livestock report 2006

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livestock report

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Foreword

The livestock sector is undergoing rapid changes in response to pressures from globalization and rapidly growing demand for animal food products in developing countries. The centre of gravity of livestock production is moving South, and a few developing countries are emerging as powerful new players on the global scene. At the same time, the market chains for livestock and their products are rapidly being transformed. While trade is expanding much faster than production, it is constantly under threat by disease outbreaks and this puts increasing pressure on veterinary services to improve their management of transboundary diseases.

There are social and environmental consequences of this growth and transformation of the sector and increasingly policy makers are realizing that the impressive performance in production and trade comes at a cost. Small scale producers are being marginalized and environmental degradation is occurring, both from industrial and extensive forms of livestock production. Intensification of livestock systems and market demands also create a threat to the diversity of animal genetic resources.

The Animal Production and Health Division of FAO has a global mandate to foster informed decision-making on the challenges facing the livestock sector, particularly those of developing and emerging economies. The Livestock Report 2006 is intended as a vehicle to generate debate and feedback from those most concerned with the development of the livestock sector, be they policymakers, researchers, producers or facilitators. It seeks to highlight critical and diverse issues of the global livestock sector in the area of animal production and health, and associated economic analysis and policies. This is the first of a series of reports. Suggestions for topics to be covered in future editions would be welcome, as well as comments on the issues raised in the Livestock Report 2006.

Samuel Jutzi
Director
Animal Production and Health Division
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global perspective

Old players, new players

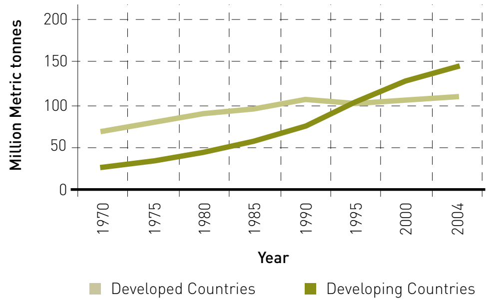
Henning Steinfeld and Pius Chilonda

In 1995, for the first time, meat volume produced in the developing countries exceeded that of developed countries and since then the gap in milk output between developing countries and developed countries has been narrowing. In 1998, India surpassed the United States as the world's largest milk producing country. Earlier in the same decade, China overtook the United States and the entire European Union of then 15 countries in terms of meat production. These events mark a substantial shift of the "centre of gravity" of livestock production, from the North to the South, from temperate regions, to tropical and sub-tropical environments.

Until about the early 1980s, diets with daily consumption of milk and meat were the privilege of OECD country citizens and a small wealthy class elsewhere. At that time, most developing countries, with the exception of Latin America and some Near East countries, had per caput meat consumption of substantially less than 20 kg. For most people in Africa and Asia, meat, milk and eggs were an unaffordable luxury, consumed only on rare occasions.

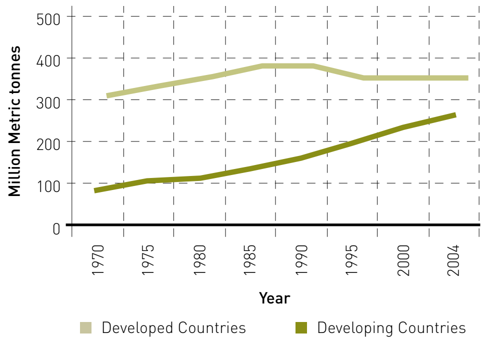
Rather than supplying food, livestock performed many functions, such as providing draught power and manure, and as a capital asset, that was only disposed of in times of emergency. A large proportion of the livestock in developing countries was not primarily kept for food.

MEAT PRODUCTION



Source: FAO (2005)

MILK PRODUCTION



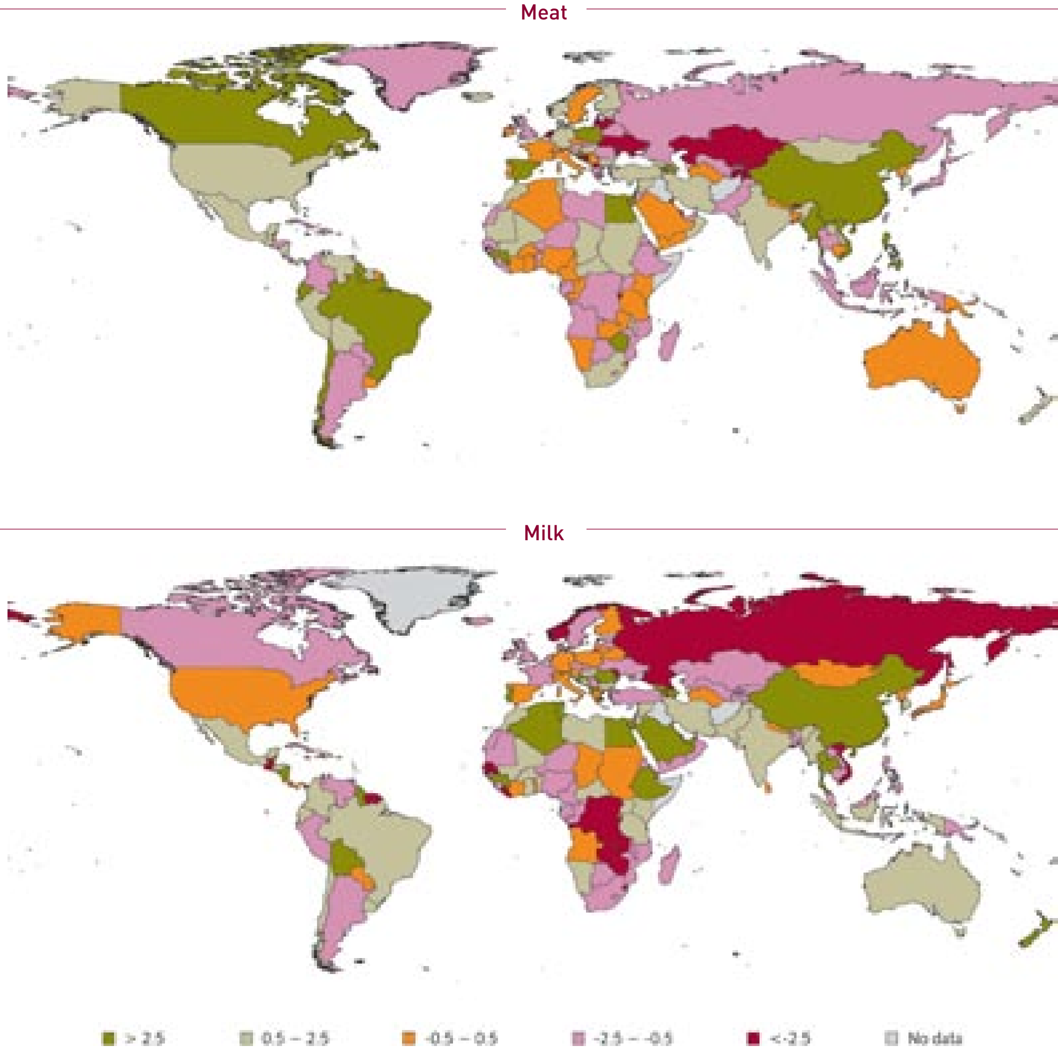
Source: FAO (2005)

CHANGES IN CONSUMPTION OF ANIMAL PRODUCTS

	Developing countries				Developed countries			
	1970	1980	1990	2002	1970	1980	1990	2002
Annual per caput meat consumption (kg)	11	14	19	29	65	75	82	80
Annual per caput milk consumption (kg)	19	23	27	31	122	99	92	93
Total meat consumption (million MT)	29	47	74	139	70	88	103	105
Total milk consumption (million MT)	82	119	167	256	307	346	372	343

Source: FAO (2005)

ANNUAL GROWTH RATE (%) IN PER CAPUT PRODUCTION OF TOTAL MEAT AND MILK (1994-2004)



Source: FAO (2005)

This is changing rapidly. In the developing countries, per caput consumption of meat has doubled since 1980 from 14 kg/cap/year to 29 kg in 2002.

Total meat supply has tripled from 47 million tons to 139 million tons over the same period. Developments have been most dynamic in countries that have shown rapid economic growth, notably East Asia, led by China. China alone accounted for 57 percent of the increase in total meat supply in the developing countries. Looking at milk, developments are less spectacular but still remarkable. Total supply in developing countries has expanded by 122 percent between 1980 and 2002; and 40 percent of that increase came from one country, India. Most of the expansion in supply comes from increased production, and only a relatively small part from imports. For all developing countries, imports only account for about 0.5% and 14.5% of total meat and milk supply

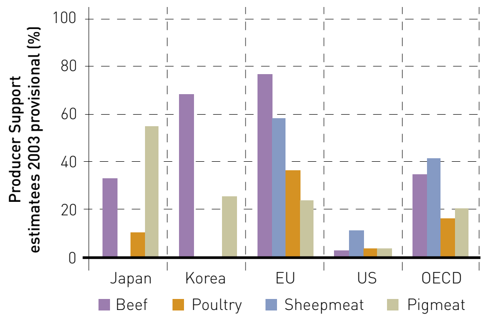
What is triggering these rapid developments? The consumption of meat, milk and eggs is closely linked with income, and a new middle class in many developing countries, that has emerged from economic growth over the past decades, is diversifying its diet. These more affluent people move away from cereals and other staples to a richer diet that includes increased amounts of livestock products, but also of fruits, vegetables, sugars and fats. This trend is amplified by population growth which, while slowing, is still adding another 72 million people to the population in developing countries every year. Other factors, like urbanisation and changing lifestyles, further feed the trend. In contrast, the absence of sustained economic growth also explains why some countries, notably in sub-Saharan Africa, have not yet entered the "meat phase".

The dramatic developments in rapidly growing developing countries are in stark contrast with trends in developed countries where consumption of livestock products is growing only slowly or stagnating. With low or no population growth, most OECD countries are past the "meat phase" and markets as well as people are saturated. Consumers there worry about the health effects of high intake levels of livestock products, in particular red meat, animal fats, and eggs. Continuous high level consumption of these products is associated with a series of cardio-vascular diseases, and certain types of cancer.

Other health aspects associated with animal products, such as the presence of residues (of antibiotics, pesticides, dioxins) and of pathogens (e-coli, avian influenza, salmonella, foot and mouth disease), sporadically and sometimes permanently suppress demand for animal products.

Traditionally, developed countries have been giving varying levels of support to livestock producers, but have now started to reduce the levels of producer support which has helped to reduce

SUPPORT TO LIVESTOCK PRODUCERS IN DEVELOPED COUNTRIES



Source: OECD (2005)

some of the surplus, particularly of the EU. This is in conjunction with the trend within the EU to subsidize incomes rather than production. This has contributed to increasing world market prices, as surpluses dumped at low prices have become less common.

Australia and New Zealand have played and continue to play important roles as exporters of beef, mutton and dairy products, particularly to Japan and to the Near East, and have increasingly moved up-market, with their mainly grass-fed production differentiating their products from the mass market.

The previously centrally planned countries (ex Soviet Union and Eastern Europe) experienced a sharp decline in the livestock sector as it went through dramatic structural change and purchasing power of consumers declined rapidly. With consumer purchasing power now rising again, most countries are now recovering, but at different speeds, and increasing demand is not always met by domestic supply. Russia's chicken meat production in 2002, for example, is still 35 percent lower than in 1992 (935,000 MT down from 1,428,000 MT) but her imports have surged to 1,205,000 MT. In 2002, imports contributed 56 percent to total food supply of chicken meat.

The Eastern European countries that have entered the EU in May 2004, had to go through rapid adjustments in order to prepare for accession. But these countries now have access to premium markets in the older EU member states. For the previously centrally planned countries as a whole, because of their ongoing process of structural change, they are expected to reach 1990 consumption levels again only by 2030. In contrast, many developing countries show a combination of continuing high population growth and growing per caput incomes. This combination has led to a dramatic increase in demand for livestock products, termed the livestock revolution, since about the mid 80s and this trend is poised to continue for another 10 to 20 years before slowing down (Delgado *et al.* 1999).

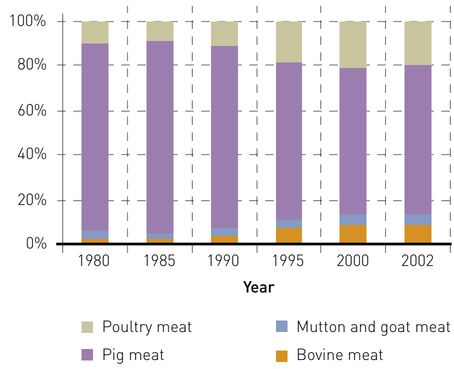
Three developing economies i.e China, India and Brazil account for almost two thirds of total meat production in developing countries and for more than half of the milk. They also account for close to three quarters of the growth in production in all developing countries in both commodity groups. While these countries are very different in their economic structures and consequently, also their livestock sectors, they have one thing in common: they are big. They are accompanied by other countries of their respective regions which follow the same livestock development model. The "big three" are also emerging as world players in the trade of livestock and livestock products, as we will now explore in more detail.

THE BIG THREE IN DEVELOPING COUNTRY LIVESTOCK IN 2004

Country Group/ Country	Meat (million MT)	Milk (million MT)	Meat (%)	Milk (%)
Developing Countries	148.2	262.7	100	100
China	70.8	22.5	47.8	8.6
India	6.0	90.4	4.0	34.4
Brazil	19.9	23.5	13.4	8.9
"big three"	96.7	136.4	65.2	51.9

Source: FAO (2005)

COMPOSITION OF TOTAL MEAT CONSUMPTION IN CHINA



Source: FAO (2005)

China and East Asia

China is the largest producer and consumer of livestock products in Asia and globally is the number one producer of pork, mutton and eggs. Although the per caput consumption of livestock products in China is lower than in developed countries, that of China is rapidly increasing fuelled by economic growth and rise in personal incomes. Since China's accession to the WTO in 2001 and because of the sheer size of China's livestock sector, relatively small changes in livestock inventory growth and demand for livestock products, can have significant implications for global trade in livestock feed and livestock products.

China has a dichotomous pattern in food consumption with urban per caput consumption of almost all types of animal protein products double or triple that of rural residents. The per caput consumption of animal source foods has been increasing at the rate of 5.6 percent, 8.0 percent and 8.1 percent for meat, milk and eggs respectively in the last decade and is poised to continue.

Pork accounts for almost 66 percent of the total meat consumed in China and per caput consumption has increased from a low base in 1980 of 12.0 kg to 34.2 kg in 2002. It is the largest component of China's livestock production, and although its share in total production and consumption is declining, it still accounts for 65.7 percent of the total meat produced. Partly due to government policies discouraging backyard pork production to favour more efficient animal protein operations, the structure of the pork production in China is changing. It is moving from traditional, farm based waste converter systems and is rapidly intensifying with increased use of concentrates and emergence of large scale production units which are increasingly privately owned. China is self sufficient in pork and has traditionally been an exporter of pork. Although imports have increased in the last few years, it still enjoys a positive net trade in pork. Exports and imports are both less than 1 percent of total production and consumption, respectively.

Growth in poultry and egg output is expected to remain strong, with their share gradually increasing in total output of livestock products in China. China has moved to the second place behind the United States in total output of poultry meat. Expansion in output has been driven by increasing demand and has been facilitated by general market-oriented policy reforms, government support for such projects as specialised poultry breeding operations. Consumption of poultry meat has more than doubled in the last decade from a low base of 3.9 kg in 1992 to 10.0 kg per person in 2002. China's policy is geared towards self-sufficiency in poultry products, due to the high internal demand. However, trade in poultry products has been increased in the last decade.

Beef and mutton account only for a small share of total meat consumption, but their shares have been increasing. This has mostly been due to a boom in beef production, facilitated by rapid mechanisation in the early nineties, releasing large numbers of cattle and changing the herd structure towards a larger proportion of breeding females. The result has been a rise in the share of beef from 2.2 percent in 1980 to 9.0 percent in 2002.

In the last decade, production has more than doubled as per caput consumption has tripled. More efficient use of crop residues in intensive crop-growing regions, contributing to the rapid growth and adoption of efficient feeding practices, is likely to further boost production. However, beef production is likely to increase more slowly than in the past because of consumer preferences for other meats (Economic Research Service, 1998). Mutton and goat meat output has more than doubled in the last decade largely due to expansion in cropped areas in eastern China, the result of government policies supporting more efficient feeding of crop residues

Milk only accounts for 3.4% of the total animal proteins consumed in China. Per caput consumption is still low at 11.0 kg per annum but has doubled in the last decade. Dairy output has expanded dramatically from 8.4 million tonnes in 1994 to 22.5 million tonnes in 2004, but tighter feed grain supplies over the next decade are likely to reduce the rate of growth (Economic Research Service, 1998)

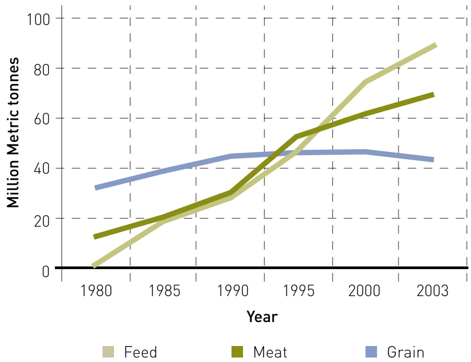
Along with increased production and consumption of meat, milk and eggs, demand for animal feed in China has been ever-increasing. Land scarcity limits China's ability to continue expanding its production to meet the growing domestic demand without increasing its imports of livestock

LIVESTOCK PRODUCTION IN CHINA: TOTAL OUTPUT, WORLD RANKING AND ANNUAL GROWTH RATES

	Output Million MT 2004	World rank	Percentage of world total	Annual growth rate (1994-2004)
Pork	46.7	1	46.5	4.1
Mutton	3.6	1	29.6	9.2
Eggs	28.1	1	44.7	6.6
Poultry meat	12.9	2	16.5	7.1
Beef	6.2	3	10.6	9.6
Milk	22.5	8	3.7	10.4

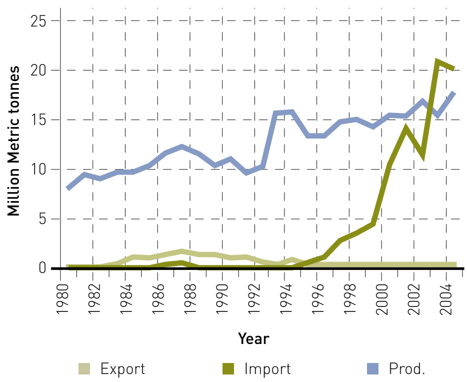
Source: FAO (2005)

PRODUCTION OF GRAINS, FEED AND MEAT IN CHINA



Source: Bingsheng (2004)

SOYBEANS PRODUCTION AND TRADE IN CHINA



Source: Bingsheng (2004)

feedstuffs. Since China's accession to the WTO in 2001, the country has increasingly resorted to importing feed to sustain its rapidly growing pig and poultry industries.

Feed production as well as imports have increased. Total feed imports have surged to 1.2 million tonnes in 2003 from 0.8 million in 1993, giving rise to fears that the expansion of China's livestock industry could lead to price hikes and global shortages of grains, as has been predicted many times in the past. China is still a net exporter of feed stuffs, but this is gradually declining, reduced by 42 percent in the last decade.

