New and Desert Land	3	914	358	427	257	1 803	-	-	-
Grand total	14	1 633	620	582	318	2 110	3	230	67

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A29

Distribution of quail enterprises and capacity, 2005

Governorate	Number of enterprises	Hutches	Total capacity (birds)	Used capacity (birds)
Dakahlia	1	120	44 600	34 000
Port Said	1	6 885	4 400 000	2 600 000
Lower Egypt	2	7 005	4 444 600	2 634 000
Giza	4	1 300	711 900	647 900
Middle Egypt	4	1 300	711 900	647 900
Upper Egypt	-	-	-	-
Noubaira	3	303	22 100	20 186
New and desert Land	3	303	22 100	20 186
Grand Total	9	8608	5 178 600	3 302 086

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A30
The geographical distribution of parent stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Number of chickens (1 000)			Hatching eggs (million)		
		Active	Not active	Total Capacity	Used capacity	Used capacity	Total capacity	Used capacity	Unused capacity
Alexandria	10	44	14	231.3	133.8	97.5	41.3	20.5	20.8
Behairah	39	193	31	912.2	630.24	281.96	146.98	67.79	7919
Kafr El sheikh	32	38	14	146.2	79.6	66.6	25.55	14.21	11.34
Dakahlia	56	263	29	1 128.5	872	256.5	218.96	154.16	64.8
Damietta	7	55	-	125.45	112.6	12.85	22.36	12.87	9.49
Sharkia	60	272	85	1 427.4	969.6	457.8	295.4	150.34	145.06
Port said	5	27	9	118.8	65.2	53.6	17	4.9	12.1
Ismailia	8	189	2	898	753	145	102.45	72.95	29.5
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	275	385	127	1 083.15	659.14	424.01	198.48	83.83	114.65
Menoufia	18	78	23	310.6	214.6	96	51.56	21.51	30.05
Qalyoubia	82	123	21	328.5	220.2	108.3	53.16	34.05	19.11
Cairo	13	23	23	174	76.2	97.8	40.38	7.34	33.04
Lower Egypt	605	1 690	378	6 884.1	4 786.18	2 097.92	1 213.58	644.45	569.13
Giza	47	125	75	568.8	284.2	284.6	89.2	49.4	39.8
Beni Suef	11	18	24	104.4	32.6	71.8	14.65	4.4	10.25
Fayoum	21	96	22	456.5	320.3	136.2	83.2	38.5	44.7
Menia	1	16	-	54	54	-	10.8	9.7	1.1
Middle Egypt	80	255	121	1 183.7	691.1	492.6	197.85	102	95.85
Assuit	2	4	3	65	18.7	46.3	10	3.4	6.6
Suhag	7	12	17	118	50.3	67.7	15.5	6.3	9.2
Qena	2	12	-	31	23.4	7.6	4.1	3.4	0.7
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	11	28	20	214	92.4	121.6	29.6	13.1	16.5
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	60	874	1	4 668.7	4 146	522.7	745.5	5 936	1 519
North Sinai	5	7	6	63	27.2	35.8	13	3.94	9.06
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	3	4	4	126.5	71	55.5	17.31	9.05	8.26
Red Sea	-	-	-	-	-	-	-	-	-
New and desert Land	68	885	11	4 858.2	4 244.2	614	775.81	60 659	16 922
Grand Total	764	2 858	530	1 3140	9 813.88	3 326.12	2 216.84	13 6614	8 507

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A31

Distribution of parent stock farms according to management system 2005

	Active enterprises			Non-active enterprises projects	
	No. of enterprises	Total capacity	Used capacity	No. of enterprises	Total capacity
Private sector	581	1 659.27	1 193.85	151	173.54
Governmental sector	14	85.52	38.84	4	75.65
The cooperative sector	2	10.70	8.80	-	-
Investment sector	11	187.66	124.65	1	24.50
Public business sector					

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A32

The distribution of parent stock farms according to Activity on year 2005

	Project No	Number of poultry houses		Chickens (1000)			Number of hatchings (million)		
		Active	Non active	Full capacity	Used capacity	Non-used capacity	Full capacity	Used capacity	Non-used capacity
Broiler parents	242	2 031	269	10 071.27	7 954.20	2 117.07	1 650.81	1 116.76	534.05
Layer parents	150	316	127	1 776.92	1 045.24	731.68	35179	157.74	1 9405
Duck parents	365	496	129	1 276.31	802.74	473.57	212.28	90.59	121.69
Turkey parents	7	15	5	15.5	11.7	3.8	1.96	1.05	0.91
Grand total	764	2 858	530	13 140	9 813.88	3 326.12	2 216.84	136 614	8 507

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A33
Geographical distribution of broiler parent stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Number of chickens (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Non-used capacity	Full capacity	Used capacity	Non-used capacity
Alexandria	10	44	14	231.30	133.80	97.50	41.30	20.50	20.80
Behairah	11	131	4	569.10	473.50	95.60	88.33	42.08	46.25
Kafr El sheikh	5	7	10	56.10	21.70	34.40	10.20	4.40	5.80
Dakahlia	39	240	27	1 041.00	804.00	237.00	203.90	143.65	60.25
Damietta	7	55	0	125.45	112.60	12.85	22.36	12.87	9.49
Sharkia	25	230	58	1 277.40	886.80	390.60	225.00	140.60	84.40
Port said	3	23	9	111.00	59.50	51.50	15.90	4.00	11.90
Ismailia	5	177	2	843.00	713.00	130.00	91.60	66.00	25.60
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	7	19	12	74.52	48.10	26.42	12.91	6.12	6.79
Menoufia	18	78	23	310.60	214.60	96.00	51.56	21.51	30.05
Qalyoubia	4	41	11	140.00	104.00	36.00	27.40	18.20	9.20
Cairo	12	22	23	172.50	74.90	97.60	40.20	7.19	33.01
Lower Egypt	146	1067	193	4 951.97	3 646.50	1 305.47	830.66	487.12	343.54
Giza	35	104	51	446.10	248.00	198.10	69.70	45.10	24.60
Beni Suef	5	8	15	78.00	20.00	58.00	11.75	3.00	8.75
Fayoum	8	24	0	70.40	65.30	5.10	13.40	11.70	1.70
Menia	1	16	0	54.00	54.00	0.00	10.80	9.70	1.10
Middle Egypt	49	152	66	648.50	387.30	261.20	105.65	69.50	36.15
Assuit	1	1	2	50.00	15.00	35.00	8.00	3.20	4.80
Suhag	2	8	2	44.00	25.80	18.20	4.60	2.60	2.00
Qena	1	8	0	24.00	16.40	7.60	3.00	2.50	0.50
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	4	17	4	118.00	57.20	60.80	15.60	8.30	7.30
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	38	788	0	4 289.80	3 836.00	453.80	685.90	547.90	138.00
North Sinai	5	7	6	63.00	27.20	35.80	13.00	3.94	9.06
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	-	-	-	-	-	-	-	-	-
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	43	795	6	4 352.80	3 863.20	489.60	698.90	551.84	147.06
Grand Total	242	2031	269	10 071.27	7 954.20	2 117.07	1 650.81	1 116.76	534.05

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A34
Geographical distribution of layer parents stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Chickens (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Non-used capacity	Full capacity	Used capacity	Non-used capacity
Alexandria	-	-	-	-	-	-	-	-	-
Behairah	22	40	21	237.40	107.54	129.86	45.47	20.75	24.72
Kafr El sheikh	1	3	-	36.00	22.50	13.50	7.2	4.5	2.7
Dakahlia	-	-	-	-	-	-	-	-	-
Damietta	-	-	-	-	-	-	-	-	-
Sharkia	-	-	-	-	-	-	-	-	-
Port said	-	-	-	-	-	-	-	-	-
Ismailia	1	9	-	50.00	35.00	15.00	10	6.3	3.7
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	85	123	39	472.00	271.60	200.40	122.5	44.41	78.12
Menoufia	-	-	-	-	-	-	-	-	-
Qalyoubia	2	6	-	28.00	25.00	3.00	5.6	5	0.6
Cairo	-	-	-	-	-	-	-	-	-
Lower Egypt	111	181	60	823.40	461.64	361.76	190.8	80.96	109.84
Giza	8	7	24	101.82	16.00	85.82	16.99	2.68	14.31
Beni Suef	4	4	5	21.20	9.00	12.20	2.6	1.2	1.4
Fayoum	13	72	22	386.10	255.00	131.10	69.8	26.8	43
Menia	-	-	-	-	-	-	-	-	-
Middle Egypt	25	83	51	509.12	280.00	229.12	89.39	30.68	58.71
Assuit	1	3	1	15.00	3.70	11.30	2	0.2	1.8
Suhag	5	4	15	74.00	24.50	49.50	10.9	3.7	7.2
Qena	1	4	-	7.00	7.00	0.00	1.1	0.9	0.2
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	7	11	16	96.00	35.20	60.80	14	4.8	9.2
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	6	39	-	248.40	198.40	50.00	43.6	32.3	113
North Sinai	-	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	1	2	-	100.00	70.00	30.00	14	9	5
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	7	41	-	348.40	268.40	80.00	57.6	41.3	163
Grand Total	150	316	127	1 776.92	1 045.24	731.68	35 179	157.74	19 405

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A35

Geographical distribution of duck parent stock farms and capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Ducks (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Unused capacity	Full capacity	Used capacity	Unused capacity
Alexandria	-	-	-	-	-	-	-	-	-
Behairah	6	22	6	105.70	49.20	56.50	13.18	4.96	8.22
Kafr El sheikh	26	28	4	54.10	35.40	18.70	8.15	5.31	2.84
Dakahlia	17	23	2	87.50	68.00	19.50	15.06	10.51	4.55
Damietta	-	-	-	-	-	-	-	-	-
Sharkia	35	42	27	150.00	82.80	67.20	70.40	9.74	60.66
Port said	2	4	-	7.80	5.70	2.10	1.10	0.90	0.20
Ismailia	2	3	-	5.00	5.00	-	0.85	0.65	0.20
Suez	-	-	-	-	-	-	-	-	-
Ghrabia	183	243	76	536.63	339.44	197.19	63.04	33.30	29.74
Menoufia	-	-	-	-	-	-	-	-	-
Qalyoubia	76	76	10	160.50	91.20	69.30	20.16	10.85	9.31
Cairo	1	1	-	1.50	1.30	0.20	0.18	0.15	0.03
Lower Egypt	348	442	125	1 108.73	678.04	430.69	192.12	76.37	115.75
Giza	4	14	-	20.88	20.20	0.68	2.51	1.62	0.89
Beni Suef	-	-	-	-	-	-	-	-	-
Fayoum	-	-	-	-	-	-	-	-	-
Menia	-	-	-	-	-	-	-	-	-
Middle Egypt	4	14	-	20.88	20.20	0.68	2.51	1.62	0.89
Assuit	-	-	-	-	-	-	-	-	-
Suhag	-	-	-	-	-	-	-	-	-
Qena	-	-	-	-	-	-	-	-	-
Luxor	-	-	-	-	-	-	-	-	-
Aswan	-	-	-	-	-	-	-	-	-
Upper Egypt	-	-	-	-	-	-	-	-	-
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	12	40	-	121.70	104.50	17.20	14.40	12.60	1.80
North Sinai	-	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	1	-	4	25.00	-	25.00	3.25	-	3.25
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	13	40	4	146.70	104.50	42.20	17.65	12.60	5.05
Grand Total	365	496	129	1 276.31	802.74	473.57	212.28	90.59	121.69

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A36

The geographical distribution of Turkey Parents stock farms and actual capacity 2005

Governorate	Number of enterprises	Number of poultry houses		Turkeys (1000)			Number of hatchings (million)		
		Active	Not active	Full Capacity	Used capacity	Unused capacity	Full capacity	Used capacity	Unused capacity
Lower Egypt	-	-	-	-	-	-	-	-	-
Giza	-	-	-	-	-	-	-	-	-
Beni Suef	2	6	4	5.2	3.6	1.6	0.3	0.2	0.1
Fayoum	-	-	-	-	-	-	-	-	-
Menia	-	-	-	-	-	-	-	-	-
Middle Egypt	2	6	4	5.2	3.6	1.6	0.3	0.2	0.1
Upper Egypt	-	-	-	-	-	-	-	-	-
Matruh	-	-	-	-	-	-	-	-	-
Noubaria	4	7	1	8.8	7.1	1.7	1.6	0.8	0.8
North Sinai	-	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-	-
New Valley	1	2	-	1.5	1	0.5	0.06	0.05	0.01
Red Sea	-	-	-	-	-	-	-	-	-
New and Desert Land	5	9	1	10.3	8.1	2.2	1.66	0.85	0.81
Grand Total	7	15	5	15.5	11.7	3.8	1.96	1.05	0.91

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A37

Capacity of duck and turkey parent stock farms 2001 to 2005

Year	Duck parent stock farms				Turkey parent stock farms			
	Ducks		Hatching eggs		Turkeys		Hatching eggs	
	Production (1 000 ducks)	Index	Production (million eggs)	Index	Production (1 000 turkeys)	Index	Production (million eggs)	Index
2001	406	100	48.8	100	5	100	0.4	100
2002	484.9	119.43	59.69	122.32	14.2	284.00	0.7	175.00
2003	532.5	131.16	70.1	143.65	14	280.00	1.5	375.00
2004	556.18	136.99	72.95	149.49	10.2	204.00	0.65	162.50
2005	802.74	197.72	90.59	185.64	11.7	234.00	1.05	262.50

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A38
Geographical distribution of poultry feed plants and enterprises capacity 2005

Governorate	No. Enterprises	Enterprises		Capacity (tonnes)			Planned projects	
		Active	Non active	Full capacity	Used capacity	Unused capacity	Number	Capacity (tonnes)
Alexandria	3	2	1	153 000	7 452	145 548	1	20 000
Behairah	1	1	-	3 600	900	2 700	-	-
Kafr El sheikh	8	7	1	52 800	4 916	47 884	1	12 000
Dakahlia	83	50	33	678 200	48 581	629 619	33	157 200
Damietta	-	-	-	-	-	-	-	-
Sharkia	45	42	3	348 445	176 682	171 763	3	19 720
Port said	-	-	-	-	-	-	-	-
Ismailia	3	2	1	88 100	36 300	51 800	1	3 650
Suez	1	1	-	7 200	806	6 394	-	-
Ghrabia	13	4	9	184 800	11 470	173 330	9	134 400
Menoufia	19	16	3	189 459	23 587	165 872	3	39 000
Qalyoubia	12	5	7	227 328	15 750	211 578	7	149 328
Cairo	4	3	1	53 450	710	52 740	1	150
Lower Egypt	192	133	59	1 986 382	327 154	1 659 228	59	535 448
Giza	13	9	4	1 050 660	237 166	813 494	4	144 000
Beni Suef	5	4	1	17 340	835	16 505	1	1 920
Fayoum	2	2	-	8 160	2 589	5 571	-	-
Menia	16	14	2	148 993	67 536	81 457	2	6 520

(continued)

TABLE A38
(Continued)

Governorate	No. Enterprises	Enterprises		Capacity (tonnes)			Planned projects	
		Active	Non active	Full capacity	Used capacity	Unused capacity	Number	Capacity (tonnes)
Middle Egypt	36	29	7	1 225 153	308 126	917 027	7	152 440
Assuit	9	6	3	94 750	32 100	62 650	3	12 100
Suhag	3	1	2	50 000	400	49 600	2	25 000
Qena	1	-	1	4 800	-	4 800	1	4 800
Luxor	-	-	-	-	-	-	-	-
Aswan	3	3	-	43 400	142	43 258	-	-
Upper Egypt	16	10	6	192 950	32 642	160 308	6	41 900
Matruh	-	-	-	-	-	-	-	-
Noubaria	2	2	-	122 800	28 700	94 100	-	-
North Sinai	-	-	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-	-	-
New Valley	2	1	1	10 760	500	10 260	1	5 760
Red Sea	1	-	1	24 000	-	24 000	1	24 000
New and Desert Land	5	3	2	157 560	29 200	128 360	2	29 760
Grand Total	7	175	74	3 562 045	697 122	2 864 923	74	759 548

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A39

Distribution of poultry feed plants according to management sector, 2005

Sector	Active enterprises			Non-active enterprises	
	No. of enterprises	Full capacity (tonnes)	Used capacity (tonnes)	No. of projects	Capacity (tonnes)
Private	147	2 242 477	567 882	62	537 178
Governmental	10	146 460	9 405	9	186 720
Cooperative	7	80 400	31 161	-	-
Investment	9	297 160	84 738	3	35 650
General public business	2	36 000	3 936	-	-

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A40

Number and capacity of local hatcheries, 1991 to 2005

Year	No. of active hatcheries	Number of eggs	Number of chicks produced	Hatching rate (%)
1991	506	85 210 770	55 274 515	65
1992	520	87 367 845	55 681 142	64
1993	476	84 777 955	54 021 242	64
1994	482	86 656 737	55 588 603	64
1995	535	87 218 215	60 164 998	69
1996	533	87 917 030	54 038 720	62
1997	573	99 208 263	61 253 263	62
1998	570	104 171 640	56 243 278	54
1999	618	113 004 696	66 654 043	59
2000	661	99 061 769	68 402 078	69
2001	886	175 629 000	119 460 000	68
2002	992	17 234 000	133 724 000	75.5
2003	974	173 520 000	124 066 000	71.5
2004	964	156 333 000	120 696 000	77.2
2005	942	158 703 000	121 190 000	76.4

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A41
Number and capacity of industrial hatcheries, 1991 to 2005

Year	No. of active hatcheries	No. of eggs	No. of chicks produced	Hatching rate (%)
1991	118	283 036 625	213 321 417	76
1992	123	283 288 752	213 886 822	76
1993	116	304 986 498	224 399 741	74
1994	121	298 841 072	210 622 177	71
1995	115	297 146 842	221 070 561	74
1996	129	245 632 171	173 483 641	71
1997	126	291 742 972	213 599 303	73
1998	127	315 689 816	232 248 771	74
1999	96	350 121 283	259 878 897	74
2000	113	348 406 264	266 152 050	76
2001	150	626 846 000	499 038 000	796
2002	167	929 690 000	732 202 000	788
2003	162	894 351 000	656 984 000	731
2004	158	938 070 000	736 979 000	78.6
2005	169	755 752 000	599 964 000	79.4

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A42
Geographical distribution of automated poultry abattoirs, 2005

Governorate	Number of enterprises		Active			Non active
	Active	Non active	Total capacity (1 000 birds)	Used capacity (1 000 birds)	Unused capacity (1 000 birds)	Capacity (1 000 birds)
Alexandria	4	1	11 280	543	10 737	4 680
Behairah	-	-	-	-	-	-
Kafr El sheikh	-	-	-	-	-	-
Dakahlia	-	-	-	-	-	-
Damietta	-	-	-	-	-	-
Sharkia	10	0	27 927	13 921	14 006	-
Port said	-	-	-	-	-	-
Ismailia	1	-	6 300	2 400	3 900	-
Suez	-	1	36 000	-	36 000	36 000
Ghrabia	-	-	-	-	-	-
Menoufia	2	5	700	200	500	500
Qalyoubia	3	1	48 480	9 864	38 616	12 000
Cairo	0	1	43 200	-	43 200	43 200
Lower Egypt	20	9	173 887	26 928	146 959	96 380
Giza	1	-	3 000	1 995	1 005	-
Beni Suef	1	1	3 400	300	3 100	2 400
Fayoum	-	-	-	-	-	-
Menia	-	-	-	-	-	-
Middle Egypt	2	1	6 400	2 295	4 105	2 400
Assuit	1	-	36	30	6	-
Suhag	1	-	6 000	540	5 460	-
Qena	2	-	1 100	432	668	-
Luxor	-	-	-	-	-	-
Aswan	-	1	24 000	-	24 000	24 000
Upper Egypt	4	1	31 136	1 002	30 134	24 000
Matruh	-	-	-	-	-	-
Noubaria	-	1	135	-	135	135
North Sinai	-	-	-	-	-	-
Sinai South	-	-	-	-	-	-
New Valley	-	1	1 560	-	1 560	1 560
Red Sea	-	1	180	-	180	180
New and Desert Land	-	3	1 875	-	1 875	1 875
Grand Total	26	14	213 298	30 225	183 073	124 655

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A43
Distribution of operational poultry automated abattoirs by management system 2005

Sector	Active enterprises			Non-active enterprises	
	No. of enterprises	Total capacity	Used capacity	No. of enterprises	Unused capacity
Private	16	30 971	13 320	7	17 215
Governmental	3	7 500	988	5	40 240
Cooperative	-	-	-	-	-
Investment	6	32 892	15 708	-	-
General public business	1	17 280	209	2	67 200
Total	26	88 643	30 225	14	124 655

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A44
Refrigerators used in refrigeration freezing process 2001 to 2005

Years	Volume of refrigerators		Actual storage	
	1 000 m^3	Index	1 000 tonne	Index
2001	2 255	100	1 389.6	100
2002	2 261	100.27	1 289.6	92.8
2003	2 282.70	101.23	1 365.92	98.3
2004	2 377.51	105.43	1 540.09	110.83
2005	2 469.11	109.5	1 769.1	127.31

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A45
Household poultry – number of animals and number of holdings (data from the last of comprehensive census of 1999/2000)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Cairo	2 901	52 810	401	2 352	2 228	19 165	802	7 050	3 009	100 055
Alexandria	25 981	419 595	4 348	24 275	22 734	230 174	11 071	105 403	5 998	95 089
Port Said	5 023	115 001	147	1 153	4 897	90 035	258	3 282	625	10 599
Suez	4 210	82 937	1 274	6 992	3 568	36 205	1 034	11 706	1 868	29 118
Damietta	47 111	821 663	8 548	46 276	44 454	560 357	10 809	111 382	47 744	1 680 074
Dakahlia	333 349	6 796 142	59 624	381 511	316 751	4 419 729	75 322	658 470	82 695	947 505
Sharkia	408 338	8 000 902	57 045	394 649	382 343	5 348 472	81 463	723 266	158 783	1 799 413
Qalyoubia	135 698	2 291 883	30 341	188 775	126 898	1 385 969	37 236	290 390	60 353	569 690
Kafr El sheikh	229 240	4 318 664	53 736	347 069	223 636	3 668 474	87 871	712 953	55 625	629 075
Ghrabia	222 648	3 722 007	45 375	268 146	208 494	2 484 138	54 584	445 908	58 811	577 140
Menoufia	232 634	3 467 105	55 166	336 175	215 465	2 286 499	55 028	425 415	103 095	918 827
Behara	326 667	5 429 844	61 706	412 625	315 260	4 516 124	128 355	1 119 070	123 393	1 321 125
Ismailia	45 313	1 115 362	7 346	49 846	42 229	640 794	7 419	72 813	17 630	281 919
Lower Egypt	2 019 113	36 633 915	385 057	2 459 844	1 908 957	25 686 135	551 252	4 687 108	719 629	8 959 629
Giza	127 275	2 127 764	20 637	122 484	103 838	980 568	43 257	383 444	49 662	462 380
Beni Suef	182 759	3 021 652	48 668	271 067	162 294	1 355 242	59 006	407 334	71 242	504 873
Fayoum	196 370	4 108 841	29 588	163 372	173 952	1 738 645	46 796	381 637	71 650	576 816
Menia	297 814	3 921 556	63 781	329 988	218 668	1 367 139	123 977	762 491	107 614	610 243

(continued)

TABLE A45
(Continued)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Assuit	266 512	3 647 136	41 556	196 750	181 058	1 174 416	120 643	794 272	204 084	1 602 436
Suhag	312 733	4 352 929	47 596	240 677	256 798	1 946 096	138 652	1 085 771	277 325	2 637 652
Qena	210 107	2 181 140	27 229	103 276	159 635	953 250	81 306	490 375	163 448	1 376 093
Luxor	19 669	254 120	1 604	7 404	12 069	85 197	4 398	27 350	11 389	122 294
Aswan	84 761	1 044 626	16 976	67 262	66 241	419 775	37 634	207 116	62 955	520 740
Upper Egypt	1 698 000	24 659 764	297 635	1 502 280	1 334 553	10 020 328	655 669	4 539 790	1 019 369	8 413 527
Red Sea	2 646	42 194	186	1 057	1 070	10 382	419	4 301	2 783	76 503
New Valley	14 100	211 262	6 355	20 964	12 825	100 333	5 919	44 773	12 573	172 669
Matruh	12 659	219 511	1 920	10 262	6 853	68 339	4 735	51 347	5 617	171 458
North Sinai	16 177	234 565	1 039	4 347	9 971	72 494	3 008	21 281	5 801	63 337
Sinai South	2 314	39 178	18	91	599	5 388	68	1 063	936	22 332
Desert Land	47 896	746 710	9 518	36 721	31 318	256 936	14 149	122 765	27 710	506 299
Grand Total	3 765 009	62 040 389	692 210	3 998 845	3 274 828	35 963 399	1 221 070	9 349 663	1 766 708	17 879 455

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A46
Household poultry – number of birds and number of holdings (data from 2004/2005 census)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Cairo	1 129	28 109	470	2 294	881	6 405	195	1 805	442	5 011
Alexandria	27 124	472 664	5 469	27 695	22 855	235 338	11 352	106 583	6 896	97 249
Port said	5 448	146 628	103	872	4 953	98 698	735	6 851	766	12 368
Suez	3 247	91 514	1 055	7 536	3 078	37 135	1 152	12 871	1 989	30 137
Damietta	47 359	909 347	6 565	36 405	44 720	563 356	6 100	59 232	27 589	1 151 912
Dakahlia	336 614	7 486 563	61 427	387 072	318 857	4 426 041	75 615	659 081	85 952	955 337
Sharkia	412 567	8 809 330	58 387	398 556	385 619	5 357 018	79 940	715 123	164 395	1 808 539
Qalyoubia	136 225	2 524 729	31 012	191 882	127 388	1 389 012	37 315	290 895	61 103	574 195
Kafr El sheikh	232 767	4 758 466	54 271	349 805	226 055	3 676 292	88 283	713 978	57 431	635 083
Ghrabia	237 188	4 119 783	46 815	275 115	211 653	2 501 567	55 737	447 101	65 168	581 905
Menoufia	235 683	3 823 311	56 270	340 211	218 941	2 293 848	52 698	419 849	104 172	923 151
Behara	328 983	5 981 147	62 602	417 303	316 292	4 523 065	125 924	1 105 251	124 975	1 326 548
Ismailia	47 155	1 236 147	7 522	50 841	40 539	615 911	7 448	73 018	18 221	283 524
Lower Egypt	2 051 489	40 387 738	391 968	2 485 587	1 921 831	25 723 686	542 494	4 611 638	719 099	8 384 959
Giza	133 108	2 347 845	22 089	125 929	104 456	985 589	43 643	386 419	50 119	465 425
Beni Suef	186 459	3 332 779	49 626	273 565	164 873	1 360 333	59 671	409 073	73 443	511 115
Fayoum	198 361	4 529 643	30 541	166 460	175 932	1 745 802	47 891	386 781	73 076	581 894
Menia	299 906	4 324 541	64 815	332 574	222 046	1 375 251	121 455	756 305	109 445	614 525

(continued)

TABLE A46
(Continued)

Governorate	Chickens		Turkeys		Geese and ducks		Rabbits		Pigeons	
	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head)	Holdings	Animals (head))
Assuit	269 743	4 022 039	42 191	198 769	182 901	1 179 482	120 740	794 764	206 208	1 607 671
Suhag	316 773	4 803 007	49 992	244 764	258 866	1 951 187	118 982	1 007 659	282 522	2 645 575
Qena	212 665	2 409 703	28 218	105 637	161 499	959 342	79 892	485 687	165 674	1 381 839
Luxor	19 976	282 753	1 797	9 231	13 283	87 610	4 857	29 156	11 833	125 313
Aswan	85 992	1 170 502	18 013	71 259	68 066	421 794	38 313	208 629	63 228	521 894
Upper Egypt	1 722 983	27 222 812	307 282	1 528 188	1 351 922	10 066 390	635 444	4 464 473	1 035 548	8 455 251
Red Sea	2 101	32 798	100	915	615	6 998	93	1 172	821	12 561
New Valley	15 895	237 033	8 626	23 165	13 120	109 526	6 414	45 564	13 431	176 396
Matruh	15 393	248 475	2 515	12 579	7 654	72 129	5 306	52 840	7 516	173 208
North Sinai	19 101	260 690	1 901	9 750	11 503	76 893	3 311	23 281	6 139	65 593
Sinai South	2 807	62 834	108	416	710	6 187	275	2 382	1 347	23 530
Desert Land	55 297	841 830	13 250	46 825	33 602	271 733	15 399	125 239	29 254	451 288
Grand Total	3 829 769	68 452 380	712 500	4 060 600	3 307 355	36 061 809	1 193 337	9 201 350	1 783 901	17 291 498

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A47
Geographical distribution of household poultry (data from 1999/2000 census)

Type	Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total	Share of total (%)
Chickens	36 633 915	24 659 764	746 710	62 040 389	48.01
Turkey	2 459 844	1 502 280	36 721	3 998 845	3.09
Geese and ducks	25 686 135	10 020 328	256 936	35 963 399	27.83
Rabbits	4 687 108	4 539 790	122 765	9 349 663	7.23
Pigeons	8 959 629	8 413 527	506 299	17 879 455	13.84
All household poultry	78 426 631	49 135 689	1 669 431	129 231 751	100.00
Share of household poultry (%)	60.69	38.02	1.29	100.00	

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

FIGURE A3
Geographical distribution of household poultry (data from 1999/200 census)