Elsewhere in East Asia, Vietnam, Thailand, Malaysia and the Philippines are experiencing rapid growth in their livestock sectors, in particular pig and poultry production. Thailand has taken rapid steps in the nineties to establish a thriving poultry industry and has become one of the leading exporters of broilers worldwide, ranked number five in 2003 after the United States, Brazil, France and the Netherlands before the recent Avian Influenza crisis. In fact Thai poultry and pig production has been scaling up at a rapid pace in the last decade. However, with outbreaks of Avian Influenza in 2004 and 2005, it is currently at risk of losing its export status for unprocessed poultry meat altogether. In the Philippines, the livestock sector (including poultry) almost single-handedly carried the lagging agricultural sector and doubled total agricultural value added in the last 20 years.

SELF SUFFICIENCY IN COARSE GRAINS IN SELECTED SE ASIAN COUNTRIES 1980 TO 2003

Country	1980	1985	1990	1995	2000	2003
Indonesia	99.8	98.4	102.0	90.1	88.5	89.1
Malaysia	1.2	2.1	2.3	1.8	2.8	2.6
Philippines	92.5	93.2	93.2	95.0	90.6	97.4
Thailand	364.9	234.7	145.7	96.1	93.8	105.1
Viet Nam	100.0	109.3	105.4	100.9	91.4	95.2

Source: FAO (2005)

Except for Thailand, most other main producers in South East Asia have based their expanding livestock sectors on increased feed imports and have been characterised by gradual declines in self-sufficiency rates.

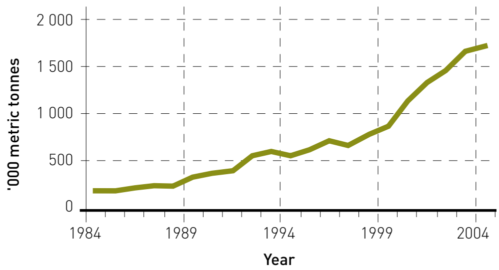
India and South Asia

With an estimated annual production of 90.4 million tonnes of milk in 2004 and an annual growth rate of 3.9 percent, India has emerged as the No. 1 producer of milk and dairy products. Based on its vast ruminant population, and traditional dietary patterns with dairy products, and driven by economic growth, the dairy sector is expected to continue to grow rapidly. Milk production in India continues to be smallholder based, but larger holdings and outside investments are taking hold. Furthermore, cooperative movements, such as the National Dairy Development Board have been very successful in linking smallholders to growing urban markets, providing the smallholders with essential feed and animal health inputs, and basic knowledge for intensification of dairy production. Most of India's dairy production is based on the utilisation of roughages (pastures and crop residues) and if concentrates are fed, they are usually derived from agro-industrial by-products. The availability of fodder will partly determine further expansion of milk production in India.

Despite rapid expansion of production and the potential for surpluses, India finds it difficult to enter international markets with its dairy products. This, to a large extent, is due to food safety and quality issues. In the particular case of India, this is compounded by the fact that millions of smallholders are part of the food chain, and that feed residues are often not private and traceability difficult to establish.

Poultry meat production has tripled in the last decade and has been experiencing double digit growth rates at 12 percent per annum, while egg production has been growing steadily at 2.8 percent. Since 1997, the total poultry population has increased by 32.8 percent from 368 million to 489 million in 2003 (Government of India, 2005). In 1998, poultry meat has overtaken small ruminant meat in importance. The increased consumption of poultry meat is associated with changing eating habits in India, where at least some population groups have moved away from strict vegetarian diets, and many young people are eating fast foods.

TRENDS IN POULTRY MEAT PRODUCTION IN INDIA 1984-2004



Source: FAO (2005)

Like elsewhere, the development of poultry production is rather discontinuous i.e. there is typically no "organic" growth on the production side where small poultry farmers gradually expand and intensify their production. Rather, as soon as urban markets develop, investors step in, often with no previous association with livestock production, and establish industrial type units and associated processing and marketing methods. There are considerable economies of scale in broiler and egg production, and smallholders are quickly losing out to their emerging large-scale competitors. This leads to a rapidly changing structure of the poultry industry which varies from region to region, with three states only, Andra Pradesh, Tamil Nadu and West Bengal, accounting for 51 percent of the total poultry population (Government of India, 2005).

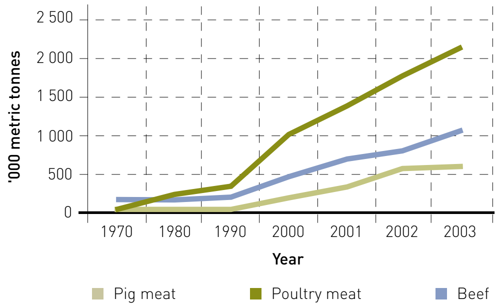
While independent and relatively small-scale producers account for the bulk of production, integrated large-scale producers make up a growing share of output in some regions. Integrators

PER CAPUT CONSUMPTION OF RUMINANT MEAT, POULTRY, AND MILK FOR SOUTH ASIAN COUNTRIES (KG/CAP/YEAR) IN 2002

Country	Bovine meat	Mutton and goat meat	Poultry meat	Milk
Bangladesh	1.3	1	0.8	12.4
India	2.5	0.7	1.3	38.5
Nepal	7.1	1.7	0.6	30.3
Pakistan	6.2	3.5	2.4	86.3
Sri Lanka	1.8	0.1	4.6	36.4

Source: FAO (2005)

BRAZILIAN EXPORTS OF BEEF, PIG AND POULTRY MEAT

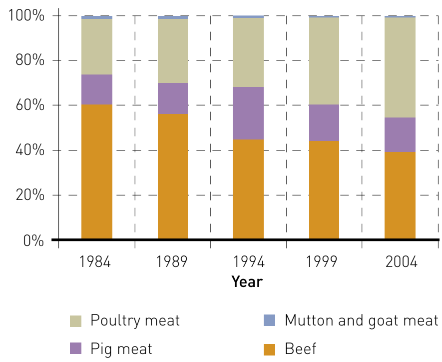


Source: FAO (2005)

include large regional firms that incorporate all aspects of production, including raising grandparent and parent flocks, rearing day old chicks, contracting production, compounding feed, providing veterinary services, and wholesaling (Delgado *et al.* 2003)

Contrary to the trend in East and South East Asia, increasing feed demand for dairy and poultry meat production has not been met by the importation of feed grains into South Asia. Until now, limited domestic supplies of feed grains, together with heavy use of food processing by-products have sufficed. However, this may be explained by the still very low meat consumption, and it is doubtful whether such a pattern can be maintained if consumption expands further. Echoing the Indian example, neighbouring countries such as Pakistan, Bangladesh, Nepal, and Sri Lanka are predominantly consumers of milk rather than meat. Pakistan as a predominantly Moslem country has comparatively high, and rising, levels of meat consumption, with ruminants playing a larger role. Bangladesh, Nepal and Sri Lanka are more similar to India in their production structure, importance of dairying and with poultry as a rapidly emerging business. Bangladesh has notable developments in terms of cooperative structures in the poultry sectors. Smallholders are likely to continue to play a significant role in dairy and small ruminant production.

COMPOSITION OF TOTAL MEAT PRODUCTION IN BRAZIL



Source: FAO (2005)

Brazil and South America

Currently, Brazil is the No. 2 exporter of meat and projections have put Brazil as the No. 1 exporter of livestock products in the long term future. Brazil has emerged as an important exporter of a variety of livestock products, including dairy products, pork, poultry meat and beef. It accounts for 20.7 percent, 12.8 percent and 6.4 percent of the global exports of poultry meat, beef and pork meat exports, respectively.

In the last decade, exports of beef have tripled, while poultry meat has quadrupled and pork meat has risen by a factor of eleven. In terms of production, Brazil accounts for 71 percent, 70 percent, 60 percent, 50 percent, and 35 percent of the total pig meat, poultry meat, beef, milk and mutton and goat meat respectively produced in South America.

This is largely because Brazil has increasingly taken advantage of low feed production costs for its livestock industry and is poised to continue to be an important producer of feed stuffs. The combination of land abundance and recent infrastructure developments has turned previously remote areas such as Mato Grosso and the Cerrado region of central Brazil into feed baskets as they have the lowest production costs for maize and soyabeans globally. Since about the early nineties, Brazilian producers have started decisively to take strategic advantage of their position. Rather than producing and exporting maize, soyabeans and other feed items, they have started to convert their feed into exportable surplus of livestock commodities and consequently the relative composition of livestock outputs has been changing.

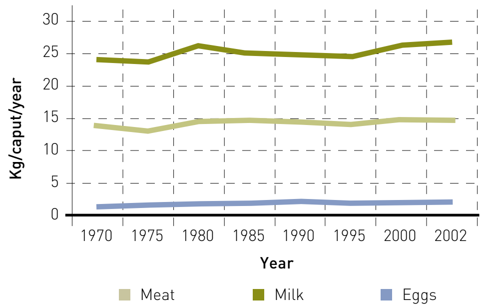
Other Latin American countries, some of which are long term traditional exporters such as Argentina and Uruguay, continue to play a major role, others are emerging, such as Chile and Mexico which are taking advantage of relatively large land endowments and favourable disease status.

Africa

Although Africa is one of the continents with the largest feed resources, it has lagged behind in the development of the livestock revolution which has characterised other developing regions (Mwangi and Omore, 2004). Growth in livestock production has in the last decade not matched growth in the human population and consequently Africa has increasingly become a net importer of livestock products.

For Africa as a whole, although total production of meat, milk and eggs has been increasing at an annual rate of 2.6 percent, 3.0 percent and 2.5 percent for meat, milk and eggs respectively, growth in per caput production has been marginal, only 0.3 percent, 0.7 percent and 0.2 percent for meat, milk and eggs. However, North African countries, have experienced increased consumption levels, largely sustained by imports. In sub-Saharan Africa as a whole, consumption levels for meat, milk and eggs have not only been low, but have remained static and even declined over the last decade.

TRENDS IN PER CAPUT CONSUMPTION OF LIVESTOCK PRODUCTS IN SUB-SAHARAN AFRICA

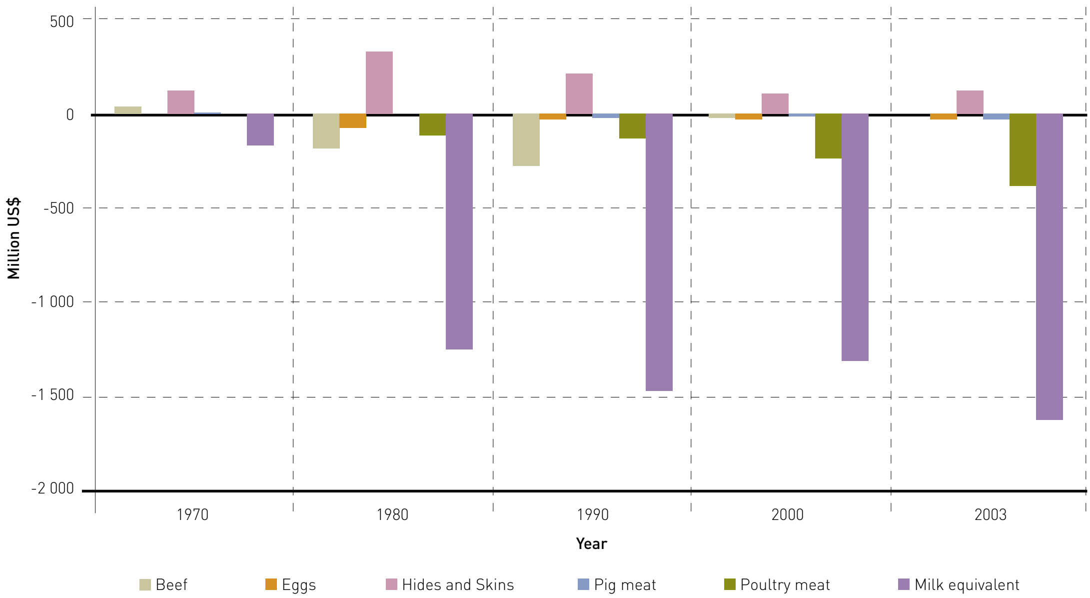


Source: FAO (2005)

Per caput consumption of meat, milk and eggs in 1980 were 12.8 kg, 24.8 kg and 1.3 kg and have changed marginally since then to 11.4 kg, 24.2 kg and 1.3 kg in 2002. This is largely because of rapidly expanding human populations coupled with factors such as the dominance of low yielding livestock breeds, presence of animal diseases, feed constraints as well as institutional and policy constraints affecting the livestock sector.

Africa is a net importer of all livestock products with the exception of skins and hides. The tendency has been that of increasing net imports and this is likely to continue in the coming decades. Total net imports of livestock and livestock products stood at US$ 2,258 million in 2003. The north African countries i.e. Algeria, Egypt, Libya, Tunisia and Morocco account for 40% of the total imports of livestock and livestock products into

NET TRADE IN LIVESTOCK PRODUCTS IN AFRICA



Source: FAO (2005)

Africa, while the rest is imported by sub-Saharan African countries including South Africa. In particular, the African countries have to contend with the imports from the European Union and increasingly from Brazil.

However, within this picture, some success stories have emerged, notably Botswana, Namibia and South Africa which have accessed high value markets in developed countries and are also experiencing higher per caput consumption levels for livestock products. For example, in East Africa, Kenya has developed a strong position in milk production and has one of the highest per caput consumption of milk products in sub-Saharan Africa at 83.4 kg per person.

Near East

Although permanent pastures occupy about 80 percent of all the land suitable for agriculture, the Near East countries are net importers of virtually all livestock products. Growth in production has not matched growth in consumption due to factors such as the rapid growth in the human population, shrinking of traditional pastures, recurrence of drought and outbreaks of transboundary animal diseases. The region has experienced stagnation in per caput production and where consumption is rising this has mainly been due to increasing imports. The region is a net importer of livestock products i.e. in 2002 net imports were a total of 1,296 million, 3,855 million and 47 million metric tonnes of meat, milk and eggs which represent 16.3 percent, 40.8 percent and 6 percent of total consumption, respectively. Furthermore, importation of livestock products into the region is increasing. The region is a net importer of live animals. A total of 11.9 million sheep and goats and 500 thousand bovines were imported in to the region in 2003, when the total value of live animal imports was US$1,205 million.

Conclusions

Looking at the key players in the world of livestock, there is a great deal of variation in terms of the extent and the nature of livestock sector growth. The "old players", i.e. the developed countries led by the US and the EU, although characterised by high production levels, are experiencing stagnation in livestock sector growth in the absence of further increases in demand for livestock products. China and East Asia have experienced the most impressive growth in consumption and production, first in meat and more recently also in dairy products. The region will need to import increasing amounts of feed, and perhaps also livestock products, to meet future consumption growth. In contrast, India's livestock sector continues to be dairy-oriented, using traditional feed resources and crop residues. This picture is likely to change as the booming poultry industry will pose feed demands which will by far exceed current supplies. In stark contrast, Brazil, Argentina and other Latin American countries have successfully expanded their domestic feed base, taking advantage of low production costs and abundance of land. They have moved to adding value to feed, rather than exporting it – they are poised to become the major exporting region for OECD and East Asian countries.

As markets are globalized and tariff barriers become weaker, trade in livestock products has increased much faster than trade in feed. While the share of traded feed grains in total production has remained fairly constant in the range of 20 to 25 percent over the last decade, that of meat and milk has increased from 13.9 and 18.5 percent in 1980 to 20.8 and 21.0 percent respectively, in 2002. Growth in trade in livestock products is also outpacing growth in production. This points to a gradual trend towards producing livestock where feed is available rather than close to consumption centres. It appears that this is facilitated by infrastructure development and cold chains in major producing countries.

This trend of faster growth in trade in livestock products is remarkable when viewed against the background of important disease outbreaks, such as FMD, BSE and Avian Influenza, which have often had a dramatic disruptive impact on the export capability of countries, such as the UK and Thailand. In the global picture, however, these are hardly noticeable.

Challenges differ greatly from region to region but some general observations can be made. On the production side, the trend towards rapidly increasing livestock production in the tropics poses a series of technical problems (climate, disease), some of which countries do not appear to be readily prepared for, as demonstrated by the series of outbreaks of Avian Influenza in the last two years. The surge in production, as has been shown above, also entails an expansion of food supplies, and in particular in Asia, an increasing amount will need to come from imports. Some countries will be faced with the question as to whether to meet this demand by feed import-based domestic production, or whether to opt for imports of livestock products. Production moves away from established production areas with high environmental standards; this potentially creates opportunities for circumventing locations with high environmental standards.

On the consumption side, we observe that diets converge globally. Cultural peculiarities become increasingly blurred as demonstrated by the surge of poultry consumption in South Asia. These changing patterns are further supported by the fact that the same eating habits, such as fast and convenience food, are catching hold almost everywhere.

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Underneath the Livestock Revolution

Achilles Costales, Pierre Gerber and Henning Steinfeld

The sustained rise in demand for food of animal origin, driven by growing populations, increasing consumer affluence, and increasing urbanization, is underpinned by structural changes along the whole animal food supply chain. Distribution, processing and production sites are affected. This "livestock revolution" is characterised by prominence of large retailers, a tendency towards vertical integration and coordination along the food chain, and industrialisation of the production process. Since each of these developments may raise market barriers for small scale operators, sustaining the revolution may not be compatible with sustaining small scale livestock production. Moreover, the structural changes are accompanied by an increasing use of crops for livestock feed, rather than human food, raising questions about food security and poverty. Industrialisation if poorly managed can result in externalities in the form of environmental damages. This paper explores each of these factors and highlights issues that policy makers must take into account when responding to the livestock revolution.

The rise of large retailers

Rising per capita incomes and the urbanizing populations in developing countries have been observed to be leading to the westernization of diets and transformation of food systems (Pingali 2004). Increasingly affluent urban consumers in developing countries are associated with an increase in prominence and reach of large-format retail stores, in particular supermarkets, responding to and perhaps shaping the increasing demand for convenience, variety, and quality assurance. While the main target of the supermarkets in developing countries is the urban middle class, the competition among rival chains brings prices of similar products down, thus also accommodating lower income households in search of opportunities to stretch the purchasing power of their food budget.

The rapid expansion in supermarket penetration in developing countries is a fairly recent phenomenon, notable only over the last 5-10 years, proceeding at different rates and depths in the various regions of the developing world. Reardon and Timmer (2005) describe the diffusion of supermarkets in three successive waves. The first wave covered much of Latin America and East Asia (except China), North-Central Europe and South Africa. While a number of supermarkets already existed in these countries in the 1970s and 80s, they were local firms using local financing, catering to niche markets for the wealthier classes in major cities. Entering the 1990s, these supermarkets accounted for only 5-10% of agri-food retail sales. By 2000, the modern supermarkets had captured 50-60% of the agri-food retail market. The second wave of supermarket diffusion took place in the mid-1990s, covering parts of Central America and Mexico, Southeast Asia, and South-Central Europe, with the share of supermarkets in total food retail reaching about 30-50% by the early 2000s. The take-off of supermarkets in the third wave of diffusion started only in the late 1990s. Countries affected included China, India and Russia, some countries in Central and South America, in Southeast Asia, and some in Africa. By the mid-2000s, supermarket share of food retail had already reached 10-20%.

There are regional differences in the speed at which these transformations are taking place. In general, the diffusion took place a little earlier and has now penetrated deeper in Latin America, followed by East Asia (except China), and then Eastern Europe. Apart from the size and rate of expansion of the economy, urban population, and the middle class, these developments have been facilitated (or slowed down) by country policies on trade and retail sector liberalization, as well as those relating to foreign direct investment (FDI). The late entry of China and India was related to the remaining policy restrictions on the entry of foreign investments in the food retail sector in the early 1990s.

At the forefront of supermarket diffusion are the large transnational food agribusiness conglomerates. Their spread has been facilitated by full or partial liberalization of the retail sector, inducing FDI in food processing and distribution. Although reinforced by multilateral trade liberalization, the breaking down of quantitative restrictions and lowering of tariffs, and the laying down of rules and standards for food quality and safety (Sanitary and Phytosanitary standards, Codex Alimentarius, private standards), the entry of FDI to the developing regions of the world since 1990 has been more crucial to the take-off of supermarkets.

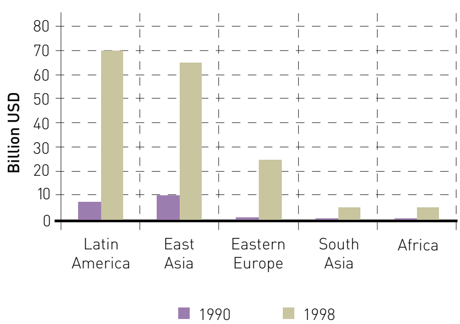
The increase in FDI investments in the agri-food sector by transnationals has been more or less in proportion with expansion in overall FDI (Reardon and Timmer, 2005). Concomitant with the first wave of supermarket diffusion, the leading regions in FDI expansion were also in Latin America and East Asia. In the same way that supermarket diffusion lagged behind in India and Africa, so has the entry of FDI.

The main markets of these large-format retail units are the domestic urban consumers, whose growth in demand for higher-value fresh and processed agri-food products has been expanding. The entry of FDI allowed transnational food retailing companies to bring with them their state-of-the-art technology in product specification, quality control, labeling and packaging, as well as in logistics and accompanying infrastructure in procurement and distribution. From these investments are built the economies of scale and the capacity to meet competitively price and quality standards in both international and domestic markets (Berdegué and van de Kop, 2005).

The emergence of supermarkets 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. It is a change that has deep impacts on livestock and milk producers, particularly on who can and who cannot participate in the mainstream supply chains. A segmentation of markets can be seen, between the 'formal' and the 'informal' supply chains, and between the 'wet' markets for fresh and warm meat and the supermarket outlets of processed, frozen, packaged and branded meat. The relative significance of each market segment is tied to the level of economic development. It 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 they give to notions of food that is 'safe'.

While the informal supply chains for livestock and raw milk, and the wet markets for meat, still constitute the dominant segments in developing countries, with the expansion of their economies, the large scale retail sector is growing. The rapid expansion of large retailers in Latin America, East Asia and the Near East has been accompanied by a relative decline of traditional wholesale

GROWTH IN FDI IN DEVELOPING COUNTRIES, 1990 AND 1998



Source: Reardon and Timmer (2005)

markets in regions where the restructuring of the agri-food markets and industries have been most dynamic. With the expansion of the formal supply chains and the displacement of the chains leading to the traditional wholesale markets, comes a contraction in the productive activity that supplied these traditional markets as well.

In regions where economic growth has been relatively slow, such as Sub-Saharan Africa, the informal and traditional markets for livestock products remain dominant and production for home consumption is still very important. In Ethiopia, for example, only about 20% of total milk output reaches the market, either through informal or formal links. In the capital Addis Ababa, where market transactions take place, the share of the informal market is estimated to be around 70%, consisting of traditional raw milk and traditional butter (Jabbar *et al.*, 2005). Even in Kenya where the government has poured significant investments into the establishment of modern dairy processing plants, the formal dairy sector has collapsed, and the informal market chains, which took 70% of the market in the 1980s, increased their share up to 90% by 2003, mainly by exploiting local tastes and preferences for traditional milk and dairy products (Omiti *et al.*, 2005).

Apart from South Africa where supermarkets have become a significant force, and to some extent Kenya, Zambia and Zimbabwe, most of Sub-Saharan Africa has not yet experienced a substantial takeoff of supermarket diffusion. Particularly the very poor countries such as Ethiopia, Sudan, Burkina Faso and Mali, are unlikely, even in decades, to witness the growth of supermarkets. It will require a critical mass of urban consumers, purchasing power, improved farm-to-market infrastructure, better FDI investment climate, and political stability (Reardon and Timmer, 2005).

The resilience of informal markets is apparently providing relief to small livestock producers supplying informal markets in the rural as well as urban areas on the basis of strong consumer preferences for traditional products. There are, however, no guarantees that these markets will continue to be the locus of economic opportunities for smallholders in the longer run. While consumption patterns and habits appear to be embedded in tradition, the power of structural change in modern market chains to overcome seemingly immutable hurdles cannot be underestimated.

Vertical coordination and integration along the food chain

The entry of transnationals into the agri-food chain, particularly in the retail and processing sectors in developing countries, has transformed the manner in which agri-food products are purchased from suppliers, transformed into differentiated products, and distributed to consumers. As these new distribution and large retail units have to compete for market share, between themselves and even with traditional suppliers and traditional wholesalers in the domestic market, they must offer competitive prices. They can only maintain and/or expand market share by cutting costs.

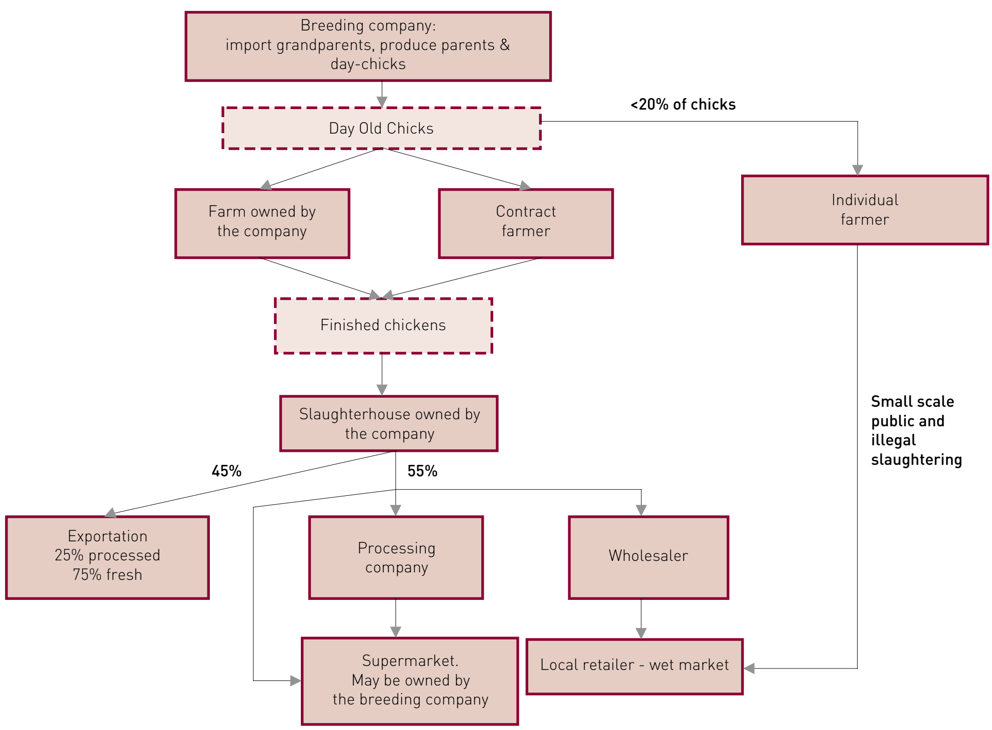
At the same time they must compete in delivering consistent product quality that is demanded by their main market. The concept of 'quality' from the producers' perspective is complex, and its attributes evolve over time. Its definition varies according to suppliers' strategies on the one hand, and to cultural influences on the other. It includes food safety, nutrition and attributes related to the commercial differentiation of the products (Reardon, *et al.*, 2005). Large retailers require a reliable supply of agricultural products from their suppliers (producers) with consistency in volume and in quality.

Vertical coordination presents the opportunity to keep control of operating and transaction costs while at the same time meeting high standards for food safety. It demands organizational and institutional changes in the relationship between the primary producer and the agri-food processor or supermarket distributor, giving rise to either various forms of vertically coordinated transactions (the retailer contracts suppliers and/or processors), or in the extreme form, fully integrated systems (all units in the food chain owned by one company). Large retailers in developing countries are increasingly tending towards vertical coordination, although vertically coordinated chains may interact with informal markets by supplying inputs of live animals or products.

Several studies (Weatherspoon and Reardon, 2003; Reardon *et al.* 2003) indicate that supermarkets' procurement systems involve purchase consolidation, a preference for specialised wholesalers, and tough private quality and safety standards. The introduction of clearly specified quality and safety standards and contractual production arrangements reduce transaction costs associated with information asymmetry, but require investment in physical and human capacity. Through vertical coordination and governance at each stage in the chain, production efficiency as well as product quality can be monitored, and standards imposed. Vertical coordination not only allows gains from economies of scale, but it also secures benefits from market ownership and control over product quality and safety by controlling the technical inputs and processes at all levels. Large multinational firms have strength in achieving economies of size and scope, and by sourcing supplies at different levels and across national boundaries.

The move toward non-market transactions (e.g. contract farming, dedicated suppliers) within a

COMMERCIAL CHICKEN PRODUCTION AND SUPPLY CHAIN IN THAILAND IN 2003



Source: Department of Livestock Development, personal communication.

framework of vertical coordination has profound economic and social implications for rural and peri-urban livestock producers in developing countries. To meet quality requirements by agri-food processors, producers have to make investments and adopt new practices. In this situation, there are both challenges and opportunities. Where there are many large producers to choose from, who can make the necessary investments to still operate profitably, large agri-food processors will find little incentive to source supply from small producers. Under these circumstances, the burden is entirely put on the smallholders to make the investments. If they are unable to do so, they are taken out of the market chain loop, as in the case of the small dairy farmers in Brazil (Farina, 2002), in Argentina (Gutman, 2002) and Chile (Dirven 2001). The move towards non-market transactions, however, does not automatically mean the demise of smallholders under all circumstances. Where there are few alternative large suppliers, and smallholders have the human capacity to meet product quality requirements, and incentives exist for the agri-food processor/distributor to make profits from such capacity, interlinked financing contracts and technical assistance are often provided in exchange for adjusted payment schemes on the output side, as in the case of smallholder dairy farmers in Poland (Dries and Swinnen, 2004).

While many farmers recognize the opportunities presented by consumer-driven agriculture, great challenges remain for small scale farmers in developing countries. The large number of small scale farms makes it difficult to organize, monitor and standardize the quality of products. Further downstream, the ability of the traditional wholesale market systems to meet demands by modern procurement systems is low. For example, Ahold company in Thailand has limited ability to meet large retailer requirements in the supply of fresh fruits and vegetables (Boselie, 2002). Fresh products marketing is characterized by poor infrastructural and institutional support. Risks and uncertainties are high. This can only be compensated by costly investments in an alternative system (Reardon and Timmer, 2005).

Under conditions of high risk and uncertainty of output and input markets, where guaranteed product quality is required (e.g., absence of avian influenza disease), 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 high price volatility. It is also an efficient way to provide technical assistance to the producers and to diffuse new technologies. For example, the Charoen Pokphand Group has been promoting new housing and manure management systems over the last 5 years in Thailand, resulting in drastic shifts among its contract farmers.

These challenges for smallholders, however, are not insurmountable. It is rather the approach to integrating them into the more dynamic and dominantly private-sector business transactions that needs to be explored. This may require different methods to the conventional technology upgrading and skills transfer programmes and strategies to small producers provided by the public sector.

Under marketing environments where volume or/and quality assurance is important, a major incentive for some form of coordination or another is a wish to limit transaction costs. Even in traditional marketing, these are often prohibitively high for small-scale producers because of the small quantities of marketable product produced and the absence of adequate physical and market infrastructure in remoter areas. Transaction costs are also increased where producers lack negotiating power or access to market information and remain dependent on middlemen. Moreover, the lack of facilities for the formation of producers associations, or other partnership arrangements, makes it more difficult for smallholder producers to reduce transaction costs through economies of scale. Economic forces towards vertical coordination are sometimes further strengthened

STANDARDS IN THE LIVESTOCK MARKET AND IMPLICATIONS FOR SMALL SCALE PRODUCERS

	Positive factors	Negative factors
Process standards		
UHT treatment of milk, government requirement.	Clearly specified process	Administration costs of inspection. Investment in equipment and training may exclude smallholders.
HACCP in abattoir, 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 small scale (e.g. honey production in Chile). Favours labour-intensive systems	Several certifying bodies, harder to achieve in developing countries. Costs of certification. Achievable by smallholders working in co-operatives.
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 standard. Cost of tests may be prohibitive unless subsidized by government.
Combined standards		
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 Reduce risks related to variations in input and output prices	Risk of total market loss if fail to produce required quality. Not all producers meet requirements. Social stigma if fail to "make the grade".

if governments tax market transactions for, e.g. feed, as described by Delgado and Narrod (2002) for the case of poultry producers in Andhra Pradesh (India). The combined effect of economic gains from lowering transaction costs by vertical integration, and favourable tax regimes, may severely disadvantage independent and small scale producers.

Industrialization of production

Livestock sector industrialization can be a natural consequence of vertically integrated food chains and supply to large retailers; it can also happen independently. Scaling up, regional concentration and intensification each represent a form of industrialization.

Scaling up

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, 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 rapid decline. In Brazil, between 1985 to 1996, the two largest categories of pig farms increased their proportion of the total number of farms (De Camargo Barros *et al.*, 2003).

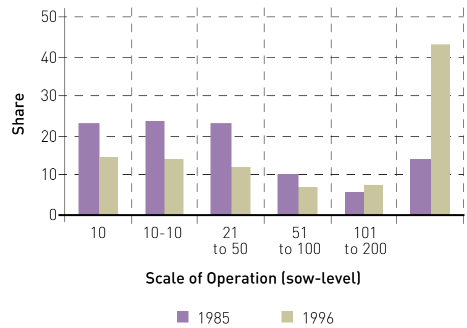
Similarly in Thailand, only the largest category of farms grew in number (Poapongsakorn *et al.*, 2003). In Southern Luzon region of the Philippines, one of the main pig producing regions, while smallholders as a whole still exhibited growth in pig numbers from 1980 to 2000, the pig numbers in commercial farms exhibited phenomenal growth (Costales *et al.*, 2003).

Smallholders can stay in business by providing their labour input to their own farms at below market price, which works well in countries where there are limited employment opportunities in other sectors. But as soon as employment opportunities in other sectors rise, many smallholder producers opt out.

Different commodities and different stages in the production process reveal different potential for economies of scale. They tend to be high in the post harvest sectors (slaughterhouse, dairy plants). In commodity production, poultry is most easily mechanised and shows a trend towards industrial forms of production even in least developed countries.

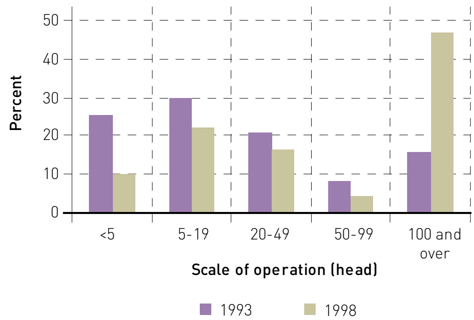
In pig production in Asia, the potentials for scale economies depend on the type of activity and final output. In finished pig production, where investments in breeds, programmed nutrition, and animal health have significant impacts on productivity gains (reflected in better feed conversion ratios and premium prices for output due to

CHANGES IN THE SIZE DISTRIBUTION OF PIG FARMS IN BRAZIL, 1985 AND 1996



Source: De Camargo Barros *et al.* (2003)

CHANGES IN SHARE OF PIG HOLDINGS BY SCALE OF PRODUCTION, THAILAND, 1993 AND 1998



Source: Poapongsakorn *et al.* (2003)

perceived quality differences), larger farm size is an advantage. In piglet production for sale to finished pig producers, size is not the main factor in generating higher profits per unit of output, because caring for piglets up to weaning and sale both require intensive labour, but at the same time a critical mass in terms of scale is needed to exploit the advantages of technology (Poapongsakorn, *et al.*, 2003). Dairy production also has high labour requirements, and farm-level production costs on small farms are often comparable with those of large scale enterprises, usually resulting from the provision of family labour below the level of minimum wages. As a result, dairy production continues to be dominated by family-based production. However, the expansion of smallholder production beyond a semi-subsistence level is constrained by a number of barriers, lack of competitiveness and risk factors.

Recent studies (Delgado and Narrod, 2002) confirm the substantial impact of hidden and overt subsidies that facilitate the supply of cheap animal products to the cities, to the disadvantage of small-scale rural producers. There is often no public support for the adaptation or dissemination of new technologies for small-scale use. Production costs other than labour are higher for smallholders because of both market and production risks. Smallholders have fewer assets and strategies than large scale producers to cope with market risks such as price fluctuations for inputs and products, or production risks related to resource degradation and control, climatic variations such as drought and floods, and infectious diseases.

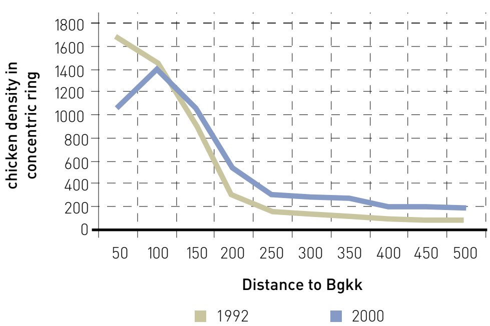
Regional concentration

As countries industrialise, they follow a pattern in relocating livestock production. Traditionally, livestock production is based on locally available feed resources, particularly those of limited or no other value, such as natural pasture and crop residues. The distribution of ruminant livestock can be explained by the availability of such resources, while the distribution of pigs and poultry follows closely that of humans, because of their role as waste converters. For example, in Vietnam, a country that can be considered to be in its early stages of industrialization, 90 % of the poultry distribution pattern can be explained by the distribution of the human population (Gerber *et al.*, 2005).

As soon as urbanization and economic growth translate rising incomes into "bulk" demand for animal food products, large scale operators emerge that, at the initial stage, are located close to towns and cities. Livestock products are among the most perishable products, and their conservation without chilling and processing poses serious problems. Therefore, livestock have to be produced in the vicinity of demand.

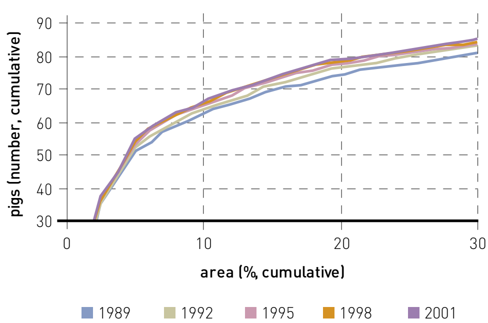
In a subsequent phase, infrastructure and technology develop sufficiently to make it possible to keep livestock further away from people, and livestock production shifts further away from demand centres, driven by a series of factors such as lower land and labour prices, access to feed, lower environmental standards, tax incen-

GEOGRAPHICAL CONCENTRATION OF POULTRY AROUND BANGKOK, 1992 AND 2000



Source: Gerber (2004)

INTENSIFICATION OF PIG PRODUCTION, FRANCE



Source: Gerber (2004)

tives, and fewer disease problems. The poultry density in areas less than 100 km from Bangkok decreased between 1992 and 2000, with the largest decrease (40%) in the areas close to the city (less than 50 km). It increased in all areas further away than 100 km. These trends were encouraged by tax incentives. In developed as well as developing economies, increased concentration of pig and poultry production continues. The pig populations in France, Brazil and Thailand continue to concentrate in fewer, larger units (Gerber, 2004).