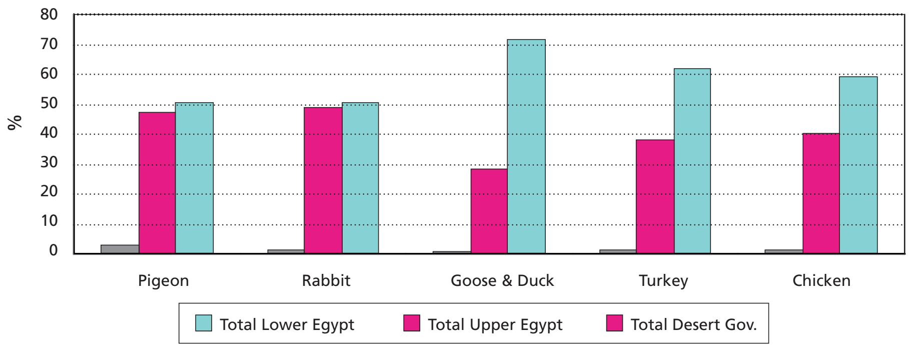


TABLE A48
Geographical distribution of household poultry (data from 2004/2005 census)

Type	Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total	Share (%)
Chickens	40 387 738	27 222 812	841 830	68 452 380	50.68
Turkey	2 485 587	1 528 188	46 825	4 060 600	3.01
Geese and ducks	25 723 686	10 066 390	271 733	36 061 809	26.70
Rabbits	4 611 638	4 464 473	125 239	9 201 350	6.81
Pigeons	8 384 959	8 455 251	451 288	17 291 498	12.80
All household poultry	81 593 608	51 737 114	1 736 915	135 067 637	100.00
Share of household poultry (%)	60.41	38.30	1.29	100.00	

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A49
Geographical distribution of household poultry holdings (data from 1999/2000 census)

Type		Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total
Chickens	Number of holdings	2 019 113	1 698 000	47 896	3 765 009
	Number of holdings (%)	53.63	45.10	1.27	100.00
	Number of chickens	36 633 915	24 659 764	746 710	62 040 389
	Number of chickens (%)	59.05	39.75	1.20	100.00
	Average of number of chickens per holding	18.14	14.52	15.59	16.48
Turkeys	Number of holdings	385 057	297 635	9 518	692 210
	Number of holdings (%)	55.63	43.00	1.38	100.00
	Number of turkeys	24 59 844	1 502 280	36 721	3 998 845
	Number of turkeys (%)	61.51	37.57	0.92	100.00
	Average of number of turkeys per holding	6.39	5.05	3.86	5.78
Geese and ducks	Number of holdings	1 908 957	1 334 553	31 318	3 274 828
	Number of holdings (%)	58.29	40.75	0.96	100.00
	Number of geese/ducks	25 686 135	10 020 328	256 936	35 963 399
	Number of geese/ducks (%)	71.42	27.86	0.71	100.00
	Average of number of geese/ducks per holding	13.46	7.51	8.20	10.98
Rabbits	Number of holdings	551 252	655 669	14 149	1 221 070
	Number of holdings (%)	45.14	53.70	1.16	100.00
	Number of rabbits	4 687 108	4 539 790	122 765	9 349 663
	Number of rabbits (%)	50.13	48.56	1.31	100.00
	Average of number of rabbits per holding	8.50	6.92	8.68	7.66
Pigeon	Number of holdings	719 629	1 019 369	27 710	1 766 708
	Number of holdings (%)	40.73	57.70	1.57	100.00
	Number of pigeons	8 959 629	8 413 527	506 299	17 879 455
	Number of pigeons (%)	50.11	47.06	2.83	100.00
	Average of number of pigeons per holding	12.45	8.25	18.27	10.12

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A50
Regional distribution of household poultry (data from 2004/2005 census)

Type		Governorates of Lower Egypt	Governorates of Upper Egypt	New Land Governorates	Total
Chickens	Number of holdings	2 051 489	1 722 983	55 297	3 829 769
	Number of holdings (%)	53.57	44.99	1.44	100.00
	Number of chickens	40 387 738	27 222 812	841 830	68 452 380
	Number of chickens (%)	59.00	39.77	1.23	100.00
	Average of number of chickens per holding	19.69	15.80	15.22	17.87
Turkeys	Number of holdings	391 968	307 282	13 250	712 500
	Number of holdings (%)	55.01	43.13	1.86	100.00
	Number of turkeys	2 485 587	1 528 188	46 825	4 060 600
	Number of turkeys (%)	61.21	37.63	1.15	100.00
	Average of number of turkeys per holding	6.34	4.97	3.53	5.70
Geese and ducks	Number of holdings	1 921 831	1 351 922	33 602	3 307 355
	Number of holdings (%)	58.11	40.88	1.02	100.00
	Number of geese/ducks	25 723 686	10 066 390	271 733	36 061 809
	Number of geese/ducks (%)	71.33	27.91	0.75	100.00
	Average of number of geese/ducks per holding	13.38	7.45	8.09	10.90
Rabbits	Number of holdings	542 494	635 444	15 399	1 193 337
	Number of holdings (%)	45.46	53.25	1.29	100.00
	Number of rabbits	4 611 638	4 464 473	125 239	9 201 350
	Number of rabbits (%)	50.12	48.52	1.36	100.00
	Average of number of rabbits per holding	8.50	7.03	8.13	7.71
Pigeons	Number of holdings	719 099	1 035 548	29254	1 783 901
	Number of holdings (%)	40.31	58.05	1.64	100.00
	Number of pigeons	8 384 959	8 455 251	451 288	17 291 498
	Number of pigeons (%)	48.49	48.90	2.61	100.00
	Average of number of pigeons per holding	11.66	8.17	15.43	9.69

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A51
Total and Actual capacity for Broiler production and for slaughtering in surplus governorates

Governorates	Total capacity for Broiler	Actual capacity for Broiler	Total capacity for Slaughters	Actual capacity for Slaughters	Shortage of Slaughters
Behairah	66 432,33	51 125,67	1350	417	49 775,67
Gharbia	115 745,33	93 478	0	0	9 3478
Dakahlia	145 977	91 485,33	0	0	91 485,33
Damietta	32 578,33	19 871,33	0	0	19 871,33
Sharkia	178 292,67	107 111,33	25 660	13 852	81 451,33
Ismailia	28 951	14 048	6 300	14 222	7 748
Qalyoubia	99 051,33	63 426,33	48 480	7 252	14 946,33
Matrouh	5 899	2 953,67	0	0	2 953,67

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

TABLE A51

Estimating Variables used for Suitable Distribution for Slaughters in Egypt (2002/2004)

Governorates	Population No. 1 000	Production (Tonnes)*	Demand (Tonnes)	Balance (Tonnes)	Total capacity for Slaughters (Tonnes)*	Actual capacity for Slaughters (Tonnes)
Alexandria	3 693	21 043	51 000.33	-29 957.3	11 280	2 239
Behairah	4 516	112 886	62 365.96	50 520.04	1 350	417
Gharbia	3 792	137 503.6	52 367.52	85 136.08	0	0
Kafr El sheikh	2 494	32 306.6	34 442.14	-2 135.54	0	0
Dakahlia	4 748	133 539.9	65 569.88	67 970	0	0
Damietta	1 035	29 215.7	14 293.35	14 922.35	0	0
Sharkia	4 905	155 931.9	67738.05	88 193.85	25 660	13 852
Ismailia	826	21 017.5	11 407.06	9 610.44	6 300	1 422
Port Said	522	1 047	7 208.82	-6 161.82	0	0
Suez	469	2 558	6 476.89	-3 918.89	600	567
Menoufia	3 112	40 118.6	42 976.72	-2 858.12	430	228
Qalyoubia	3 732	90 876.7	51 538.92	39 337.78	48 480	7 252
Cairo	7 505	2 685.7	103 644.1	-100 958	8 333	1 892
Lower Egypt	41 349	780 730.2	571 029.7	209 700.5	102 433	27 869
Giza	5 425	52 326.7	74 919.25	-22 592.6	3 000	2 402
Beni Suef	2 161	9 797.6	29 843.41	20 045.8	2 400	0
Fayoum	2 319	15 720.2	32 025.39	-16 305.2	0	0
Menia	3 872	31 540.5	53 472.32	-21 931.8	0	0
Middle Egypt	13 777	109 385	190 260.4	-40 783.8	5 400	2 402
Assuit	3 278	16 261.5	45 269.18	-29 007.7	36	26
Suhag	3 655	10 660.8	50 475.55	-39 814.8	6 000	416
Qena	2 819	2 715.3	38 930.39	-36 215.1	1 117	591
Luxor	407	605.6	5 620.67	-5 015.07	0	0
Aswan	1 078	79.3	14 887.18	-14 807.9	1 600	399
Upper Egypt	11 237	30 322.5	155 183	-124 860	8 753	1 432
North Sinai	295	3 532.5	4 073.95	-541.45	0	0
South Sina	62	112.4	856.22	743.82	0	0
Matrouh	255	4 430.5	3 521.55	908.95	0	0
New Valley	163	966.8	2 251.03	-1 284.24	1 560	0
Red Sea South	179	168.6	2 471.99	-2 303.39	180	0
New and desert	954	9 210.8	13 174.74	-3 963.94	3 090	0
Grand Total	67 317	938 859.3	942 822.6	-3 963.26	121 416	31 703

* Meat poultry production includes broiler, spent-layers, improved baladi (produced in the commercial sector) and baladi (produced in traditional sector) chicken.

Source: Economic Affairs Sector (EAS) Ministry of Agriculture And Land Reclamation.

Future trends and developments in poultry nutrition

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SUMMARY

This paper gives recognition to the recent rapid technological, scientific and industrial changes that have taken place in the poultry sector, and uses these as a baseline for the prediction of future trends in nutrition. It is predicted that elevated levels of poultry feed will be required, in the fast-developing poultry sectors of Asia in particular, to meet the burgeoning consumer demand for poultry products. This significant migration of feed demand from west to east will be associated with increased outputs of formulated compound feeds. Globally, relatively few protein and energy ingredients are used in the manufacture of poultry feed for landless and large-scale commercial operations, with a significant reliance on soybean and traditional cereal grains to achieve nutrient supply and balance. The feed versus fuel debate over cereal usage is set to continue, accompanied by uncertainty as to the likely impact on feed and livestock production levels, and on feed-industry dynamics. Further refinements of technologies used for the production of ethanol by-products with desirable nutritional characteristics – for example, dried distillers' grains with solubles (DDGS) – will be necessary in the future, parallel to the economic evaluation and justification of such products with respect to competitor feed ingredients.

Additional legislation will affect most aspects of the feed sector, including those pertaining to environmental protection, feed hygiene, and those linked to food-safety issues throughout the poultry supply chain. Parallel to the continued inclusion and utilization of traditional feed ingredients in the poultry industries of both developed and developing countries, will be the ongoing requirement for nutritional evaluation of more locally grown and novel indigenous crop sources, which may have the potential to offer reasonable (alternative) protein and energy yields. The future use of a greater diversity of protein feeds in formulations, despite the fact that they may contain less than optimal natural amino acid profiles, will be assisted by the increasing availability of relatively cheaply manufactured synthetic forms of essential amino acids, which will facilitate the dietary creation of "ideal" protein. There will be continued selection for genetically improved and more location/climate-tolerant plant cultivars that have potential nutritional value and widen the feed options for more countries.

Greater accuracy in dietary macronutrient and micronutrient provision not only results in enhanced bird performance characteristics, but also reduces the likelihood of nutrient waste posing a pollution threat to the environment, which will be an increasingly important issue in the future in an increasing number of countries. Manipulation of voluntary feed intake (VFI) in birds is key to the control of nutrient intake levels, and therefore ultimate

performance and productivity; the factors influencing VFI will merit further scientific and commercial evaluation in the future, particularly with the prospect of climate change and the effect of elevated temperatures and other climatic variables on appetite.

The genetic selection emphasis of recent times linked to nutrition, that of feed conversion efficiency and maximal growth, is likely to change in favour of traits associated with bird welfare, meat and egg quality, and "robustness" of genotypes or strains of bird capable of adapting to, and being productive in, a range of commercial environments. There is already recognition of the potential of indigenous poultry breeds and their adaptive role in more suitably converting locally available feed resources into sustainable production, albeit on a smaller scale.

Husbandry practices which support effective immune response in chickens are vital. Two perspectives have influenced the focus of research in recent years on this subject: firstly, determining the most appropriate nutrient feeding strategies to optimize the immune response; and secondly, the study of the influence of immune response on the growth and nutrient requirements of the bird. The maintenance of immunocompetence and optimal health status in birds in a range of husbandry situations will remain a priority. Such physiological well-being can be challenged by a number of anti-nutritional factors (ANF) in feeds, and by mycotoxin presence in the birds' environment. The latter, if ingested or inhaled over a sustained period, has the potential to cause varying degrees of mycotoxicosis in poultry, with the associated negative effects on growth and reproductive performance. With regard to the presence of feed ANF, a significant number of research results, in which a range of exogenous enzyme treatments have been applied and evaluated, have indicated success in ameliorating the negative effects which such compounds have on feed digestibility and palatability. As far as mycotoxin contamination is concerned, surveys from around the world indicate that protein sources such as rapeseed meal, groundnut cake, sunflower meal, copra meal and palm kernel meal, for example, are more susceptible to mycotoxin contamination than are conventional raw materials such as soybean meal.

A successful poultry production system, irrespective of scale and sophistication, requires a continuous enterprise cycle, which can be better achieved by embracing the important elements of sustainability both physical and financial. Systems of the future, in the context of poultry nutrition, will need to apply greater focus on "resource sufficiency" not scarcity, which will necessitate the constant consideration and evaluation of alternative protein and other nutrient input sources, for example a reduced reliance on the traditional proteins – fishmeal and soybean – in broiler and layer diets. There will remain the need to achieve and exploit efficiencies throughout the system, particularly opportunities for further feed conversion economies through improved general flock management. A more holistic and integrated approach to the development of feeding programmes will assist the poultry industries and individual producers of chicken products to pursue their goals of enhanced production within a sustainability context. Endemic and local occurrence of infectious diseases will remain an omnipresent threat, and on occasion will stifle the progress achieved in bird performance through the adoption of improved nutrition strategies.

Key words: poultry, future, feed.

1 CHARACTERIZATION OF THE FEED INDUSTRY

1.1 Subject emphasis

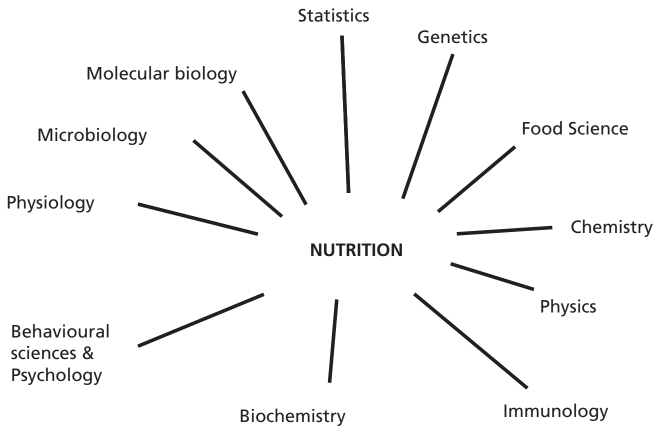
The livestock feed industry, irrespective of scale and size, is an integral and growing segment of the food supply chain. It supplies the feed ingredients needed to promote health and productivity in birds which, in turn, provide a growing global human population with essential dietary protein and energy sources. The title of this paper gives recognition to the recent rapid technological, scientific and industrial changes which have taken place in the poultry sector, and uses these as a baseline for the prediction of future trends in nutrition. The latter subject, together with general quality management and breeding, continue to be the central themes of livestock production. Adequate, physiologically balanced nutrition is vital to the health, fertility and optimal performance of birds. As vital links in the food chain, the feed manufacturer and producer, alike, are having to give due consideration to changing social and economic climates. The significant proportion of costs of production attributable to feed now has to be considered alongside bird welfare, food safety and environmental protection concerns which have attracted increasing volumes of legislation, particularly in the European Union (EU). Such issues are now having an impact globally, as reviewed thoroughly recently by Steinfeld *et al.* (in FAO, 2006).

Over the last century, there has been considerable research endeavour, and important milestones, in poultry nutrition science. These have been documented by Larbier and Leclercq (1994) – from the discovery of vitamin A, through to the commercial manufacture and development of synthetic amino acids. Feeding, which is a major factor in controlling profitability, has evolved and progressed both in terms of understanding the physiology and metabolism of the bird, and in the more precise evaluation of the quality of dietary raw materials. The science of nutrition, applied to both meat and egg production sectors, has changed its emphasis from the effect of feed on the whole animal to the impact of (individual) nutrients on selected organs and tissues. Thus, the emphasis in research today is less on outcomes, and more on mechanisms investigated at the cellular level. This is likely to be the immediate future scenario, with more efficient and focused use of financial resources.

The importance of nutrition as a science in its own right has been the focus of much researcher discussion, and the science of poultry nutrition is very much a multidisciplinary subject. A key feature of the study of nutrition is its absolute reliance on other, more fundamental, sciences (Figure 1). The relationships depicted are, nevertheless, oversimplified; each discipline can influence nutrition in several ways.

For example, the science of microbiology is important because of the large indigenous microbial population in the gastro-intestinal tract. These organisms intercept nutrients, thereby enhancing or detracting from the host's nutrition. Microbiology also interacts with nutrition in that infections may influence appetite, and therefore food intake, as well as the animal's ability to metabolize nutrients. Although most studies have been carried out on large bird populations and under experimental protocol conditions, it is the application of such results and the dissemination of scientific findings to both the large and small producer, perhaps through extension services, which is of paramount importance to facilitating improvements in bird productivity at the practical husbandry level.

FIGURE 1
Nutrition – A Multi Disciplinary Science

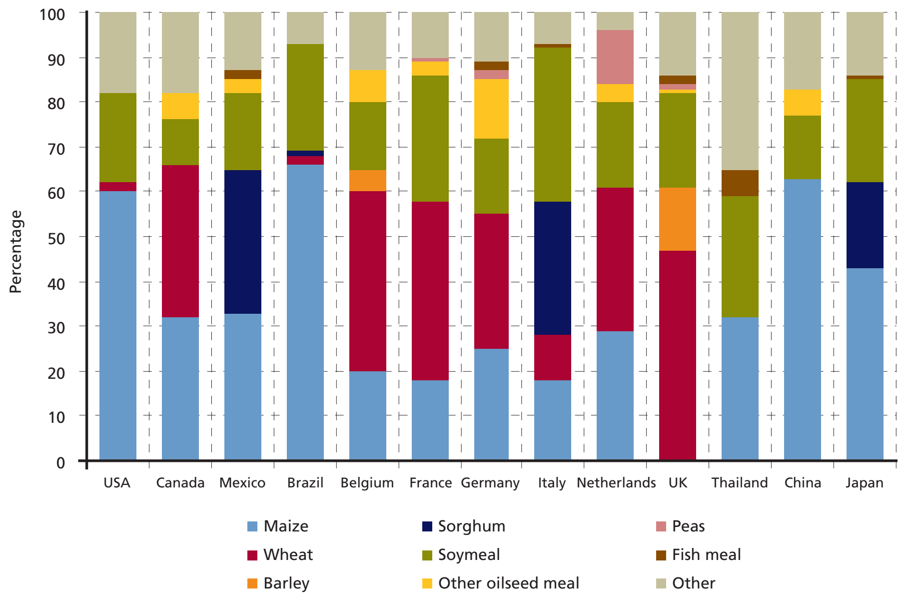


1.2 Poultry feed industry dynamics

The global demand for livestock commodities, namely milk, meat and eggs, has seen significant growth globally, the drivers of change being improved incomes, growing populations and urbanization (FAO, 2004a; Steinfeld *et al.*, in FAO, 2006). At the forefront of consumer demand is poultry, and in particular broiler meat. There is a shift in developing countries towards monogastric production, with poultry and pigs accounting for 77 percent of the expansion – this in contrast to the consolidation and relative stagnation of poultry activity within the EU (Geers and Madec, 2006). To support such a large increase, there is a need for significantly elevated levels of poultry feed, both raw materials and, particularly, concentrate compound forms. The concern remains, therefore, that the booming poultry industries will pose feed demands that will far exceed supplies (Steinfeld *et al.*, in FAO, 2006). There are regional differences, with the strongest growth being in Asia. Gilbert (in FAO, 2004b) estimates the global production of animal feed annually to be in the region of 1 000 million tonnes, 60 percent of which is compound; poultry account for the greatest tonnage produced. The growth in large, industrial-scale, vertically integrated poultry operations, the so-called landless systems, tends to be associated with, and mainly responsible for, the increased demand for purchased compound feed products.

International trade in raw materials is the key to the dynamics of the global feed industry. The economics of accessing the industry's products present a challenge for small-scale production in developing countries. Traditional poultry production was (and still is) based on the availability of local (indigenous) feed resources, with access to markets, appropriate infrastructure, land price, labour and transport issues being important determinants of poultry locations (Steinfeld *et al.*, in FAO, 2006). FAO (2003) document a projected increased demand for grains up to 2030 of 1 billion tonnes, and for maize a projected rise from 625 to 964 million tonnes for the period 2002 to 2030. Traditionally, there has been a

FIGURE 2
Relative composition of chicken feed ration in selected countries (by weight)



Source: Steinfeld *et al.* (in FAO, 2006).

high reliance on cereal grains as the main energy source in poultry diets, irrespective of the country concerned, as can be seen in Figure 2. The demand for cereals globally is balanced by the popularity of soybean as the major protein source (Figure 2).

Fish production is an increasing competitor for the compound feed market. Others have recently reviewed the growing importance of aquaculture and implications for feed manufacturers (Morris, 2005). Gill (2006) comments that aquafeed continues to be the fastest growing sector of feed production on an industrial scale, although this trend is not predicted to continue indefinitely. Clearly, the poultry-feed sector has other competing species with respect to feed raw material usage. Both monogastric industries are intensive operations which require similar high-quality protein resources. One of the reasons for an increased demand for soymeal in other animal diets is the elevated use of fishmeal to sustain the aquaculture sector, the latter being more dependent on fishmeal than are terrestrial animals (Steinfeld *et al.*, in FAO, 2006).

1.3 Feed manufacturing technology and regulatory constraints

Much technological sophistication and innovation has been applied in the feed manufacturing sector in recent years. In addition to catering for large-volume outputs of an increasingly diverse range of products, the milling business and industries across the world also face increasing competition. More than 80 percent of the world's feed is now produced by as few as 3 800 mills (Gilbert, in FAO, 2004b). This consolidation of feed manufacturing capacity has resulted in the adoption of state of the art engineered equipment to produce high-quality and safe products, which from a food-chain perspective, provide the consumer with greater confidence and the birds with the opportunity to maximize their performance potential. It is imperative that high-volume outputs are combined with safeguarding quality in terms of the end product, and comply with various official directives (Van der Bunt and West, 2006).

Today, most poultry feed is manufactured by employing a combination of technologies – grinding or rolling, heat moisture and pressure by pelleting, expanding or extruding, and applying heat via anaerobic pasteurizing conditioners. The range of raw materials incorporated into modern poultry diets is continually changing over time due to a number of factors, which were identified by Kersten *et al.* (2005) as price changes and fluctuations, component price dynamics, availability of raw materials, government regulatory permissions, and customer supply and demand. Many advantages can be attributed to feed processing – improved availability of protein and energy, destruction of inhibitors and toxins, facilitation of the use of a wide range of raw materials in diet formulations, production of hygienic compounds, and reduction of feed wastage. There have been some informative reviews on aspects of emerging feed-processing technologies, and some of the potential problems involved in achieving feed end-product quality (van der Barneveld, 2001; Thomas and var der Poel 2001; Kersten *et al*, 2005).

A major concern in the feed industry is that of ensuring food safety. There is a direct link between animal-feed quality and hygiene issues and the safety of foods of animal origin when consumed. It follows, therefore, that feed production and manufacture should be considered as an integral part of the food production chain (Tielen, 2005), and that it should therefore be subject to quality assurance and food safety systems (Manning *et al.*, 2006a ; Manning *et al.*, 2007). The quantity of legislation, regulations, recommendations and guidelines that the feed industry has to comply with or take note of is increasing; much originates in Brussels with the purpose of being applied across the European Union (EU) member states (currently 27). Detail relating to the specifics of such regulatory frameworks is provided in two recent papers (Millar, 2006; Nelson *et al.*, 2006). The legislation considered includes issues such as feed-additive and hygiene regulations, organic feed legislation, ingredient declaration, labelling and by-product definitions. It can be expected that this steady stream of animal feed regulations will continue, and that the principle of Hazard Analysis and Critical Control Points (HACCP) will be implemented rigidly throughout the food production chain (Manning *et al.*, 2006b). Clearly, countries engaged in trading poultry products with EU member states will have to give due consideration to existing legal frameworks and standards.

1.4 Country focus

The levels of sophistication which characterize the so-called feed industry sectors in different countries are very much determined by the scale of poultry production, both meat and eggs. This ranges from highly industrialized landless intensive systems as defined by Devendra (2007) to family poultry production with modest feed-sourcing requirements. The latter remains important in low-income food-deficit countries (FAO, 2004c; Guèye, 2002). Within individual countries, there is significant regional variation and contrast with respect to the scale and complexities of the poultry-feed manufacturing sectors. An example of this is found in Asia, a region which in general has seen rapid development in feed production technology linked to, and in support of, improvements in commercial poultry performance.

Meggison (2005) predicts increasing opportunities in the future in the Far East for feed and feed-related companies linked to the "shift" from west to east of the production and consumption of livestock products. China is singled out in terms of future influence – it produces more compound feed than the rest of Asia together. The growth of compound feed production is predicted to exceed 10 percent *per annum* for the foreseeable future. It is worth noting, however, that most Asian countries rely on the net import of unsubsidized grains and pay world market prices to complement locally grown feed raw material commodities. Bootwalla (2005) provides statistics on the magnitudes of poultry feed production in South Asia, the total is estimated at 19 million tonnes (India, 13.2, Pakistan 3.7, Bangladesh 1.45, Sri Lanka 0.6 and Nepal 0.25 million tonnes *per annum*, respectively). The same author comments on the continued growth of vertical integration and ownership consolidation among feed companies, a trend which is set to continue. Integration embraces improvements in technology, particularly in laboratory raw material evaluation and least-cost ration formulation techniques.

The introduction of high-density pelletized feed operations in India has resulted in much improved production efficiency in the poultry sector. This is a country which has made significant progress towards modernization of its livestock industry, and poultry in particular, in recent years. The 1990s were associated with advances in integration, automation and feed production. Such developments help to underpin and support a very significant broiler and egg industry, but the commercial progress tends to be focused mainly in the south. Availability of raw materials has increased in recent years due to elevated production levels of grains and oilseeds and, currently, the improved cultivation of maize varieties (Balakrishnan in FAO, 2004d).

In contrast, however, and despite the success in commercialization of the organized feed sector, many rural households continue to rely on backyard subsistence poultry rearing, which contributes substantially to the nutritional requirements of the individual family unit. This small-scale and modest poultry enterprise system is characteristic in many countries in Asia, including Viet Nam in the southeast. Dinh Tu (2002) estimates that 75 percent of the poultry population in Viet Nam is kept in small households. The productivity of such birds is low, as would be expected given the less than optimal nutrient intake, and they are viewed essentially as having a scavenging role and existence. Supplementary feeds of a higher quality may be offered, but these are very much dependent on the family's economic situation and circumstances. Some improvements in conservation and storage technology have brought improvement in chicken diets even at this level – including earthworm production and preservation methods for increasing the shelf life, and therefore quality, of paddy rice, maize and peanuts. As with many of the countries of this region, improvements in the nutrition of indigenous birds are countered by the presence of endemic diseases such as Newcastle disease.

Climate extremes are a complicating factor in the poultry economics of South Africa (Shane, 2002), where rainfall (or lack of) influences the yield of maize and domestic pricing and, together with extremes of humidity, can impair bird performance and predispose stored crops to mould development. Mugga (2007) reporting on another African country, Uganda, comments on the significant move in recent times towards self-sufficiency in maize production and improved quality in commercial feeds, brought about mainly by adopting improved milling expertise. However, a shortage of grain-storage facilities means that the country has to export a substantial amount of maize at unfavourable prices. Clearly, there are a number of challenges confronting the poultry-feed industries in various countries, with constraints at production level and in terms of product quality requiring particular attention in the future.

2 ESTABLISHING NUTRIENT REQUIREMENTS

2.1 Feed intake predictability

Applying accuracy and a degree of precision in diet (ration) formulation requires an intimate knowledge of the bird, its daily nutrient requirements, and a more comprehensive understanding of the ability of the selected feeds to provide the most desirable nutrient status. The ingestion of the optimal level of dietary nutrients, whether for birds involved in egg or boiler meat production, is very much dependent on the level of feed intake. In the case of poultry in most commercial situations ad libitum provision of feed is practised, in which the bird is permitted to give expression to its appetite (or voluntary feed intake [VFI]). The level of consumption observed in practical commercial situations, the actual feed intake (AFI), is often lower than the bird's potential feed intake (PFI) (the quantity of feed required to fulfil all the nutrient requirements) due to physical or physiological constraints and/or negative interaction with environmental situations.

The complexities of the factors which determine nutrient intakes and causative reasons and hypotheses for under- or over-consumption, have been reviewed extensively by others (Forbes, 1995; van der Heide *et al.*, 1999; Forbes, 2006). Birds have precise requirements for nutrients, both macro and micro, and energy-yielding components. Therefore, knowledge of their feed-intake capacity is essential if dietary concentrations are to be appropriate. A bird's daily consumption of feed ultimately governs its health, development and potential for reproduction. Diets are usually formulated on the basis of specific expectations for feed intake; alternatively, in special circumstances, we may dictate the level of intake through controlled feeding systems. An understanding of the complexities and interacting mechanisms that control feed intake is, therefore, essential in designing nutritional programmes and production systems. Figure 3 illustrates the range of variables that can act either as VFI stimulators or constraints. A "cascade" of feedback signals regulates and modifies nutrient supply to the tissues.