The geographical concentration of livestock in areas with little or no agricultural land leads to high impacts on the environment, which are mainly related to manure and waste water mismanagement, although air pollution and loss of biodiversity can also be undesirable results. Nutrient overloads can result from several forms of mismanagement amongst which are over-fertilisation of crops, over feeding of fish ponds, and improper waste disposal of agricultural (e.g. livestock) or industrial wastes. Nutrient overloads in the crop-livestock systems mainly occur when the nutrients present in manure are not properly removed or recycled. Phosphate (P_2O_5) overload is a concern in almost a fifth of cropland in South, East and South East Asia (Gerber *et al.*, 2005).

The concentration of livestock production and processing in peri-urban areas undermines the possibility for the rural poor to benefit from new market opportunities. While cheap animal protein favours poor consumers, the poverty and equity effects, of industrial livestock production, are on balance largely negative (De Haan *et al.*, 2001). There are also a number of animal diseases associated with increasing intensity of production and concentration of animals in limited space, and many of them pose a threat to human health (zoonotic diseases). Industrial and intensive forms of animal production may be a breeding ground for emerging diseases (Nipah virus, Bovine Spongiform Encephalopathy, Avian Flu), with public health consequences.

Intensification

Intensification of livestock production is taking place with regard to most of the inputs. In particular, feed efficiency has been greatly improved over the last decades. While large parts of the developing world are moving up the food chain, enjoying a richer and more diverse diet, so are livestock; traditional fibrous and energy-rich feed stuffs are in relative decline, and protein-rich together with sophisticated additives that enhance feed conversion are on the rise.

Traditionally, livestock production used to be based on locally available feed resources, including local fodder, crop residues, and unconsumed portions of household food. Feed had no value as food. Traditionally, natural pastures were the venue of livestock production. In recent times, however, most pasture land in developing countries is situated in areas which are unfit or marginal for cropping. Often, degraded crop land is converted into pastures. On balance, pasture land productivity has lagged far behind that of cultivated areas, although detailed estimates are difficult to make. A number of factors contribute to this trend. First, intensification of the areas classified as pastures is often technically difficult and unprofitable. Constraints to productivity of pastures most commonly relate to climatic features, topography, poor soil quality, and disease pressure, among others. The difficult conditions of these pasture lands is exemplified by the pastoralist and agro-pastoralist areas in arid and semi-arid lands in Sub-Saharan Africa. These constraints can be overcome only with massive investments to address them on various fronts, otherwise, piecemeal interventions will have no effect. Additionally, in much of Africa and Asia, most pastures are under common property which further complicates their intensification. Without firm institutional arrangements, private investments into these areas are difficult to organize as returns accrue to individuals, proportional to their livestock number on communal land. Lack of infrastructure in these remote areas further contribute to the difficulty in obtaining successes in productivity improvements through individual investments.

As livestock production grows and intensifies, it depends less and less on locally available feed resources but increasingly on feed concentrates that are traded domestically and internationally. In 2004, a total of 690 million tonnes of cereals were fed to livestock (34 % of the global cereal harvest) and another 18 million tons of oilseeds (mainly soya). In addition, 295 million tons of protein-rich processing by-products were used as feed (mainly bran, oilcakes and fish meal).

Species that can profitably make use of such concentrate feed (pigs and poultry) have an advantage over those that do not (cattle, sheep, goats). Among the monogastrics, it is poultry that show the highest growth rates and lowest costs per unit of output, mainly because of favourable feed conversion. Where the use of concentrate feed for ruminants is observed, it is limited to countries with high meant/grain price ratios. Where these ratios are low, typically in grain- or cereal-deficit developing countries, grain feeding to ruminants is not profitable.

What is driving the increasing use of feed grains? First, there is a decline in grain prices, a trend that is basically unchanged since the 1950s. Despite growing demand over that period, supply has not lagged behind. On the contrary total supply of cereals increased by 46% over the last 24 years (1980 to 2004). In real (constant USD terms) international prices for grains have halved since 1961. Expanding supply at declining prices has been brought about predominantly by intensification of existing cropped area and to a lesser extent by area expansion (globally, cereal harvested area shrank by 5.2% over the same period). Intensification is a result of technological advances and higher input use in crop production. In contrast to developed countries, expansion of area dedicated to cereals has been an important contributor to growing supplies in the developing countries between 1980 and 2004, with rates highest in Sub-Saharan Africa (64.0%) and East and South East Asia (15.2%). In Latin America, expansion of the area dedicated to cereal production has been slower (3.9%) however, the area for oil crops rose by 97%. Some countries have seen a particularly strong expansion of cropped area, most of it at the expense of previous forest (Brazil and other Latin America countries). Large parts of this area expansion are on account of concentrate feed production, notably soya and maize (FAO, 2005).

Intensification draws on other technical improvements, such as genetics, health, and farm management that have contributed to raising natural resource use efficiency and output per animal. Between 1980 and 2004, the pig meat, chicken and milk offtake per unit of stock has increased by 61%, 32% and 21% respectively (FAO, 2005). These new possibilities, however, have to be transformed into techniques that can be adapted to local conditions, for their profitable adoption to be likely. These technical advances are supported by increasing use of external service providers and by the specialisation of production, with a substantial shift from backyard and mixed systems to commercial, single product operations.

Conclusions

The rapid expansion in demand for meat and milk in developing countries, and the increasing demand for differentiated and higher-value products of livestock origin, are transforming the livestock industries in these countries. Following the trends in the growth and modernization of global agri-food systems, so too are the livestock production patterns in developing countries being transformed, toward larger, more industrialized, and more vertically coordinated organization. The speed of change is highly variable among countries, depending on the levels of economic development and the socio-political conditions. The pace quickens where there is sufficiently high demand, to reach a critical mass to exploit economies of scale, and accelerates where there is entry of significant foreign direct investment (FDI) to complement or compete with local investments. The speed of change also varies among livestock species, with the activity being most dynamic in the monogastrics (pigs and chicken).

The trends, from a system of livestock production that mainly converts waste and organic material of low value to meat and milk, to one that is based on sophisticated breeding, animal health care, and livestock nutrition, and from a livestock marketing and distribution system that follows informal chains and traditional wholesale markets to one that has to compete with modern agri-food value-chains, have a number of policy implications.

In countries where transformations have been most notable, there has been a shift towards fewer and larger farms, towards the employment of contracts or other agreements between distributors and producers, and increasing formal investment and employment, particularly in the processing of livestock products. Taking control on the processing and distribution side of the industry, while allowing the modern agri-food industries to rapidly respond to consumer preferences, also provides them leverage to exercise pressure on producer-suppliers. The exercise of private standards by modern agri-food chains is not scale neutral, and can result in easing out of smaller scale producers. Even policies to introduce public standards defining the minimum requirements of food quality and safety for participants in formal markets may have the impact of raising barriers to market participation. It is important to examine policies and measures that support and provide subsidy to capital investment and employment of labour, in order to ensure that the privileges and incentives extended do not unduly favour large business institutions. As markets transform and the informal markets shrink, policies and strategies are needed to raise the capabilities of small scale operators who have the potential to meet the volume and quality demands of the formal markets. At the same time, exit strategies should be designed for those who are unable to cope.

The livestock sector has become the engine of growth for a large part of the crop sector, making demands on land and associated commercial inputs. The sometimes popular view, that the world hunger problem could be resolved by simply curtailing demand for meat and other livestock products, and thereby releasing grain used as feed for human consumption, is flawed. In the absence of demand for feed grains, less would be produced, and the hungry would still go hungry. This underlines the notion that world hunger is a demand (income) problem rather than a supply problem. However, it is clear that the growing livestock sector demand for feed grains and other feed ingredients raises the price of these and other similar commodities to higher levels than would otherwise be the case. This makes grains and other staples less accessible to the poor who have to buy them. On the other hand, producers, many of whom are small-scale and poor, stand to earn higher income from higher prices. The balance between winners and losers, when looking at poor households, as well, is not clear cut, and differs from country to country. Yet it is also clear that the more income opportunities are created among rural households, whether in staples, feedgrains, livestock production, or from employment along the agri-food processing and distribution chains linking rural to urban areas, the greater is the likelihood of reducing hunger and poverty. Response to the demands of future generations for rich and diverse diets depends as much on crop research and technology, including associated input use and natural resource management, as it does on pushing productivity in the livestock sector in the strict sense.

Care needs to be taken that policies do not lead to the proliferation of intensive livestock production activities close to demand centres in developing countries, with serious environmental impacts, and health consequences on the urban and peri-urban population. There is a strong case for policies and public investments that create incentives for formal livestock production activities and supporting agri-food processing and distribution chains to locate and spread out in the rural areas of developing countries. As access to markets for inputs and outputs are a critical element of the incentive for industry to invest in such areas, the development of infrastructure must be such that even over large distances, production areas, processing plants, and demand centres can be efficiently linked. The ruralisation of the animal products food chain has the potential to considerably reduce the negative externalities that emanate from the concentration of unregulated peri-urban animal production, while at the same time creating new employment and income opportunities among the rural communities. Policy instruments can take the form of public investments in functional rural-to-urban transport and communications infrastructure, and time-bound tax breaks, covering the investment phase and early operations period. Moreover, incentives may be designed such that they are linked to measurable parameters such as land-livestock balances achieved on an area-wide framework, to discourage the build up of clusters or high concentrations of livestock. Similarly, training and organisation of rural communities is required to ensure their capacity to contribute to the livestock supply in different capacities along the agri-food market chains.

At the same time, there is high potential for better integration of livestock and crop activities. Livestock waste management can be improved by effective policy frameworks, clearly linking specific environmental concerns to the operational aspects associated with livestock production technologies and practices. Strategies should be designed for capacity building at the national and local government levels for the strict enforcement of the existing environmental and zoning regulations, and for a broad-based education and information on the public health risks and cumulative environmental impacts associated with inadequately regulated and poorly managed livestock waste disposal.

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Managing transboundary animal disease

Jonathan Rushton, Anni McLeod and Juan Lubroth

Despite strenuous efforts, the control of transboundary animal diseases continues to elude livestock services in certain parts of the world. Good scientific progress has been made in the development and application of technologies and tools for control, including diagnostic tests, vaccines and remote sensing methods, as well as context-adapted disease investigation methods such as participatory epidemiology. However, the management of disease control in many countries lags behind the science. Controlling transboundary animal diseases (TADs) poses severe management challenges to veterinary services, since disease emergence and spread is affected by a range of social and environmental factors that are outside of the control of the state.

The veterinary service ideally provides leadership and carries out actions that complement and reinforce private sector activities and are appropriate to the epidemiological conditions. Controlling TADs requires from the government a strategy and operational plans (a national prevention plan and an emergency contingency plan) backed up by sufficient resources and an appropriate organisational structure and culture within the animal health system. Indicators of good management include: disease status that is accurately known; outbreaks occurring seldom and quickly controlled; and minimal costs to producers and government. Co-operation between producers and between the private sector and the government, as well as management of biosecurity in individual units, all contribute to good disease management.

Even the best leadership within the livestock sector is limited by the national economic and institutional environment. Economic development, institutional systems and social factors such as increasing urbanisation and human mobility all impact on the spread of disease and the functioning of veterinary services. Governance of the country, manifested by indicators (World Bank, 2005) such as the rule of law, regulatory quality and control of corruption, as well as general government effectiveness, can be expected to affect the extent to which the veterinary service is able to develop effective disease control policies and implement regulations.

This paper examines the management of four major transboundary diseases on three continents: Classical Swine fever (CSF) and Foot-and-Mouth Disease (FMD) in Latin America, Contagious Bovine Pleuropneumonia (CBPP) in Africa and Highly Pathogenic Avian Influenza (HPAI) in South East Asia. The diseases affect cattle (CBPP), pigs (CSF), poultry (HPAI), and multiple species (FMD). They are found in countries with large livestock economies that are aggressively seeking export markets as well as countries whose livestock sectors do not satisfy their own protein demands. By reviewing successful and less successful attempts at control of these diseases, the paper identifies the economic and institutional conditions that must be met within and outside the veterinary service before a sustainable TAD management programme can be established.

Disease status

HPAI in South East Asia

Of the four diseases reviewed in this paper, HPAI has had the most recent and dramatic impact on a global scale. Although strains of avian influenza circulate regularly in poultry and wild birds with relatively mild effects, the H5N1 strains that recently emerged in Asia created serious economic impacts on the poultry sector and in some cases the general economies of the countries affected.

As well as causing high rates of mortality in chickens, HPAI can cause mortality in humans. At the time of writing, 122 human cases and 62 deaths were known to the World Health Organisation (WHO). Most cases to date could be attributed to the direct transmission of the virus from poultry or raw poultry products to humans, but there was a great concern that reassortment with human influenza might result in a global pandemic, with disease spreading from human to human.

In 1997, 2001 and 2002, outbreaks were reported in Hong Kong, SAR China, but the country has been free of clinical disease since 2002. More recently, outbreaks of H5N1 were reported in 2004 and 2005 from Cambodia, China, Indonesia, Japan, Lao PDR, Malaysia, South Korea, Thailand and Viet Nam. Although progress has been made in containing HPAI, cases are still occurring, notably in Viet Nam, Thailand and Indonesia and occasionally in other countries in East and South East Asia. At the time of writing, the disease was spreading across central Asia and into Europe, probably introduced by migratory birds.

In Cambodia and Lao PDR, the poultry economies are dominated by backyard producers. Neither country was involved in formal poultry exports prior to the HPAI epidemic. HPAI had a very minor impact in Cambodia in terms of direct poultry deaths and control measures of stamping out, but a negative impact on egg and poultry meat markets, including chickens and ducks. In Lao PDR, HPAI had a major impact in the small commercial chicken layer and quail systems in the province of Vientiane Prefecture.

In Indonesia it was reported that the most important impact was on the small-scale commercial producers. Indonesia has a heavily protected poultry industry (Fabiosa *et al*, 2004) with a high proportion of its production in large industrial systems and in smaller commercial systems. In addition there are a large number of backyard producers. Indonesia has not been an important exporter, but it has a growing domestic demand for poultry meat, which provides the cheapest form of animal protein. Currently, vaccination is compulsory. Commercial producers finance and organise it themselves, while only limited vaccine coverage is maintained in backyard systems.

Thailand was the fifth largest poultry meat exporter in the world before 2003 (FAOSTAT data). It suffered a severe drop in export values in 2004 and has now switched to processed products. A large proportion of the Thai poultry population and production are in the industrial system, although the majority of its producers are small scale. While outbreaks are still being reported,

POULTRY SYSTEMS IN FIVE SOUTH EAST ASIAN COUNTRIES AFFECTED BY HPAI IN 2003-5

Country	Industrial	Large commercial	Small commercial	Backyard
Cambodia		<1% poultry	<1% poultry	99.9% farms, 90% poultry
Indonesia	3.5% poultry, export & national consumption	21.2% poultry	11.8% poultry	63.4% poultry
Lao PDR		Small	10% poultry	90% poultry
Thailand	70% production, export important	20% production	10% production, 98+% producers	
Viet Nam	Small	20-25% production, few producers	10-15% production, few producers	65% production, possibly 70% of poultry

Source: adapted from Rushton *et al.* (2005).

PHOTO: A. MCLEOD

Duck herding in Vietnam

they are few in number and generally quickly controlled. The herded duck systems associated with paddy rice production pose a particular danger since ducks can carry the virus without showing clinical signs. Thailand prohibits vaccination. The government and private sector are assessing the use of compartmentalisation as part of the national disease control strategy, the only country in the region where this approach is seriously being considered.

Viet Nam has experienced continuing outbreaks in 2004 and 2005, although, like Thailand, the speed of outbreak control has been increasing and the number of birds dead or culled was considerably reduced in 2005 compared to 2004. The poultry economy is dominated by backyard systems, in terms of production and the number of producers, but there are emerging large commercial systems. Herded duck systems are found in and close to the two main river deltas. There has been a steadily growing domestic demand for poultry meat and some official exports were reported prior to the outbreaks. The HPAI impact on the backyard systems in Viet Nam was very severe, with high mortality rates in affected flocks (Dolberg, 2004).

CSF and FMD in Latin America

CSF is being pushed back in Latin America to geographically circumscribed areas. FMD has also been pushed back to a certain extent, but outbreaks in recent years in certain countries of Latin America show that progress is fragile.

Both diseases threaten the export of livestock and livestock products, and constitute a major concern for commercial producers in the Southern Cone[1] of Latin America, where a large proportion of cattle and pigs are found in extensive commercial systems. The majority of countries in the Southern Cone have managed to attain free status from both CSF and FMD, although FMD freedom was temporarily upset by outbreaks in 2000 and 2001 in Argentina, Brazil and Uruguay. Paraguay has maintained FMD free status with vaccination, but is one of the poorest countries in South America and has a weak disease control infrastructure. In Brazil problems continue to exist.

The Andean and Caribbean countries, by contrast, mostly have low numbers of livestock units

[1] The southernmost areas of Latin America, including Argentina, Chile, Uruguay, Paraguay and Southeastern Brazil.

(LSUs) per person, and rely on intensive monogastric systems to satisfy protein demand. They also have a significant proportion of LSUs from sheep and camelids. CSF is more problematic than FMD in these countries for two reasons: the majority of the pig population is found in backyard smallholder systems that are difficult to reach with existing veterinary delivery services, and most countries, with the exception of Colombia, have not yet mounted serious campaigns for the eradication of the disease (Viscarra and Rushton, 2004).

Central America has relatively few LSUs per person, and it contains some of the smallest economies and poorest countries in Latin America. Central America has never had FMD. With assistance from the Organismo Internacional

CSF STATUS IN LATIN AMERICA, 2004

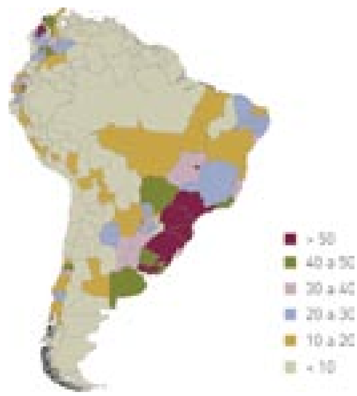
Source: Rushton and Viscarra, 2004

FMD STATUS IN LATIN AMERICA, SEPTEMBER 2005

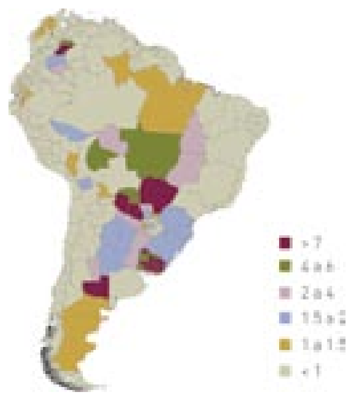
Source: Rushton and Viscarra, 2004

LIVESTOCK UNITS IN SOUTH AMERICA

Livestock Units per km^2



Livestock Units per person



Source: Rushton and Viscarra, 2004

Regional de Sanidad Agropecuario (OIRSA) and FAO, some success has been seen in the control and eradication of CSF.

Mexico is large in terms of geographic size, population and economy, but with few LSUs per head. It is also a country of tremendous diversity with numerous livestock producers in the northern States and the Yucatan Peninsula who maintain large ranches and large intensive pig production units. These large-scale commercial producers have been successful in controlling and eradicating CSF, but the country faces challenges with the eradication programmes for CSF, particularly in areas where there are commercial producers near to backyard systems. The country has been free of FMD since 1954.

CBPP in Eastern and Southern Africa

Levels of CBPP control have fluctuated across Eastern and Southern Africa over the past 50 years, but this disease has become more problematic in these regions in the last 10 years. CBPP has been repeatedly mentioned as important to the success of African livestock production (Provost and Davies, 1996; Roeder and Rweyemamu, 1995; Windsor and Wood, 1998), although studies to confirm its importance are few (Twinamasiko, 2002) and analysis of the official data submitted to the World Organisation for Animal Health (OIE) indicate that in an eight year period between 1996 and 2003 only 48,748 cattle either died or were sacrificed in order to stop its spread.

The livestock economies in Eastern and Southern Africa are dominated by cattle, with over 90% found in pastoral, semi-arid, subhumid and highland mixed systems (Otte and Chilonda, 2002). In the pastoral areas livestock are critical to the livelihoods of producers, but in the mixed systems they are often a secondary activity that in many areas is well integrated into the general farming system. In terms of importance to the general society, there are relatively few LSUs per person in all countries of the region except Sudan, Botswana and Namibia. In addition, the consumption of meat and milk is relatively low in all countries except Botswana and Namibia for meat and Sudan, Somalia and Kenya for milk. Tambi and Maina (2003) report that livestock productivity is low and that while beef production has increased it has come from cattle population increases. In the case of Southern Africa there has been a reduction in overall productivity. Botswana, Namibia (and formerly Zimbabwe) export to the EU while other countries engage in regional trade to varying degrees.

In East Africa, CBPP is important in southern Sudan, Tanzania and in drier areas of Uganda and Kenya inhabited by pastoralist livestock keepers. It was eradicated in Tanzania in 1964, reappeared in 1990 and subsequently spread across much of the country, causing the death of some 350,000 cattle in a ten year period (Kusiluka and Sudi, 2003). In the pastoral production systems of Western Uganda, Twinamasiko (2002) found that in high prevalence herds the majority of the disease occurrences (77%) were due to CBPP, but in the general population only 13% of the disease occurrences were due to CBPP. In pastoralist herds in Tanzania, AU/IBAR (2002) learned that the disease would enter a herd and cause high mortality in the first year and then sporadic mortality in subsequent years. CBPP is defined as either the first or second most important disease in pastoral systems of the Masai and Afar and ranked as second or third in importance by the agropastoralists in Ethiopia (Bonnet, personal communication). However, it is reported to be sporadic and of limited importance in the drier areas of northern Sudan and north-eastern Kenya (Mariner, personal communication), although in herds that experience the disease, losses can be very high.

In Southern Africa, southern Angola has been associated with harbouring the disease and being a source of infection for neighbouring countries. Cattle movement was particularly important in its spread during the heavy periods of the civil war which ended in 2004. Botswana experienced a serious CBPP outbreak in 1995 that halted

OUTBREAKS OF CBPP REPORTED IN EASTERN AND SOUTHERN AFRICA BETWEEN 1996 AND 2003

	Eastern Africa			Southern Africa		
Year	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths
1996	105	1,567	717	97	3,951	2,657
1997	89	2,454	777	66	4,226	252
1998	133	6,642	3,726	12	560	127
1999	283	11,188	3,773	4	15	2
2000	188	3,029	1,429	18	514	167
2001	224	8,878	4,139	9	41	17
2002	236	11,064	2,197	171	934	424
2003	218	7,349	1,388	106	7,966	4,128
Total	**1,476**	**52,171**	**18,146**	**483**	**18,207**	**7,774**

Source: OIE, 2005

exports and ended with the destruction of 320,000 cattle. CBPP impact and control measures appear strongest in Kenya, Tanzania, and Namibia followed by Ethiopia, Uganda and Zambia. Botswana has been free since 1995, Zimbabwe last reported the disease in 1904, with Malawi and Mozambique have never reported it.

Disease management

HPAI in South East Asia

Prior to 2004, HPAI was controlled at the sub-national level in the USA (1983), Italy (2000) and Chile (2001). However, the large-scale occurrence of HPAI in Asia due to H5N1 and H5N2 viruses in 2003-2005 represents a challenge. Among Asian countries/regions that have recently experienced HPAI outbreaks, Hong Kong, SAR China and Malaysia stand out for successful management of the disease, with Thailand making good progress in spite of initially serious outbreaks. In all three of these countries, disease management has been carried out entirely or substantially without external financial support.

Hong Kong, SAR China, is an interesting case in that, while poultry are important to the local economy and domestic consumption, export is minimal, and most production takes place on small commercial farms. The outbreak in 1997 was controlled by culling of all chickens in the country. When disease returned in 2001, mass culling was not repeated. There was a strong economic and social incentive for the government, poultry producers and market stallholders to find an alternative approach. A disease management plan was developed, based on farm and market biosecurity, surveillance and compulsory vaccination for all but very small flocks (Wong, 2005). It is jointly funded by the public and private sectors and very strictly enforced (for example, if a market stallholder fails to observe compulsory "rest days" their licence is permanently removed). Since 2002 the country has been free of disease. The national animal health institutions are stable, and quite well funded from an economy with a strong tax base, and the country scores highly on rule of law, regulatory quality and control of corruption (World Bank, 2005).

Malaysia had only a single outbreak, which it rapidly controlled by culling and disinfection of premises and strict movement controls in the infected area. There was a considerable incentive and pressure from commercial producers not to lose the export market, and a concern that presence of HPAI would damage tourism. The animal health service is stable, well organised and relatively well funded, it has well established policies and disease control regulations, and funds were quickly made available to deal with the outbreak. Malaysia, like Hong Kong SAR China, scores highly on governance indicators.

In Thailand, poultry export is important to the economy, although the agricultural sector is not large, and the major producers and exporters work in partnership with the government. Zoonotic disease emerging from the livestock sector is a threat to tourism as well as to general human health. Over approximately 18 months, the country has considerably reduced the number of outbreaks. In an attempt to eradicate the disease without vaccination there has been an increased speed of response to new outbreaks and an active surveillance programme has been initiated based on clinical inspection of all poultry operation. The country's interest in compartmentalization is partly driven by the need to find a solution that accommodates the needs of both the exporters and the large number of smallholder farmers who keep poultry (FAO TCP and staff mission reports, 2004). Thailand's government is stable, its public service generally effective and the society is generally law abiding.

Viet Nam and Indonesia share the benefit of growing domestic demand for poultry (at least, prior to HPAI) and the challenge of decentralised government systems. In Indonesia, decentralisation is especially pronounced with decisions at district level having a major influence on the execution of national plans. Compulsory vaccination was introduced partly to reduce the need for compensation, and has been funded and organised in commercial flocks by the producers, leading to some success in controlling clinical disease. Commercial producers are many in number and fairly well organised, with producer associations. However, funds for vaccination of backyard flocks, surveillance or compensation are very limited. Issues relating to vaccine quality in Indonesia remain unresolved to date. Viet Nam also has a decentralised government with funding decisions made at both central and provincial level, but a large proportion of finance for HPAI control in 2004 came from the central government (Riviere-Cinnamond, 2005). Funds for disease control, especially compensation of small producers, are limited, and the government has recently reviewed its compensation policy to try to address this problem. Although domestic demand and the commercial poultry sector are growing, there are still relatively few commercial poultry producers.

Most of the countries affected by HPAI have a large proportion of their poultry in backyard systems where there is private ownership of the birds, but these animals are using communally owned land. Therefore there are no clear boundaries in land use and frequent mixing of birds from different flocks.

There is a need for information on regional movements of birds and poultry products, in order to plan regional strategies of control (at the time of going to press, efforts to this end were accelerating, driven by the need to understand the consequences of wild bird migration). At present it would appear imperative to implement regionally supported campaigns to eradicate HPAI in countries that export poultry and/or poultry products (legally or informally) in order to eliminate the risk of continued movement of the disease to neighbouring countries. Such eradication efforts, combined with the need for the poor or middle income countries affected by HPAI to take on international responsibilities in order to reduce the risks of a human influenza pandemic (WHO, 2004a; 2004b), deserve consideration for regional or international finance, as proposed by FAO and OIE.

FMD and CSF in Latin America.

Effective management of FMD and CSF can be found in the southern cone of Latin America and Brazil. Here, cattle and pig production has a high importance for GDP and export earnings. Meat consumption is high at 77 kg/caput/year in Brazil and 89 kg in the Southern Cone, and the region contains major world meat exporters. The livestock sector is dominated by commercial systems with very strong producer associations and aggressive systems of marketing, supported by government state veterinary services, especially when lobbied by organised producer groups. The exception is Paraguay. Although the economies of the biggest countries have experienced problems, they are growing, with a relatively large tax base, and government institutions are predominantly stable, although only Chile and Uruguay score very highly on governance indicators. Disease control policies and guidelines are well established and regularly reviewed. Success in managing FMD and CSF has been built on a strong collaboration between the private sector and the governments. Dubois and Moura (2004) estimated that in Brazil between 1992 and 2003 for every dollar spent by the state on the control of FMD US$2.66 were invested by the private sector. The private investments are primarily in vaccines, but significant contributions are also made to salaries and to an eradication fund. FMD was very difficult to control during the periods of high inflation as cattle were used as a hedge. This did not encourage medium to long term cattle health management and also meant that movements were difficult to predict. The big challenge for this region in the future is the maintenance of FMD and CSF disease freedom (Rushton, 2004).

The Andean and Caribbean countries, by contrast, are some of the poorest countries in South America with low GDP per caput and a small tax base bolstered by aid receipts and tax revenues from the export of non-renewable resources. The livestock sector is not of great importance to the overall national economies of these countries and investment in livestock services and disease control has been limited. This region includes some of the weakest governments with pressures on representation from indigenous populations, problems of controlling drug production, and, in the case of Colombia an ongoing civil war. Despite these difficulties there have been significant advances in the control of FMD, which over the last five years appears to have largely been controlled and potentially eradicated in some zones. It would also appear that the commercial sectors in these countries are free of CSF. Some of this success has been helped by regional collaborations. In the case of Colombia there has been strong private/public sector partnership with the national FMD campaign being largely financed and implemented by FEDEGAN, the private sector livestock association. Money is raised through levies placed on sales of cattle and animal products and national plans are formulated with the official veterinary service within the Instituto Colombiano Agropecuario (ICA). It is ICA's responsibility to oversee that the actions taken correspond to the general national plan. The success of the partnership can be demonstrated by the high vaccine coverage in Colombia surpassing 95% in most areas and only two limited outbreaks since 2002.

Central America contains some of the smallest economies and poorest countries in Latin America. However with the help of the United States and the formation of a regional animal health network (OIRSA) these countries have created a system where money can be raised through levies to support animal and plant health control programmes. Central America is free of FMD. OIRSA and FAO have worked closely and with some success in the control and eradication of CSF. Veterinary services of the region have undergone profound changes in the aftermath of imposed government restructuring programmes from international loaning bodies, leaving them weakened and limited in operational capability. Creative mechanisms to finance campaigns have emerged in attempts to fill resource gaps independent of typical donor or international organisation contributions. Belize has an interesting example of having created an organisation to run its animal and plant health activities (BAHA[2]) that is funded in part by the government and by

[2] Belize Agricultural Health Authority

user fees, and is controlled by a board of directors from the public and private sectors (Rushton, 2003). The institution was expected to be run at a profit, and its financing arrangement had fostered a strong link between BAHA and the commercial poultry and cattle farmers. However, the recent problems of the Belize government to meet its fiscal debt could jeopardise this system.

In Mexico, large scale commercial producers in the northern States and the Yucatan Peninsula have been successful in controlling and eradicating CSF and as a consequence have gained benefits in terms of export markets to the USA and to Japan. However, the country as a whole faces challenges with the eradication programmes for CSF, particularly in areas with a large proportion of producers and production in backyard systems. The recent decentralisation process has increased these challenges by giving the budgets for field actions to the states, but leaving the federal government with animal health control responsibilities (Ayala *et al*. 2004). What is interesting is that many of the successes in animal disease control in Mexico have been led by either the private sector and/or an external country working with the country (i.e., New World screwworm). In general, the country has good regulatory policies and a reasonably effective public service.

The control and eradication of FMD and CSF are most difficult in areas where the cattle are in extensive systems and pigs are in backyard systems. In both cases the animals are privately owned, but the land is either communally managed or boundaries between herds and land are not clear, allowing the mixing of herds and flocks. These problems have been overcome in the majority of Latin America in the control of FMD through strong coordination between the private and public sector. However, the 2001 FMD epidemic in Argentina, Uruguay and Paraguay demonstrated the fragility of its control. With CSF a number of countries have run successful eradication campaigns again through strong coordination between public and private sectors. This disease remains a problem in countries with weak governments and private sectors and where a high proportion of pigs are in backyard systems.

CBPP in Eastern and Southern Africa

The livestock sectors of Botswana and Namibia stand out as exporters that also have moderately high domestic meat consumption (26 kg/caput/year in Botswana and 56 in Namibia) and strong commercial players. These two countries are also the richest in terms of GDP per caput in the region. Relative to other countries in the region they have a reasonable tax base, generated mostly from non-renewable natural resources, although none of the economies in the region is growing rapidly. They also have stable animal health institutions and well established disease control policies, and, with South Africa, they score highly on governance indicators. To counter the threat of diseases including CBPP from neighbours, Namibia maintains a surveillance and vaccination zone with a fence in the northern part of the country. Botswana has a free zone bounded by fences. When CBPP was detected in 1995, Botswana took drastic action by slaughtering 320,000 cattle in order to eradicate the disease and retain its access to the lucrative, export market. However, the impacts of these control measures have been widespread due to links between the livestock sector and other sectors of the economy (Townsend *et al.*, 1998) and these impacts continue with some producers still unable to find an alternative to cattle raising (Mullins, 2000).

Economies with weak and in some cases negative growth, governments with weak tax bases and limited government investment in veterinary education have all contributed to a low capacity for control of TADs including CBPP. Crises in government financing in the 1980s led to the sudden and often poorly implemented and understood privatisation of veterinary services in many African countries after years of state subsidised services. Financing of animal health has been

LIVESTOCK UNITS PER VETERINARIAN, VETERINARY SCHOOL AND VETERINARY GRADUATE IN THE DIFFERENT CONTINENTS OF THE WORLD

	LSUs per veterinarian in the:			LSUs per	
Continent	Public sector	Private sector	Total	Veterinary School	Graduates in 2002
Africa	12,758	11,058	5,924	3,957,069	64,343
America	12,852	2,984	2,421	1,850,810	35,365
Asia	4,869	3,635	2,081	2,288,854	48,032
Europe	3,170	1,888	1,183	1,893,605	21,040

Source: data from Moura *et al.* (2004), analysis by the authors

dominated by international aid. Some countries in the region have suffered some of the bloodiest conflicts of the last 20 years. Therefore, it is hardly surprising that CBPP control has not been consistently applied and there have been reappearances of this disease in countries that had been free for many years.

This same premise would hold true for other epidemic diseases that affect the success and sustainability of livestock production. The cascade effect on the poor and in some cases falling livestock productivity in these regions (Otte and Chilonda, 2002; Tambi and Maina, 2003) is worrisome. Rather than investing in animal health to support disease control and encourage the adoption of improved management practices, the figures on the number of veterinary schools and graduates per livestock unit in the continent underline the inadequate investment in key livestock professionals, which continues to be below the worldwide trend. CBPP appears to be a particular problem in areas where cattle are in extensive systems, where there is private ownership of animals, but communal management of land. Herds are allowed to mix and there is much movement relating to seasonal availability of pasture. These movements have been disturbed in a number of areas due to social strife.

Since the early 1990s, livestock owners have used antibiotics to cure and prevent clinical CBPP, even when they were not licensed for this use. There has been controversy over antibiotic use because of concerns that animals treated with antibiotics might develop a carrier status, creating a situation where mortality was reduced but the disease could continue to spread. Nevertheless, livestock owners have continued to use antibiotics (AU/IBAR, 2002; Twinamasiko, 200), most commonly tetracyclines as they are widely available.

There have been limited concerted interventions against CBPP. Although control of the disease has been noted as important to the success of African livestock production (Provost and Davies, 1996; Roeder and Rweyemamu, 1995; Windsor and Wood, 1998), only in exporting countries is there a sufficiently strong economic incentive to establish well-funded TAD prevention measures. Twinamasiko (2002) proposed that different parts of Uganda, with different epidemiological conditions, might be treated differently for CBPP control, which could be regarded as a public good in areas with epidemic disease and as a private good in areas where the disease is endemic. Moreover, the possibility of using antibiotic as a control measure offers livestock owners in endemic areas an alternative to participating in mass vaccination campaigns. Between 1996 and 2003 only 33.8 million cattle are reported to have been vaccinated, representing 3.38% of animal years. It is recognised that control programmes will need to include vaccination, with vaccine made widely available, and antibiotic treatment (FAO-OIE-AU/IBAR-IAEA, 2003).

Economic and institutional requirements for effective disease management

Only countries with a healthy GDP and tax base have the financial foundation from which to carry out TAD control on a sustainable basis. The political will to control disease usually flows from commercial pressure. When the livestock sector makes an important contribution to GDP and export earnings, and the commercial operators are strong and well organised and have an effective working relationship with the government, the private sector encourages government ministries to plan and support effective disease management, and then contributes to their financing. Additional pressure is applied when the health of the livestock sector has a demonstrable effect on the economic health of other sectors such as tourism.

Equally important are the indicators of governance within the economy, such as rule of law and strong deterrents against corruption. It is impossible to enforce movement control or import regulations if public servants can be bribed. Governance is also about the ability to formulate acceptable policies. Farmers will be reluctant to report disease where an adequate compensation scheme does not exist, or where they receive conflicting messages from central and local government. Both of these conditions hampered reporting of HPAI in 2003 and 2004. Government level commitment to international norms is equally important. The majority of the major TADs outbreaks in the past few years have been characterised by late and incomplete reporting to the OIE. Commitment to international norms at government level sends a message about the principles of accountability and transparency of actions to the people which is strengthened when funds for livestock disease control are also managed transparently and accountably. Effective fiscal management is essential when disease control may require rapid access to emergency funds and when the private sector directly contributes to funds such as animal health trusts.

Countries with widely dispersed livestock systems and/or livestock kept on publicly owned land face particular challenges. Costs of control are much higher when animals are widely dispersed, live in remote areas, follow transhumant grazing patterns or roam freely within villages. When they are kept on publicly owned land, the private returns to transboundary disease control are lower and less easily captured and the incentive of livestock keepers to participate in government vaccination campaigns or observe movement control regulations are fewer. This problem is particularly acute in rural Africa, where vaccination programmes against CBPP achieve very low coverage in pastoralist areas. The scavenging pigs and poultry of Latin America and Asia are also difficult to fit into programmes for preventing CSF and HPAI, or other public health problems.