Aspects such as the sight and smell of the feed, its taste (flavour), gastric and intestinal effects, and liver and blood metabolite parameters appear to be likely feedback mechanisms. The latter can be used to create learned associations that can be employed to influence feed consumption in situations where the bird is allowed to be discriminatory in feed selection.

Clearly, the anticipated level of productivity from birds will be dependent on the scale and commercial intensity of the enterprise, and on whether it is characterized by the high-input, high-output production associated with large-scale vertically integrated systems or by the modest expectations for egg or meat output typical for a family backyard operation. However, the principle of VFI relationships remains the same regardless of the context. If VFI is too low, productivity may be compromised, making the requirements for maintenance nutrients a relatively large proportion of the total. The converse is true in the event of excessive nutrient intake or imbalance, in which case undesirable partitioning of nutrients into carcass fat deposition may occur or there may be a potential environmental pollution threat. The optimal level of production in a given situation depends to a large extent on the relative costs of different types of feed, their nutritional values and the anticipated production response to changes in feed quality. Under most practical feeding situations the energy level of the diet is the major factor influencing feed intake. Figure 4 identifies the range of factors which are associated with the regulatory effect of energy in various dietary scenarios, and which have often been evaluated in experimental situations.

The choice of dietary energy level in commercial poultry businesses is often based on economic decisions, and this contributes to the range of different energy concentrations used worldwide. In areas of the world where high-energy grains and feed-grade fats are relatively inexpensive, high-energy diets are often the most economical (i.e. the lowest-feed cost per unit of product). Conversely, in areas where lower-energy grains and by-products are less expensive, low-energy diets are often the most economical. The effect of the environment, particularly climatic variables should not be overlooked in terms of modifying effects on feed consumption levels (Figure 3). Chickens, being homeotherms, have to maintain their body temperature irrespective of fluctuating environmental circumstances.

FIGURE 3
The physiological and production components involved in the determination of voluntary feed intake in birds

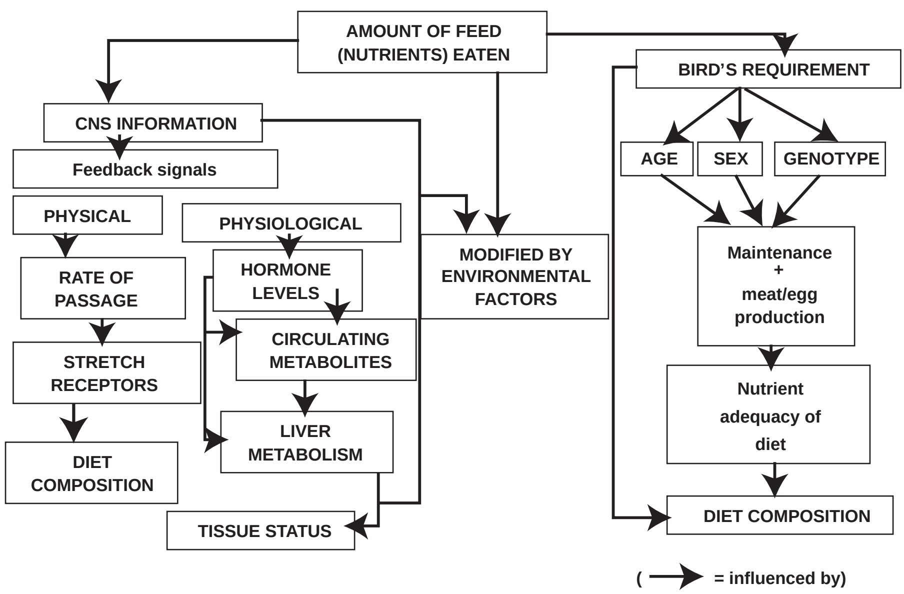
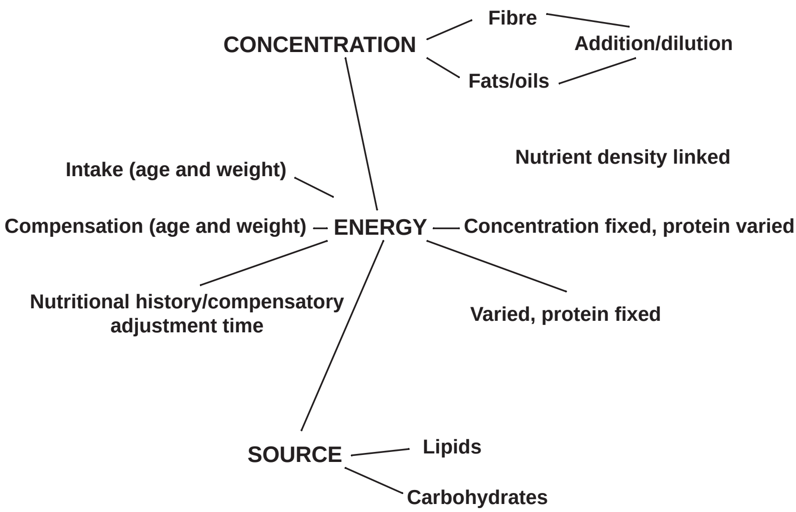


FIGURE 4
Potential dietry energy status scenarios



Temperatures and humidity deviations below or above the thermoneutral zone for the bird will prompt an adjustment in feed intake (NRC, 1994; Leeson and Summers, 2001; Gous 2007). Feed intake, therefore, with its multifunctional complexity and importance in economic terms, also has a fundamental role as a variable in the interpretation of nutritional responses. To this end, predicting the responses of poultry to various nutrient input scenarios has engaged researchers and scientists in recent times, and is likely to do so for the foreseeable future as computer modelling becomes a more popular predictive tool. Various authors including Ferguson (2006), Gous and Berhe (2006), Gous (2006) and Gous (2007) have documented the significant ongoing progress in the development of simulation models – not only for predicting VFI, but also for layer and broiler feeding programmes.

2.2 Critical nutrient relationships

In order to maximize performance, poultry diets must contain the correct balance of the essential nutrients required to meet the nutritional needs of various categories of bird. Much research effort has been directed over recent times into establishing the optimal inclusion levels for these nutrients to promote desirable, commercially important, outcomes such as maximizing VFI, and improving feed conversion and lean tissue deposition. The ability to create diets with such a degree of precision is made relatively easy by the availability of computer linear programming procedures, which access the nutrient profiles of large feed databases. At the industrial and commercial level, such formulation techniques are commonplace. However, in country situations where the array of raw materials for dietary inclusion is restricted, the ability to ensure precise nutrient balance and availability is inevitably compromised; this would certainly be true for village or backyard-scale production and basic feeding scenarios. Greater accuracy in dietary nutrient provision not only results in enhanced bird performance characteristics, but also reduces the likelihood of nutrient waste and the threat of environmental pollution – an increasingly important issue for the future in an increasing number of countries.

An example of the important associations that exist between nutrients is that of the balanced essential amino acid (EAA) profiles embraced within the concept of the ideal protein. This is linked to the definition of protein quality with respect to the feed source and the extent to which it can meet the EAA needs of birds, for which (along with other monogastrics) these nutrients are indispensable.

The provision of quality protein devoid of any EAA deficiency is particularly critical in the early nutrition of young poultry (Dibner, 2006; Noy, 2006). There has been and continues to be research interest regarding the most deficient (limiting) amino acid in the diet and the quality of the protein mixture from which it is supplied. This has arisen from a recognition of the diversity of protein feed sources used throughout the world, concern about nitrogen in effluents from poultry enterprises, and argument about the validity of empirical methods used to measure the amino acid requirements of poultry. Amino acids represent the most costly feature of poultry diets and therefore continued studies to establish more precise nutrient requirements are merited (Wijtten *et al.*, 2004). The formulation of diets appropriately balanced in EAA sequences has been much assisted by the availability of synthetic and crystalline forms, particularly of lysine, methionine and threonine. Their use is likely to increase in the future as manufacturing costs decline in a growing international industry. Most commonly, the use of synthetic forms is associated with economic factors, and their trade price tends to shadow the major protein (amino acid) source worldwide, which is soybean. Many experiments have sought to elucidate the efficiency with which EAA are utilized by the bird to support improved levels of egg, meat and broiler breeder production (Gous, 2006; Ciftci and Ceylan 2004; Kidd *et al.*, 2004).

Other important nutrient inter-relationships have been identified (Leeson and Summers, 2001), which are important with regard to the nutritional integrity of diets, and which can have negative effects on poultry performance if ignored. Such relationships include various interactions between vitamins, between vitamins and minerals, and between minerals, particularly trace elements. Many relate to the effects of imbalances and antagonisms. Research focus has recently been on the dynamics of calcium utilization by laying hens (Lichovnikara, 2007) and the importance and role of selenium in the maintenance of bird health (McCartney, 2006) and broiler-breeder fertility (Renema and Robinson, 2006).

Another important association is that of the dietary energy:protein ratio. Protein deposition in the bird is an energy-demanding process and, therefore, may only proceed if adequate dietary energy is provided (assuming other nutrient adequacy). This fundamental relationship can be incorporated into the dietary association of energy and lysine, where the latter is used as the reference EAA, as in the concept of ideal protein. The ratio has been further explored recently by Wiseman (2006), in research which considered the consequences, particularly on broiler carcass tissue components, of changing energy:protein ratio under a variety of circumstances. Clearly, in countries and poultry management situations where the sourcing of protein, energy and micronutrient feed is difficult, and the choice limited, such precision and choice of formulation strategies will also be limited. However, the principles of achieving correct nutrient associations should be adhered to whenever possible in the cause of improved efficiency and bird performance.

2.3 Genotype–nutrient interactions

Laying hen and broiler chicken performance capabilities and phenotypic manifestations in industrial, commercial and backyard situations will be determined by the effects of a combination of genetic and environmental factors. Both are associated with degrees of variation in commercially important traits that are usually observed in chicken populations irrespective of flock size. In poultry production, more so than other livestock systems, nutritional progress is intimately linked with genetic developments – correct nutrition giving opportunity for full expression of genetic potential, and thus complementing the process of genetic selection.

The majority of nutritionists accept the fact that different types of poultry have different nutrient requirements. In commercial production, for example, diet specifications for boilers versus laying hens are deliberately differentiated. However, it has been shown experimentally that avian species have fairly similar requirements for the essential nutrients. Certainly, while birds have changed somewhat genetically over time, their digestive anatomy and physiological function has not. That said, it is obvious that for layers and meat-producing birds there must, of necessity, be a different selection emphasis in terms of commercially important traits. It follows, therefore, that there is genetic variance related to the need for nutrients, which does create an interesting opportunity for selecting birds that can survive and perform well on lower planes of nutrition, particularly in the context of parts of the world where feed resources are scarce.

For a farmer to get the most out of the genetic potential of his or her birds, it is vital that due consideration is given to nutrition and general good management practice, particularly hygiene and disease minimization. There needs to be recognition of the biological limits to the gains achievable through classical selection practices. Breeding goals globally are now inextricably linked to ultimate safe food production, and represent an important aspect of the multidisciplinary approach to poultry production. Genetic potential cannot be viewed in isolation. The theory of feed intake and growth proposed by Emmans (1989) was based on the premise that birds attempt to grow to meet their genetic potential, which would imply that they would attempt to eat as much of a given feed as necessary to support such growth rates.

Change has certainly been witnessed over time, with present-day commercial poultry breeds and strains appearing more efficient in utilizing nutrients, and the current commercially prepared feeds being better formulated to meet the nutrient requirements of modern-day genotypes. In terms of the future direction of genetics linked to nutrition, costs of feed will remain a factor in the economics of production, and therefore the optimization of feed utilization by birds will remain a priority to geneticists in making economic decisions (Hoste, 2007). The same author predicts a breeding focus on other traits which will indirectly have nutritional management consequences and implications, such as selection for the characteristics of "robustness", environmental sensitivity and disease resistance.

Dawson (2006) has also reported on the future benefit of nutrigenomics, studies which will enable a better understanding of the interaction between genes and nutrition at the molecular level, to (in the context of the paper) evaluate the effects of nutrition on fertility. By way of contrast, in developing countries genetic and breeding upgrading in local bird populations continues in a modest and more conventional way. Development initiatives in the past have emphasized genetic improvement, normally through the introduction of exotic genes, arguing that improved feed (nutrition) would have no effect on indigenous birds of low genetic potential. There is a growing awareness of the need to balance the rate of genetic improvement with improvement in feed availability, health care and general management. There is also an increased recognition of the potential of indigenous breeds and their role in converting locally available feed resources into sustainable production.

2.4 Nutrient support of immunocompetence

One of the possible consequences of intensive genetic selection in recent years, both in the layer and the broiler sectors of the poultry industry, is that such selection pressures for high-performance traits are associated with an increased susceptibility to infectious diseases and compromised health status. Health and disease control should constantly remain a high priority in the management of industrial, commercial and backyard-scale poultry enterprises. Various aspects of poultry husbandry can impact bird health in addition to genetics – including environment, vaccination programmes, prophylactic and therapeutic medication, feed additives, sanitation and farm biosecurity. In addition, there is an important relationship between the nutrition of the bird and the maintenance of health status in the flock. Suboptimal provision in terms of nutrient balance in the diet can compromise the immunocompetence of the bird.

The contribution that nutrition makes to disease resistance should not be underestimated, and both under provision and imbalanced provision of nutrients should be avoided. Such scenarios render the bird more susceptible to viral and bacterial pathogen overload. Husbandry practices which support effective immune responses are therefore vital. Two perspectives have influenced the focus of recent research on this subject: first, determining the most appropriate nutrient feeding strategies to optimize the immune response; and second, the study of the influence of immune response on the growth and nutrient requirements of the bird (Klasing *et al.*, 1999). The latter authors also comment on the important difference that can exist between the sanitation standards found in experimental situations and the less-controlled standards prevailing at the farm level. Immunological stressors resulting from poor sanitation, whether individual or multiple, are associated with, and manifested by, inferior growth rates, substandard feed conversion efficiency and modulated nutrient requirements; an infection usually results in a reduction in feed intake.

Koutsos and Klasing (2006) and Meijer (2006) have produced recent research review papers which comprehensively deal with interactions between the immune system, nutrition and livestock productivity. The consequence of immunosuppression in terms of altered metabolism and requirements for a range of individual macro- (energy-yielding, protein) and micro- (vitamins and minerals) nutrients is considerable. Nutrient demand associated with a challenged immune system is a component of the maintenance "costs" of a bird. As a system, it competes (for nutrients) with other commercially important productive processes. This repartitioning and diversion of nutrients away from production in favour of supporting immune-related functions is not efficient or desirable. It goes without saying that although quality nutrition in poultry is an important component of management efforts to promote disease resistance, there is no substitute for good general management practice, embracing high standards of hygiene at the farm level.

3 FEED DIVERSITY AND CHARACTERIZATION

3.1 Desirable nutritional properties

A diverse range of raw materials with potential to supply nutrients to poultry has been identified over the years. However (and perhaps surprisingly) poultry diet formulations across the world, particularly at the commercial level, are characterized by relatively few feed ingredients (see Figure 2). Having established the nutrient requirement of a bird, the remaining part of the formulation procedure is to identify a mix of feeds which most (cost-) effectively supplies the essential nutrients in the right balance. The ability to achieve this is dependent on the nutritional properties and quality of the raw materials, and on the ability of the formulator to acquire the most appropriate feeds to support and maximize muscle growth or egg production. Variability in the nutritional value of feed raw materials is not surprising, as most are of plant origin and will have been subjected to many husbandry and climatic variables during production, harvesting and storage.

The true nutritive value of any feedstuff is influenced by its chemical composition, and the degree to which the bird fed is able to digest, absorb and utilize these components. Maize and soybean (meal) are the two crops that (when processed appropriately) form the main basis of most poultry diet formulations – representing 70 to 80 percent of the components of a compound feed. The use of other ingredients and substitutes for these two key energy and protein sources, respectively, will depend on availability. To ascertain with accuracy and speed the actual nutrient profile of individual raw materials and the final compounded nutrient status, the use of near infrared spectrometry techniques have helped considerably, particularly at the commercial production level where the scale of operation is sufficient to justify the cost (Bertrand, 2001).

For convenience, individual feeds are often categorized by adopting a set of criteria which allows a judgement to be made regarding their nutritional significance or emphasis. An example of such a classification would be: cereals, cereal by-products, vegetable proteins and animal protein. Such a grouping is, however, over simplistic in terms of reflecting the more precise nutrient quality, balance and availability of each type of feed. For example, cereal grains are primarily an energy-yielding feed component and are recognized as such, although cereals, particularly wheat, also make a contribution to the crude protein (nitrogen) balance of the overall feed. The presence of soybean meal or fishmeal in the diet of broilers or laying hens is commonly the chosen way to include a major protein source. Again, such feeds also have a significant metabolizable energy contribution to make. The largest of these suggested categories in terms of potential alternatives is the "vegetable protein" group, which is most able to appreciably contribute to a rise in the overall protein specification. As far as poultry feeds are concerned, fishmeal as a quality protein (amino acid) source, tends now to be the sole representative of the category "animal protein". This is mainly due to the withdrawal of meat and bone meal and carcass products from use by the feed industries of many (but not all) countries. Substituting the latter, with its commendable balance and profile of essential nutrients, has not been easy and will continue to represent a loss to diet formulators. Most of the feeds mentioned here can be traded internationally, assuming that this is financially feasible for the countries concerned and that movement of such materials can be logistically facilitated. If this is not the case, then the use of alternative indigenous protein and energy-yielding feed ingredient sources need to be considered (Chadd *et al.*, in FAO, 2004e) and evaluated for the local poultry sector.

3.2 International research perspectives

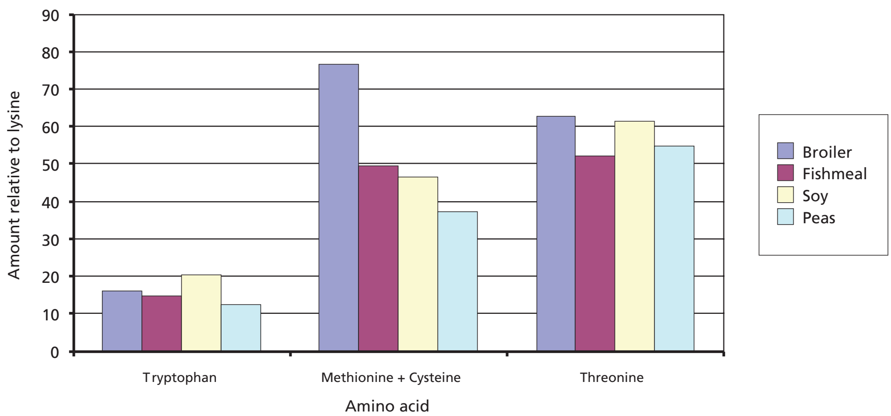
There have been efforts by a number of international researchers not only to give further consideration to the nutritional evaluation of the familiar components of poultry diets, but also to examine alternatives. Wheat continues to be the staple starch energy-providing ingredient for many poultry birds across many countries (Figure 2). Some time ago, Wiseman and Inborr (1999), however, drew attention to the variability in broiler performance which, it was hypothesized, could have been due to variability in batches of wheat over time and consequent variations in nutrient levels. The husbandry and climatic conditions which are associated with crop growth and harvest are considered to have a particular influence on the nutritional value of the grain. Results pointed to variability in the apparent metabolizable energy of wheat fed to young broilers, but also indicated that this was linked to differences between birds in terms of their ability to digest and utilize high-wheat diets (ibid.). More recently an English study conducted by Pirgozliev *et al.* (2003) addressed similar concerns – nutritive variability in wheat – by evaluating different wheat cultivators over three harvest years; it was concluded that there was an association between the endosperm hardness and ash content of grains and the observed variability in growth rate, feed intake and feed conversion efficiency. Such an understanding could assist plant breeders in selecting and breeding new wheat cultivars that enhance rather than detract from bird performance.

In a further study involving wheat, Norwegian researchers, Svitius *et al.* (2004), compared the feeding of whole wheat grains to broiler chicks with wheat in a ground form. The motivation for the study was the inconsistent results obtained for such comparisons in other studies. Feeding whole grains has the advantage of reduced handling and processing costs. Results suggested that benefits in bird performance associated with feeding whole grains were due to increased pancreatic and liver secretory activity which facilitated improved digestion overall.

The importance of EAA status in cereal grains generally, and the production of a high-lysine maize variety in particular, is reported by Vassal (in FAO, 2004f) in relation to plant breeding work carried out at the International Maize and Wheat Improvement Centre (CIMMYT), Mexico. It is well established that feeds offered to poultry have, as individual components, deficiencies in EAAs (Figure 5). However, although crop manipulation in the interests of improvements in poultry nutrition is feasible, given the relative ease of availability of synthetic forms of EAA, and particularly those classically limiting in the diets of layers and broilers, such efforts may be questionable.

Alternatives to maize as a key energy ingredient have been considered and reported on in recent times. A number of millet types were evaluated by Rao *et al.* (2006a) in India, and their potential investigated as substitute feeds. For example, foxtail millet (*Sevaria*

FIGURE 5
Amino acid balance of three raw materials relative to that required by the young broiler



Source: Wiseman (2000).

italica) is grown in Asia, Africa and some parts of Europe, and has superior protein, oil, sugars, lysine and methionine content compared to maize. The metabolizable energy content of the millet was slightly lower than that of maize (2 915 to 3 304 kcal/kg, respectively) (ibid.). Performance of boiler birds fed millet as an energy basis, compared very favourably with control birds fed on a conventional maize ration, especially when offered in a pellet form.

The nutritional potential of another potential energy source in broiler diets, sorghum, has been investigated recently by Nyannor *et al.* (2007) in work done at Purdue University. The background to this work is the ever-increasing diversion of demand for maize from use as feed into ethanol production, and therefore the need to consider alternatives. Results indicated that weight gain, VFI and feed conversion efficiency were not too dissimilar in chicks fed a sorghum–soybean diet compared to those fed on conventional maize–soybean diets. The use of sorghum across the world has its appeal, as it is a drought tolerant crop and is able to withstand a wide range of environmental conditions. However, improved cultivars – providing digestibility comparable or superior to that characteristic of other grains – would be welcome.

The growth of the ethanol industries will bring with it the opportunity to explore the production of co-products which have potential as poultry feed. One such is distillers dried grains with solubles (DDGS). Essentially, this product is the dried residue remaining after the starch fraction of maize is fermented with selected yeasts and enzymes to produce ethanol and CO_2. Refinements of new technologies are now capable of producing a product suitable for inclusion in discrete amounts (approximately 10 percent maximum) in poultry diets, which can offer energy, digestible amino acids and available phosphorus (Gibson and Karges, 2007).

Rice by-products are another potential energy source; their use in the context of the Sri Lankan poultry industry is described by Mellor (2004). This provides an example of a country which, rather than relying on expensive import commodities, has focused on the evaluation of local cheaper energy sources. The report expands on the use and application of enzyme technologies (phytase or xylanase) to rice to release greater nutritional potential. Cuba has been evaluating a by-product from its considerable sugar-cane processing sector – high-test molasses (sugar cane juice). Valdivie (2003) commented on its utilization in poultry feed as providing total or partial substitution for cereals, which would represent a substantial import-cost saving. Performance results derived from some basic experimental substitution trials for both broilers and layers indicate a favourable outcome.

In many developing countries, the opportunity to switch protein sources from the traditional use of soybean meal would be welcome because of import pricing structures, and also because of the feed-hygiene risks associated with animal protein sources. To this end, recent studies in India conducted by Rao *et al.* (2006b) have looked at the extent to which soybean meal can be safely replaced with sunflower seed meal. There had previously been some concern regarding the higher fibre, and low energy and lysine values of the sunflower alternative. However, it was concluded from this study that sunflower can replace up to two-thirds of soybean in the diet, corresponding to an inclusion of 345 and 296 grams per kg for starter and finisher phases in broiler diets, respectively. In another Indian study, peanut and sunflower meal were combined successfully in poultry diets – reinforcing the opportunity for utilizing home-grown alternatives and making significant economies without compromising bird performance.

Allymehr *et al.* (2007) considered the nutritional potential of rapeseed derived from biofuel production. Approximately 80 percent of the biofuel in the EU is produced from rapeseed. Although there is a significant amount of scientific evaluation of conventional oil-extracted rapeseed, there is a dearth of information on rapeseed meal derived in this alternative way. Results were promising particularly when exogenous enzyme treatments were applied – especially those that would degrade the non-starch polysaccharide (NSP) fraction.

Peas and beans are also regarded as relatively well-balanced nutrient providers including respectable amino-acid profiles and energy-yielding capability. The main constraint to their use is the well-documented presence of anti-nutritional factors (ANF) inherent in their biochemistry (Crèpon, 2007). These include resistant starches, refractory proteins, tannins and trypsin inhibitors. However, with appropriate treatments and technologies applied at the point of processing, such negative influences on their potential nutritive value for layers and broiler chickens can be minimized. Chadd *et al.* (in FAO, 2004e) reported on other indigenous legumes with potential for inclusion in layer diets in Australia – including mungbean, chickpea and cowpea; the consideration of such ingredients in diet formulations would help reverse the trend of increasing soybean imports.

Clearly, the alternative options for poultry-feed ingredients mentioned above are those that can be considered in the future compilation of diet specifications for poultry operations and enterprises at the commercial level, where high-quality diet specifications are achievable. Many challenges remain, however, to provide adequate nutrients to birds at the level of family, backyard systems in developing country situations, where there is a heavy reliance on scavenged resources. Under such circumstances, particularly in times of drought, the initial challenge remains that of offering nutrition at a level that exceeds maintenance. A well-balanced diet is difficult to achieve with poor or unpredictable, availability and/or lack of diversity in raw material resources. The provision of minerals, so vital in egg production, is particularly difficult, and alternative local mineral sources have to be utilized in place of commercial premixes (FAO, 2004c). The latter publication lists potential substitutes for expensive commercially formulated feeds. The principles of calculating nutritional requirements remain the same irrespective of the system of poultry keeping, but will need to be modified to take into account the level of productivity expected and the genetic capability of the birds to meet these requirements.

3.3 Anti- and pro-nutritional factors

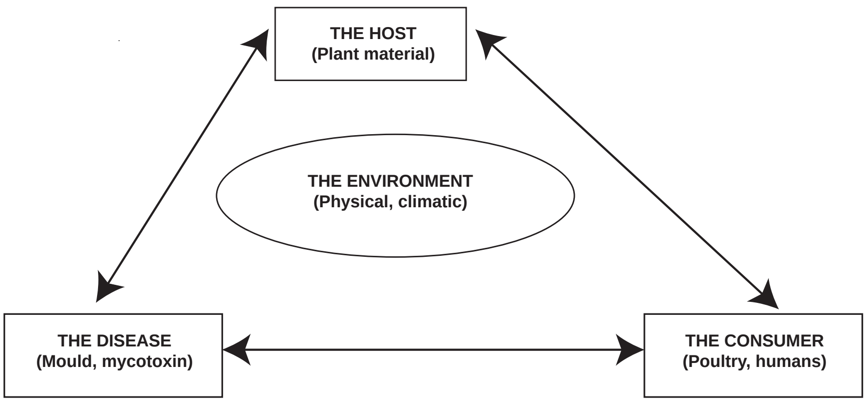
In the future, major improvements in poultry nutrition are far from likely to come from the discovery of new nutrients or even the refining of nutrient requirements; rather, improvements in production efficiency, a desirable objective commercially, must depend on achieving maximum nutrient utilization from feedstuffs. This would also enable the use of a larger range of feed ingredients, including those currently considered to be nutritionally inferior for one reason or another. It is recognized within the feed industry that a proportion of the nutrient content of feeds is not subjected to effective digestion and absorption by poultry. Certain feed commodities are overlooked or underutilized due to inferior nutrient availability, high levels of NSPs and/or the presence of undesirable anti-nutritional fractions. A varied number of anti-nutritional and/or potentially toxic compounds are located integrally in cereal grains, seeds of legumes, and other feeds of plant origin used in the manufacture of poultry diets. Most of these substances are naturally occurring constituents of varying chemical composition (e.g. proteins, alkaloids, glycosides and fatty acids). Such compounds can be relatively easily inactivated by subjecting them to washing, soaking and heating processes. Care in the application of such processes is needed to avoid further spoiling of the nutrient profile or the inadvertent creation of further toxic compounds. The detailed characterization of the many commonly found ANFs and their (negative) interaction with feed nutrient supply and livestock host are provided in the literature (de Lange *et al.*, 2000).

One subject receiving much attention from researchers at present is that of mycotoxicity. It is an issue which has important implications for the global feed industry, bird performance and potential negative consequences for the food chain. The prospect of elevated temperatures, and other climatic variables, resulting from climate change means that study of the subject will continue to be of paramount importance in the future.

Mycotoxins are a structurally diverse group of secondary metabolites produced by different genera of toxigenic fungi (Chadd, 2004). Aflatoxins, deoxynivalenol, zearalenone, fumonisin, T-2 toxin and ochratoxin A are toxins of importance worldwide, which are produced by fungi on pre- and post-harvest food and feeds (Fokunang *et al.*, 2006). Figure 6 highlights the complexity involved in the study of the subject, and in the prevention and solution of contamination, resulting from the interaction between the host, the toxin properties and the consumer of the product in question.

Of particular concern is that mycotoxin surveys from around the world indicate that protein sources such as rapeseed meal, groundnut cake, sunflower meal, copra meal and palm kernel meal, for example, are more susceptible to mycotoxin contamination than

FIGURE 6
The multifactorial challenge of mycotoxin contamination



conventional raw materials such as soybean meal. Due to cost implications, the move by the feed industries of different countries to seek alternatives to soybean will only serve to exacerbate the situation and the degree of risk.