While veterinary services cannot control the conditions of the wider economy, they have at least some power over their own management, and can choose to be innovative.

- Dialogue and co-operation with stakeholders is essential for the design of enforceable regulations. Concern about loss of livelihood leads people to sell sick animals rather than report them (observed during HPAI and CSF outbreaks when compensation was uncertain) or to refuse to vaccinate (e.g. the 28 day withholding period for certain HPAI vaccines makes farmers reluctant to vaccinate broilers which will be sold before the withholding period has expired). Concern for the health or appearance of animals leads owners to refuse to vaccinate (e.g. against CBPP, when it was feared that the tail would be damaged). Enforcing "rest days" in markets can reduce the livelihood of stallholders unless provision is made for them to earn additional income at other times. Restricting the use of vaccine to mass campaigns can, for many reasons, reduce coverage. However, innovative approaches can be effective. In some provinces of Viet Nam, making CSF vaccine available at all times through local animal health systems has increased its use. Colombia, in the face of a civil war, has managed to achieve high FMD vaccination coverage by means of a private/public sector partnership. The continued use of antibiotics against CBPP by livestock keepers in the face of government disapproval suggest a need to consider situation-specific solutions, applying different approaches in endemic and epidemic situations.

- Many opportunities exist for government services to work with NGOs and civil society. For example, it is well documented that veterinary services, either state or private, have difficulties reaching poorer producers (Ahuja *et al*, 2003). This can be a problem where these systems provide a continuous pocket of naïve animals to TADs. Education and outreach are often designed as mass campaigns, yet experience in the livestock and human health sectors and in other sectors shows that a long term process of stakeholder engagement is necessary to change human behaviour. Examples of innovative approaches to outreach include the use of participatory epidemiology (Mariner, 2001; Rushton & Viscarra, 2003) for disease surveillance in Africa, Pakistan and Bolivia, and improving biosecurity in wet markets in Hong Kong, SAR China, The Philippines and Malaysia.
- Veterinary services have the opportunity to encourage collaboration between large scale commercial operators and small scale farmers. In Mexico it has been reported that commercial poultry systems finance veterinary services in order to provide Newcastle disease vaccination for the backyard producers in their vicinity (G. Ayala personal communication). In Chile the control and eradication of CSF was due in part to the coordination of the commercial and the small scale pig owners. In the cattle sector, the control of FMD in many South American countries has only been achieved with investment and implementation by the livestock owners.
- Decentralisation of veterinary services, while it offers the possibility of services oriented to local needs, also poses a considerable challenge for financing and management of TAD control. The problems are not insurmountable (the USA, for example, has a decentralised veterinary service) but they do require a "federal" or central level of control and funding, in emergencies, that overrides the usual decentralised operation. Most countries have this in principle, many find it hard to operate in practice. They also, and this has received less attention, need a mechanism for negotiating agreed norms for longer term activities such as surveillance, emergency warning and preventive vaccination.
- Novel financing mechanisms may assist compensation/insurance schemes to be implemented for lower income countries, but trust in payment and accountability processes will be a major challenge. The most successful financing processes usually involve a partnership between the public and private sectors (Dubois and Moura, 2004). This recognises that disease control actions generate both private and public goods (Leonard, 2000). The review of financing of disease control measures in Europe by van Asseldonk *et al* (in press) clearly demonstrates that no one model is appropriate in all situations. Some control programmes are beyond the means of national governments, and if the disease being controlled is of international concern for zoonotic or poverty alleviation reasons, there are strong arguments for concerted international support.
- Increasing the capacity for rapid response is essential, particularly when a control programme relies on disease reporting without vaccination, rather than widespread vaccination. A number of approaches have been piloted to improve emergency reporting (participatory epidemiology among pastoralists in Africa, community animal worker networks in Asia). They will only be successful in the long

term if reporting results in rapid (and helpful) response. Capacity of veterinary services to respond is based on well-designed policies and operational plans for emergency response, as well as sufficient trained staff within the animal health system. Increasingly, contracting of private sector animal health practitioners will be the most effective and cost-efficient way to conduct public sector activities and at the same time to encourage the development of the private service. Most of the veterinarians involved in controlling the last FMD outbreak in the UK were from the private sector, from several countries. Para-professionals have taken part in vaccination campaigns in Indonesia and recently in Viet Nam.

- The approaches proposed above will be most effective when the core of the system, the government veterinary service, is institutionally stable and supported by a strong professional drive and up to date training. A number of management "drivers" are important, such as competitive salaries and meritocracy. A monitoring system based on appropriate indicators is also needed to measure progress, and a review of the appropriate indicators would be timely. For example, the focus for preventive vaccination invariably is on numbers of animals vaccinated (coverage) rather than whether the animals vaccinated are in key endemic areas or during the appropriate season. One indicator for a good surveillance system might be a large number of false positives, and this would also indicate the development of an open reporting culture.
- Regional co-ordination of various kinds (harmonising regulations, co-operative disease control activities, sharing information, joint funding) has considerable potential to enhance the above initiatives. Although in most cases regional co-ordination is not well established for disease control, the few successful examples that exist suggest that this is an approach needing to be exploited. Mexico and the USA have a long history of plant and animal health collaboration which has achieved the eradication of FMD and screwworm and has made important advances in the control of CSF, tuberculosis, brucellosis, and Mediterranean fruit fly. Regional co-ordinations are also being carried out in the control of FMD with Argentina and Brazil working alongside Paraguay and Bolivia. It is hoped that these types of collaborations will be implemented in the control of HPAI in Asia, where embryonic initiatives exist within ASEAN and in the Mekong Delta and networks have been supported by FAO that may in time lead to formal co-ordinated action. East Africa is exploring harmonisation of disease control regulations through its regional trading groups, with a view to improving regional trade and eventually developing more stable export markets.

Conclusion

Effective TAD management is possible, and has been achieved by several of the countries reviewed here, across all of the regions and diseases included in the review. It is, however, highly dependant on national governance and political support.

Political will flows from commercial pressure. A country with a strong commercial sector, operating within a livestock sector that is important to GDP and export, is more likely to have political commitment to TAD control than one with a weak economy, poor tax base and poorly organised producers.

The institutional conditions supporting disease control activities stem from national governance, including the rule of law, prevention of corruption and the ability to formulate effective policies.

With or without favourable national economic and institutional conditions, veterinary services have the choice to improve their own leadership and management. It is within the control of a veterinary service to develop a TAD control strategy and operational plans (a national prevention plan and an emergency contingency plan). It is also within the veterinary service mandate to lobby for financial and human resources, and to deploy those available as effectively as possible. The veterinary services reviewed in this paper do not all operate under ideal conditions, yet some of them have managed to introduce innovative ideas and achieve good results.

An effective management system includes a good performance monitoring system with appropriate performance indicators. Outcome indicators suggested in this paper are: disease status that is accurately known; outbreaks occurring seldom and quickly controlled; and minimal costs to producers and government. To these might be added capacity indicators such as: a strong relationship with commercial operators, NGOs and civil society; mechanisms for overcoming the constraints to TAD control posed by decentralisation; innovative financing mechanisms backed up by accountability and transparency; continued development of professionals in public and private service; and strong regional networks. Many veterinary services around the world work to such indicators; it is time for a review of those used in developing countries.

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The future of small scale dairying

Anthony Bennett, Frederic Lhoste, Jay Crook and Joe Phelan

The value of milk and dairy products as part of the human diet is well documented. Milk is a highly nutritious natural food of particular benefit for growing infants and lactating mothers. Milk contains valuable minerals, vitamins, protein and fat which are the building blocks for healthy growth and development. Recognition of the value of milk is reflected in the increasing interest in development programmes focused on small scale dairying in developing countries where malnutrition and poverty are the main challenge. Market oriented small scale dairying has the potential to increase household income, reduce losses and generate employment in processing and marketing. Potentially, therefore, small-scale dairying is a viable tool to spur economic growth and alleviate poverty. Interventions in small scale dairying need to be relevant to the informal market given that the informal market is and will continue to be important in the foreseeable future. However, the growing demands of milk markets for quality and food safety need to be taken into account when designing interventions. This paper examines the types and importance of small scale milk producers in developing countries, shows projected market demands and indicates the complexities of the multiple dairy market chains. It examines interventions and approaches to successful dairy development and identifies issues for consideration in designing small scale dairy development. A Market Oriented Dairy Enterprise (MODE) approach is suggested as a possible pathway to improving the income of small scale dairy producers using a graduated risk based approach.

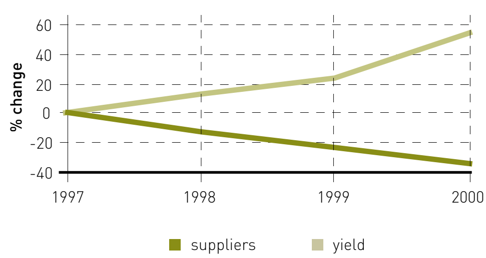
Small-scale milk producers

Demand for milk in developing countries is expected to increase by 25 percent by 2025 (Delgado *et al*, 1999), partly due to population growth but also because disposable income is being spent on a greater diversity of food products to meet nutritional needs. Small scale producers generate the vast majority of this milk. They include smallholder farmers, who practice a mixture of commercial and subsistence production, provide the majority of labour from within the family, and produce a variety of crops and livestock products to spread the risk of failure, as well as pastoralists who depend mainly on livestock.

Milk production systems vary hugely across agro-ecological zones but are usually dependent on the availability of range or pasture land (for grazing and fodder production), the dairy animals to produce the milk and the water needed to maintain the animals. Feed forms the largest input to most milk production systems while support services such as animal health, AI, etc., are essential to ensure productivity can be achieved and maintained.

Trends in developed nations show intensification of milk production in order to reap the benefits of economies of scale. The same is true of some emerging economies, such as Brazil, where the number of small scale producers has decreased as national production has increased, whereas in many developing countries with a

INTENSIFICATION OF DAIRY MARKETS IN BRAZIL



Source: Dries (2004)

potential for dairy development, milk production remains small-scale, scattered and poorly integrated into the market chain.

Milk markets and market chains

One of the unique aspects of the dairy sector in many developing countries in the informal[1] nature of the milk market. It is estimated that over 80 percent of milk consumed in developing countries, an estimated 200 billion litres annually is handled by informal market traders, with inadequate regulation (FAO, 2004a). Substantial work has been done on characterising dairy supply chains but local markets have largely been ignored. Increasing urbanisation means expanding markets for producers particularly in developing countries and countries in transition where the highest rates of urbanisation are predicted. Additional analysis of informal milk value chains is required to assess what is driving the changes that are occurring, whether they are expanding or shrinking, and how to improve market access for small scale producers to the emerging peri-urban markets.

Although direct sale to the consumer is the most common route, recent studies have shown that up to five transactions may take place in the formal dairy chain between the producer and the consumer (FAO, 2004b). Each transaction carries its own cost which is reflected in the price paid by the consumer. Farm gate prices for raw milk vary widely e.g., from US$0.10 during wet season in rural Guinea-Conakry in West Africa to US$0.36 in Ghana.

Milk processing can play a major role in improving milk and dairy product safety, mainly through a variety of heat treatment processes. An emerging trend in formal markets is the adoption of approaches to improve the safety of milk and dairy products as consumers become more aware of

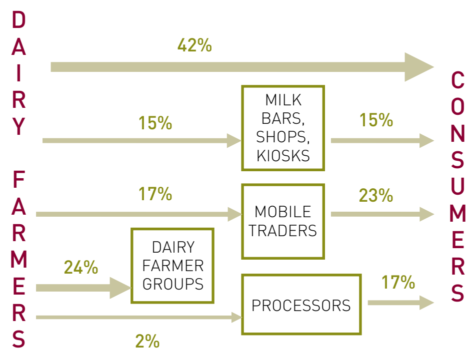
[1] Informal is normally interpreted as an unlicensed or unregulated activity (FAO 2003)

INFORMAL AND FORMAL MARKETS SUPPLIED BY SMALL SCALE PRODUCERS

	Informal	Co-operatives	Source of information
Tanzania	98%	4%	MAC/SUA/ILRI
Uganda	90%		MAIF/ILRI
Nicaragua	86%	4%	CIAT
India	83%	6%	Dairy India
Costa Rica	44%	54%	CIAT
Sri Lanka	40%	7%	MLD&EI

Source: FAO (2005)

DAIRY MARKET CHAINS IN KENYA IN 2004



Source: MoFLD/KARI/ILRI SDP Policy Briefs (2004)

health risks. There is also a growing awareness and acceptance in formal markets of farm to table approaches such as the Codex Alimentarius approved Hazard Analysis Critical Control Point (HACCP) system.

In particular, large retailers and larger dairy industry concerns are promoting a host of other Good Manufacturing Practices or Good Agricultural Practices which are increasingly raising the standards but not necessarily to the advantage of small scale milk producers. "The failure of many African produced food products to meet international food-safety and quality standards hampers the continent's efforts to increase agricultural trade both intra-regionally and internationally, locking many farmers out of a chance to improve their economic well-being. Establishing pan-African food safety standards will not only save lives and improve the health of African people, it will go a long way towards helping Africa join in international trade and raise African living standards, particularly in rural areas where most of the poor are subsisting" (DeHaen, 2005).

Dairy imports to developing countries have increased in value by 43 percent between 1998 and 2001. Demand for dairy products in developing countries is expected to continue rising (Delgado *et al.*, 1999). Consequently, through mobilising the small-scale dairy sector to increase production, benefits such as increased incomes and food security can be received by small scale producers. However, the possibility that dairy imports may reach 38 900 tonnes of milk equivalent by 2030 severely challenges the potential success of the local dairy sector in developing countries (FAO/IDF, 2004).

Recently, formal chains have been affected by foreign direct investment, typically controlled by large retailers such as international or national supermarkets and fast food companies (FAO, 2005), and by the growth of dairy processors that have increased the diversity of products on the market.

Significant increases in demand are reported for local or regionally specific products which may be considered as niche products. The National Dairy Development Board (NDDB) of India recently reported an increase of their production in response to market demand for indigenous fermented milk products from 26 623 MT in 1999/2000 to 65 118 MT in 2003/4 and of paneer[2] from 2 008 MT in 1999/2000 to 4 496 MT in 2003/4. (NDDB, 2004/5) This shows not only the capacity of the Indian dairy industry to expand to meet consumer demand but also the growing appreciation of processed products by mid to high income groups who have the purchasing power to afford these products.

Market pull and push factors such as pricing and payment practices can also have an effect on milk availability. The distance between source and sales areas, or the density and scale of the production system, even without product processing can also increase the number of intermediaries, due to the need for assembling, bulking, transporting and distributing. The number of intermediaries involved will have a bearing on both producer and consumer milk prices. The shorter the channel the more likely that the consumer prices will be low and the producer will get a higher return, although it also depends on the way that the chain is organised and whether it is subsidised. The cost of packaging represents an excessively high proportion (up to 30% in some cases) of the liquid milk retail price in many developing countries.

In response to these changes and opportunities there is a need for a more market-oriented risk based approach to dairy development which firmly positions the smallholder farmer/group as the client beneficiary with decision making powers.

Benefits of small scale dairy farming

As a nutritious food and a source of regular income, milk plays a key role in the household food security in many developing nations. In small scale dairying, milk is available for the family needs first and surplus milk is marketed. One of the most important, but often ignored, direct benefits of small-scale milk production is the immediate nutritional benefit provided to growing children (Calcium and Vitamin A for example) which greatly contributes to a balanced and nutritious diet.

Good nutrition is also a major factor in the ability to fight disease and resist infections. There is growing recognition for the nutritional value of milk and dairy products in communities where

[2] Paneer: defined as "a heat –acid coagulated dairy product" http://www.indianmilkproducts.com/aboutthebook/technology.htm#b

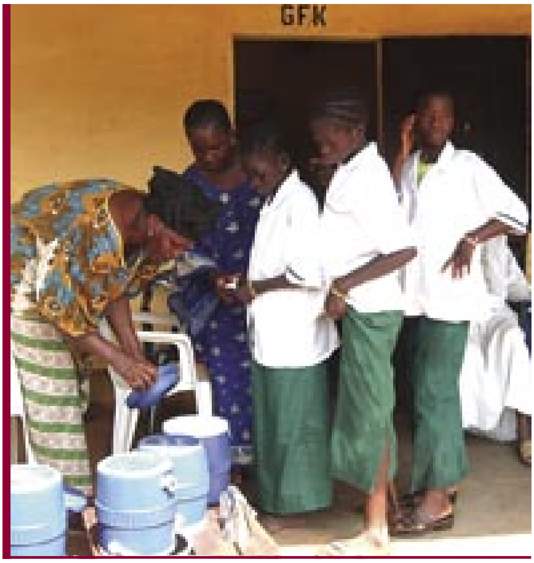


PHOTO: F. LHOSTE, GUINEA, 2003

School children buying yoghurt at the dairy plant

there is a high prevalence of immuno deficient (HIV/AIDS) diseases and in aged populations e.g. fighting osteoporosis.

Women in developing countries play a key role in dairy animal husbandry. Decisions on the amount of milk to be marketed are often determined by the woman of the household and it is normally the woman who controls and decides how the milk money is used at the household level. Frequently quoted priorities include food for the family, school fees and basic healthcare.

Lack of regular income is one dominant cause of poverty. Crop farming and meat production both not only require investment but only yield periodic returns. Dairying, even on a very small scale, can provide modest but regular returns. This not only directly benefits the family but fosters an appreciation and gradual adoption of saving and loans approaches.

Small scale dairying can also be successfully carried out with a limited land base provided access to water, fodder and basic animal health services are available. The growth of milk production in Bangladesh is a good example where even with minimal land resources available, landless smallholders can sustainably produce milk (FAO 2001).

NO. OF OFF FARM JOBS CREATED FOR EVERY 100 LITRES OF MILK COLLECTED PROCESSED AND MARKETED

Country	Direct jobs	Indirect jobs	Total jobs
Bangladesh	7.1	7.3	14.4
Ghana	13.7	3.5	17.2
Kenya	3.0	0.7	3.7

Source: adapted from FAO/ILRI (2004)

Off farm employment represents a significant benefit of small scale dairying, particularly where small scale processing also practised. From four to seventeen jobs can be created and sustained in small scale dairying for every 100 litres of milk collected, processed and marketed. In Bangladesh most of the indirect jobs are in high value products such as milk sweets. There are relatively fewer jobs per 100 litres in Kenya as milk is normally consumed fresh and the highest figures for Ghana perhaps reflect the low supply, high demand situation with retail jobs accounting for much of the employment.

Milk is a highly nutritious food, but it is also an excellent growth medium for bacteria. Raw milk has the potential to transfer zoonotic diseases and milk-handling procedures must minimise associated health risks. Safety and quality assurance programmes for milk and dairy products must cover the whole dairy chain from farm to table. Processing and proper handling are the most critical steps to ensure safety of products and can be effectively implemented through a tailored quality based milk payment system.