The cost of maize has also reinforced the need to assess other "vulnerable" energy sources including by-products such as rice bran, wheat bran and screenings. The additional concern here is that many of the mycotoxins are concentrated in the outer covering of the seeds. The toxicological effects on poultry and the mode of action associated with such toxins are varied, but the extent of mycotoxicosis manifest in chickens will depend on factors such as duration of exposure to toxins either ingested or inhaled, breed type, age and physiological status (Chadd, 2004).

In addition to disrupting the normal metabolism of nutrients, the presence of such a toxin in the chicken can have the overall effect of compromising immune-system function, and thereby negatively affecting bird performance. Devegowda *et al.*, (1997) in their study of the immunosuppressive effect of aflatoxins in poultry, linked compromised protein synthesis with a cascade "knock on" effect, the consequence of which is that normal body immune status can be breached (Figure 7).

With a significant number of industries and organizations involved in feed and food production and technologies employed to improve efficiency, it is imperative that in the future more integrated (including regulatory) approaches to prevention and control of mycotoxin occurrence are considered and adopted. Bhatnagar *et al.* (2004) identified a twin approach to priorities for future research. First, an emphasis on devising more rapid procedures for detecting the presence of fungal and toxin contamination of crops, raw feed materials and manufactured products, which have greater sensitivity and accuracy; and, second, the recommendation that more effective strategies be employed through demonstrating good agricultural practice, controlling contamination prior to harvest, and decontamination of commodities post-harvest. Hygienic storage conditions particularly in tropical climates are imperative.

FIGURE 7
A cascade of immunosuppression effects in aflatoxin-challenged poultry

Depressed protein synthesis

↓

Lowered serum albumin and globulin levels

↓

Reduction in circulating antibody levels

↓

Impaired reticulo-endothelial system

↓

Reduced cell-mediated immunity

Source: adapted from Devegowda *et al.* (1997).

In contrast to factors that exert a negative influence on poultry production, other developments and technologies current and emerging, are offering opportunities to enhance the quality of feed, improve utilization by birds and promote optimal health status. One reason for the expansion of interest in exploiting new technologies and product creation is the recent demise of the use of antibiotics as growth-promoting agents in the poultry industry (mainly in Europe). One alternative "pro-nutrient" is the use of exogenous enzymes in poultry diets (Rosen, 2006). Exogenous enzymes added to the feed or used during feedstuff processing, have the potential to improve feed efficiency, reduce pollution associated with poultry manure, and increase the use of low-cost feed ingredients. One important development, now widespread in the poultry feed sector, is the use of exogenous phytases (Touchburn *et al.*, 2006). Despite the significant volume of literature on the ability of phytase to increase phosphorus availability and reduce pollution, this latter benefit is only of economic value in regions where phosphorus concentrations in the diet and/or manure are associated with a disposal cost.

Fibre (NSP)-degrading enzymes increase digestibility of the entire ration through the degradation of anti-nutrients (arabinoxylans in wheat and Β-glucans in barley) and enable the feed compounder to utilize more cereal and less fat and/or protein supplements, thus enabling potential economies in formulation. Looking to the future, it is to be hoped that in many countries new technologies will provide solutions which will increase the benefits derived from enzyme use and increase the size of the global market in which they are used. An example of this would be further exploitation of the advantages that solid-state fermentation technology has to offer, as described recently by Purser (2007).

There are many other natural alternatives to antimicrobial growth-promoting agents which merit continued research and development attention in the coming years. These include, pre- and probiotics, organic acids, herbs and spices (plant extracts), yeast cultures, oligosaccharides and flavourings. The purposes and claimed benefits of these alternatives are several. First, providing the bird with more available nutrients; second, reducing the metabolic demands for maintaining the absorptive and immunological function of the gastro-intestinal tract; and, third, reducing the susceptibility of the bird to enteric disorders. However, the mode of action of the various products can be quite diverse. The common objective is, in addition to providing improved nutrient balance in the diet, to exploit the full health-enhancing properties of feeds. This is implicit in the concept of "total nutrition" and the term "neutraceuticals", as discussed at length by Adams (2001).

There are many natural components of feed, the so-called "nutricines", that have valuable and beneficial effects and which relate health to nutrition. In most countries, attention is increasingly given to the whole food chain – whether associated with egg or meat production – in relation to bird welfare, protection of the environment and the pursuit of higher standards of food safety for the consumer. On the theme of consumer acceptability, and as the genetic modification (GM) "debate" continues (Horlick-Jones *et al.*, 2007), there is little doubt that genetic modification of both crops and poultry genotypes will contribute to nutrient availability and utilization, and offer particular desirable commercial applications to developing countries. Hard (in FAO, 2004g) discusses the value of pursuing controlled GM of crops for feed purposes in parallel to both conventional breeding approaches and other biotechnologies. The prediction is made that the next wave of genetically improved crops will focus on "output" traits providing enhanced feed values to benefit poultry productivity – for example, protein quality (amino acid balance) and improved digestibility (particularly fibre and starch). Aumaitre (2001) provides a thorough review of challenges and successes in the transgenetics of crops and of future opportunities to extend the variety and diversity of genetically, and thereby nutritionally, "customized" feeds available for dietary inclusion.

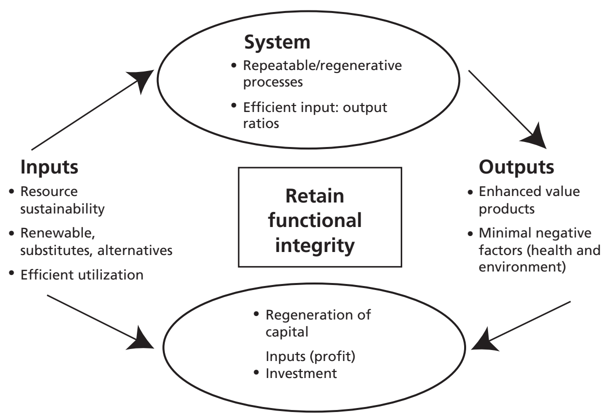
3.4 Redefining the systems approach

The familiar and now well-established model which enables analysis of the role of essential inputs and the effectiveness of their conversion by the bird into a defined output has become increasingly important for researchers and the feed industry (see Section 2.1). At the commercial level, the farmer is also able to manipulate the biological (including nutritional), technical and social factors of input in order to enhance the chicken's ability to transform these into a saleable commodity. The model, therefore, can be considered at the level of the individual bird, the flock or the farm system, and is a useful management tool. Scientists and nutrition researchers are interested in the fundamental and biological mechanisms and limits to the conversion of a nutrient or nutrients, and their consequences for output (quantity and quality). Such a conventional model appears rather basic and oversimplified; it does not take into account, the need (increasingly important in current and future poultry production) to apply a "sustainability dimension". Figure 8 illustrates a model which includes a continuous enterprise cycle embracing the important elements of sustainability – both physical and financial.

The model assumes a greater focus in the future on "resource sufficiency" not scarcity, which will necessitate the constant consideration and evaluation of alternative protein and other nutrient input sources, for example, a reduced reliance on the traditional proteins fishmeal and soybean in poultry diets. A continued objective will need to be to achieve and exploit efficiencies throughout the system, particularly opportunities for further feed conversion economies. On the output side, the future expectation is that the whole food chain, and its quality assurance, will be considered from the perspective of consumer acceptance. This is an increasing requirement for poultry production practices in developed countries and, increasingly, globally. From the perspective of the maintenance of an economic livelihood, a measure of investment back into the system is vital. A sustainable system, therefore, has to retain "functional integrity" (Thompson, 1997) whether high-input, high-output as in the case of industrial scale production, or low input–modest output expectations as is usually the case for small-scale production.

Such a theoretical approach to (and examination of) the importance of feed costs and quality in a system, involves the association of such inputs with the type of production enterprise and the management system used. In the EU there has been, for environmental and welfare reasons, a shift from intensive (high input resources) to more extensive systems (Guy and Edwards, 2006). Despite major improvements in bird performance, and in particular feed conversion efficiency, in recent years, brought about through improved breeding and nutrition management strategies (i.e. phased feeding), advances in exploiting the biological potential of the chicken are likely to be slower in the future (Steinfeld *et al.*, in FAO, 2006) with greater focus on more sustainable practices. The development of alternative production systems in the tropics and developing countries, using locally available feed resources, must start with knowledge of the impact on nutritional requirements of using new feed resources, which are often rich in sugars, lipids and fibre, in contrast to the starch-rich feeds used in temperate countries. A more holistic approach to the development of feeding programmes will assist the poultry industries and individual producers of chicken products to pursue the goal of enhanced production within a sustainability context.

FIGURE 8
A system's approach embracing sustainability



4 CONCLUSION

This paper has given recognition to recent rapid technological, scientific and industrial changes that have taken place in the global poultry sector, with focus on nutrition, and has used these as a baseline to predict likely future trends and developments. The size and dynamics of the feed industries in different countries reflects the significant level of growth in demand by consumers for poultry products, particularly meat. Regional differences indicate the continuation of a strong demand for poultry feed in Asia, while the manufacturing output from European countries remains fairly static, reflecting industry consolidation. Various "drivers of change" will exert increasing influence in the future on the practical feeding of poultry, whether kept for broiler meat or egg production. For example, feed costs as a proportion of the variable costs for producers of poultry products will remain high, in particular, the protein sources included in diet formulations.

Additional legislation will affect many aspects of the feed sector including regulations associated with environmental protection, and hygiene and food safety issues throughout the poultry food chain. There will be challenges to the continued popular use and dietary inclusion of the traditional protein and energy-yielding ingredients – soybean meal and maize cereal, respectively. Due to cost and environmental reasons, developing poultry production sectors will not be able to sustain soybean imports, and will have to consider alternative oilseed or legume feed options. Likewise, the likely diversion of cereals such as maize into ethanol production will require a switch to viable substitutes.

There is ongoing scientific evaluation of locally grown indigenous crop sources that can offer reasonable protein and energy yields. The future use of alternative protein feeds in formulations, despite the fact that they contain less than favourable natural amino-acid profiles, will be assisted by the increasing availability of relatively cheap synthetic forms of EAA. Even the growth of the ethanol industries will be accompanied by opportunities to explore the production of co-products with some nutritional merit for poultry rations.

The focus of poultry nutrition research in the future will be increasingly dependent on commercial sponsorship, and very much applied to the practical scenarios and challenges of commercial poultry farming. Manipulation of VFI in birds is key to the control of nutrient intake levels, and therefore ultimate performance and productivity, and the factors influencing VFI will merit further scientific and commercial evaluation in the future, particularly with the prospect of climate change and the effect of elevated temperatures and other climatic variables on appetite.

The genetic selection emphasis of recent times linked to nutrition, that of feed conversion efficiency and maximal growth, is likely to change in favour of traits associated with bird welfare, meat and egg quality, and "robustness" of genotypes or strains of bird capable of adapting to, and being productive in, a range of commercial environments. Production prediction models will increase in sophistication and remain a valuable tool for research purposes and formulation of practical diet solutions. The maintenance of immunocompetence and optimal health status in birds in a range of husbandry situations will remain a priority. A shift towards alternative, less-conventional feeds which are subject to established manufacturing processes may mean that birds' diets contain chemical elements that can be identified as ANF. The latter can compromise immune status, and adversely affect performance. The presence of mycotoxins in poultry feed also compromises immune status and an increased level of vigilance will be required by farmers in the future to identify, prevent and control such situations. Good agricultural practice and management, particularly of stored feeds in hot climates, is vital. There is likely to be continued interest in the value and nutritional "virtue" of the range of "natural" pro-nutrients, and the advancement and application of the "holistic" approach to poultry nutrition. Future poultry production systems globally will need to embrace and incorporate sustainable practices in pursuit of business viability at the commercial level and to address the scarcity of feed-resource inputs often associated with subsistence farming.

REFERENCES

Adams, C.A. 2001. *Total nutrition: feeding animals for health and growth*. Nottingham, UK, Nottingham University Press.

Allymehr, M., Pirgozlier, V. & Acamovic, T. 2007. The nutritional value for poultry of rapeseed residue from biofuel production. *British Poultry Science*, 48: 29–31 (abs.).

Aumaitre, L.A. 2001. New feeds : safety, substantial equivalence and feeding value for farm animals. *In* A.F.B. van der Poel, J.L. Vahl & R.P. Kwakkel, eds. *Advances in nutritional technology*. Proceedings of the First World Feed Conference, pp. 229–248. Wageningen, the Netherlands, Wageningen Academic Publishers.

Bertrand, D. 2001. Near infrared spectroscopy and it applications for feed quality control. *In* A.F.B. van der Poel, J.L. Vahl & R.P. Kwakkel, eds. *Advances in nutritional technology.* Proceedings of the First World Feed Conference, pp. 11–45. Wageningen, the Netherlands, Wageningen Academic Publishers.

Bhatnagar, D., Payne, G.A., Cleveland, T.E. & Robens, J. F. 2004. Mycotoxins: current issues in the USA. *In* D. Barug, H. van Egmond, R. Lopez-Garcia, T. van Osenbruggen & A. Visconti, eds. *Meeting the mycotoxin menace*, pp. 275–280. Wageningen, the Netherlands, Wageningen Academic Publishers.

Bootwalla, S. 2005. Poultry and the population on the Asian Subcontinent. *World Poultry*, 21(4): 10–12.

Chadd, S.A. 2004. Mycotoxicological challenges to European animal production: a review. In *European Association of Animal Production Book of Abstracts*. No. 10, p. 262. Bled, Slovenia, Wageningen Academic Publishers.

Ciftci, I. & Ceylan, N. 2004. Effects of dietary threonine and crude protein on growth performance, carcase and meat composition of broiler chickens. *British Poultry Science*, 45(2): 280–289.

Crèpon, K. 2007. Nutritional value of legumes (pea and faba bean) and economics of their use. *In* P.C. Garnsworthy & J. Wiseman, eds. *Recent advances in animal nutrition*. pp. 331–366. Nottingham, UK, Nottingham University Press.

Dawson, K.A. 2006. Nutrigenomics in pig and poultry production: feeding the genes for fertility. *In* J.A. Taylor-Pickard & L. Nollet, eds. *Nutritional approach to arresting the decline in fertility of pigs and poultry*, pp. 13–24. Wageningen the Netherlands, Wageningen Academic Publishers.

De Lange, C.F.M., Nyachoti, C. M. & Verstegen, M.W.A. 2000. The significance of antinutritional factors in feedstuffs for monogastric animals. *In* P. J. Moughan, M.W.A. Vestegen & M.I. Visser-Reyneveld, eds. *Feed evaluation: principles and practice*, pp. 169–188. Wagneningen, the Netherlands, Wageningen Academic Publishers.

Devendra, C. 2007. Perspectives on animal production systems in Asia. *Livestock Science*, 106(1): 1–18.

Devegowda, G., Aravind, B.I.R. & Morton, M.G. 1997. Immunosuppression in poultry caused by aflatoxins (Yea-Sacc 1026) and mannanoligosaccharides (Mycosorb). *In* J.P. Lyons & K.A. Jacques, eds. *Biotechnology in the feed industry.* Proceedings of Alltech's 13th Annual Symposium, pp. 205–215. Nottingham, UK, Nottingham University Press.

Dibner, J. 2006. Early nutrition in young poultry. *In* J. Wiseman & P.C. Garnsworthy, eds. *Recent developments of non-ruminant nutrition*, pp. 127–142. Nottingham, UK, Nottingham University Press.

Dinh Tu, T. 2002. Village poultry production dominates in Vietnam. *World Poultry*, 18(7): 12–14.

Emmans, G.C. 1989. The growth of turkeys. *In* C. Nixey & T.C. Grey, eds. *Recent advances in turkey science*, pp. 135–166. London, Butterworths.

FAO. 2003. *World agriculture: towards 2015/30. An FAO perspective*, edited by J. Bruinsma. Rome.

FAO. 2004a. *Protein sources for the animal feed industry.* Proceedings of the expert consultation and workshop. Bangkok, 29 April–3 May 2002. Rome.

FAO. 2004b. The world animal feed industry, by R. Gilbert. In *Protein sources for the animal feed industry*. Proceedings of the expert consultation and workshop, Bangkok, 29 April–3 May, 2002. Rome.

FAO. 2004c. *Small-scale poultry production*. Technical Guide. Rome.

FAO. 2004d. Developments in the Indian feed and poultry industry and formulation of rations based on local resources, by V. Balakrishnan. In *Protein sources for the animal feed industry*. Proceedings of the expert consultation and workshop, Bangkok, 29 April–3 May, 2002, pp. 214–224. Rome.

FAO. 2004e. Practical production of protein for food animals, by S.A. Chadd, W.P. Davies & J.M. Koivisto. In *Protein sources for the animal feed industry*. Proceedings of the expert consultation and workshop, Bangkok, 29 April–3 May, 2002, pp. 77–123. Rome.

FAO. 2004f. The role of high lysine cereals in animal and human nutrition in Asia, by S.K. Vasal. In *Protein sources for the animal feed industry.* Proceedings of the expert consultation and workshop, Bangkok, 29 April–3 May, 2002, pp. 167–183. Rome.

FAO. 2004g. Innovative developments in the production and delivery of alternative protein sources, by D.L. Hard. In *Protein sources for the animal feed industry*. Proceedings of the expert consultation and workshop, Bangkok, 29 April–3 May, 2002, pp. 125–139. Rome

FAO. 2006. *Livestock's long shadow: environmental issues and options*, by H. Steinfeld, P. Gerber, T. Wassenaar, V. Castel, M. Rosales & C. de Haan. Rome.

Ferguson, N.S. 2006. Basic concepts describing annual growth and feed intake. In R.M. Gous, T.R. Morris & C. Fisher, eds. *Mechanistic modelling in pig and poultry production*, pp. 22–53. Wallingford, UK, CABI.

Fokunang, C.N., Temba-Fokunang, E.A., Tomkins, P. & Barkwan, S. 2006. Global impacts of mycotoxins on human and animal health management. *Outlook on Agriculture*, 35(4): 247–253.

Forbes, J.M. 1995. *Voluntary food intake and diet selection in farm animals.* Wallingford, UK, CABI.

Forbes J.M. 2006. Food choice and intake in chickens. *In* V. Bels, ed. *Feeding in domestic vertebrates from structure to behaviour*, pp. 108–119. Wallingford, UK, CABI.

Geers, R. & Madec, F. 2006. *Livestock production and society*. Wageningen, the Netherlands, Wageningen Academic Publishers.

Gibson, M.L. & Karges, K.K. 2007. By-products from non-food agriculture: technicalities of nutrition. *In* P.C. Garnsworthy & J. Wiseman, eds. *Recent advances in animal nutrition*, pp. 209–227. Nottingham, UK, Nottingham University Press.

Gill, C. 2006. World feed panorama: feed more profitable, but disease breeds uncertainty. *Feed International*, (January): 5–11.

Gous, R.M. 2006. Broiler breeder nutrition and management: What's new? *In* J.A. Taylor-Pickard & L. Nollet, eds. *Nutritional approaches to arresting the decline in fertility of pigs and poultry*, pp. 147–159 Wageningen Academic Publishers.

Gous, R.M. 2007. Predicting nutrient responses in poultry: future challenges. *Animal*, 1: 57–65.

Gous, R.M. & Berhe, E.T. 2006. Modelling populations for purposes of optimisation. *In* R.M. Gous, T.R. Morris & C. Fisher, eds. *Mechanistic modelling in pig and poultry production*, pp. 76–96. Wallingford, UK, CABI.

Guèye, E.F. 2002. Family poultry research and development in low-income food-deficit countries: approaches and prospects. *Outlook on Agriculture*, 31(1): 13–21.

Guy, J. H. & Edwards, S.A. 2006. Alternative production systems. *In* R. Geers & F. Madec, eds. *Livestock production and society*, pp. 273–286. Wageningen, the Netherlands, Wageningen Academic Publishers.

Horlick-Jones, T., Walls, J., Rowe, G., Pidgeon, N., Poortinga, W., Murdock, G. & O'Riordan, T. 2007. *The GM debate: risk, politics and public engagement.* London, Routledge.

Hoste, S. 2007. Genetics and nutrition : what's around the corner? *In* P.C. Garnsworthy & J. Wiseman, eds. *Recent advances in animal nutrition*, pp. 275–288. Nottingham, UK, Nottingham University Press.

Kersten, J., Rohde, H.R. & Nef, E. (eds.) 2005. *Principles of mixed feed production: components, processes, technology* . Bergen/Dumme, Germany, Agrimedia.

Kidd, M.T., Burnham, D.J. & Kerr, B.J. 2004. Dietary isoleucine responses in male broiler chickens. *British Poultry Science*, 45(1): 67–75.

Klasing, K. C., Johnstone, B. J. & Benson, B.N. 1999. Implications of an immune response on growth and nutrient requirement of chicks. *In* J. Wiseman & P.C. Garnsworthy, eds. *Recent developments in poultry nutrition* 2, pp. 35–47. Nottingham, UK, Nottingham University Press.

Koutsos, E. & Klasing, K.C. 2006. Interactions between the immune system, nutrition and productivity of animals. *In* J. Wiseman & P.C. Garnsworthy, eds. *Recent developments in non-ruminant nutrition,* pp. 365–381. Nottingham, UK, Nottingham University Press.

Larbier, M. & Leclercq, B. 1994. *Nutrition and feeding of poultry*. Nottingham, UK, Nottingham University Press.

Leeson, S. & Summers, J.D. 2001. *Scott's nutrition of the chicken*. Guelph, Canada, University Books.

Lichovnikova, M. 2007. The effect of dietary calcium source, concentrations and particle size on calcium retention, eggshell quality and accurate calcium requirement in laying hens. *British Poultry Science*, 48(1): 71–75.

Manning, L., Baines, R.N. & Chadd, S.A. 2006a. Quality assurance models in the food supply chain. *British Food Journal*, 108(2): 91–104.

Manning, L., Baines, R.N. & Chadd S.A. 2006b. Food safety management in broiler meat production. *British Food Journal*, 108(8): 605–621.

Manning, L., Baines, R.N. & Chadd S.A. 2007. Quality Assurance: a study of the primary producers perspective. *British Food Journal,* 109(4): 291–304.

McCartney, E. 2006. Selenium: an essential nutrient for animals and humans. *World Poultry*, 22(5): 16–18.

Meggison, P. 2005. Changes in the Asian livestock industries: the implications for European producers and the feed industry. *In* P.C. Garnsworthy & J. Wiseman, eds. *Recent advances in animal nutrition 2004*, pp. 137–148. Nottingham, UK, Nottingham University Press.

Meijer, J.C. 2006. Nutrition and immunity in farm animals. *In* J. Wiseman & P.C. Garnsworthy, eds. *Recent developments in non-ruminant nutrition*, pp. 383–394. Nottingham, UK, Nottingham University Press.

Mellor, S. 2004. Sri Lanka looks for effective feed additives. *World Poultry*, 20(7): 14–15.

Millar, K. 2006. Legislation update for the feed industry. *In* P.C.Garnsworthy & J. Wiseman, eds. *Recent advances in animal nutrition 2005*, pp. 153–187. Nottingham UK, Nottingham University Press.

Morris, P. 2005. Aquaculture: current status and issues for feed manufacturers. *In* P.C. Garnsworthy & J. Wiseman, eds. *Recent advances in animal nutrition*, pp. 73–101. Nottingham, UK, Nottingham University Press.

Mugga, R. 2007. Rising demand for Ugandan poultry requires better practices. *World Poultry,* 23(2): 10–11.

Nelson, J., Raine,H.D. & Oliver, T. 2006. Interpretation and application of EC rulings. *In* P.C. Garnsworthy & J. Wiseman, eds. *Recent advances in animal nutrition 2006*, pp. 153–187. Nottingham, UK, Nottingham University Press.

Noy, Y. 2006. Nutrition of the newly hatched chick: an opportunity to maximise broiler performance? *In* J.A. Taylor-Pickard & L. Nollet, eds. *Nutritional approaches the decline in fertility of pigs and poultry*, pp. 163–175. Wageningen, the Netherlands, Wageningen Academic Publishers.

NRC. 1994. *Nutrient requirements of poultry.* Ninth revised edition. Washington, DC, National Academy Press.

Nyannor, E.K.D., Adedokun, S.A., Hamaker, B.R., Ejeta, G. & Adeola, O. 2007. Nutritional evaluation of high-digestible sorghum for pigs and broiler chicks. *J. Anim. Sci.*, 85: 196–203.

Pirgozliev, V.R., Birtch, C.L., Rose, S.P., Kettlewell, P.S. & Bedford, M.R. 2003. Chemical composition and the nutritive quality of different wheat cultivars for broiler chickens. *British Poultry Science,* 44(3): 464–475.

Purser, M. 2007. Producing enzymes on feed ingredients: the solid state formulation story. *In* J.A.Taylor-Pickard & P. Spring, eds. *Gaining the edge in pork and poultry production*, pp. 155–167. Wageningen, the Netherlands, Wageningen Academic Publishers.

Rao, S.V.R., Raju, M.V.L.N. & Panda, A.K. 2006a. Utilising millet in poultry diets. *World Poultry*, 22(1): 12–14.

Rao, S.V.R., Raju, M.V.L.N., Panda, A.K. & Reddy, M.R. 2006b. Sunflower seed meal as a substitute for soybean in commercial broiler chicken diets. *British Poultry Science*, 47(5): 592–598.

Renema, A. & Robinson, F.E. 2006. Examining the impact of nutrition on the fertility of broiler breeders. *In* J.A. Taylor-Pickard & L.Nollet, eds. *Nutritional approaches for arresting the decline in fertility of pigs and poultry*, pp. 127–146. Wageningen, the Netherlands, Wageningen Academic Publishers.

Rosen, G. 2006. Exogenous enzymes as pro-nutrients in broiler diets. *In* J. Wiseman & P.C. Garnsworthy, eds. *Recent developments in non-ruminant nutrition*, pp. 163–191. Nottingham, UK, Nottingham University Press.

Shane, S.M. 2002. Economic factors drive the South African broiler industry. *World Poultry,* 18(10): 12–13.

Svitius, B., Juvik, E., Hetland, H. & Krogdahl, A. 2004. Causes for improvement in nutritive value of broiler chicken diets with whole wheat instead of ground wheat. *British Poultry Science,* 45(1): 55–60.

Thomas, M. & van der Poel, A.F.B. 2001. Functional properties of diet ingredients: manufacturing and nutritional implications. *In* A.F.B. van der Poel, J.L. Vahl & R.P. Kwakkel, eds. *Advances in nutritional technology*. Proceedings of the first World Feed Conference, Utrecht, 7–8 November 2001, pp. 109–122. Wageningen, the Netherlands, Wageningen Academic Publishers.

Thompson, P.B. 1997. The varieties of sustainability in livestock farming. *In* J.T. Sorensen, ed. *Livestock farming systems: more than food production*. Proceedings of the Fourth International Symposium on Livestock Farming Systems. EAAP Publication No. 89. pp. 5–15. Wageningen, the Netherlands, Wageningen Academic Publishers.

Tielen, M. 2005. European feed industry anticipates new feed hygiene legislation. *Feed Tech.*, 9(5): 25–27.

Touchburn, S.P., Sebastian, S. & Chavez, E.R. 2006. Phytase in poultry nutrition. *In* J. Wiseman & P.C. Garnsworthy, eds. *Recent developments in non-ruminant nutrition,* pp. 143–162. Nottingham, UK, Nottingham University Press.

Valdivie, M. 2003. Poultry utilisation of sugar cane high-test molasses. *World Poultry*, 19(8): 19–21.

Van der Barneveld, R. 2001. Managing the nutritional quality of stock feed ingredients. *In* A.F.B. van der Poel, J.L. Vahl & R.P. Kwakkel, eds. *Advances in nutritional technology*. Proceedings of the First World Feed Conference. Utrecht, 7–8 November 2001. pp. 31–45. Wageningen, the Netherlands, Wageningen Academic Publishers.

Van der Bunt, H. & West, A. 2006. The use of modern technology in compound feed production plants bringing significant savings. *Feed Compounder*, (November).

Van der Heide, D., Huisman, E.A., Kanis, E., Osse, J.W.H. & Verstegen, M.W.A. 1999. *Regulation of feed intake.* Wallingford, UK, CABI Publishing.

Wijtten, P.J.A., Prak, R., Lemme, A. & Langhout, D.J. 2004. Effect of different ideal protein concentrations on broiler performance. *British Poultry Science*, 45(4): 504–511.

Wiseman J. 2000. Nutrition and feeding. *In* D. Khan, ed. *The poultry production guide*. Doetinchem, the Netherlands, Elsevier International.

Wiseman, J. 2006. High energy diets for poultry – effects of diet composition on performance and carcass quality. *In* J. Wiseman & P.C. Garnsworthy, eds. *Recent developments in non-ruminant nutrition*, pp. 193–212. Nottingham, UK, Nottingham University Press.

Wiseman, J. & Inborr, J. 1999. The nutritive value of wheat and its effect on broiler performance. In J. Wiseman & P.C. Garnsworthy, eds. *Recent developments in poultry nutrition 2*, pp. 123–148. Nottingham, UK, Nottingham University Press.

Future trends for poultry genetic resources

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SUMMARY

Local breeds make up most of the world's poultry genetic diversity, and are still very important in developing countries where they represent up to 95 percent of the total poultry population. These local breeds, which are well-adapted to extensive husbandry systems and suitable for resource-poor poultry farmers endowed with very limited means, should be thoroughly studied as a basis for enhancing their use and conservation.