When considering the broader benefits of dairying, it is clear that successful small scale dairy production, processing and marketing can be a powerful tool for sustainable rural economic development. This is particularly so when generation and sustaining off farm dairy related employment is considered

PHOTO: F. LHOSTE, GUINEA, 2003

Women selling milk on the local market

Constraints

Specific constraints which limit entry into small scale dairying include:

- Capital investment - the cost of a dairy animal, feed and equipment. This outlay can however be reduced by starting dairying with goats or sheep instead of dairy cows or buffaloes or by using indigenous animals initially. Although their output will be smaller, it represents a lower risk.
- Water and power availability - water is needed not only for the dairy animals to drink but also for the hygienic value added through processing which often makes small scale dairying attractive.
- Knowledge of animal husbandry, particularly nutrition. For a smallholder farmer keeping dairy animals, animal feeding typically makes up 60 -70 per cent of the cost of milk production.
- Access to support services such as feed supply, animal health extension and AI.
- Access to adapted and known production and processing technologies - recent technological developments include low cost packaging and pasteurisation systems which are in high demand in developing dairy nations.

Clearly there are instances when the cost of milk production and the level of required basic infrastructure render dairy production uncompetitive. The measure of competitiveness should also consider strong influencing factors such as local market preferences (e.g., for local fresh milk). Farmers are often not aware of what is needed by the market and have neither the time nor capacity to research market demand. Middlemen or intermediaries are often maligned for their role and considered as an unnecessary element in dairy supply chains. In the dominant informal chains however they play a key role in linking the producer to the consumer. Intermediaries frequently provide credit and savings for the farmer although there are concerns about the cost of the services provided.

Farmer groups may be the best mechanism to improve bargaining power and inform farmers of market needs and demands. The increasing use of modern Information Communication Technology (ICT) is playing a major role in improving instant and periodic market information provision e.g., using SMS messaging, mobile phones and local and national radio stations.

Physical infrastructure such as poor road access and lack of a reliable electrical supply also limits market access. A major constraint to establishing or expansion of a dairy enterprise is the lack of means of milk preservation. Fresh milk is highly perishable with a shelf life of around three hours at tropical temperatures after which it acidifies or sours. Poor seasonal access to rural farms results in huge milk losses for small scale producers who do not have the means to invest in cooling equipment.

Losses along the milk value chain can also be high, resulting from spillage and spoilage due to lack of adequate refrigeration. FAO currently promotes the Lactoperoxidase System (LPS) of raw milk preservation, a safe and natural method that can be used in situations where no cooling facility is available or affordable. It is intended for use by trained people at the level of collection points, not by individual farmers (FAO, 1999) but does not replace pasteurisation (FAO/WHO, 1991).

Approaches and lessons learnt

Working directly with farmers is the most direct means of influencing their decisions and raising their awareness of market opportunities. It is however prohibitively resource intensive and therefore not practicable for public or private partners. An assessment of successful small scale interventions across the five continents by FAO over the last 40 years indicates that the best choice is farmer groups or organisations as an entry point.

Working with groups substantially reduces costs and empowers communities to sustainably manage their own affairs. Small scale dairying is often most successful when it initially addresses local demands, either through accessing existing markets with competitive products or opening up new product streams for consumers.

Milk processing offers further benefits in terms of return and markets for small scale dairying. Returns from processed products are significantly higher than for raw milk and result in significant off farm rural employment in milk collection, transportation, processing and marketing. Additional benefits include improved safety, lowered risk of zoonoses transmission and longer product shelf life.

Strong institutional support is critical to the success of national dairy development initiatives. There is a need to promote milk and dairy product consumption and to facilitate the full participation of smallholders in dairy development. Given the increasing devolution of government towards a purely regulatory role, this leaves a major institutional gap in supporting small scale dairying from the provision of support services, input suppliers, payment systems design through to quality standards and practices. This institutional gap also highlights the need for a change towards a market responsive approach, active capacity building and adaptive technology development and innovation.

Poor governance and weak institutions have been the stumbling block for many dairy enterprises. Milk collection, processing and marketing organisations are attractive 'cash rich' enterprises and therefore at high risk of 'leakage' or misappropriation of funds to the detriment of the shareholder producers. Guidance on milk group formation, operation and activities has been documented by FAO (2002).

An enabling policy and regulatory environment allows market forces to react effectively to market demand. The example of Milk Vita from Bangladesh details the key steps and factors in the success of the transformation of a former parastatal to one of the most successful dairy enterprises in Bangladesh today.

Dairy boards are widely promoted as a suitable institutional framework within which small scale dairy development can take place. Perhaps the best known case is that of India which, through a commodity monetization programme under Operation Flood, has grown to become the second largest milk producer in the world. This was due not only to the massive investments in commodities but also to the management and organisation skills of the National Dairy Development Board of India. It is however important that national institutions are representative of smallholders who form the majority of dairy producers in most developing countries. This can only be achieved when there is, in parallel, development of local producer, collector and marketing institutions.

From the above evidence, it can be seen that a successful intervention in the smallholder sector has to be focused on milk or producer groups as an entry point. An appropriate approach should be risk based, graduated and move progressively to a market oriented dairy enterprise based on group members being empowered to make well informed decisions. A Market Oriented Dairy Enterprise (MODE) approach is suggested as a guide for successful small scale dairy development. The approach is characterised by a stepwise movement towards being a successful dairy enterprise. Essentially three key steps are recognised in the approach:

MILK VITA IN BANGLADESH

From the mid 1970's to the late 1980's FAO, UNDP and DANIDA provided technical and financial assistance through the Government of Bangladesh to establish a sustainable co-operative dairy development programme. From a modest start, providing 4,300 very poor, often landless, households in remote rural areas with a complete package of milk production enhancing technologies, village level organisational skills and a milk collection-processing-marketing system, the two-tier Milk Vita Co-operative has grown into a successful commercial dairy enterprise. Today, milk is collected from 40,000 farmer-members organised into 390 primary village co-operatives, then processed and distributed to all the major cities in the country. In 1998, producers delivered 30 million litres of milk surplus to their household requirements and received a total of Taka 467.4 million (US$ 9.3 million). Since start-up, average milk deliveries per member have quadrupled to 2.1 litres a day, while regular earnings from milk have increased ten-fold in real terms to Taka 32.5 a day (65 US cents). This has helped to lift average earnings above the poverty line and to sustainably improve rural livelihoods. The resultant increase in milking cow numbers and savings generated also serves as a cushion against the devastating effects of severe flooding that regularly afflict the country.

Democratically elected milk producer and distributor co-operative members are now in the majority on the Milk Vita Board of Directors. This encouraged the Government to withdraw from day-to-day management enabling the Board to hire professional managers. This, in turn, improved performance and created a platform for further expansion to bring more poor people in to the remunerative milk collection network. In the 1998/99 financial year Milk Vita made a profit of Taka 40.2 million (US$ 0.8 million) on a turnover of Taka 782.0 million (US$ 15.6 million). Much of the profit was distributed as a dividend to milk producers and reinvested in an expansion programme.

Milk Vita continues to be a flourishing concern, which can be seen not only from its encouraging financial performance and plans for growth, but also from its recent imitators who have set up similar dairy enterprises to process and market 50 million litres of milk annually. The Grameen Bank is currently adapting the model to reach out to some 8,000 of its poorest female clients involved in inland fish farming, again with UNDP and FAO technical assistance.

Step 1: Groups are set up and operational

Step 2: A low level of activities are recorded with limited returns

Step 3: A market oriented approach is adopted and a successful enterprise put in place

At **Step 1**, there is increasing collective activity, e.g. contact with input suppliers such as bulk purchase of feeds, and a clear increase in incomes for the group. Measurement of continuous successful activity (even at this low level in terms of volume or for low profit level) can indicate that the group can move on to the next level. The group or individual will decide when and how to make the move to take the next step.

At **Step 2**, following a period of time and with their expanded perspectives and understanding of market opportunities and acceptance of a low risk level of activity, the group may decide to build up their capacity to expand. This is a key limiting factor in current group development and represents the most significant step in the MODE approach.

At **Step 3**, groups become organised as an enterprise entity or group, expand and consolidate their activities and should also be able to

MODE - A RISK BASED APPROACH TO STEPPED MARKET ORIENTED SMALL SCALE DAIRYING

STEP 3

Group auditing
Preparation of enterprise and investment plans
Application of suitable technologies
Market monitoring and analysis
Group strengthening
Advanced negotiation skills (contracts/agreements)
Sanitation and maintenance
Adding value to optimise profit
Milk and dairy product quality monitoring
Loss reduction
Processing and transaction costs

STEP 2

Development of enterprise business plan
Enterprise accounting and reporting
Exposure to applicable technologies
Milk and dairy product quality assessment
Loss reduction
Group strengthening
Basic negotiation skills (individual to individual)
Sanitation and maintenance
Market research and transaction costs

STEP 1

Milk maps
Transaction recording
Loss reduction
Basic market research
Group formation and enterprise organisation
Improved feed and fodder
Sanitation and maintenance

show that they have regular dairy based activities generating a profit which provides regular incomes to their members. The entity (Self-Help Group, co-operative, company etc.) can then be considered to be a success.

The MODE process is characterised by progressions of (a) institutional arrangements and (b) enterprise and market orientations. The institutional arrangements progression is evidenced by: groups or individuals with dairy animals and dairy activities (i.e., excess milk available); holding regular meetings; initiating group activities of common interest; building group trust; refining group activities; having elected officers; agreement on a constitution; relations with other groups; and participation in stakeholder fora.

The enterprise and market orientation progression is evidenced by: activities generating a benefit; activities generating a profit (cash); market awareness; increased availability of market information; market research; market analysis and identifying and quantifying opportunities; testing products on the market and consumer preferences; analysing feedback and preparing a market entry strategy; limited investments for products or marketing; launching of products on the market; regular streams of income recorded and reported; volume of production/sales increasing with market demand; increasing profitability; and linkages with other enterprises.

Issues

Market access. Local markets for milk and dairy products are often overlooked while milk export potential is overemphasised. Milk marketing should therefore be more oriented to local market potential, identified through the design, implementation and proper market research and analysis to quantify market supply and demand. Rural market infrastructure can be improved not only by central government but also by local communities through innovative partnerships including those with the private sector.

Small scale milk producer and processing **groups** can be excluded from larger formal supply chains due to rapid introduction of high standards or technical specifications without any price incentives. In addition group members may not be willing or able to absorb the prolonged credit periods demanded by large wholesalers or retailers.

Shortcomings in the organisation of milk collection, processing and marketing systems have seriously undermined the potential of smallholder dairy producers to exploit urban markets in many developing countries. Strong institutions are needed to support the development of these systems.

Capacity building on contract negotiation skills is required in addition to a clear division or timetable for the movement of a milk producers group from a socially oriented grouping to an enterprise driven entity.

Upgrading of technical and organisational skills to accelerate developments in the area of **producer organisations**, at local, regional and national or federal levels is needed. The role of government is to create an enabling environment through a legal and regulatory framework and training to promote a democratic approach to group formation and operation.

Governance. Empowerment of farmers groups is a sensitive and often painstaking process which requires substantial investment. Farmers are naturally risk adverse but understand risk management and are alert to alternative sustainable income generation opportunities. Milk is therefore a powerful 'pull' factor for many farmers groups and organisations as they rapidly receive returns on their investments.

There is a growing **awareness** of changing roles of public stakeholders towards privatisation and the need for institutional reform. The dairy sector is often at the forefront in this tendency with local regional and national institutions being privatised including the provision of research, technical support and extension services. The growing importance and positioning of the powerful global dairy industry also influences the role which can be played by the small scale dairy sector.

A facilitative and conducive **policy environment** is required for sustainable dairy development. Dairy policy must be linked to the national livestock development policy and implemented through detailed strategies. The strategies must be participatory, combine public and private sector interests and delivered through relevant stakeholder institutions.

Barriers. The increasing importance of regional standards and trade provides both opportunities and challenges. In recent years there has been a strong drive for regionalisation of trade policies and regulations governing the movement and trading of goods. This presents an opportunity for groups or enterprises that can meet the standards but also a challenge to those who determine such standards to ensure they are inclusive and not exclusive of their smallholder producers.

Small scale dairying may not appear competitive based on production costs but can be competitive in a market due to consumer preferences e.g., fresh locally produced milk can command a premium over imported products. This represents a major opportunity for small scale dairy groups, provided they can be effective in marketing and producing 'quality' products.

Conclusions

In countries where intensification of the dairy sector is proceeding very quickly (this would apply to a number of Latin American countries), the very small scale producers will decrease in number. In much of Asia and Africa, however, there is still a potential for small scale dairying to be an important contribution to rural development and a means of improving smallholder livelihoods. A market oriented approach however will require a fundamental change of thinking by both the public and private sectors.

A revised focus is needed to facilitate the 'pull' factors in market led dairy development rather than the traditional production inputs emphasis. This will require investment in building local, national and regional capacities in dairying, ranging from marketing through to safe milk production.

Farmers groups are the key to success for small scale dairying. Empowering producers is essential to make an effective impact on sustainable rural development in areas where dairying can be competitive. Competitiveness should not be only measured on production cost alone but also by market demand/elasticity, particularly for local products, tailored to local tastes. Dairy processing provides significant benefits in terms of employment and value addition and warrants inclusion in small scale dairy interventions.

To reach farmers groups a risk-based, stepped approach, such as MODE is considered as an appropriate means to ensure that small scale dairying can improve livelihoods and contribute the local and national economy. The application of the approach requires tailoring for each national situation – an area in which FAO and its development partners are active

Dairy enterprise groups need also the autonomy to select the form of organisation or institution which ensures good governance, accountability and best suits their needs.

Further study and analysis of informal smallholder dairy sector chains is needed to design appropriate interventions and understand the dynamics and forces which are predicted to shape smallholder dairy development. FAO is planning to develop and source funding for some of this work.

Finally there is no magic solution to successful small scale dairying. A market oriented and integrated approach addressing a variety of constraints as outlined above can be effective but tailored solutions are required in many countries due to market preferences and quality requirements. A participatory risk based approach such as the MODE may offer the best way forward.

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Animal genetic resources – time to worry?

Irene Hoffmann and Beate Scherf

The genetic resource in domesticated animals has built up over thousands of years and many generations, in environments ranging from frozen tundra to hot semi-desert, through the breeding and selection efforts of farmers. Several thousand domestic animal breed populations have been developed in the 12,000 years since livestock were first domesticated, each adapted to specific environmental and farming conditions and each representing unique combinations of genes.

Within the animal species that are used, or may be used, for the production of food and agriculture, can be found wild and feral populations, landraces and primary populations, standardized breeds, selected lines, varieties, strains and conserved genetic material, all of which are currently categorized as breeds. Breed is is often accepted as a cultural rather than a biological or technical term. The differences, both visual and otherwise, between breeds account for much of the diversity associated with each domestic animal species. In the absence of direct measures of genetic diversity, breeds provide the best indication of total farm animal genetic diversity. Breeds are commonly classified as indigenous or exotic, where indigenous breeds are mainly kept in low-input – low-output production systems while exotic breeds are usually adapted to intensive, high-output systems and do not flourish in unimproved local production environments.

Genetic diversity measured at the molecular level does not always correspond to phenotypic breed diversity, because a long history of exchange, upgrading and crossbreeding has sometimes created similar genotypes in different phenotypes, or different genotypes within similar phenotypes. Brazilian sheep breeds (Paiva *et al.*, 2005) provide an example of similar genotypes in different phenotypes. The opposite has been observed in Djallonké sheep in West Africa where several sub-populations can be distinguished within the one breed using molecular methods (Wafula *et al*, 2005). About half of genetic variability may be found between breeds (Hammond and Leitch, 1996) but the share of within- and between-breed diversity varies among species and traits (Ollivier, 2004).

Why preserve animal genetic resources?

National governments must balance their priorities between demands that often conflict: shorter and longer term needs, the needs of small and large scale farmers, economic growth against equity, food security against agrobiodiversity, national priorities against international responsibilities. Developing country governments are under strong pressure to meet immediate needs for economic growth and equity. By comparison, conservation of genetic resources can seem a long term and less pressing goal. Why, then is it important to conserve the genetic resource of domestic animals?

There are different types of societal benefits, and beneficiaries. Genetic improvement is an important source of productivity in livestock. Moreover, animal genetic resource (AnGr) contributes to cultural heritage (Notter, 2004). There is also a moral commitment involved towards future generations. Future needs that have not been defined in the present day may require inputs from a diverse genetic pool and it would be undesirable to throw away what has not been evaluated.

Countries are the responsible legal entities for AnGR management and conservation under the Convention on Biological Diversity. There are no direct beneficiaries for the existence values of AnGR, but society globally is concerned. In the case of the conservation of specific genes of future importance (e.g. disease resistance), beneficiaries are likely to be found in many countries, and it can be argued that such programmes should be an international responsibility. In the case of locally defined cultural values or landscape or environmental benefits from AnGR conservation, the beneficiaries are mostly national, hence such programmes are a national concern.

The primary challenge for the conservation of AnGR is identifying sound reasons why society (national or international) should conserve breeds that farmers have already abandoned or that are in a critical state of endangeredness (Mendelsohn, 2003). The argument for public interest and conservation of AnGR is the same as with other types of biodiversity: to maintain use and non-use values, to preserve important components of cultural heritage or typical landscapes, or to preserve traits of future value.

Valuation of animal genetic resources

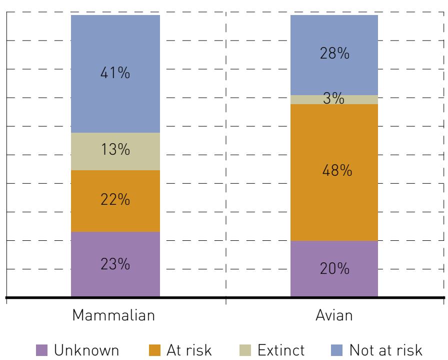
Goods that are rarely traded on markets tend to be undervalued, with prices, if recorded at all, not necessarily reflecting their economic scarcity. The value of the vast majority of AnGr is poorly understood by scientists and policy makers. Lack of valuation of local AnGR was noted in the majority of country reports submitted to FAO within the State-of-the World's Animal Genetic Resources reporting process.

Qualitative breed assessment has been done by a few groups in the recent past, mainly based on participatory assessment of priorities and preferences of livestock keepers and their communities, mostly in traditional or modified traditional livestock systems (e.g. Steglich and Peters, 2002; Lokhit Pashu-Palak Sansthan, 2005, Tempelman and Cardellino, 2005). Besides participatory methods, various economic tools such as conjoint analysis (Tano *et al.*, 2003) or hedonic price models assessing buyers' preferences for certain traits and breeds on livestock markets (Jabbar and Diedhiou, 2003) have proven useful for AnGR valuation. All these methods aim at assessing the use and non-use values of a breed. Use values indicate the direct value derived from food or fibre or other products or services, as well as the indirect value of contributing to landscapes or ecosystems. Another use value is the option value, which is the flexibility to cope with unexpected future events (e.g. climate or ecosystem change) or demands (e.g. disease resistance or product quality). Non-use value (existence value) is the satisfaction of individuals or societies stemming from the existence of the diversity.