There is evidence to show that there is considerable scope for improving the performance of local breeds. However, these breeds cannot compete with highly selected commercial hybrids. Thus, a breeding programme involving local breeds should identify alternative breeding goals, and capitalize on the breeds' specific attributes. Commercial laying hens can produce as many as 325 eggs per year, and broilers can reach 2.5 kg in 42 days. This is the result of long, structured and intensive selection, which also focused on feed efficiency and product quality. A handful of breeding companies account for most of the genetic improvement that is currently taking place; the products of this improvement process reach the world market through multiplication and distribution networks. Most of these breeding companies are located in temperate regions, while their products are marketed all over the world – including tropical, semi-arid and arid regions where conditions are challenging in terms of climate, husbandry, feeds and feeding practices. To account for genotype by environment interaction, these companies either test their animals across a range of environments or establish satellite breeding programmes in various locations. The use of specific genotypes, such as homozygote or heterozygote naked-neck or featherless birds, could be another option for hot climates.

In the developed world, food production is changing from being producer driven to consumer driven. The consumer is increasingly concerned about health, environment, ethics and animal welfare, and demands for certified products such as a free or organic meat and eggs have emerged. This trend is supported by new regulations, especially in Europe. Breeders have adjusted their programmes to include welfare-related traits. No direct actions have yet been taken to address environmental issues and the use of resources. However, it is argued that benefits are obtained indirectly, through genetic progress in growth and feed conversion ratio.

In the developing world, the production of local chickens is consumer-driven, with

demand for quality, typical products and cultural uses; industrialized meat and egg production is still producer driven.

Technology, especially genomics, has evolved very fast and expectations are high. Yet, these developments are costly and out of reach of most developing countries. Without doubt, major breeding companies will use them to select for disease resistance and robustness. If they succeed, local indigenous breeds will be at higher risk of erosion, unless actions are taken to apply genomics also to the characterization and conservation of local populations and to increase awareness among policy-makers and the international community of the importance of these breeds. *The State of World's Animal Genetic Resources for Food and Agriculture* contributed to raising awareness, and the *Global Plan of Action for Animal Genetic Resources* adopted through *Interlaken Declaration* provides, for the first time, an agreed international framework for the management of these resources.

Key words: genetics, poultry, future

1 POULTRY GENETIC RESOURCES

Generally speaking, two poultry production systems coexist: a commercial production system, with varying levels of integration and industrialization, and a village or backyard system. These two systems use different breeds of poultry. Commercial hybrids are used by the commercial system, while the village system makes use of indigenous or local breeds.

The companies providing the commercial hybrids keep their breeding information secret. There is, therefore, no information available on the provenance of these strains. In the case of chickens, most strains appear to be derived from the White Leghorn, Rhode Island Red, Plymouth Rock, New Hampshire and White Cornish breeds. Commercial turkeys are derived mainly from Black, Bronze and White Holland. The latter is the ancestor of the Broad-Breasted White, the commercial turkey of choice for the turkey industry and the most commonly produced. Commercial duck strains are mainly derived from Indian Runner, Khaki Campbell and Pekin. In geese, the major commercial strains are White Toulouse, Emden and Chinese. These breeds are relatively well-documented.

According to *The State of the World's Animal Genetic Resources for Food and Agriculture* recently published by FAO (FAO, 2007), there are 1 644 local, 85 regional transboundary and 157 international transboundary avian breeds reported in the Domestic Animal Diversity Information System (DAD-IS). The latter group includes the above-mentioned commercial breeds. These figures clearly indicate that local or indigenous breeds make up most of the world's poultry genetic diversity. As shown in Figure 1, chicken breeds make up the vast majority (63 percent) of the total number of avian breeds, followed by ducks (11 percent – excluding Muscovy ducks), geese (9 percent) and turkeys (5 percent).

1.1 Regional distribution of avian breeds

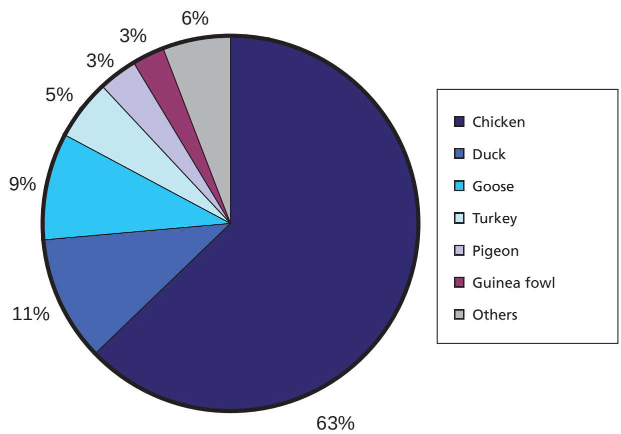
The Europe and the Caucasus region accounts for 52 percent of the world's local avian breeds. Asia accounts for 25 percent, Africa for 9 percent, and Latin America and the Caribbean for 8 percent. North America accounts for less than 2 percent of the total (FAO, 2007). The large number of breeds in Europe and Caucasus is partly a result of the fact that in this region breeds are more likely to be recognized as separate entities. It also reflects the more advanced state of breed recording and characterization in this region. Molecular studies of European chicken breeds show they are not particularly closely related; they are genetically distinct, but harbour moderate to low within-breed diversity, because the populations are of limited genetic size.

Indigenous chicken breeds are widely distributed, but their contribution varies between regions: very limited in the developed world (Europe and North America), but still important in the developing world. In many of the developing countries of Africa and Asia, the estimated average proportion of indigenous birds in the population is close to 80 percent (Guèye, 1998). Given the level of productivity of indigenous birds, their relative contribution to meat and egg production is, however, likely to be very much lower than their numerical contribution. Predictions of the extent of this contribution are subject to a high degree of error. The very approximate estimates produced by Pym *et al.* (2006) suggest that the contribution of indigenous genotypes to egg production is probably quite low in most countries, but that the contribution to meat production is likely to be quite substantial.

Ducks are also found in all regions; however, they are less numerous and show a less even distribution than chickens. Domestic ducks have a long history of domestication, and were kept in ancient Egypt, Mesopotamia, China and the Roman Empire. However, production is now concentrated in China, which has 70 percent of the world's domestic duck population. Other major producers are Viet Nam, Indonesia, India, Thailand and other countries in Southeast Asia. Among European countries, France and Ukraine have large numbers of ducks. The Muscovy or Barbary duck (or Criollo duck in Latin America) is a unique duck species that belongs to a group of waterfowl that can reproduce without water.

Geese and turkeys have a relatively narrow distribution. This can be explained by tradition and consumer preferences rather than by agro-ecological conditions. Nearly 90 percent of the world's domestic geese are found in China. Turkeys originated in Central America,

FIGURE 1
Distribution of the world's avian breeds by species



Note: Avian species with more than 50 recorded breeds are displayed separately; the remaining avian species are aggregated as others.
Source: FAO (2007).

and were brought to Europe shortly after their discovery by colonists; many breeds were developed in the latter region.

Most of the examples and developments described in the following sections are related to chickens – despite our efforts to cover all major poultry species. The chicken not only accounts for the vast majority of poultry genetic diversity, but is also the economically dominant species.

2 PAST DEVELOPMENTS IN POULTRY BREEDING

2.1 Attempted breeding programmes for indigenous poultry

Most breeding programmes aimed at improving the productivity of indigenous chickens have used cross-breeding. This approach has provided significantly higher productivity, but has resulted in a loss or dilution of the indigenous birds' morphological characters and instinct for broodiness. For example, the system used in Bangladesh for a number of years, and often referred to as the Bangladesh model (Jensen and Dolberg, 2002), which was designed to alleviate poverty among vulnerable people, was based on a cross between Fayoumi and Rhode Island Red chickens. The cross-bred chicken, known as the Sonali, turned out to be a high-yielding breed combination under semi-scavenging conditions (Rahman *et al.*, 1997). The Sonali is quite popular where it is kept, and it has a good reputation among Bangladeshi smallholders. However, its production faces a major obstacle in that new parent stocks are not readily available. In addition, smallholders' acceptance declined when they discovered that they had no success in reproducing Sonalis. The Central Avian Research Institute in India has produced various types of cross-breeds by crossing Rhode Island Red birds with local breeds (Singh *et al.*, 2004). However, when these birds were distributed, villagers complained about the dilution of morphological characters. They also found it difficult to market the eggs.

Experience has made it clear that the structure of such programmes was too complex for village conditions, where crucial inputs such as feed and medication were not readily available. The need for periodic re-supply of cross-bred chicks to the villagers presents a challenge. This has to be carried out either by an NGO or by a government agency, which has to maintain the pure lines of the indigenous birds as well as of the exotic birds on an appropriate selection programme. A mechanism for re-supplying the birds, providing minimum inputs, and marketing the eggs and culled birds has to be put in place in order to achieve success with programmes of this type.

Another cross-breeding strategy which has been practised for many years in some African countries is the cockerel exchange programme (FAO, 2004). This type of scheme involves distributing cocks of improved breeds to smallholders. However, several reports have concluded that this type of improvement has not changed the basic populations, except for contributing to a larger variation in plumage colour.

2.2 Development and trends in organized poultry breeding

Concentration in the breeding sector

In the 1960s, there were literally hundreds of breeders with significant market influence. Slowly, the breeders started expanding into more distant markets, including overseas. Only those who could cater for different market requirements and those who had efficient production and delivery systems survived. The rest disappeared. By 1980, only 12 layer breeding companies and 13 broiler breeding companies survived. Poultry breeding is an international industry. Survival in such a highly competitive industry is dependent on a number of factors:

- Primary breeders must have well-structured and efficiently operated breeding programmes to maximize genetic gains per unit of time in traits that are relevant in a given market or markets.
- Primary breeders must have efficient schemes for the multiplication of commercial products to meet market demands for quality and quantity in a timely manner.
- Breeders are also expected to provide technical recommendations and service support to ensure that customers achieve the genetic potential of the product provided.

A primary breeding company may have taken care of all the three above-mentioned requirements and still fail, if the geneticist conducting the breeding programme pursues an inappropriate goal. There is a long (four to five year) timeline from selection of pedigree stock to realization of results in the field. Once the geneticist realizes that the goal he or she pursued is not helping the company in the market, it will take a minimum of four years before any correction will be seen in the market. By that time, market will have been lost, and regaining the confidence of the customers may take months or years and require much effort.

Product performance is generally evaluated in relative terms, with competitors' products serving as a benchmark for all the attributes desired by the customer. Thus, it is important for product performance to be superior to that of the competitors as market requirements change. Breeding companies that could not foresee, or did not acknowledge, forthcoming changes in the market place, and did not modify their once-successful breeding programmes, have either vanished or been relegated from first or second to fourth or fifth place in terms of market share, despite having most of the ingredients needed to run a successful breeding business.

By the year 2000, layer breeding companies achieved more than 300 eggs per hen housed for 72 weeks, with a peak of lay of more than 95 percent. This means that the majority of birds were laying to their biological limit. Similarly, the broiler farmers were getting almost 2.5 kg body weight at 42 days of age with 1.75 feed conversion ratio. In other words, broilers were also approaching their biological limit. In order to obtain further genetic gains in production, feed efficiency or liveability, more sophisticated technologies were adopted by the breeding companies:

- Information and communication technologies – in order to estimate breeding values more efficiently, the breeding companies had to use best linear unbiased prediction (BLUP) methods, which require more sophisticated computers and state of the art software.
- With the approach of biological limits, breeding companies had to use larger populations per line, with a wider sire base in order to find minor differences between sire and dam families and between individual birds.
- With the advent of a global market, the breeding companies had to have efficient distribution channels throughout the world. The companies had to place not only grandparents, but also great grandparents, in different countries and continents.

All these developments strained the profitability of the breeding companies. Some could not cope in terms of finance and human resources. These companies became prey to the big multinational pharmaceutical or holding companies. By 2001, nine major layer breeding companies had been acquired by only three holding companies. By 2006, all nine were owned by only two companies – Hendrix Genetics and Erich Wesjohann (Table 1). Similarly, eight broiler breeding companies from the year 2000 are now owned by only four companies – Aviagen, Cobb, Hubbard and Hybro.

Impact of concentration in the poultry breeding sector on breeding programmes and the use of genetic resources

Two major concerns have been expressed regarding the concentration of the poultry breeding sector in a few hands:

1. The main concern expressed by many is the loss of genetic resources (lines) due to mergers and acquisition of breeding companies. It is feared that the breeding companies will keep only those lines that in their opinion are useful at present in product formulation or have potential to be used in the future. Economics could compel the companies to discard lines perceived not to be useful. Once the line is discarded it is gone for ever. Due to the proprietary nature of the lines, there is no information available as to how many lines have been discarded. This trend is definitely going to reduce the available gene pool across the breeding companies.

TABLE 1
Layer breeders and ownership since 1991

Breeders	1991 Location	1991 Ownership	2001 Ownership	2006 Ownership
Babcock	Ithaca, United States of America	Rhone/Merieux	Merial	Hendrix Genetics
Bovans	Ospel, Netherlands	Hendrix	Hendrix/Nutreco	Hendrix Genetics
Dekalb	Dekalb, United States of America	Dekalb Genetics	Hendrix/Nutreco	Hendrix Genetics
Hisex	Boxmeer, Netherlands	BP Nutrition	Hendrix/Nutreco	Hendrix Genetics
H & N	Redmond, United States of America	Lohmann	Erich Wesjohann	Erich Wesjohann
Hy-line	Des Moines, United States of America	Lohmann	Erich Wesjohann	Erich Wesjohann
ISA	Lyon, France	Rhone/Merieux	Merial	Hendrix Genetics
Lohmann	Cuxhaven, Germany	Lohmann	Erich Wesjohann	Erich Wesjohann

Source: adapted from Albers and Van Sambeek (2002).

2. The reduced number of breeding companies has raised concerns about reduced competition and associated reduction in the potential for innovative research and development (Sheldon, 2000). However, competition among the remaining breeders is more intense than it has ever been. Consumer demands are much more diverse on a global scale than they ever were. This means that the breeding companies are required to supply products that are much more diverse than those of the recent past. The few remaining layer breeding companies are increasing their range of products rather than decreasing them. As the remaining breeders have access to a much larger market share, they have more income and their spending in the research is far greater today than it has ever been.

2.3 Selection criteria

Indigenous populations

The village chicken is invariably a coloured bird. The colour can be brown, yellow, black or a mixture of these. According to farmers, multiple colours serve as camouflage against aerial predators. The village chicken is very alert and has long shanks with which to run away from predators. If necessary, they even fight with predators to safeguard their chicks. Hens can incubate their eggs and brood their chicks. This enables them to reproduce without any assistance.

Indigenous chickens appear to have an inherent scavenging and nesting habit. Years of natural selection, under scavenging conditions, has made them robust and resistant to various diseases, especially to those caused by bacteria, and protozoa and other internal and external parasites; they have better survival than the commercial hybrid strains under village production conditions (Minga *et al.*, 2004; Sonaiya *et al.*, 1999). However, the village chicken is a poor egg producer, laying on average 40 to 60 eggs per year in three or four clutches, with an average egg weight around 35–45 grams (Guèye, 1998). They generally have small body size; for various African chicken breeds, mature body weight varies between 1.3 and 1.9 kg for males and between 1.0 and 1.4 kg for females (Musharaf, 1990; Shanawany and Banerjee, 1991). Egyptian breeds seem to be somewhat heavier: around 2 kg for the males and 1.7 kg for the females. Village chickens require very little attention from the farmer, but closer management could improve production.

The challenge with respect to improving the productivity of indigenous chickens is to conserve the above-mentioned attributes, which are appreciated by the villagers. The best way to improve productivity without altering any of the morphological characters is to select for production traits within a given population. In terms of rate of improvement, this is a slow process compared to cross breeding. Iyer (1950) conducted selection in a non-descript flock of Indian deshi fowl and was able to increase the annual egg production from 116 eggs to about 140 eggs per hen through six generations of selection. The average egg weight of the flock also increased from 43 to 49 grams. It would be particularly interesting to identify selection criteria related to adaptation or disease resistance features, which are often reported but not precisely described.

Commercial lines

Laying hens

From the early twentieth century, the selection of egg-type chickens led to tremendous improvements in their productivity. The number of eggs per hen per year improved from 170 eggs in 1925 to as many as 325 eggs in 2006.

The primary objective of breeding programmes is to maximize the return on investment of different stakeholders in the layer business. In order to achieve this, a layer geneticist has to consider the following selection objectives: number of saleable eggs per hen housed per year, efficiency of converting feed into eggs, external and internal egg quality.

Egg production, which determines the overall returns on investment to the layer farmer, is tested in cross-lines and pure-lines, with emphasis on production during the later part of the laying cycle – known as "persistency of lay". Feed efficiency is generally defined in terms of the kilograms of feed required to produce one kilogram of eggs. In the early 1980s, the concept of residual feed consumption – the deviation from calculated demand to satisfy maintenance and production requirements – was introduced in commercial breeding programmes as a fine measure of efficiency.

The most important external egg-quality criteria are shell strength and egg weight. As shell strength decreases with the age of the hen, it is measured as late as possible in the laying cycle, and selection is based on these measurements. For egg weight, the objective is to select towards an intermediate optimum, which helps to maximize the percentage of eggs in the preferred weight range. Shell colour is also receiving attention, especially in brown-egg stocks, in response to consumer preferences for uniform, dark brown eggs. Traditional internal quality criteria are albumen height, and incidence of blood and meat spots (which are to be minimized). With increasing use of eggs for further processing, selection for higher yolk percentage and dry matter, and strength of vitelline membrane has become more important in recent years. However, it is difficult to select for these traits within line as there is very little variation among the hens within a line. The best way to improve them is by replacing or crossing different lines. Fertility and hatchability are traits that are best handled by eliminating the worst individuals for these traits (Gowe *et al.*, 1993).

Broilers

During the last 50 years, there has been tremendous improvement in broiler traits like growth rate, feed efficiency, liveability and yield. Poultry meat production developed from numerous small broiler farms into a well-defined global broiler industry. The world broiler industry can be divided into three broad market segments.

Live broiler market

In most Asian and African countries, broilers are sold on a live-weight basis. In this type of market, a producer buys day-old chicks from a hatchery, grows the broilers and sells them after the required market weight is attained. In this scenario, the broiler producer and the hatchery are two independent entities. Thus, there are two distinct profit centres: 1) the hatchery operator who owns the parent breeder and the hatchery and supplies the day-old broiler chicks to broiler farmers; and 2) the broiler farmer who grows the broilers and sells them to wholesalers and retailers. The broiler farmer's profitability is dependent on: age at market weight (growth rate); feed conversion ratio; and mortality. The hatchery operator's profitability depends mainly on the number of chicks obtained per breeder housed. Knowing that reproductive traits and broiler traits have negative correlation, geneticists in this segment of the market have to strike a balance between the two.

Live broiler/processed broiler integration

Here the breeders themselves grow and sell the broilers, either live or dressed. There is only one profit centre. Shortfall in any one of the breeder traits, say egg production or fertility, can be compensated by incremental gain in broiler traits, such as feed efficiency or growth rate. In this scenario, in addition to the traits mentioned with respect to live broilers, dressed yield also becomes important if the producer is selling dressed whole chicken or cut ups.

De-boned meat

In North America, western Europe and some other countries, almost 50 percent of broilers are sold as deboned meat. In these countries, the broiler industry is completely vertically integrated; the producers keep breeders, grow broilers either by themselves or through contract, process the broilers, and sell primarily deboned meat or processed chicken products. In this context, meat yield, especially the breast meat yield, becomes profit determinant, as breast meat fetches a premium over leg meat. Low-price cuts are often exported to developing countries – affecting their local industry.

Relative selection pressures applied by geneticists to develop products for the three different market segments are shown in Table 2.

TABLE 2

Relative selection pressure for various traits in different broiler-market scenarios

Selection trait	**Relative selection pressure for different markets**		
	Live broiler market	Live/dress broiler marker with one profit centre	Deboned meat market with one profit centre
Hatching egg production	+++	++	+
Fertility/ hatchability	++	+	+
Growth rate	+++	+++	++
Feed efficiency	++	+++	+++
Meat yield traits	+	++	+++
Liveability	++	++	++
Leg and skeletal strength	+	+	++
Plant condemnation	-	+	++

Economic performance is not the only criteria used by breeders/broiler producers when deciding which breed/product to buy. For example, mortality during the later part of the growing period, which requires the producer to remove dead birds daily, is disliked even when in economic terms the product could still be relatively profitable. Similarly, producers like to maintain a certain level of egg production in the breeders, even in the deboned yield market, despite the fact that a 1 percent increase in yield could economically balance as many as 20 to 25 eggs.

It should always be remembered that improvement of performance in industrial birds has been contemporary with improvements in management conditions.

3 CURRENT AND FUTURE CHALLENGES

3.1 Increasing demand for poultry products

Poultry consumption in developing countries is projected to grow at 3.4 percent *per annum* to 2030, followed by beef at 2.2 percent and ovine meat at 2.1 percent. In the world as a whole, poultry consumption is projected to grow at 2.5 percent *per annum* to 2030, with other meats growing at 1.7 percent or less (FAO, 2007). The increasing demand for poultry meat and eggs in many parts of the developing world favours the industrialization of production systems. The poultry sector is the most industrialized of all forms of livestock production, and large-scale production is now widespread in many developing countries.

Industrialization and globalization imply stricter requirements for product uniformity and food safety, which limit the range of marketable livestock products and restrict the production conditions under which poultry are kept. This, in turn, favours the use of a narrow range of genetic resources that are highly productive under these conditions. While this process is a threat to the diversity of poultry genetic resources, it has also contributed greatly to increasing the supply of food of animal origin in the face of rapidly growing demand.

Industrial systems, in which environmental stresses are removed by keeping animals in closed systems and intensive use of veterinary inputs, have allowed a greater focus on efficiency, maximizing benefit per animal place, and quality traits (see above), with less focus on adaptation to local environments or disease resistance or tolerance. However, consumers' demands are changing; they are increasingly concerned by health, environmental, ethical and animal welfare issues; new demands for certified products, such as free range or organic meat and eggs, have emerged. These issues also have an important influence on global costs, such as waste management, building costs and environmental taxes.

3.2 Increased threat of disease epidemics

Transboundary zoonotic diseases are serious threats to human health and the poultry economy. Outbreaks provoke concerted control efforts, including large-scale culling programmes, surveillance, vaccination and controls on the movement of animals. The highly pathogenic avian influenza (HPAI) outbreak in 2003/2004 in Thailand resulted in the loss of around 30 million birds (Ministry of Agriculture and Cooperatives, 2005). Approximately 43 million birds were destroyed in Viet Nam in 2003/2004, and 16 million in Indonesia – roughly equivalent to 17 percent and 6 percent of the respective national populations (Rushton *et al.*, 2005).

Non-transboundary (zoonotic or otherwise) diseases also significantly affect the economy of the poultry sector. Salmonellosis, campylobacter, Marek's disease, Newcastle disease and infectious bursal disease are among major diseases of this category. They are more or less kept under control in the commercial sector though disease control strategies which include chemotherapy, vaccination, control of disease vectors and appropriate management methods. However, there are constraints to the sustainability of such strategies. Problems include the evolution of parasite resistance to the treatments applied, such as virus resistance to vaccines (Marek's disease virus) or bacterial resistance to antibiotics. There are also concerns regarding residues in the food chain and the implications for human health of the emergence of antibiotic-resistant micro-organisms. Another issue is the affordability and accessibility of treatments to poorer livestock keepers. Outbreaks of Newcastle disease and infectious bursal disease frequently devastate village chicken flocks, and farmers have had to live with these losses.

For commercial production systems, the major impact of disease epidemics, such as the HPAI outbreak, is market shock and ban on international trade. With respect to backyard poultry production systems, changes to management practices and cultural activities may be introduced. For example, the raising of multiple species like keeping ducks or geese alongside chickens has been prohibited in some Southeast Asian countries; cultural and social events involving the mixing of birds (for example cock fighting or the exhibition of songbirds) may be banned. Such measures could result in a future poultry sector which has fewer backyard producers (FAO, 2007). Small-scale commercial poultry producers (who largely keep imported breeds) also face great difficulties in responding to the threat of HPAI, and their future may also be in doubt.

It is generally difficult to quantify the impact of disease epidemics on poultry genetic diversity – mortality data are rarely broken down by breed. However, it is clear that large numbers of birds can be lost, and that it is often culling rather than the disease itself that accounts for the largest number of deaths and poses the greatest risk for poultry genetic resources. It is only recently that threats to local genetic resources have been given any consideration in the planning of disease control measures. Limited steps to address this issue have been taken in Europe, but the potential for conflict between animal health and breed conservation objectives remains considerable.

3.3 Environmental issues and climate change

There is a double challenge; the first is the effect of the poultry industry on the environment, and the second is the effect of climate change on the poultry sector in general and poultry genetic resources in particular.

The industrialization of poultry production and the rapid genetic progress made in growth rates and reproduction have had both positive and negative influences on the environment. These processes have been accompanied by major positive effects on the use of resources. On the negative side, people living near poultry units may be affected by odour and increased fly populations. There is also the problem of manure disposal. In areas with a high density of livestock production, excess nitrogen and phosphorus often enters local water courses; poultry production contributes to this problem. Ammonia produced by bacteria in the litter is ventilated into the atmosphere, which also adversely affects the environment.

Climate change is likely to have significant impact on the world's environment. Climatic zones could shift towards the poles, and vertically – affecting forests, deserts, rangelands and other ecosystems (FAO, 2007). Climate change has the potential both to gradually affect the distribution and characteristics of production systems, and to increase the frequency of weather-related disasters such as droughts, floods and hurricanes. Hydrometeorological and geophysical disasters became, respectively, 68 percent and 62 percent more frequent over the decade between 1994 and 2003 (IFRCS, 2004). The occurrence of disasters is relatively unpredictable, at least in terms of the intensity of their impact and the specific locations that are affected. Hence, foreseeing their effects on poultry genetic resources presents a difficult challenge.

It is likely that intensively managed livestock systems such as the commercial poultry industry, which depend less on local resources, will more easily adapt to climate change than extensive production systems. The question is at what cost?

The poor and disadvantaged will be the most vulnerable to the negative consequences of climate change. These are the poultry keepers who keep indigenous and local breeds. A breed population whose numbers and range have declined as the result of gradual changes to the production systems in which it is kept is more vulnerable to being wiped out by an acute disaster. Restocking after disasters could also be a threat to poultry genetic diversity if it is not well-planned and carefully implemented.

3.4 Increased competition for feed resources

Domestically and internationally traded concentrate feeds are increasingly important. In 2004, a total of 690 million tonnes of cereals were fed to livestock (34 percent of the global cereal harvest) and another 18 million tonnes of oilseeds (mainly soy). Poultry, along with pigs, are the biggest user of feed cereals.

In developing countries, especially in the densely populated rural areas of Asia, poultry is in direct competition with humans for feed resources. In addition, the growing use of cereals and oilseed to produce ethanol and biodiesel will increase the pressure on the land area used for agriculture – already high as a result of increased population size and urbanization. This will inevitably lead to higher crop prices and subsequently to higher feed costs.

In high cereal producing regions or countries (e.g. Brazil and the United States of America), poultry will continue to be a profitable business. Where the grain:meat/egg price ratio is high, typically in developing countries, feeding grain will be more difficult. This may lead to movement of production to the high cereal producing regions; indeed, the process has already started.

The higher cost of concentrate feed may present an opportunity for local birds, which may be less disadvantaged when fed on locally available feed resources such as crop residues and unconsumed household food. The balance between all inputs and outputs should be the decisive criterion when comparing breeds and/or production systems (i.e. not only output should be considered).

3.5 Erosion of poultry genetic resources

According to FAO (2007), Europe and the Caucasus, and North America are the regions with the highest proportion of their breeds classified as at risk – 49 percent and 79 percent of avian breeds, respectively. These are also the regions where the highest numbers of breed extinctions have been recorded. These regions have the most highly specialized poultry industry. The high proportion of at-risk breeds in these regions may also relate to the greater levels of breed recording that have taken place there. In Africa, for example, population size has not been reported for over two-thirds of breed populations. Besides missing population data, a big weakness of the current monitoring of breed erosion is that it does not capture genetic dilution of local breeds by uncontrolled cross-breeding.

As noted in Section 2.1, various cross-breeding efforts have been undertaken in many developing countries. Often, they were conducted by NGOs with the support of local authorities – an example being the Bangladesh poultry model. In addition, the supply of hybrid males by large private hatcheries to neighbouring smallholders leads to indiscriminate cross-breeding with the imported stock, often without significant gains in production levels. The genetic impact of these formal and informal cross-breeding schemes and practices is unknown. As a consequence, the identification of poultry as indigenous may be merely a matter of convenient labelling, as there has been at least one attempt at cross-breeding in most developing countries.

The loss of poultry genetic resources is also happening in the breeding sector as a consequence of the merger and acquisition of breeding companies (see above). Besides this loss, there has also been planned and unplanned loss of stock kept as a resource population in the public sector (Pisenti *et al.*, 2001). Some of the lost stock was developed over a period of many years; its loss reduces the scope of future research.

4 CURRENT AND FUTURE DEVELOPMENTS FOR POULTRY GENETIC RESOURCES

4.1 Developments based on current technologies

Niche market or alternative systems

Food production is changing from being producer-driven to consumer-driven. Consumer confidence in the livestock industry has broken down in many countries (Lamb, 2001). Fears about the quality and safety of animal products have been heightened in recent years by various crises in developed countries: bovine spongiform encephalopathy, dioxin, and more recently, avian influenza. At the same time, the majority of consumers in developed countries have become less connected to the countryside and know less about farming. In short, there is a growing demand for "natural", "ethical" or "ecological" production, but often without a clear description of what this should encompass.

Welfare issues

Welfare has become an important element of consumers' perception of product quality. Special welfare-driven brands have been established in some European countries, and even fast-food chains in the United States of America are introducing minimum cage-space requirements for the laying hens kept by their egg suppliers. It is expected that similar developments for poultry meat production will follow.

The main welfare issues for laying hens are related to the limited space and the restriction of natural behavioural expression associated with conventional cages. Based on the European Union's Directive on the Welfare of Laying Hens (1999), conventional cages will be banned in 2012; during the transition period more space has to be given to birds housed in conventional cages. In the future, hens may be housed in so-called enriched or furnished cages, barn systems or aviaries, which may be combined with access to free-range areas. Production costs are likely to increase significantly as a consequence of these changes; this may affect the future of poultry production in Europe as compared to that in other continents.

While changing from conventional to enriched cages should have no consequences for layer breeding, the change to non-cage management systems requires effective control of feather pecking and cannibalism, for both of which there are differences between breeds. Breeders are selecting against these two behavioural problems, which are more difficult to control in floor management (large groups) than in cages (small groups). This will require many generations, while specific management tools such as beak trimming, control of light intensity and balanced nutrition can help in the short term. Issues like nesting behaviour, floor eggs and resistance to a range of infectious diseases will also become more important in floor systems. Conversely, increased space and enriched environment stimulate birds' activity and reduce the problem of weak bones (osteoporosis) which has been identified as a cause of bone breakage in spent hens.

The main welfare issues in broilers are cardio-vascular insufficiency (sudden death syndrome and ascites) and leg disorders. Selection for body weight gain, intensive feeding and some management procedures contribute to these problems. The locomotive activity of commercial broilers is very low compared to slow growing-poultry breeds. The lack of exercise increases the incidence of leg problems and may cause foot lesions, hock burns and dermatitis under unfavourable climatic conditions and in wet litter. Turkeys are more active, but periodically leg problems appear, often associated with digestive upsets to which the turkey is prone. Breeders of broilers and turkeys are selecting against the incidence of leg disorders and malfunction of the cardio-vascular system. Until these causes of mortality and potential suffering are effectively reduced by selection, they can be alleviated to some extent by improved management.

Environmental issues

Genetic improvements and technological advances have had a positive effect on the use of resources. In 1977, 20 kg of feed was required to produce 1 kg of chicken breast meat; now, it takes only 6.5 kg (Mckay, 2005). Similar improvements can be quoted for other meat-type poultry (turkeys and ducks) or laying hens. Genetic improvements in productivity will continue to indirectly improve the use of resources such as feed and energy. Furthermore, there is a need to genetically improve the efficiency of digestion of amino acids and phosphorus. However, in the short term, the greatest potential for reduced nutrient load is offered by improved feed additives such as enzymes and acids.

Developments for hot climates and challenging conditions

Most of the world's leading poultry breeding companies are located in temperate regions (Europe and North America) while their products are marketed all over the world, including tropical, semi-arid or arid areas, where conditions are challenging in terms of climate, husbandry, feeds and feeding practices. Poultry production under such conditions leads to a general depression in performance, which may not be uniform in all genotypes, revealing significant genotype by environment interactions (termed GxE). A number of authors have reported strain by location or housing-system interactions for traits such as egg production and mortality in layers (Muir, 1985; Besbes, 2004), body weight gain, feed conversion and liveability in broilers (Hartmann, 1990; Cahaner, 1990).

The question for poultry breeders is whether selection should be carried out under favourable environmental conditions that allow maximum expression of the genotype, or should be carried out in the environment where the genotype is actually designated to live. Layer breeders select based on information collected in both environments. Pure-line pedigreed birds in breeding farms are housed in single-bird cages to measure individual egg production and quality traits. Under these controlled conditions, there is no competition between birds, and mortality is very low. However, commercial birds are housed in multiple-bird cages or in large pens. These conditions may be stressful and can result in injuries due to aggression, flightiness and cannibalism, leading to high mortality and depression of egg production. To select birds that cope with these conditions, layer breeders conduct several tests representative of field conditions in different geographical regions. The assumption behind these tests is that the effects of housing type on animal welfare cannot be isolated and studied independently from the effects of nutrition, management, local environmental conditions, etc.

Some poultry-meat breeders have chosen to establish satellite breeding programmes in various locations. This could be viewed as a safety measure against unknown GxE interactions which might affect the programme. In most cases, however, the establishment of satellite programmes seems to be more a commercial choice inspired by logistic considerations and business partnerships than a technical matter (Albers *et al.*, 2002). However, the appropriateness of such a strategy is illustrated by the example of an Indian breeding company which started 27 years ago to select and breed chickens under Indian environmental conditions and for Indian market requirements. Its locally bred broilers and layers have, in general, outperformed those based on imported grandparents in traits of economic importance (Jain, 2004).

To overcome unfavourable effects caused by GxE interactions, breeding companies may advise poultry farmers to install specific devices to control temperature, humidity and air flow. This advice is given to ensure that conditions in the broiler/layer houses are close to the environment in which the birds have been selected. For small-scale poultry farmers in developing regions, this is an expensive proposal and usually impracticable due to the high cost of electricity and frequent power breakdowns. Moreover, the depressed broiler growth or reduced egg production caused by high temperature cannot be completely alleviated by such measures (Cahaner and Leenstra, 1992).

Under hot conditions, fast-growing broilers cannot dissipate all the heat they generate, resulting in lower feed intake, and consequently lower growth and, even, higher mortality. Heat dissipation is hindered by the insulation provided by the feathers. The introduction of genes that reduce feather coverage has been suggested as a means to improve heat dissipation in fast-growing broilers. The "naked-neck" (Na) gene, which is quite common in rural and commercial chicken breeds in hot regions and also in Europe, reduces feather coverage by about 15–20 percent in heterozygous (Na/na) and 30–40 percent in homozygous

(Na/Na) chickens. Compared to their normally feathered counterparts, naked-neck broilers have been shown to have a higher rate of heat dissipation and better thermoregulation in hot conditions; consequently their growth rate is less depressed. A series of studies conducted under artificially hot conditions and in hot climates (Egypt, Israel, Turkey and Viet Nam) have demonstrated the advantage of naked-neck broilers over their normally-feathered counterparts. However, although less affected than normally-feathered broilers, the naked neck chickens also suffer under heat stress. This observation led to the hypothesis that total elimination of feathers might maximize heat-tolerance among fast-growing broilers under hot conditions. Featherless broilers are being produced by an Israeli team. However, despite the apparent advantages exhibited by such birds, they face difficulties in terms of acceptance by the market.

Developments for better poultry health

The physical health of commercial poultry has been improved continuously, along with the ongoing development of modern production systems. All parties involved in poultry production worldwide have contributed to this process, but breeding companies have played a critical role. They have eradicated vertically transmitted poultry diseases such as *Salmonella* spp, *Mycoplasma* spp, avian leucosis and egg drop syndrome, and using the pyramidal multiplication structure of the industries, they have rendered the vast majority of production flocks virtually free from these diseases. This has been achieved mainly by biosecurity measure, as to our knowledge, no breeder has, as yet, a formal programme to directly select for resistance to a specific disease, although some breeders have for a long time been screening for major histocompatibility complex, known as the B locus, in their lines.

Increased production potential in conjunction with improvements in nutrition, health care and general bird management have increased production levels per bird to all time highs. This, in itself, has increased the vulnerability of poultry populations to a number of diseases and defects if any part of the system fails.

Breeding for resistance to a specific disease caused by micro-organisms involves exposure of the birds to disease-causing microbes in controlled conditions. Obviously, this can not be done on a pedigree farm. For this reason, disease challenge is sometimes carried out at an isolated location, using the siblings or progeny of the birds under selection. Selection is based on the relative susceptibility of the families. The identification of genetic markers for resistance to a particular disease will enable more focused selection, which does not require the evaluation of breeding stock through welfare-unfriendly challenge experiments.

Developments in information technologies

Animal breeding requires extensive data collection. The availability of robust portable computers that can be used in harsh environmental conditions (dust, temperature, humidity) has greatly facilitated data collection. The size of computerized files has very much increased with the development of breeding-value estimation using mixed model methodology and animal models. These have been routinely applied in poultry since the early 1990s. However, computer capacity has also greatly progressed, so that very large data files can now be handled relatively easily. Most software for genetic evaluation and inbreeding calculation are in the public domain, but those designed for the management of small populations are still expensive.

Electronic identification has been available for large animals for several years. In the case of poultry, the cost of an individual device was too high relative to the economic value of individual birds. However, the situation has now changed, with electronic identification having been described for a commercial breeding programme in laying hens (Thurner *et al.*, 2006). In combination with electronic devices such as egg captors and electronic scales, electronic identification makes it possible to measure individual performance (body weight, egg laying) without directly handling the animal. This renders individual measurement in extensive production systems possible, thus contributing to the adaptation of breeding programmes to new environmental conditions.

4.2 Developments based on new biotechnologies

Characterization and study of genetic diversity

The most recent progress in the characterization of poultry resources has been based on the use of molecular markers. The European project AvianDiv (1998–2000) provided the first large-scale study of genetic diversity in domestic chickens using microsatellite markers (Hillel *et al.*, 2003). The project included 5 types of population, the wild ancestor, unselected populations, standardized breeds, commercial lines and inbred lines. The range of heterozygosity varied from 10 percent to 65 percent. Among commercial lines, broilers exhibited the highest level of variation, brown-egg layers showed moderate values (below 50 percent) and white-egg layers showed the lowest values (35 percent). The unselected populations were generally among the most variable, but the standardized breeds exhibited a wide range – from 20 to 65 percent depending on population history and population size. It was clear that molecular tools were available to study the genetic structure of a wide range of populations, to quantify the genetic variability at the genome level, to reconstruct scenarios for population history, and to propose new management programmes. Since 2000, molecular studies of poultry genetic resources have developed across countries and continents, including China (Qu *et al.*, 2004) and Africa (Mwacharo *et al.*, 2007).

A pilot study (Hillel *et al.*, 2007) compared the use of single nucleotide polymorphisms (SNPs) to the use of microsatellite markers as a means to characterize diversity. This study showed the need for a high number of SNPs (in the order of thousands) to study the fine structure of the genome and identify chromosomal segments showing selection signatures. This is because SNPs are biallelic markers, with a low level of information content as compared to microsatellites, which are multi-allelic and informative in most cases.

In addition to the characterization of genome variability, molecular markers allowed individuals to be assigned to a breed with a success rate above 95 percent for most of the breeds studied within the AvianDiv project (Rosenberg *et al.*, 2001). Thus, it could be possible to confirm the breed origin of an animal, provided that a reference data set has been defined for the breed. This shows that breed traceability as well as breed definition for conservation issues may benefit from the use of molecular markers.

It is generally necessary to complement molecular study with population data, using a field survey to describe the main socio-economic features of the population as well as phenotypes. Georeferencing is a quite useful tool for providing an accurate view of the geographic distribution of local populations. Furthermore, it allows overlay of further bio-physical data from the environment (climate, soil, vegetation cover, water availability, type and level of disease challenges) with the morphological or performance data. Collecting these data on local populations would benefit from the use of portable computers and electronic devices, provided that power supply is available.

QTL detection, gene identification and transgenics

Microsatellite markers have been used for quantitative trait locus (QTL) detection in several programmes involving chickens, turkeys, ducks and quails in various parts of the world (Hocking, 2005). These programmes were set up in commercial and experimental lines. The aim was to identify chromosomal regions likely to control performance traits such as growth rate, egg production, behaviour and disease resistance. Such chromosomal regions can, thus, be proposed for an approach focused on functional diversity. This functional approach is all the more useful in that candidate genes are identified within the chromosomal region and their polymorphism can be readily compared across populations. Investigating the polymorphism of a candidate gene across various populations has been quite efficient in identifying causal mutations for morphological traits, such as feather colour, that are controlled by a major gene. This has been illustrated successfully in the case of the silver locus (Gunnarson *et al.*, 2007).

Large-scale studies of gene expression with microarrays have been used to identify candidate genes within QTL regions, as genes differentially expressed between genotypes differing at the QTL are good candidates to explain the QTL effect. This has been illustrated for Marek's disease resistance (Liu *et al.*, 2001). The approach raises a number of questions, regarding the tissue to be sampled and the stage of sampling; furthermore it may require slaughtering animals in order to get the tissue needed for the function to be studied.

The use of transgenesis has been mainly investigated for the production of high-value therapeutic proteins, with the chicken, and particularly the laying hen, being considered as a bioreactor (van de Lavoir, 2006; Lillico *et al.*, 2007).

Cryopreservation and gene banks

Sperm freezing is currently the only cryopreservation technology that can be used routinely in chickens. However, the rate of success, estimated by fertility with thawed semen, still exhibits large variability between individuals. Thus, it is difficult to guarantee that the whole range of genetic variability of a given population will be preserved; only a subset of males may be suitable sources of semen for freezing. In addition, neither the W chromosome nor mitochondrial genes can be preserved using this technology. This may not be a major limitation for population performance, but it will prevent any further study of population history through the female pathway.

To date, a few cryobanks have been set up in Europe and in the United States of America, housing collections of frozen semen for chicken breeds or experimental lines (Blackburn, 2006; Blesbois *et al.*, 2007). A simulation study has shown that a large number of straws (a few hundreds) are necessary to restore a breed that would otherwise have totally disappeared (Blesbois *et al.*, 2007). In Canada, a set of experimental lines were saved in the 1990s by freezing blastodermal cells from early embryos.

5 GAPS, OPPORTUNITIES AND EXPECTATIONS

5.1 Characterization and study of poultry genetic diversity

Poultry genetic diversity and options for its utilization are usually discussed in terms of breeds. "Breeds" are cultural concepts rather than physical entities, and the concept differs from country to country. This makes characterization at the genetic level very difficult. Furthermore, genetic diversity needs to be considered and understood at the species level, between breeds, and within breeds. This should be taken into account when defining indicators for animal genetic diversity.

Data on production systems, phenotypes and molecular markers should be used together in an integrated approach to characterization. A comprehensive description of production environments is needed in order to better understand the comparative adaptive fitness of specific animal genetic resources. In addition, defence mechanisms against pathogens should be a priority, given the significance of the threats posed by epidemics and climate change. Field and on-station phenotypic characterization is therefore needed.

The need to characterize the specific traits of local populations is quite urgent, and genomics may facilitate the search for genetic variants. This could be easier than recording phenotypes for adaptive traits, which are not well defined. A more accurate characterization of these populations will support their development and could lead to monitored cross-breeding strategies – avoiding uncontrolled absorption which might result in the loss of the local resource. The number of populations studied should be increased, particularly in Africa, South America and Asia. However, marker analysis may detect cases in which local populations have already been subject to introgression from imported lines. In such cases, it may be concluded that the local population is no longer "local" or is at least a mixture of genetic resources from different countries.

In the short term, microsatellite markers are likely to remain the first choice for the assessment of genetic diversity and population structure. However, isolated studies that do not share a sufficient number of markers in common with the FAO recommended set will not contribute to a global view of chicken genetic resource diversity. The use of a reference set of markers is, therefore, highly recommended. Such a reference set has been developed for chickens; similar developments should also be considered for other poultry species such as ducks and geese (particularly in Asia), guinea fowl, turkeys, quails or even pigeons. Laboratory procedures need to be standardized in order to merge data sets; the distribution of reference samples is a prerequisite for the calibration of genotyping across laboratories. Within a country, or even a region, it would be advisable to concentrate all typing work in a common reference laboratory.

The characterization of functional diversity will benefit from the progress in gene identification, comparing populations for genes associated with a known phenotype – provided that such genes are not patented. In fact, the issue of property rights becomes more important the longer specific gene effects are studied.

A large-scale functional diversity approach using microarrays can be used in order to search for specific adaptive metabolic traits. An interesting example was provided in salmon, where gene expression patterns appeared to correlate better to environmental conditions than to population history established with microsatellite markers (Giger *et al.*, 2006). Functional genomics also requires specific technology and extensive capacity-building, as pitfalls and statistical errors may occur even more easily than with the approach based on DNA markers, in which common software are available to estimate the usual parameters of populations genetics.

5.2 Sustainable use and development of poultry genetic resources

The utilization of poultry genetic resources is the best means to ensure that they remain available for future generations. To be sustainable, this utilization must efficiently meet current economic and social objectives without compromising the natural environment and resources. The situation varies greatly between the commercial populations kept in high-input production system and the indigenous populations kept in subsistence-oriented and low–input systems.

For indigenous populations, the challenge is to improve the survival rate, especially of chicks, through simple and applicable biosecurity measures, and to ensure access to markets. Genetic improvement of these populations is a challenging but not impossible task. Guidelines for the design and implementation of improvement programmes need to be developed. But, perhaps the most urgent task is to increase awareness of the values of these populations, especially among policy-makers.

For commercial populations, the balance between animal health and welfare on the one hand, and production efficiency on the other, is very delicate. With high and ever-increasing efficiencies and highly specific product requirements, it will be increasingly difficult to maintain this balance. However, probably the most obvious risks for the poultry industry are related to diseases; viral or bacterial disease agents may spread vertically or horizontally. The concentration of primary breeding, suggests that the risk of new disease variants combined with international distribution could become a major hazard. However, the remaining large companies are investing heavily in new biotechnologies to help them cope with these new challenges.

It is likely that SNPs will be used by breeding companies for selection purpose. Although this technology may be less costly per unit of information provided than the use of microsatellites, it is designed for large-scale studies, and so the total cost is still high. With high-throughput sequencing, it should be possible, within few years, to have a draft genome sequence for one chicken within a few days. Of course, utilizing this technology will require extensive capacity-building in bioinformatics and data analysis, but it may completely change the structure of breeding programmes. Indeed, phenotype recording could become focused on a few crucial steps, in which close association between genome polymorphism and performance is established and remains valid over a few generations within a given population. A reliable association can be achieved only with a very high density of markers all over the genome; thus, whole-genome sequencing will be more efficient than the genotyping of thousands of SNPs. This could be very useful for disease-resistance traits, which require challenge tests and tailored procedures that are not easy to implement in routine breeding programmes. The use of genomics in commercial lines may help to define criteria for improving their adaptation to environments other than the standard intensive and protected production system.

5.3 Conservation of poultry genetic resources

There is a need to establish a comprehensive conservation strategy for poultry genetic resources in the face of global trends and growing uncertainties. Securing poultry genetic resources is best carried out proactively, giving time for the development of effective *in situ* or *ex situ in vivo* conservation schemes wherever possible. Where this is not the case, cryoconservation and gene banks could be an alternative.

Sperm freezing is currently the only technology that can be used routinely to cryoconserve genetic material from chickens. The technology has to be adapted to the biology of the sperm cell in each species of bird; thus sperm freezing is not yet a routine procedure for most species – see the review by Blesbois (2007). However, it is preferable to start implementing conservation measures immediately, utilizing current best practice, rather than delay and leave genetic resources unsecured and at risk.

To be useful, the material stored in gene banks must be described. Thus, characterization and cryopreservation should be connected. Furthermore, a gene bank should be safe from animal diseases. This issue is a major problem for cryobanking local populations. Thus, improvement of health conditions among in situ populations should be a priority for local authorities. This requires capacity-building in developing countries, and recurrent support in developed countries. Moreover, current sperm freezing technology is not easy to implement in the field; this means that current cryobanks include experimental lines and some commercial lines, but very few indigenous populations.

The possibility of setting up a gene bank based on embryonic cells could be appealing, as it requires only the collection of fertile eggs, and the provision of a centralized incubation and cell culture facility. Moreover, saving totipotent cells would allow the restoration of an extinct breed more efficiently than would storing frozen semen. Nonetheless, decisions will depend on the efficiency rate and operating costs of each procedure. As this method produces chimaeric chickens during one stage of the procedure, it should be used only if the donor genome can be distinguished from the recipient genome – which can be done using molecular markers. Currently, there is no routine system of this type set up in any developed country.

Somatic cloning would represent the most convenient and appealing method, as there would be no intermediate stage involving chimaeras. However, considering the difficulty involved in manipulating the avian ovocyte, this approach is not likely to be developed in the short term or even the medium term.

Finally, coordination of gene banks through multilateral or bilateral agreements will be needed. In this context, there is a need to resolve how cryoconserved material can be stored in duplicate (or more) locations, to reduce the risk of catastrophic failure in an individual gene bank; how access and use can be made timely and traceable, with appropriate security to manage pathogens; and how replenishment of gene banks can be achieved after access and use. These aspects are discussed in the relevant FAO guidelines (FAO, 1998).

6 CONCLUDING REMARKS

Economic development and globalization, changing market demands, environmental impacts including climate change, and trends in science and technology are the major drivers of change influencing the management of poultry genetic resources. Globalization favours intensive production systems and the use of a narrow range of genetic resources. Market demands are changing, mainly in the developed world; this could constitute an opportunity for local poultry populations. Changes to the climate will tend to affect extensive production systems (and hence local poultry populations) more than intensive production systems, as the latter depend less on local resources. Advances in science and technology constitute the driver that will probably have the greatest influence on the future management of poultry genetic resources. The trends in commercial populations will differ from those in indigenous populations.

Selection of commercial lines is likely to benefit from the use of new genomic tools, which could be particularly profitable for disease resistance. Gene identification is likely to make impressive progress in the near future, meaning that functional diversity will be much more fully studied. Transfer of knowledge from one animal population to another will be easier for known genes than for QTL.

However, new technologies are costly, and substantial investments are needed. The breeding sector has already undergone strong concentration; thus, a few big companies will compete in the use of genomics. The quality of the phenotypes to be correlated with genomic information will determine future success. Considering the diversification of markets and production conditions, breeders may be interested in robust animals, which can maintain a good level of production across a range of environments. If breeding companies succeed in providing such genotypes, able to produce much better than local populations in harsh environments, then indigenous genetic resources are likely to disappear rapidly, or in the best-case scenario local commercial chickens would drive the local indigenous ones out of the market.

Yet, it should be recalled that local chickens not only provide meat, but are also maintained for their cultural values. Their survival will depend on future changes in rural societies; this raises the global issue of how development will be managed in countries where village chickens are still numerous. Moreover, developing countries may consider that they should not depend on a few international companies for the supply of chicken meat and eggs. If these countries invest in new technologies to better characterize their local populations and to design tailored breeding programmes, then chicken diversity may be maintained, in line with the diversity of climatic conditions and social uses of chickens. Genomic tools will benefit the management of genetic resources, provided that the information obtained through research is made available worldwide. Thus, capacity-building and access to knowledge are major issues that will determine the impact of genomics on the future of chicken breeding.

In the field of conservation biology, prospects are unfortunately not so promising. Techniques have not evolved as far as those in the field of genomics. This may well become the limiting factor in global strategies. Both fundamental research and technological research are needed here. Storing cells or gametes in a gene bank should always include two steps: complete documentation of the sample (genetic origin, performance, specific features) and a sanitary check to avoid storing material that will be impossible to use in the future because of sanitary restrictions.

REFERENCES

Albers, G.A.A., Broekman, K., Vissher, J., Buddiger, N. & Maatman, R. 2002. Role of genotype x environment interaction in applied breeding programmes. In *Proceeding of the 7th World Congress of Genetics Applied to Livestock Production*, 19–23 August, 2002, Montpellier, France. Communication No. 18–09.

Albers, G.A.A. & Van Sambeek, F.M.J.P. 2002. *Breeding strategies for layers in: view of new technologies*. Paper presented at the 11th European Poultry Conference, Bremen, Germany.

Besbes, B. 2004. Breeding layers for productivity and livability in sub-optimal cage and floor systems In *Proceedings of XXII World's Poultry Congress*, June 8–12, 2004 Istanbul, Turkey. CD Rom.

Blackburn, H.D. 2006. The national animal germplasm program: challenges and opportunities for poultry genetic resources. *Poultry Science*, 85(2): 210–215.

Blesbois, E. 2007. Current status in avian semen cryopreservation. *World's Poultry Science Journal*, 63(2): 213–222.

Blesbois E., Seigneurin, F., Grasseau, I., Limouzin, C., Besnard, J., Gourichon, D., Coquerelle, G., Rault, P. & Tixier-Boichard, M. 2007. Semen cryopreservation for ex situ management of genetic diversity in chicken: creation of the French avian cryobank. *Poultry Science*, 86(3): 555–564.

Cahaner, A. 1990. Genotype by environment interaction in poultry. In *Proceedings 4th World Congress on Genetics applied to Livestock production*, Edinburgh, United Kingdom, pp. 13–20.

Cahaner, A. & Leenstra, F.R. 1992. Effects of high temperature on growth and feed efficiency of male and female broilers from lines selected for high weight gain, favourable feed conversion and high or low fat content. *Poultry Science*, 71 (8): 1237–1250.

FAO. 1998. *Secondary guidelines for development of national farm animal genetic resources management plans. Management of small populations at risk*. Rome.

FAO. 2004. *Small-scale poultry production. Technical guide*, edited by E.B. Sonaiya. & S.E.J. Swan. Rome.

FAO. 2007. *The State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B. Rischkowsky & D. Pilling. Rome.

Giger, T., Excoffier, L., Day, P.J.R., Champigneulle, A., Hansen, M.M., Powell, R. & Largiader C.R. 2006. Life history shaped gene expression in salmonids. *Current Biology*, 16(8): R281–R282.

Gowe, R.S., Mc Millan, I. & Fairfull, R.W. 1993. Should all traits in a multiple trait selection program for egg stocks be included in an index? *Aviagen*, 93: 33–39.

Guèye, E.F. 1998. Village egg and fowl meat production in Africa. *World's Poultry Science Journal*, 54(1): 73–86.

Gunnarsson U., Hellström, A.R., Tixier-Boichard, M., Minvielle, F., Bed'hom, B., Ito, S., Jensen, P., Rattink, A., Vereijken, A. & Andersson, L. 2007. Mutations in SLC45A2 cause plumage color variation in chicken and Japanese quail. *Genetics*, 175: 867–877.

Hartmann W. 1990. Implications of genotype – environment interactions in animal breeding: genotype – location interactions in poultry. *World's Poultry Science Journal*, 46(3): 197–210.

Hillel, J., Granevitze, Z., Twito, T., Ben-Avraham, D., Blum, S., Lavi, U., David, L., Feldman, M.W., Cheng, H. & Weigend, S. 2007. Molecular markers for the assessment of chicken biodiversity. *World Poultry Science Journal*, 63: 33–45.

Hillel J., Groenen, M.A.M., Tixier-Boichard, M., Korol, A.B., David, L., Kirzhner, V.M., Burke, T., Barre-Dirie, A., Crooijmans, R.P.M.A., Elo, K., Feldman, M.W., Freidlin, P.J., Maki-Tanila, A., Oortwijn, M., Thompson, P., Vignal, A., Wimmers, K. & Weigend S. 2003. Biodiversity of 52 chicken populations assessed by microsatellite typing of DNA pools. *Genetics Selection Evolution*, 35(5): 533–557.

Hocking, P.M. 2005. Review of QTL mapping results in chickens. *World's Poultry Science Journal*, 61(2): 215–223.

IFRCS. 2004. *World Disasters Report 2004*. Geneva. International Federation of Red Cross and Red Crescent Societies.

Iyer, S.G. 1950. Improved indigenous hen evolved by selective breeding. *Indian Veterinary Journal,* 26: 80–86.

Jain, G.L. 2004. Breeding for the special needs of developing countries. In *Proceedings of XXII World's Poultry Congress*, June 8–12, 2004 Istanbul, Turkey. CD Rom.

Jensen, H.K. & Dolberg, F. 2002. *The Bangladesh Model and other experiences in Family Poultry Development. A conceptual framework for using poultry as a tool in poverty alleviation.* Introductory Paper, INFPD E-Conferences. International Network for Family Poultry Development. (available at http://www.fao.org/ag/AGAInfo/subjects/en/infpd/econf_bang.html)

Lamb, C. 2001. Understanding the consumer. In *Proceedings of the British Society of Animal Science,* 2001, pp. 237–238. Penicuik, UK, BSAS.

Lillico, S.G., Sherman, A., McGrew, M.J., Robertson, C.D., Smith, J., Haslam, C., Barnard, P., Radcliffe, P.A., Mitrophanous, K.A., Elliot, E.A. & Sang, H.M. 2007. Oviduct-specific expression of two therapeutic proteins in transgenic hens. *Proceedings National Academy Sciences USA.*, 104(6): 1739–1740.

Liu, H.C., Cheng, H.H., Tirunagaru, V., Sofer, L. & Burnside, J. 2001. A strategy to identify positional candidate genes conferring Marek's disease resistance by integrating DNA microarrays and genetic mapping. *Animal Genetics,* 32(6): 351–359.

Mckay, J. 2005. *Demands of the egg and meat industries, and how they are addressed by the breeding companies.* Paper presented at the Breeding Companies' Session. Fourth European Poultry Genetics Symposium, 6–8 October, 2005, Dubrovnik, Croatia.

Minga, U.M., Msoffe, P.L. & Gwakisa, P.S. 2004. Biodiversity (variation) in disease resistance and in pathogens within rural chickens. In *Proceedings of XXII World's Poultry Congress,* June 8–12, 2004 Istanbul, Turkey. CD Rom.

Ministry of Agriculture and Cooperatives. 2005. *Socio-economic impact assessment for the avian influenza crisis: gaps and links between poultry and poverty in smallholders.* Department of Livestock Development, Ministry of Agriculture and Cooperatives, The Kingdom of Thailand. (FAO/TCP/RAS/3010e).

Muir, W.M. 1985. Relative efficiency of selection for performance of birds housed in colony cages based on production in single bird cages. *Poultry Science,* 64(12): 2239–2247.

Musharaf, M. 1990. Rural poultry production in Sudan. In E.B. Sonaiya, ed. *Proceedings of an International Workshop on Rural Poultry Development in Africa*, held Ife-Ife, 13–16 November 1989, pp. 160–165. Ile-Ife, Nigeria, African Network on Rural Poultry Development.

Mwacharo, J.M., Nomura, K., Hanada, H., Jianlin, H., Hanotte, O. & Amano, T. 2007. Genetic relationships among Kenyan and other East African indigenous chickens. *Animal Genetics*, 38(5): 485–490.

Pisenti, J.M., Delany, M.E. & Taylor, R.L. 2001. Avian genetic resources at risk: an assessment and proposal for conservation of genetic stocks in the USA and Canada. *Avian and Poultry Biology Reviews*, 12, 1–102.

Rushton, J., Viscarra, R., Guern-Bleich E. & McLeod, A. 2005. Impact of avian influenza outbreaks in the poultry sectors of five South East Asian countries (Cambodia, Indonesia, Lao PDR, Thailand, Viet Nam) outbreak costs, responses and potential long term control. *World's Poultry Science Journal*, 61(3): 491–514.

Thurner, S., Wendl, G. & Preisinger, R. 2006. Funnel nest box: a system for automatic recording of individual performance and behaviour of laying hens in floor management. In *Proceedings of the XII European Poultry Conference*, 10–14 September, 2006, Verona, Italy. CD Rom.

Pym, R.A.E., Guerne Bleich, E. & Hoffmann, I. 2006. The relative contribution of indigenous chicken breeds to poultry meat and egg production and consumption in the developing countries of Africa and Asia. In *Proceedings of the XII European Poultry Conference*, 10–14 September, 2006, Verona, Italy. CD Rom.

Qu, L., Yang, N., Li, X., Xu, G., Chen, K., Yang, H., Zhang, L., Wu, G., Hou, Z. & Xu, G. 2004. Genetic diversity of 78 Chinese chicken breeds based on microsatellite analysis. In *Proceedings of XXII World's Poultry Congress*, June 8–12, 2004, Istanbul, Turkey. CD Rom.

Rahman, M., Sorensen, P., Jensen, H.A. & Dolberg, F. 1997. Exotic hens under semi-scavenging conditions in Bangladesh. *Livestock Research for Rural Development,* 9: 1–11. Ref ID: 10.

Rosenberg, N.A., Burke, T., Elo, K., Feldman, M. W., Freidlin, P.J., Groenen, M.A.M., Hillel, J., Mäki-Tianila, A., Tixier-Boichard, M., Vignal, A., Wimmers, K. & Weigend, S. 2001. Empirical evaluation of genetic clustering methods using multilocus genotypes from 20 chicken breeds. *Genetics*, 159: 699–713.

Shanawany, M.M. & Banerjee, A.K. 1991. Indigenous chicken genotypes of Ethiopia. *Animal Genetic Resources Information*, 8: 84–88.

Sheldon, B.L. 2000. Research and Development in 2000: directions and priorities for the world's poultry science community. *Poultry Science*, 79: 147–158.

Singh, D.P., Johri, T.S., Singh, U.B., Narayan, R., Singh, D. & Saran, S. 2004. Impact of constraints minimization on productivity and popularity of traditional backyard poultry production. In *Proceedings of XXII World's Poultry Congress*, June 8–12, 2004 Istanbul, Turkey. CD Rom.

Sonaiya, E.B., Branckaert, R.D.S. & Guèye E.F. 1999. *Research and development options for family poultry*. Introductory paper. First INFPD/FAO Electronic Conference on Family Poultry, 7 December 1998 to 5 March 1999. (available at http://www.fao.org/ag/AGAInfo/subjects/en/infpd/econf_scope.html).

Van de Lavoir, M.C., Diamond, J.H., Leighton, P.A., Mather-Love, C., Heyer, B.S., Bradshaw, R., Kerchner, A., Hooi, L.T., Gessaro, T.M., Swanberg, S.E., Delany, M.E. & Etches R.J. 2006. Germline transmission of genetically modified primordial germ cells. *Nature,* 441(7094): 766–769.

Perspectives on the global markets for poultry products

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SUMMARY

In the long term, poultry consumption is expected to grow at 2 to 3 percent per year. Highly pathogenic avian influenza (HPAI) H5N1 will remain a threat to animal health, poultry supply chains and poultry. The major exporters are strengthening HPAI prevention, control and response, while zoning (regionalization) and compartmentalization protocols are being used to minimize risks. Production will expand in developing and low-cost producing regions, and stagnate in higher-cost developed regions, while short-term trade interruptions will increase largely due to sanitary concerns. Brazil will continue to strengthen its position in world meat and poultry trade, and Thailand will continue to grow as an important source of cooked products; opportunities will increase for new countries to emerge as exporters in the long term. The industry has to look at issues like global warming and use of feed stocks.

Key words: poultry, global, future, warming

1 INTRODUCTION – MARKETS

A wide array of "markets" for poultry products exists across the globe. These range from local exchanges in traditional agrarian societies to international trading relationships geared to balance global supply and demand. Thus, "perspectives" on the world's poultry markets are greatly influenced by the development status of a society, its extent of urbanization and its openness to trade. Different perspectives should not be viewed as competing visions of how poultry production and marketing systems should operate. Rather, these various food systems are the result of divergent evolutionary paths. Each system developed to meet the needs of different societies – all attempt to optimize production based on available resources, cultural norms and market demand.

2 PROJECTED MEAT DEMAND AND LOCATION

Global demand for dietary animal protein is rapidly increasing, largely due to increased prosperity and urban population growth in developing and transition economies. Because of favourable nutrient conversion efficiency relative to beef and pork, global poultry production is projected to double by the year 2030 to meet this demand. The vast majority of the global demand for poultry products will be in the form of chicken meat. Production to meet the regional demand for duck and goose will remain centred in Asia.

Using global meat demand during the years 1997–1999 as a base, it is estimated that by 2030, demand will increase by 45 percent, 57 percent and 106 percent for bovine, pork

TABLE 1
Distribution of poultry production

Species	Location
Chicken	Global
Turkey	92% North America and Europe
Duck	83% Asia
Goose	93% Asia

and poultry meat, respectively. The present distribution of poultry production is presented in Table 1.

3 GLOBAL TRADE IN CHICKEN PRODUCTS

While produced across the globe, 13 percent of chicken products consumed globally are currently traded across national boundaries. The United States of America and Brazil, combined, represent 76 percent of global exports in 2005, and they are expected to be the future big exporters. This trade in chicken products is expected to increase due to the higher demand in developing economies, many of which lack adequate resources and conditions needed for cost-effective poultry production. Additionally, the relatively high production costs in many developed nations will provide market opportunities for more competitive poultry-production regions. As tariffs decline, countries with abundant grain production, such as Brazil, are positioned to expand production further, as they offer a favourable value proposition to global customers.

4 MARKET COMPETITIVENESS AND DRIVERS

While trade disruptions due to animal health concerns are a prominent feature of the meat-trading landscape of today, countries and their animal industries are adapting to the new reality of emerging diseases by adopting various risk-mitigation strategies recognized by the World Organisation for Animal Health (OIE). Tools such as zoning and compartmentalization will minimize supply-chain disruptions when appropriately applied within a country and recognized by its trading partners. Other strategies recognized by the OIE, such as pre-cooking poultry products, will be employed to prevent trade disruptions, as evidenced by the re-emergence of Thailand's poultry-meat export industry despite being situated in a region of the world with endemic H5N1 avian influenza. Overall, the traditional and emerging factors that will drive competition can be summarized as in Table 2.

5 NOT SUPPLY CHAINS, BUT FOOD SYSTEMS

There is much talk about the supply chain, but it would be more correct to talk about food systems – in plural form. There will be not one but many models of production around the world. "Feel-good" food will not go away, and large-scale (sectors 1 and 2) production will shift closer to "feel-good" production to fill niche markets. This can already be seen in the United Kingdom, with branded birds that are raised at lower stocking densities and

TABLE 2
Market competitiveness – drivers

Traditional	Emerging
Feed quality and cost	Regulatory competency
Housing and capital cost	Capacity and capability of animal health services
Domestic market profile	Trust with trading partners
Climate	Freshwater availability
Growers' margin	Environmental footprint
Talent and cost of labour	Citizenship issues
Co-product values	
Exchange rates	

take longer to grow to market size. This is the "happy hens" concept. It is predicted that commercial production will look more at these types of production methods because niche markets are growing. It would be desirable to have "principle-based" production systems. Big industry has a responsibility to do things right in terms of environmental impact, animal health, good biosafety practices and disease surveillance. Over the long term it is predicted that there will be more sector 1 and sector 4 production and fewer sector 2 and 3 production systems.

6 CONCLUSION

The industry needs to start looking at issues such as global warming and use of feed stocks. Cargill raised the issue of the use of feed stocks over two years ago and argued for caution.

Global feed issues affecting the Asian poultry industry

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SUMMARY

The global poultry industries have traditionally faced competition for feed ingredients from other animal industries such as pork and aquaculture. To this should be added the prospect of future competition from ethanol production. This situation gives rise to a need to search for alternative feed ingredients. In this paper it is argued that the use of by-products, and in particular the use of fibre, as an energy source in poultry diets will be an important means to meet future feed requirements. Technologies such as solid state fermentation complex enzyme systems hold the key to closing the feed-availability gap and providing the additional feed ingredients much needed by the poultry industry.

Key words: poultry, feed, competition, future, technologies

1 INTRODUCTION

Will ethanol displace gasoline or simply take food off our plates and feed from our animals? That was the question posed by Dr Lyons (Alltech President) to delegates at a recent feed industry symposium. To all involved in the poultry industry, this question has great significance and should perhaps sound a few alarm bells. Competition for feed ingredients will become even more pressing given the already increasing pressures that poultry industries globally are encountering from other animal industries such as pork and aquaculture, which in many cases are vying for the very same feed ingredients. In this paper we look at meat consumption, its growth trends, and the feed required to sustain this growth. In particular, we examine the competition for feed grains between the poultry and pork industries and their respective feed-ingredient requirements. We briefly look at the impact of the "ethanol for fuel movement" on maize production and availability. Finally, we look at ways to alleviate the present and future pressures on poultry feed grains and ingredient availability.

2 MEAT PRODUCTION AND CONSUMPTION

The relationship between affluence and meat consumption is well established, showing a clear increase in meat consumption with increased per capita income. As a consequence, today's feed production has tended to be concentrated in Europe and North America. For example, the Netherlands produces approximately 0.81 million tons of feed per million people, while China and India produce approximately 0.07 and 0.01 million tons of feed per million people, respectively. Asia accounts for a larger portion of the global population than any other region; China and India together account for over 2 billion people. Given this large population, there is a significant imbalance in feed production in Asia. In tomorrow's world, we will be confronted by significant increases in per capita consumption by an ever increasing global population. This situation is hugely magnified in the Asia–Pacific region, with annual meat consumption in China alone predicted to increase from about 50 kg per capita today to approximately 70 kg per capita by 2030.

It is sobering to look at this increase in meat consumption in light of the animal feed needed to deliver the required increase in production. Currently, approximately 720 million tons of feed produced globally. It is estimated that the feed required to produce 20 kg of extra meat for China's 1.5 billion people in 2030 will represent an extra 320 million tons of feed, and that this will bring global feed production to 1 300 million tons (Lyons, 2007). As a whole, Asia in 2015 will represent more than 60 percent of the global population, more than 70 percent of global pork consumption, and more than 35 percent of global chicken consumption, requiring approximately 391 million tons of pig and poultry feed. Even if the largest producers of grains such as Brazil, Argentina, the United States of America and Ukraine could double grain production, there would still be insufficient feed available to deliver the extra 20 kg of meat to China, let alone to meet the needs of Asia as a whole. The question is then: where will this extra feed come from? And, more importantly: where will the raw materials for these feeds come from?

3 ETHANOL PRODUCTION

The push towards biofuels is partly explained by a desire to be energy independent – to reduce dependency on the 140 billion gallons of gasoline consumed annually in the United States of America alone. It is also driven by the Kyoto Protocol, which mandates greenhouse gas reduction. In the United States of America, a target of 7.5 billion gallons of ethanol by 2012 has already meant that there are 111 dry mill ethanol plants in operation, with a further 80 or more being built, which will consume 60 million tons of grain and produce 20 million tons of distillers dried grains with solubles (DDGS) annually (Lyons, 2007). Increasing this target five-fold means 400 more ethanol plants. The "ethanol for fuel movement" has led to the single largest construction and investment programme ever in United States agriculture, with over US$ 70 billion invested in 2006 alone. Iowa: the heart of the country's "Corn Belt" has dozens of distilleries, with many more under construction. Ultimately, this will mean that globally about 3 million more tons of DDGS will be produced than soy (116 million tons DDGS vs. 113 million tons of soy). Where is all this grain going to come from? There are 2 000 million tons of grain scattered around the world, a quantity which while large, is very finite (Lyons, 2007).

Can we increase maize production? The answer is yes, but at a cost. In fact, in 2007 there will be a shift away from soy acreage planted towards maize (some 3–4 million acres of soy) thus driving up the price of soy. In Asia, not only will we be confronted by ever increasing grain prices, but very soon we will have major problems sourcing the grain needed to sustain increased meat production and meet the growing demands of Asian consumers.

4 GLOBAL CHALLENGES TO POULTRY FEED PRODUCTION TODAY

As previously stated, Asia in 2015 will represent more than 60 percent of the global population, more than 70 percent of global pork consumption, and more than 35 percent of global chicken consumption, requiring approximately 391 million tons of pig and poultry feed. If current trends continue, pork will be the most consumed animal protein, globally, and most certainly in Asia. What does this mean for poultry production and from where will the poultry industry in Asia get its "share" of feed grains and ingredients?

The Asian poultry industry will have to look to history for the feed solutions of the future. For tomorrow's feed solutions lie in by-product utilization. The use of vegetable by-products (from rice and wheat), oilseed meals (soy, rapeseed, coconut, palm), starch/distilling by-products (DDGS, cassava residue, sweet potato, wheat/sorghum) and other novel plant materials and by-products will become paramount in ensuring that the poultry industry has adequate feed ingredients to meet increased demand.

5 POULTRY SOLUTIONS FOR THE FUTURE

A typical poultry diet, contains approximately 70 percent cereal grains and 25 percent soybean meal, and has a digestibility of only 75 percent. This means that, in effect, 25 percent of the feed is being wasted. Can we use soy as an energy source rather than just as a protein source? Do we think of soy as a protein source, but overlook the fact that it also contains 35 percent carbohydrates – including various fibres and non-starch carbohydrates? We sometimes fail to consider these facts, and in many cases take for granted the amount of fibre we waste in both poultry and pork production. With world cereal production (soy and grain) at some 2.5 billion tons, nearly 800 million tons are wasted. When copra meal, palm kernel meal, and the myriad of fibrous by-products are added to the equation, we realize that with limited grains, animals in the future will have to use fibre in their diet. In a recent review, Lyons (2007) noted that some 4 000 years ago, the Chinese faced similar problems to those we face today – limited protein and poor digestibility of raw materials. They developed what is called the "koji" process – or solid state fermentation (SSF) – in which the organism does the digesting for us.

The role of SSF enzymes as a means to utilize the fibre component in poultry diets has been gathering significant momentum, and much has been done to demonstrate the efficacy of such technologies. Rutz *et al.*, (2007) report that a natural SSF enzyme complex is extremely effective in releasing energy and reducing gut viscosity, both of which are important considerations when utilizing by-products such as wheat bran in animal diets while maintaining performance. The future, however, will see next-generation SSF products that will be tailored to the by-product used. Different micro-organisms and strains will be screened and selected for maximum fibre utilization for particular by-products.

6 CONCLUSION

Feed is the major (65–70 percent) cost in pig and poultry production, so it is essential to minimize feed costs. The search for alternatives to maize and soybean as sources of feed ingredients, and hence of a means to reduce feed costs, is not a new matter for nutritionists. However, the situation has recently been significantly aggravated by the fact that much of the maize formerly used in animal diets will be diverted to ethanol production. In addition, in Asia we see a significant increase in poultry consumption; this will mean that we face a large gap in the availability of feed grains to sustain poultry meat production. The use of by-products, and in particular the use of fibre as an energy source, in poultry diets will be the key to meeting the increased need for feed ingredients. Technologies such as solid state fermentation complex enzyme systems hold the key to closing the feed-availability gap and providing the much needed "extra" feed ingredients to take the Asian poultry industry to 2015 and beyond.

REFERENCES

Lyons, T.P. 2007. In *Biotechnology in the feed industry*: Proceedings of Alltech's 23rd Annual Symposium. May 20-23, 2007, Lexington, Kentucky, USA, pp. 1–10. Lexington, USA, All-tech.

Rutz, F., Anciuti , M.A., Xavier E.G., Rossi, P. & Brum, B. 2007. *In* 21*st Alltech Asia–Pacific Lecture Tour.* (in press).

Feed availability inducing structural change in the poultry sector

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SUMMARY

Feed is the most important input for poultry production in terms of production costs. Poultry have high requirements for protein and energy density to ensure their performance. Feed costs for intensive boiler or layer production amount to about 70 percent of total production costs. The availability of high-quality, low-cost feed is a crucial prerequisite for poultry production. Therefore, structural changes in feed production and feed market prices have an impact on the poultry sector in structural terms. This paper presents a retrospective description of developments in feed and poultry production. The impact of developments in feed production and availability on the structure of the poultry sector is assessed. The developments considered include technological progress, subsidies and competing demand for feedstock as an input for biofuel[1] production. Current trends in the feed sector are assessed, and a hypothesis about their impact on structural changes in the poultry sector is proposed.

Key words: poultry, feed, structure, change

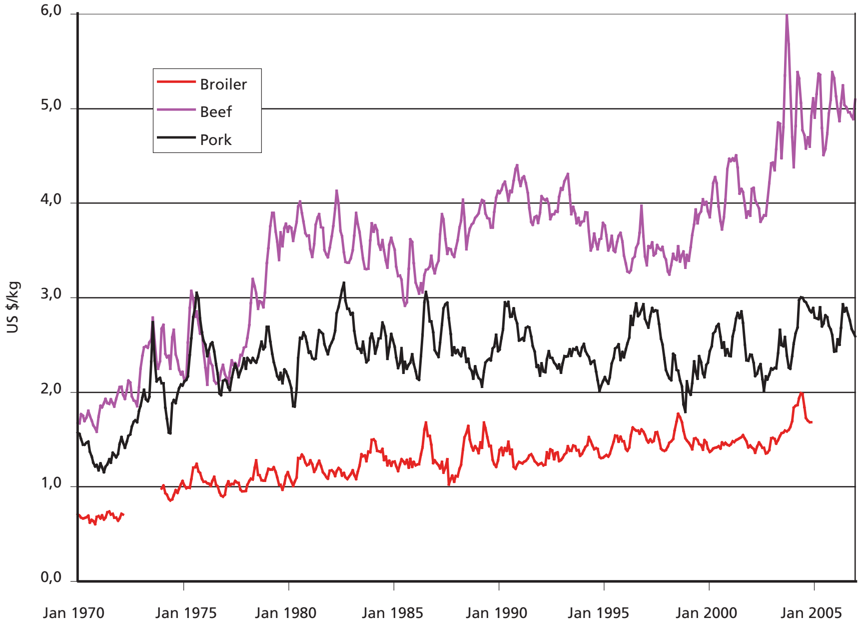
1 INTRODUCTION

The availability of relatively low-priced, high-quality feed is a crucial prerequisite for competitive poultry production. The high productivity potential of poultry, resulting from its efficient feed conversion compared to other livestock, can only be achieved with protein and energy-dense feed (Chadd, in FAO, 2008a). These high feed-quality requirements result from the relatively small monogastric stomachs of poultry. Low-intensity poultry production systems making use of low-quality left-over feed are characterized by relatively marginal meat growth rates and low egg yields.

Subsidized crop production created surpluses in Europe and North America and made feed available at relatively low costs. Before these surpluses became available, low-intensity poultry production systems prevailed not only in developing but also in developed countries. There have been several waves of poultry sector development and intensification of production systems. Together with changes in the demand for livestock products, these

[1] Biofuel is usually defined as any fuel from organic (non-fossil) material. Within the context of this paper biofuel is used for liquid fuels derived from feedstocks.

FIGURE 1
Broiler, pork and beef wholesale prices in the United States of America



Source: USDA.

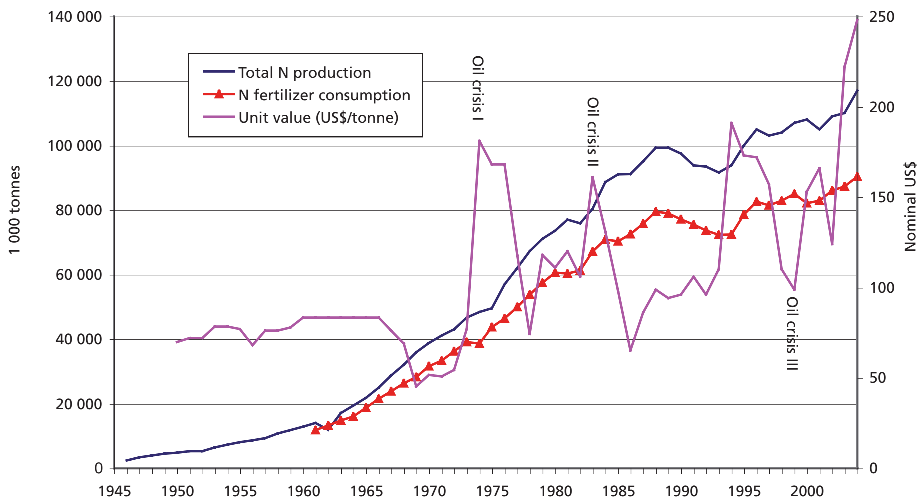
developments can be seen as a result of changes in the feed market.

Poultry meat has a comparative production-cost advantage over pork and beef because of its more efficient use of feed. As can be seen from Figure 1, the wholesale price of broiler meat in the United States of America has been below beef and pork prices.

2 FEED SURPLUSES INDUCING A FIRST WAVE OF POULTRY-SECTOR GROWTH

After the Second World War, nitrogen fertilizer became increasingly available (Figure 2). Existing production capacities were used for the Haber-Bosch ammonia synthesis process (Smil, 2004). The subsequent increased use of nitrogen fertilizer, together with other technical progress in crop production such as breeding and mechanization, resulted in significantly higher crop yields. Crop surpluses made feed for poultry production increasingly available. A first wave of intensified poultry production using high-quality feed inputs occurred in the United States of America in the 1950s and in Europe in the 1960s. Industrialized poultry production supplied the increasing demand for animal-based protein which was arising from growing incomes. Feed surpluses were a prerequisite for poultry-sector intensification and contributed to the industrialization of the sector.

FIGURE 2
World nitrogen production



Sources: U.S. Geological Survey; fertilizer consumption from IFA Databank.

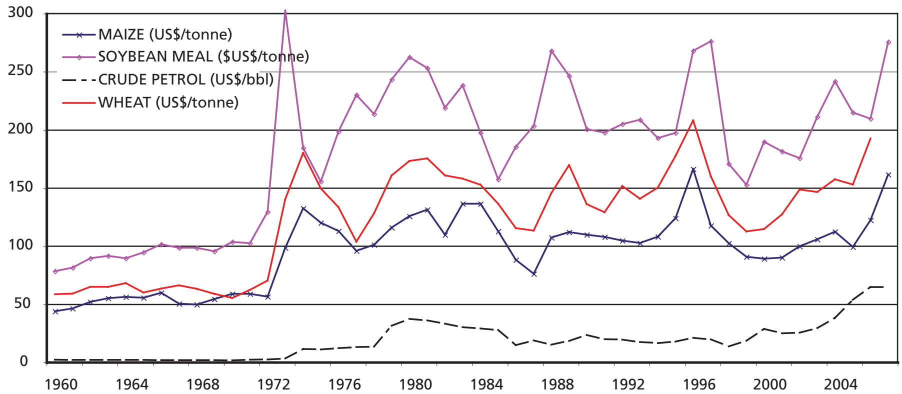
3 SUSTAINED SECTOR GROWTH FUELLED BY CROP PRODUCTION SUBSIDIES

Subsequent to the first wave of poultry-sector intensification, the demand for animal-based protein increased simultaneously with income growth in developed countries. Additional demand for meat resulted from rising incomes in developing countries, especially in emerging economies in Asia. The increased demand for meat was met through sustained growth and intensification of beef, pork and broiler production. Developing countries were applying the same intensified poultry production systems. These trends led to an accelerated demand for high-quality feed. Between 1975 and 1985 the global quantity of manufactured feed increased by 52 percent to 440 million tonnes (Feed International, 2002). During this period, several shocks and an increased nominal price level occurred for major feed commodities (see Figure 3).

A variety of substantial subsidies for crop production were paid, including for the major feed commodities. Subsidies for various agricultural products are paid in developed countries. OECD Producer Subsidy Equivalent (PSE) is an internationally recognized unit of measurement. It represents the monetary equivalent of the gross transfers to agricultural producers, measured at farm-gate prices. The PSE is the only available and internationally comparable indicator of support levels in agriculture in OECD countries. In Figure 4 the commodity PSE is presented as a percentage share of farm-gate prices.

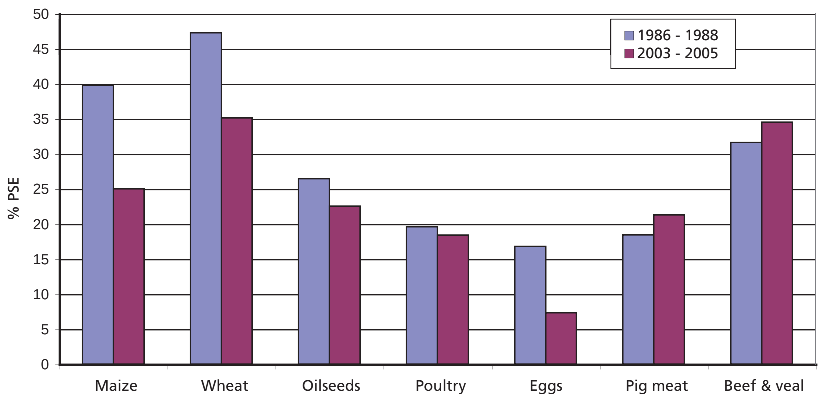
During the time period 1986-1988 the PSE for the production of maize and wheat, respectively, averaged at 40 percent and 47 percent of the farm-gate price. Compared to the level of direct support for poultry meat, eggs or pig meat, the support level for these main feed commodities was substantially higher. It is also worth noting, that all PSE levels

FIGURE 3
World market prices for maize, wheat, soybean meal and crude petrol



Note: bbl = barrel.
Source: World Bank (2007).

FIGURE 4
Subsidy levels for OECD countries for different agricultural commodities

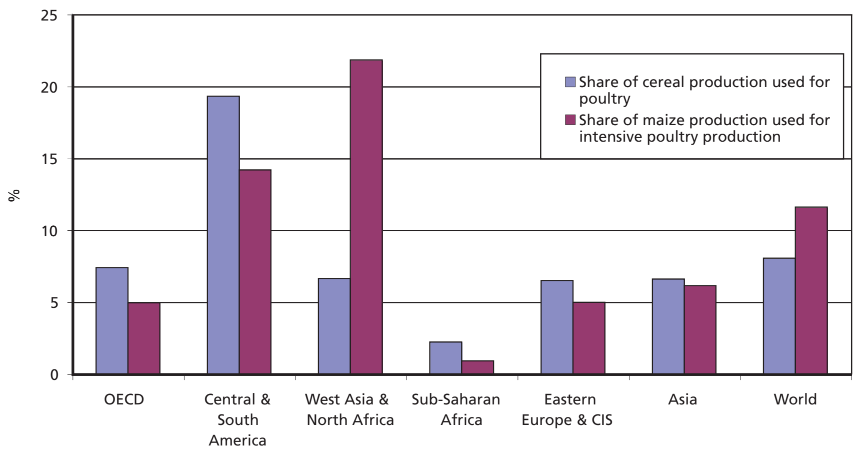


Sources: OECD (2007).

presented in Figure 4 are lower for the time period 2003-2005, with the exception of pig meat and beef and veal, which showed increased PSE levels. The high support levels for feed commodities and their subsequent use in livestock production imply a substantial indirect support.

Subsidies for crop production meant that feed continued to be available at relatively low costs in the world market; this fostered another wave of poultry-sector growth in both developed and developing countries. For example, exports of maize and soybeans from the United States of America, a major contributor to international trade in these products, are

FIGURE 5
Share of cereal production used for poultry



Sources: Gerber *et al.* (in FAO, 2008b) and FAO (2002).

estimated to have been 19 percent and 12 percent, respectively, below production costs during the period from 1997 to 2003 (IATP, 2005). In the United States of America, about 55–65 percent of maize and 45–50 percent of soybeans are used for domestic livestock production, which also results in substantial support for the sector (Wise, 2005).

The availability of low-cost feed commodities also enabled poultry-sector growth in feed-importing countries. Imports of low-cost feed stocks, together with a protection policy for poultry products, facilitated accelerated growth of the domestic poultry sector. Based on poultry production output data for boiler meat and eggs, it can be estimated that a total of 294 million tonnes of feed and 190 million tonnes of cereal were utilized for poultry production in 2004 (Gerber et al., in FAO, 2008b). About 8 percent of world cereal production is used for poultry production, but the proportion varies substantially between regions (see Figure 5). For intensive poultry production systems, the share of maize used is also shown in Figure 5. In Central and South America, the share of cereal production utilized for poultry production is relatively high. In West Asia and North Africa, large amounts of cereals are imported. During the period 2001-2003 about 8.4 million tonnes of maize were imported, while at the same time only 1.7 million tonnes of maize were exported (Steinfeld et al., in FAO, 2006, p. 367). More than 20 percent of the regional production of maize is used for intensive poultry production. Poultry production in this region is benefiting from low-cost maize imports.

4 TRENDS IN FEED PRICES AND THE IMPACT OF BIOFUEL PRODUCTION

Several factors are causing a rise in feed prices. The demand for livestock products, and therefore feed commodities, is likely to increase as a result of rising incomes in emerging countries. At the same time, direct subsidies for crop production continue to decrease, and additional demand for cereals is resulting from the fast growing biofuel production sector.

In 2006, about 45.6 billion litres of bioethanol and 7.6 million litres of biodiesel were produced (FAPRI, 2007). Brazil and the United States of America are the main producing countries for bioethanol, with a share of 80 percent of total production; conversely, the European Union (EU) is producing 81 percent of total biodiesel. The most common inputs for biofuel production are maize, sugarcane, oilseeds and cassava. The 2006 annual production of biofuel in Brazil required 206 million tonnes of sugar cane, while 55 million tonnes of maize were used in the United States of America. In the EU, about 8 million tonnes of oilseeds were used for the production of biodiesel in 2006 (OECD/FAO, 2007).

The use of feed commodities for biofuel production is likely to increase within the next decade due to the expected high oil prices, sustained policy support, and sunk investment costs in biofuel production capacity. A second generation of biofuel production techniques, utilizing non-feed cellulosic inputs is not likely to be competitive during this time horizon (Naylor et al., 2007). FAPRI (2007) projected a 94 percent increase in bioethanol production by 2016. This would require 264 million tonnes of maize, assuming it is the only feed input used and conversion efficiency stays the same. In view of these trends, the question that has to be addressed is whether increasing demand for feed commodities can be met by expanding production, and at what costs? Increased crop production via increased productivity and expansion of arable land might be feasible; the technical potential for improving crop production is under-utilized (FAO, 2002, p. 40). However, yield improvements and expansion in marginal land will only be achievable with increasing marginal costs of production. Therefore, increased prices for feed commodities can be expected in the future.

Several price shocks can be noted in the nominal price series data presented in Figure 3. Since the end of 2006, prices for feed commodities such as maize, wheat and soybean meal have increased by more than 50 percent. This might indicate a new price level for feed commodities resulting from additional demand for biofuel production.

With rising crude oil prices and policy support for biofuels, investments in biofuel production facilities are becoming increasingly profitable. Given a complete market integration of the feed market into the energy market, the break even point for feed-based biofuel production would become a long-term floor price for feed commodities. The energy market is relatively large compared to the feed market, and would therefore, in the long term, drive feed prices up to a ceiling price at which feed stocks would no longer be competitive.

Complete energy and feed market integration has not yet been reached. Sufficient capacity in terms of biofuel production facilities and an effective distribution system for a flex-fuel fleet would be the necessary conditions for full market integration. Nevertheless, impacts of feed-based biofuel production can already be observed. The Brazilian market for sugar cane, for instance, is already completely integrated, and a strong co-movement of sugar cane and oil prices can be demonstrated (Schmidhuber, 2006).

The impact of the use of maize and cassava for bioethanol production in the United States of America and China is not limited to raising the prices of these commodities. Considerable ripple effects are evident in the shape of increased prices and changes in the planted area of other feed crops (Naylor et al. 2007). In addition, the crude-oil market is relatively volatile. Over the last 25 years, the volatility of crude-oil prices has been more than twice as high as that of maize, wheat or soybean meal prices, based on the coefficient of variation. Price-shock transmissions from the energy market into the feed market can therefore be expected in the future.

In the case of protein-rich feed stocks, price increases resulting from rising demand for biofuels are expected to be limited (Schmidhuber, 2006). Additional protein-rich co-products from the use of feed commodities for biofuel production would be available for livestock. The co-products in question are: dried distiller grains with solubles (DDGS); maize gluten feed and germ meal from wheat and maize used for bioethanol; crushed stover from cassava used for bioethanol; and soybean and rapeseed meal from biodiesel production. To a limited extend, these are valuable protein ingredients for poultry diets (Chadd, in FAO, 2008a).

5 CONCLUSIONS AND OUTLOOK

The rapidly increasing demand for livestock-based protein can only be met on the basis of intensified production systems. Cereal prices and oil prices have become linked, and projections that model the impact of biofuels show significant increases in prices for feed commodities (Schmidhuber, 2006). Energy market shocks will transmit into the feed market and increase market risk for poultry production. Risk-mitigation strategies for capital-intensive poultry production will become increasingly important in order to cope with market shocks. In the competition for the scarce resource feed, poultry has competitive advantages over other livestock as it has the best feed conversion rate. Poultry production cost will rise as a result of higher feed costs, but good feed conversion rates give a comparative advantage over other livestock production systems. In particular, the efficient conversion of feed energy into meat by broilers provides a comparative cost advantage over other livestock sectors (Chadd, in FAO, 2008a). The changes in feed production are favouring and accelerating poultry-sector growth and inducing structural changes towards intensified production systems. Animal diets will become more diversified due to the use of biofuel co-products with valuable protein content.

REFERENCES

FAO. 2002. *World agriculture: towards 2015/2030. Summary report.* Rome. (available at http://www.fao.org/docrep/004/y3557e/y3557e00.htm).

FAO. 2006. *Livestock's long shadow. Environmental issues and options*, by H. Steinfeld, P. Gerber, T. Wassenaar, V. Castel & C. de Haan. Rome

FAO. 2008a. Future trends and developments in poultry nutrition, by S. Chadd. *In* O. Thieme & D. Pilling, eds. *Proceedings of the International Conference Poultry in the Twenty-first Century: avian influenza and beyond*, held 5–7 November 2007, Bangkok, Thailand. Rome.

FAO. 2008b. Poultry production and the environment – a review, by P. Gerber, C. Opio & H. Steinfeld. *In* O. Thieme & D. Pilling, eds. *Proceedings of the International Conference Poultry in the Twenty-first Century: avian influenza and beyond*, held 5–7 November 2007, Bangkok, Thailand. Rome.

FAPRI. 2007. *World Agricultural Outlook 2007*. Ames, Iowa, USA, Food and Agricultural Policy Research Institute, Iowa State University. (available at http://www.fapri.iastate.edu/outlook2007/text/OutlookPub2007.pdf).

Feed International. 2002. *World feed panorama survey 2001 data*. Rockford, IL, USA.

IATP. 2005. *WTO agreement on agriculture: a decade of dumping*. Minneapolis, USA. The Institute for Agriculture and Trade Policy. (available at http://www.iatp.org/iatp/publications.cfm?accountID=451&refID=48532).

IFA. *International Fertilizer Industry Association Databank.* (available at http://www.fertilizer.org/ifa/statistics/IFADATA/DATA/world.xls).

Naylor, L., Liska, A., Burke, M., Cassman, K., Falcon, W., Gaskell, J. & Rozelle, S. 2007. Ripple effects of crop-based biofuels on global food security and the environment. *Environment,* 49(9): 31–44.

OECD. 2007. *PSE Database*.

OECD/FAO. 2007 *Agricultural outlook*. Organization for Economic Co-operation and Development Publication No. 88353. Paris/Rome. (available at http://www.oecd.org/dataoecd/6/10/38893266.pdf).

Schmidhuber, J. 2006. *Impact of an increased biomass use on agricultural markets, prices and food security: A longer-term perspective*. Paper prepared for the International symposium of Notre Europe, Paris, 27–29 November, 2006. (available at http://www.fao.org/es/esd/Biomass-NotreEurope.pdf).

Smil, V. 2004. *Enriching the earth. Fritz Haber, Carl Bosch and the transformation of world food production.* Cambridge, MA, USA, M.I.T. Press.

U.S. Geological Survey. *United States Geological Survey Data Series 140.* (available at http://minerals.usgs.gov/ds/2005/140/).

USDA. *United States Department of Agriculture data sets on meat price spreads*. (available at http://www.ers.usda.gov/Data/meatpricespreads/).

Wise, T. 2005. *Identifying the real winners from U.S. agricultural policies*. Global Development and Environment Institute Working Paper No. 05-07, Medford, MA, USA, Tufts University. (available at http://ase.tufts.edu/gdae/Pubs/wp/05-07RealWinnersUSAg.pdf).

World Bank. 2007. *World Bank, commodity price data.*

Social impacts of structural change in the poultry sector

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SUMMARY

This paper attempts to highlight the social impacts that could be important as the poultry sector changes shape, although there is limited published evidence on which to draw. The paper begins by outlining some of the features of structural change, which are described in more detail in other papers presented at this conference. It then takes three areas of social impact and examines them briefly in relation to structural adjustments: culture change, as exemplified by changes in consumption and marketing of poultry products; livelihoods impacts, under each of the five "capitals" of the livelihoods framework; and gender effects. It concludes by drawing some lessons for policy-makers and development agencies.

Key words: adjustments, change, poultry

1 INTRODUCTION

Papers presented earlier in this conference and the working papers prepared as background indicate that the poultry sector is already changing shape and is likely to continue to do so. Changes in structure of the sector can be expected to have impacts on social factors: the food that people consume, their social networks, the way in which they make their living, and gender dynamics within households and in society.

There is limited published evidence on which to draw, and the data available from recent studies are seldom disaggregated by social criteria; nevertheless there are clear indications of the relationship between the organization of the sector and the lives of people that make a living from it or use its products. The paper begins by revisiting the features of structural change in the poultry sector, something that is described in more detail in other papers presented at this conference. It then briefly examines three areas of social impact: culture change, exemplified by changes in consumption and marketing patterns; livelihoods impacts, under each of the five "capitals" of the livelihoods framework; and gender effects. It concludes by drawing some lessons for policy-makers and development agencies.

2 STRUCTURAL CHANGE

Extrapolating from the pattern in China, India, Brazil, the United States of America and Thailand, structural change implies:

- functional concentration – fewer production units but larger ones, fewer live-bird markets and traders on bicycles, small slaughter points replaced by larger slaughterhouses, and more large retail outlets;

- geographic concentration or relocation of feed production, markets, poultry production and processing facilities; and
- integration of market chains, with control in the hands of large companies which may contract farmers to carry out operations on their own farms, or employ managers and workers in company enterprises.

Any combination of these trends will have an effect on the actors who participate in the poultry sector and on the roles that they play. The number of people making a living in the sector may remain the same, although this depends on the employment structure within a market chain – in a vertically integrated and concentrated chain there are likely to be fewer people involved in primary production and transport, but more employed in processing and retailing. However, unless cooperative models of ownership can be made to operate successfully, there will be a shift from single or family ownership of premises and enterprises towards employment in large companies.

Notwithstanding this trend is the fact that large numbers of people keep small flocks, with those scavenging in the backyard representing a safety net that requires very little investment. Table 1 shows figures for Southeast Asian countries. In Africa smallholder production is estimated to range from 16 percent (Nigeria) to over 90 percent (United Republic of Tanzania).

Small-scale commercial poultry development has been promoted by development agencies and practitioners as a route out of poverty. The model for smallholder poultry development pioneered by the NGO BRAC in Bangladesh and adapted for use in Afghanistan, India, Sri Lanka, Sudan, Uganda, and the United Republic of Tanzania, is one example that has provided many people with a route out of poverty (Dolberg in FAO, 2007a). It divides the production cycle into distinct activities with different people involved in (and specialist in) each. Will this model and others like it be competitive if there is an accelerating trend towards concentration and relocation? What are the implications for people who have invested large proportions of their income in poultry enterprises?

TABLE 1
Ownership of backyard and small commercial poultry flocks: Southeast Asia

	Small commercial	Backyard
Cambodia	< 1% of poultry	99.9% of farms, 90% of poultry
Indonesia	11.80% of poultry	63.4% of poultry
Lao People's Democratic Republic	10% of poultry	90% of poultry
Thailand	10% of production, 98% of producers	
Viet Nam	10–15% of production, few producers	65% of production, possibly 70% of poultry

Source: Adapted from Rushton *et al*. (in FAO, 2005).

3 CULTURE CHANGE

If culture is defined as the attitudes and behaviour of people or "the way we do things", then changes to the shape of the poultry sector both affect and are affected by culture. We will use food-consumption patterns to illustrate the point. On a recent visit to Hunan Province China, it was striking to find two very different cultures of marketing and consumption existing, for the time being, side by side (Figure 1).

A "wet" market had many kinds of eggs on display – from fresh to preserved, accessible to people to pick their own. Live poultry were kept in cages where the buyer could select a duck or chicken, which was promptly killed and defeathered. There was also "warm" meat on sale, nothing chilled or preserved. A large global supermarket chain, which had an outlet in the city not many kilometres away also sold many kinds of eggs, but all packed and sealed in plastic. Figure 1 shows preserved egg yolks, hygienically sealed and easy to prepare, and a rotisserie where the consumer can buy a freshly roasted bird and take it home to heat up and eat. There were also many kinds of chilled, frozen and dried poultry meat.

Economic growth and urbanization in eastern China are both affecting culture: the demand for products from supermarkets grows as more people move to cities and become richer, and women in particular have more money and less time to spend on food preparation. Economic policy is accelerating cultural change as it is easier now than formerly

FIGURE 1

Traditional" and "urbanized" marketing of poultry products, Hunan Province 2007

Traditional: a wet market

Urbanized: a supermarket

for global businesses with very large retail outlets to invest in China. These cultural and economic changes are driving a change in the structure of the sector, as large retail outlets demand reliable supplies of safe products, which are easier to obtain from larger producers. At the same time, there remains a large demand for fresh products from local markets, perhaps from less wealthy or more traditional consumers, perhaps from people who prefer to trust their judgment and buy meat from birds that they have seen alive.

If China follows a similar pattern to that of the industrialized countries, consumption patterns will split between a large demand for cheap and convenient food, and a continuing but much smaller demand for specialized (and expensive) foods including those that are very fresh and from known sources. Large retail outlets already sell such a range of products, and the products on sale vary from province to province to suit local tastes. Some people will choose to use the large outlets and diversify their food consumption – others may be forced to change their consumption habits for economic reasons.

4 LIVELIHOODS

The sustainable livelihoods framework identifies five types of "capital" that are necessary to people. Poultry contribute in some degree to all of them (FAO, 2007b).

4.1 Human capital

Human capital directly builds up the health and capability of people, particularly nutrition and education. Poultry in small flocks contribute directly and indirectly to household nutrition. A survey in rural Turkey found that poultry meat and eggs contributed on average 40 percent (minimum 25 percent, maximum 60 percent) to total protein intake (Geerlings, in FAO, 2006). In Egypt, income losses after outbreaks of highly pathogenic avian influenza (HPAI) forced households to cut down on household expenses and change their diet in favour of cheaper food items (Geerlings *et al.,* 2007). Structural change that leaves very small flocks and small rural markets untouched will allow poultry to continue to contribute to household nutrition.

4.2 Social capital

Poultry contribute to social obligations and religious ceremonies, and in some cases they need to be specialized birds of local breeds. In Egypt and Turkey, for example, it is traditional to provide poultry meat and eggs to visitors, and when these are not available social occasions are fewer. Women who own and sell birds have opportunities to network and may have increased social standing. Income from sales of poultry products provides women with money for their daughters' trousseaus or to buy cell phones. In the United States of America and the United Kingdom, the sale of turkeys for roasting soars at Thanksgiving and Christmas.

Fighting cocks form a specialized, although usually illegal, part of the social fabric. They have a very high value to their owners, some of whom are extremely wealthy, and are associated with gambling and other risky activities.

Traders of poultry and eggs have a social as well as an economic place in society. Small traders on bicycles travelling in a radius of 20 or 30 km from their home base carry information between villages, and this adds to their social standing.

FIGURE 2
"Pheriwallahs": small traders of poultry in West Bengal, India, 2007


PHOTO CREDIT: MAMTA DHAWAN.

Structural change could pose a large threat to the social capital of small-scale urban poultry keepers, such as those in Egypt with very small rooftop flocks, who may lose a source of social capital without being able to find an obvious substitute. Small traders in peri-urban and urban areas may find their supply chains disrupted or relocated beyond their reach.

4.3 Natural capital

Herded duck flocks have a special place in the ecology of paddy rice systems, where they scavenge for crop residues, insects and snails, and deposit manure; their presence has been found to increase the root growth of rice. In Turkey, rural women list insect control as one of the reasons that they like to keep chickens (Geerlings, in FAO, 2006). Mixed enterprises where ducks or geese share the same pond as fish and provide manure for nutrition are also a profitable and ecologically sound part of mixed farms in wetter areas of Asia.

Natural capital may be most affected by structural change if this involves banning extensive duck production – a possibility in Southeast Asia where there are concerns about persistence of HPAI virus in extensive ducks systems in wetland areas.

4.4 Financial capital

In many countries, poultry owned by poor families provide income for their owners. In Egypt, poultry can contribute 44 percent of income, or up to 90 percent at certain times for very poor households (Geerlings *et al.*, 2007). This is an unusually high figure; by contrast, in Viet Nam's "delta" areas in the north and south of the country, very small poultry flocks owned by poor families contribute approximately 5 percent of the income of their owners (ACI, 2006b). Small poultry flocks are a convenient part of the livelihoods portfolio because they need little investment and can be managed from home with family labour.

Small commercial flocks have been an accessible first step out of poverty for many farmers in Asia and Africa, but are particularly vulnerable to structural change. In India, the Kuroiler value chain (described by Ahuja and Sen in FAO, 2008) appears to be flourishing as an intermediate step in structural change. It is longer and more formal than the value chains usually associated with village flocks, but less concentrated than commercial broiler chains. The Kuroiler is a five-way cross that has the hardiness of a traditional bird but grows larger and faster. Eggs are supplied from the parent company to hatcheries, which produce day-old chicks for sale to "mother units" kept by village entrepreneurs. They raise the birds to two or three weeks old in netted houses, vaccinate them and sell them to pheriwallahs (small traders) or directly to owners of scavenging flocks in the same village.

An evaluation of the impact of the value chain is currently under way; initial impressions suggest that it provides a livelihood to large numbers of people, the level of investment and profit increasing with concentration up the chain. Those owning scavenging flocks have made some changes to their previous practice, as they now have to buy young birds instead of rearing them, but otherwise keep the birds and market them in much the same way as the traditional "desi" breed, which still makes up part of the village flock. Pheriwallahs retain their old modes of transport and range of travel, but spend a large proportion of their time trading in Kuroilers. The mother units are an introduction to the system for those who have more to invest and prefer a village-based enterprise to employment or a business in town.

By contrast, Viet Nam had a dynamic small commercial poultry sector with farmers in villages rearing flocks of up to a few hundred "white feather" birds from day-old chicks supplied by large breeding companies, who also provide feed and advice. During the HPAI outbreaks and subsequent adjustments to the sector in Viet Nam in 2005–2006, these farmers were badly hit and slower to recover than larger enterprises. Some have recovered and are flourishing while others have permanently lost a large part of their market share (ACI, 2006a and b).

Structural change has the potential to reduce financial capital for some while increasing opportunities for others. Entrepreneurial small-scale producers, who are able to upgrade to meet the needs of concentrated market chains, may convert to contract production, borrow money to invest in more biosecure premises or form cooperatives. Some people who have never worked in primary poultry production may find employment in processing or retailing. Producers and market operators who are less agile, more vulnerable, or located in places where regulations are more strictly applied (e.g. within or close to cities) will find their livelihoods reduced and will need to seek alternatives. If structural change is guided by risk assessment and adapted to local needs, rural backyard flocks need hardly be affected.

4.5 Physical capital

Small-scale commercial flocks require investment in physical capital: fences, poultry houses, netting to exclude wild birds, feed storage. Many owners of small commercial flocks borrow money, often at high rates, to make their initial investments. To a certain extent this is a sunk cost, as not all of it can easily be converted to other uses if the owner changes from poultry to another enterprise.

FIGURE 3
Physical capital associated with small commercial poultry flocks in Asia

4.6 Gender

Gender includes dimensions of women's welfare, children's welfare and household dynamics, in all of which poultry play a part. Backyard poultry are mostly owned and managed by women. Small-scale commercial poultry are often owned and sometimes traded by women. In many West African rural communities, children have care of poultry. This is a means by which they make a contribution to the family and also gain experience of taking responsibility and sometimes earning income. Poultry houses are constructed with very small entrance-ways, through which only children can pass, and this reduces the chance of theft by adults.

FIGURE 4
A woman owner of a backyard flock in Egypt

Source: Geerlings *et al.* (2007)

Structural change may bring up problems if it requires family members to change from ownership of a flock to employment in a business outside the home, means that people must own land or have access to capital in order to participate in changes, or requires an enterprise to be moved to a different location.

A small flock kept near the house, whether scavenging or enclosed, is a family-friendly and fairly time-flexible enterprise that allows some members of the family to earn an income from the home and to adjust their schedule around other activities. Employment in other parts of the poultry market chain, while it may be equally profitable, requires adjustment of family roles and timetable. Home-based enterprises in non-poultry activities are easy to find in some places and less available or acceptable in others.

In some countries, women do not have title to land, and this means that restructuring that requires relocation of production premises will exclude them. If they do not have title to assets, they may also be unable to borrow money to invest in larger and more biosecure premises or transport facilities, or to become part of a cooperative scheme.

5 CONCLUSIONS FOR POLICY-MAKERS AND DEVELOPMENT AGENCIES

Structural change in the poultry sector faces us with three separate social challenges: those related to very small flocks/backyard systems; those related to herded ducks; and those related to small commercial operations.

Very small flocks in cities are, perhaps inevitably, under pressure from biosecurity regulations and restructuring proposals. However, this question needs to be revisited; while birds scavenging in city streets are a human and animal health risk, those confined on rooftops need not necessarily be, and they play an important part in the lives of their owners. In rural areas, there are no compelling reasons to put backyard flocks under pressure. In places where very small poultry flocks are restricted, poor women and their families will suffer and people will keep poultry illegally – there is already evidence to demonstrate this from studies in progress. In places where backyard poultry are permitted, culturally appropriate and inexpensive biosecurity measures appropriate to the sometimes small risks posed by these systems need to be developed with local people and promoted on farms and in local markets.

Herded duck keeping is a unique system that fits the ecology and social fabric of wetland areas where paddy rice is grown, and satisfies a large demand for duck meat and eggs. However, areas with double-crop paddy rice and herded ducks coincide with areas that have had high levels of HPAI outbreaks. As the systems cannot be made biosecure by any of the methods used for enclosed birds, there is some doubt as to their long-term future. An interim solution is to vaccinate the birds and use very careful surveillance to detect the occurrence of disease. If such systems are banned, their owners have the choice to:

- enclose them, requiring investment and with possible consequences for rice production; or
- stop keeping them, with a consequent loss of livelihood and the need to change rice pest control and nutrition practices.

Where poultry keeping and sale become more tightly regulated **small-scale commercial operators** face a challenge. What choices do they have? They can:

- upgrade and/or upscale their enterprises;

- find niche markets and produce or market specialized products;
- find different ways to do business (e.g. contract farming, partnerships, cooperatives); or
- find a livelihood away from primary poultry production or trading.

All of the above require some assistance in the form of knowledge transfer or investment support if development is to be equitable.

An overall conclusion is that strategies for developing the poultry sector and adjusting its structure for safer production need to be based on a deep understanding of the sector and framing negotiations for change to take account of social as well as economic realities. This could involve activities such as:

- mapping not only product flows but human behaviour in poultry market chains, to learn about the most effective entry points for change, and about the people who will have least voice and be most at risk;
- anticipating cultural and financial barriers to change;
- giving due warning of changes so that the most vulnerable people have time to adapt; and
- knowing the full value of poultry to owners and traders so that alternative employment can provide comparable benefits.

Social change is part of life and all progress brings about social impacts. Changes to the poultry sector in developing countries will change the social fabric and the livelihoods portfolio of many vulnerable people, and so they need to be carefully considered and backed up by supporting measures where existing coping strategies will not be enough. As poultry are to a great extent private sector business, providing appropriate support will be a challenge for governments and development agencies.

REFERENCES

ACI. 2006a. *Poultry Sector Rehabilitation Project – phase I. The impact of avian influenza on poultry sector restructuring and its socio-economic effects*. Prepared for the Food and Agriculture Organization of the United Nations. Bethesda, Maryland, USA, Agrifood Consulting International.

ACI. 2006b. *Poultry Sector Rehabilitation Project – Phase II: the economic impact of highly pathogenic avian influenza – related biosecurity policies on the Vietnamese poultry sector - field interview notes. August 2006*. Prepared for the Food and Agriculture Organization of the United Nations and the World Health Organization. Bethesda, Maryland, USA, Agrifood Consulting International.

FAO. 2005. *Impact of avian influenza outbreaks in the poultry sectors of five South East Asian countries (Cambodia, Indonesia, Lao PDR, Thailand, Viet Nam) outbreak costs, responses and potential long term control*, by J. Rushton, R. Viscarra, E. Guerne Bleich & A. McLeod. Report for FAO's TCP/RAS/3010. Rome.

FAO. 2006. *Rapid assessment of HPAI socio-economic impacts in Turkey*, by E. Geerlings. Report produced for the FAO ECTAD Socio-economic Working Group, November 2006. Rome.

FAO. 2007a. *Actors: poultry as a tool in human development*, by F. Dolberg. Paper prepared for FAO. Rome.

FAO. 2007b. *HPAI and sustainable livelihoods: HPAI and sustainable livelihoods: managing risk and developing options managing risk and developing options*. Livelihoods Support Programme Brief. Rome.

FAO. 2008. Scope and space for small scale poultry production in developing countries, by V. Ahuja, & A. Sen. *In* O. Thieme & D. Pilling, eds. *Proceedings of the International Conference Poultry in the Twenty-first Century: avian influenza and beyond*, held 5–7 November 2007, Bangkok, Thailand. Rome.

Geerlings, E, Albrechtsen L. & Rushton J. in collaboration with Zahra Ahmed, Ferial Abd El-Kader Ahmed, Soad Ahmed Eldawy, Aida Saied, Hanaa Mohamed, Mervat Khalil, Emel Ramzi, Afaf Said, Nawal Abd El-Menem, Abeer Mohamed, Amira Salah, Ahlam Hazan, Mohamed Abd El-Aziz, Mona Mohamed, Mostafa, Shaakem and Hazan Omar & Sahar El-Helaly. 2007. *Highly pathogenic avian influenza: a rapid assessment of the socio-economic impact on vulnerable households in Egypt.* Unpublished Report.

Sector trends and impacts

SUMMARY OF DISCUSSION

The question of the future prospects for Sector 4 (backyard poultry) production was raised by several speakers. It was noted that small-scale poultry keeping remains widespread among the rural poor and is often particularly significant for women. Its contribution to livelihoods and nutrition at the household level attracts some attention to poultry keeping as a development tool; the importance of mircofinance to such projects was noted. In some parts of the world, the social significance of poultry keeping also favours the continued existence of Sector 4. The potential for consumers to turn away from intensively produced poultry because of safety concerns or for cultural reasons was noted. It was argued that it is possible for more than one type production system to co-exist within a single country, i.e. that the spread of industrialized production does not necessarily mean that small-scale production will disappear. There was also a suggestion that the intensification process may take longer than usually predicted and that a longer time horizon (to 2050 rather than 2030) should be taken into consideration.

It was, however, recognized that there are a number of factors likely to promote a decline of Sector 4. These included: urbanization; government policies that promote intensification; a lack of interest in poultry keeping among the younger generation; and the inability of small-scale producers to meet the demands of new markets that emerge with urbanization and higher incomes (the importance of links to the supply chain for the future of small-scale production was noted). For some speakers the decline of Sector 4 was not to be greatly regretted, because of its inefficiency and its associated human health risks. Other speakers rejected both arguments, referring to the high level of adaptation to the production environment, which makes this sector particularly efficient if family labour and environmental externalities are taken into account. Moreover, the short market chains involved minimize the risk with respect to food safety.

The situation in developed countries such as France, where small-scale poultry keeping almost disappeared but is now re-emerging to supply niche markets, was noted. There was some speculation as to whether a similar pattern would be seen in the future in developing countries, and whether this prospect should in any way be taken into account in the current advice being given to these countries. The preservation of poultry genetic resources was noted as another advantage of sustaining small-scale production.

There was some difference of opinion regarding the future of "feel good" production (free range, etc). On the one hand there was a view that such production is inefficient and will decline, while on the other hand there was a view that niche markets for such products would grow and that commercial production would seek to respond to this demand.

With regard to the location of the industry on a global scale, it was suggested that the share of poultry meat being produced in the developing world will further increase. The domination of the industry by a small number of countries was considered by some speakers to be a worrying trend. Concern was expressed regarding the potential of the highly pathogenic avian influenza situation to inhibit the entrance of small countries into the international market. The significance of regional differences within countries was noted. The rural/urban population ratio and level of income has a strong impact on demand for poultry products.

The growth of environmental concerns was also recognized as a challenge for the poultry industry. It was suggested that the industry's "free ride" with regard to environmental impacts would come to an end, and that welfare issues would also become more prominent, at least in some markets. The need to address the industry's contribution to global warming was recognized.

The future of feed inputs to the poultry industry was another issue that gave rise to some discussion. It was noted that the feed industry in the West would continue to supply the East for some time to come. A greater emphasis on "designer diets" for different types of bird under different conditions was noted as future trend. Efficiency of nitrogen and phosphorus use was suggested as an important area for research. There was some difference of opinion regarding the significance of the biofuel industry as a competitor for feed inputs. However, it was argued that the increase in the price of soy and maize would trigger a search for alternative feed crops. The by-products of ethanol production were described as having some potential as feeds, but it was noted there are still questions about the cost of production. It was argued that in future there will be more discussion about income relative to feed cost, rather than feed efficiency, and that restructuring will be driven by profitability.

In the field of genetics, it was suggested that there is a need to develop quality poultry suitable for production in a wider range of conditions. Specific efficiencies (phosphorus and nitrogen use) were also recognized as a challenge for breeders.