However, the transformation of complex relations into a single unit such as a market price encounters several problems. Production traits are of secondary importance in many smallholder production systems, therefore, conventional productivity evaluation criteria are inadequate to evaluate subsistence livestock production as they fail to capture the multiple benefits of the animals and the production process (Ayalew *et al.*, 2003; Bebe, 2003). AnGR values are made up of use and non-use values. Any economic valuation of goods and services from AnGR tends to render them commodity-like. Steinfeld (2002) noted a danger with the commodity consideration of AnGR, when in a theoretical market exchange hypothetical money is traded for hypothetical opportunities. The market is imperfect with regard to AnGR as it is for other natural resources. Besides the absence of prices, AnGR have characteristics of private and public goods, which complicates the issue further. They are private goods, as the use of a single breeding animal is exclusive and rival, and they are public goods, as the gene pool of the populations is not exclusive but can be used by other farmers and future generations. Since no single owner can obtain the value of the resource as long as other owners exist, individuals will be unwilling to pay for the continued existence of a breed. The assessment of the use and non-use values of a current breed entails the additional problem that the value contribution of a specific gene added into another breed is difficult to show.

In a fully functional agro-ecological system the value of any single component cannot be understood, or priced, separately from its contribution to the whole. This problem is not limited to AnGR, but is also valid for environmental impacts resulting from agricultural activities. In parallel to the discourse on values in economic and social science, there is an increasing focus on ecosystems services and functions in biological science. The discussion about ecosystem function is a difficult one, because for most ecosystem function attributes, such as productivity or nutrient flux and storage in rangelands, a small subset of abundant species dominate, suggesting that most ecosystem function can be maintained with a reduced number of species. However, many species may have an impact on valued ecosystem attributes beyond their obvious contributions through production. Hence, Schwartz *et al.* (2003) argue that biodiversity should be conserved on behalf of ecosystem attributes. This precautionary argument for species conservation may be far stronger than arguments based on functional relationships. In developing indicators for genetic diversity of agricultural livestock and crops, Eaton *et al.* (2004) therefore propose to concentrate on breeds and varieties that are characteristic for landscapes or production environments that are important for biodiversity.

RISK STATUS OF DOMESTIC BREEDS WORLDWIDE



Source: World Watch List for Domestic Animal Diversity

Many of the external costs and benefits of livestock systems are not accounted for. This means that the costs of negative impacts of livestock production are not borne by the originator but by society as a whole. These include resource degradation, pollution and public health costs from food-borne diseases. Equally, the originator of positive externalities is not rewarded by the market. This applies to landscape maintenance through livestock grazing, or to AnGR diversity maintenance by keeping of rare breeds.

Loss of animal genetic resources and its causes

Genetic resources naturally ebb and flow within ecosystems and it can be expected that over long periods, certain livestock breeds or even species will emerge while others become extinct. However, the actions of human beings accelerate the speed with which the genetic resource changes. Human development has created the breeds found today, but current economic and social trends have the potential to erode them very rapidly. Environmental changes or shifts in agro-ecosystems including the effects of global warming (Anderson, 2004) can affect the genetic resource. So can wars, pest and disease outbreaks and other natural disasters.

In the year 2000, over 6300 breeds of domesticated livestock were identified. Of these, over 1300 are now extinct or considered to be in danger of extinction. Many others have not been formally identified and may disappear before they are recorded or widely known. Europe records the highest percentage of extinct breeds or breeds at risk (55% for mammalian and 69% for avian breeds). Asia and Africa record only 14% and 18% respectively, but the data for developing countries are much less fully documented in the World Watch List for Domestic Animal Diversity than those of developed countries. When breeds recorded in the Global Databank for Farm Animal Genetic Resources are considered, 1687 are classified at risk. When breeds without recorded population data are included, the number at risk may be as high as 2255. These figures represent a 10 percent increase since 1995, and a 13 percent increase since 1993. (Scherf, 2000).

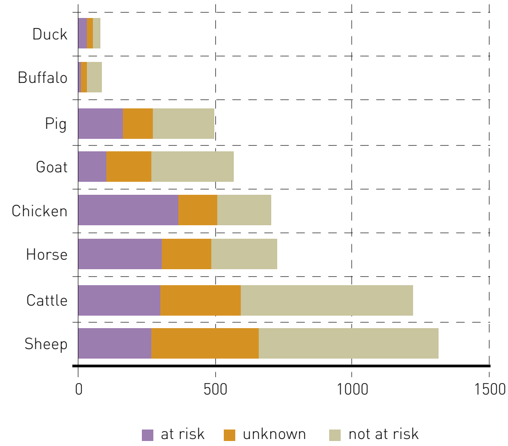
It is not easy to estimate the rate of loss of the AnGr. Besides knowledge gaps about the characteristics and the status of genetic resources, assessment is hindered because methodologies for breed survey tools (Ayalew and Rowlands, 2004; Lokhit Pashu-Palak Sansthan, 2005) and for assessing the risk status of populations (Scherf, 2000; Drucker, 2005) have not been standardized. All over the world, loss of breeds is occurring while it is still largely unknown which breeds contain significant genetic diversity or specific genes that should be targeted for conservation and/or incorporation into breeding programmes. Loss of genetic resource is related to changes in the organisation of production systems.

Intensification and changes in production systems

In most countries of the world, there is a shift from extensive, traditional systems towards more intensive systems. There are no widely available data that describe the distribution of breeds in production systems but approximations can be developed from agricultural survey data. Because intensive systems are based on high-output breeds fed on concentrate feeds, the average output in the national herd and the share of concentrate feed can serve as indicators for the level of industrialization in the sector. Also, the share of production from certain livestock production systems (Sere *et al.*, 1996) can be used as a proxy for the use of high-production breeds in these systems.

It is argued (IDL, 2002) that the risk of losing indigenous breeds is currently low as they are mainly kept by poor people in rural areas, who will not immediately change their production system or abandon their breeds. However, this situation may be changing as the poor either integrate with global market chains or move out of livestock

DOMESTIC ANIMAL BREEDS AT RISK AROUND THE WORLD

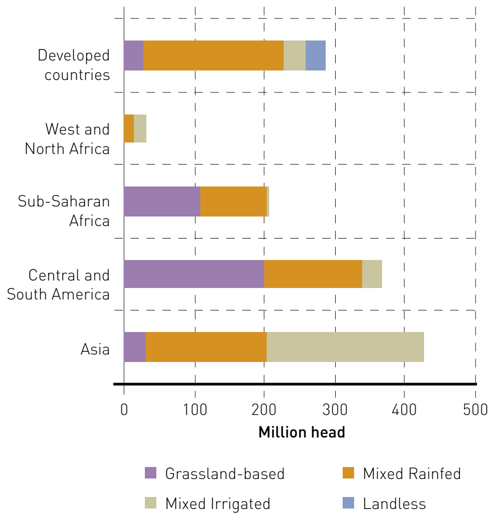


Source: Scherf (2000)

production. During the 20th century, research and development in the commercial livestock sector has concentrated on a very small number of exotic breeds, in which rapid increases in meat, milk or egg production were achieved. Only 14 of the approximately 30 domesticated mammalian and bird species now provide 90 % of human food supply from animals. While production increases have been remarkable with a reduced number of breeds, erosion of local AnGr and intensive use of high production breeds occur at the same time.

The production systems with a high expected share of high-production breeds are the landless systems for monogastric species, and highland tropical environments for dairy cattle. Landless small ruminant production is based on local or improved local breeds (Groenewold, 2004). Today, landless pig production which is mainly found in OECD and Asian countries provides more than one third of global pig supply. In poultry, about 75% of meat and 66% of egg production occurs in landless systems (Groenewold, 2004). Assuming that high-output dairy cattle breeds or their crosses are found throughout all temperate zones and tropical highlands systems, about 40% of all

CATTLE IN DIFFERENT PRODUCTION SYSTEMS AND REGIONS



Source: Groenewold, J. (2004)

dairy cattle and 67% of global dairy milk production come from these systems.

Monogastric livestock, chiefly pigs and poultry, are more and more being raised in large-scale, intensive, production systems, where they show economies of scale and can be kept in biosecure conditions. Only a small number of breeds perform well economically in these conditions, mostly the exotics, while the indigenous breeds tend not to respond as well. The majority of small ruminants are raised in grassland-based systems using mainly local or improved breeds. Large ruminants are kept in grassland-based systems and mixed rainfed and irrigated systems as well as intensive feedlot or dairy operations. Independent of the production system, ruminants are mainly selected for characteristics such as meat and frame size or high milk volume. Nevertheless in less intensive systems, often their ability to survive in harsh conditions, suitability for traction or interesting appearance remain as secondary breeding goals.

Perhaps the largest single factor affecting the animal genetic resource is globalising livestock markets, driven by consumer demand in cities and developed coutries and increasingly cheap and rapid transport. The past three decades have seen considerable growth in the consumption of livestock products particularly in developing countries. Most of the increasing demand is being met by intensive production systems located in areas with access to ports and urban markets, with a few species and breeds providing the bulk of production. The increase in the size of the potential market strengthens incentives to invest in breeding research (Narrod and Fuglie, 2000). Better off urban consumers and large retail companies demand a narrow range of specifc products and product qualities and change their demands frequently. In order to respond, producers find that change of species or breed generally offers more flexibility and quicker adaptation than making use of within breed variation.

When land pressure increases and livestock are kept more intensively, poor farmers tend to opt for crossbreds because their higher output offers higher returns to labour. Local AnGR are threatened through the indirect impact of market competition if the intensive commercial sub-sector gains a certain market share in the country. Subsidised meat imports may also play a role. In such cases, the livelihoods of farmers that supply the same markets with less productive breeds may be threatened, and if they remain in production, it may no longer be economical to keep a local breed (Tisdell, 2003).

Biotechnology has increased the variety of genetic material to include semen, embryos, oocystes, somatic cells or DNA. It has also improved the transportability and tradability of genetic material. Starting in the 1960s, the use of artificial insemination (AI) in developing countries increased, mainly in dairy cattle, and mainly based on imported semen from a few breeds. The ease of reproductive biotechnology use is highest in cattle (deep-freezing of semen and embryos), and lower in pigs (mainly fresh semen used in commercial breeding) and poultry (Hiemstra *et al.*, 2005).

Concentration in the animal industry is encouraged by reproductive rate, portability and transportation costs of breeding products, and the costs associated with breeding. Taking Europe as an example, about half of the pig breeding is in the hands of associations or cooperative companies, the other half owned by private companies, and international breeding companies of hybrid products are increasing their market share (Preisinger, 2004). In poultry breeding, because of the relatively low value of single animals, high reproductive rate and portability of eggs or day-old hatchlings, concentration is very high and all enterprises are privately owned. Fifty years ago there were hundreds of primary breeders in every Western country. Today, three groups of primary breeders dominate the international layer market while there are four major players in broiler breeding world-wide (Flock and Preisinger, 2002).

Economic growth tends to favour intensive systems and lead to reduced usage of indigenous animals. The trend in the European Union, for example, where several rare breeds are mainly kept by hobby farmers for biodiversity maintenance or very small niche markets, has shown that the food security role of local breeds declines with economic growth. However, the contribution of local breeds to household food security in developing countries, particularly in rural areas, cannot be overemphasized. For this reason it is unwise to allow loss of these breeds to occur too quickly. While the impact of food safety standards on the poor has recently been analysed (FAO, 2004a), no assessment has been made of ways to promote food safety within production systems of indigenous breeds. Some of the most valuable and interesting animal genetic resources (with regard to fitness and behavioural traits) are kept by traditional communities. Young people from these ethnic groups are no longer attracted to herding and prefer to migrate into the cities for employment, thus eroding their indigenous knowledge (Köhler-Rollefson, 2005). Although the removal of discriminatory government policies (such as land use policies that regulate common grazing grounds and displace pastoral societies) would "level the playing field", indigenous breeds would likely continue to be under economic pressure.

Assessment of needs

The analysis of country reports submitted to FAO as contributions to the State of the World's Animal Genetic Resources process revealed four major areas for action at national and international levels:

- National policies, institutional development and capacity building to ensure strong national programmes for animal genetic resources, and global and regional support to assist developing countries to build their capacity.
- Enhanced inventory and monitoring to increase understanding of the state of animal genetic resources and create a better understanding of the characteristics of animal diversity
- Identification of breeds of livestock that are at risk of extinction, and development of cost-effective monitoring and conservation measures to ensure genetic diversity is maintained.
- Enhancing the capacity to use and develop animal genetic resources by integrating traditional and modern approaches and technologies across the full range of available production systems.

Policies affecting genetic diversity

Analysis of country reports submitted to FAO shows that government policies favour intensive production systems and/or the use of narrow genetic base. Intensification and modernisation of the livestock sector are primary policy targets in food-deficit countries. Policies aim at intensification of either dairy cattle and poultry (in West and North African countries) or pigs and poultry (in Asian countries, particularly China). Associated with these production systems is the need to import exotic high-input high-output breeding stock and genetic material. In some particular cases entire production systems are imported as are all required inputs for layer operations to Saudi Arabia.

Increased economic competition, together with environmental restrictions will tend towards a migration of intensive production, in particular of monogastric species, to countries with less stringent regulations, and with available land, production technology and feed (Pomar *et al.*, 2004). Environmental concerns may also influence structural changes within countries. Poultry production in Malaysia is expected to relocate from the present farming areas to more remote areas because of rapid urbanization and the need for large-scale operations, environmental friendliness and the necessity to meet sanitary requirements. In several countries of eastern and Southern Africa, the occurrence of improved breeds has been linked to private land ownership (Bester *et al.*, 2003).

Lack of supporting infrastructure for domestic markets can pose a threat to indigenous AnGR. Larger scale and spatially better connected farmers, especially those in peri-urban areas, are able to capture a large share of the market, while it is difficult for poor farmers in remote villages, where the majority of indigenous AnGR are kept, to penetrate the market (IDL, 2002). Market and sanitary regulations may tend to impede market access for local breeds. The grading system for meat animals usually favours large-framed (exotic) animals. In South Africa, the change of the cattle grading system from size to age (price premium on animals before the change of first pair of incisors) increased the market opportunities for the late maturing local breeds (Ramsay, personal communication).

Policies to increase production are sometimes supported by direct subsidies on feed (e.g. subsidized grain imports evidence), artificial insemination (AI) or other inputs which tend to favour exotic breeds, or by indirect subsidies on production inputs. For example, subsidies on fuel and fertiliser favour concentrate feed production which is better used by exotic breeds and available to farmers with access to infrastructure (ILRI, 2005a,b). Credit and insurance schemes, inflation, interest and exchange rates also promote certain production systems and thereby breeds (de Haan *et al.*, 1998; Delgado and Narrod, 2002). Support to the sector can be indirect, for example governments may be tempted to spatially concentrate their veterinary or other livestock services in areas of high livestock concentration, leading to a decline of services in more remote areas.

Governments restrict livestock movements within the country for trade or disease control, or control the trade of breeding material thus potentially favouring certain production systems and related breeds. Some governments require licensing of male breeding animals or enforce the castration of male animals of local breeds (Bester *et al.*, 2003). They also influence the availability of semen of certain breeds directly through importation and distribution, or indirectly by setting semen prices, setting up artificial insemination (AI) stations or linking sales of genetic material and breeding stocks with health programmes. In developing countries, semen of local breeds is often not available. In Kenya for example, public and private AI service supply only Friesian semen. Zoosanitary restrictions impede the export of live breeding animals or their products from developing countries, many of which are not free from OIE list A and B diseases.

In addition to erosion of breeds, there is a potential danger of loss of within-breed genetic diversity in commercial breeds. Exchange of genetic material and genetic relationships are not confined within country borders. Globalization of dairy cattle breeding has improved selection intensity, but has also led to increased relationships among animals and thus higher risk for inbreeding with its related problems (Mark *et al.*, 2002). Increased rates of inbreeding may thus be a worldwide problem which requires actions to be taken at the international level.

When policies are designed to conserve the genetic resource, there is a need to identify whether the primary objective is maintenance of breed diversity or maintenance of genetic variability, since these aims are not fully congruent. This decision will have implications on breeding and conservation methods and on the research and technologies for characterisation and valuation needed.

Monitoring and characterization

Understanding of the extent, distribution, basic characteristics, comparative performance and the current state of each country's AnGr is essential for achieving their efficient and sustainable use, development and conservation. A good understanding of breed characteristics and current performance levels is necessary to guide decision making in livestock development and breeding programmes, and selection in breed development to achieve optimum production levels. Complete national inventories of all breeds stating their main characteristics are a basic requirement for effective management of AnGR. Since genetic resources are not static, routine inventories and ongoing monitoring are needed, to prevent breeds becoming endangered before farmers and local people, government officials and the international community are aware of their significant decline. Few developing countries have sufficient current data to make an accurate analysis of the state of their AnGr.

Conservation

Since all governments aim for economic growth, but conservation of biodiversity is also desirable, in order to slow the loss of genetic resource it may be necessary to pursue parallel policies with quite different aims. Despite the valuable efforts of individuals, governments and non-governmental organizations, animal genetic resources continue to become extinct. Enhanced strategic investments in the conservation of animal genetic resources are now critical and international collaboration is essential.

Country reports submitted to FAO indicate that many breeds at greatest risk are in developing countries which have limited resources for designing and implementing conservation programmes. This is a serious situation, as breeds used in developing countries often possess unique genetic traits that enable their survival in environments with combinations of intense stresses, such as disease and drought. Present conservation efforts vary significantly between countries, as does the capacity to implement conservation measures. Many developing countries and several developed countries report that they do not have a comprehensive national conservation programme or policies for AnGr. However they believe that the conservation of AnGr should be considered within an overall national programme for AnGr, which would encourage them to study carefully the reasons for breeds becoming less popular with farmers and provide an opportunity to re-examine policies that promote exotic breeds and may contribute to the decline of indigenous breeds. Other countries report that they have established a comprehensive national programme for animal genetic resources although the capacity for conservation measures varies significantly. A number

MONITORING OF ANGR

*Surveys in remote areas in **China** have resulted in the discovery of 79 previously unregistered breeds or populations being used by farmers.*

*In **El Salvador** there is a lack of even basic livestock statistics. The last national inventory was carried out in 1971.*

*Surveys have been conducted in **Botswana**, but they do not provide adequate information to assess the status of breeds within each animal species.*

*In **Malaysia**, general surveys on all animal genetic resources important to food and agriculture are undertaken on an annual basis.*

Source: country reports submitted to FAO.

of developing countries indicated that even when there is significant awareness of the need to conserve animal genetic resources, the lack of financial and human capacity and facilities is preventing implementation of conservation measures.

In-situ conservation (sustainable on-farm operations) is the only practical conservation measure that some countries are able to employ. When linked to utilization, conservation of AnGr has a much stronger appeal to policy-makers and producers. Some breeds would see their numbers increased to safe levels if they could be associated with a product for which there was market demand. In developing countries, there is some evidence that people prefer buffalo or zebu milk to milk from crossbreds or exotic taurine cattle. Up to double the price is paid by consumers for local poultry in Asia (Dolberg, 2005). For all animal species in Africa, higher prices are paid for animals purchased for specific cultural purposes. Marketing of non-food products, such as high-quality skins of parasite-resistant local breeds, may contribute considerably to the economic sustainability of local breeds (Ramsay, 2002).

A number of developed countries have seen the establishment of niche markets for products of specific breeds and this supports conservation, as consumers are willing to pay premium prices for speciality products. Not only the genetic characteristics of traditional breeds but also the vegetation consumed in extensive production systems, or special processing of meat or cheese contribute to its special taste (Kuit and van der Meulen, 1999). There are small but growing domestic markets for locally produced or organic animal products in countries such as Argentina, Brazil, South Africa and India and regional markets in the Middle East, Latin America and Asia. However, the registration of goods of geographical origin or trademarks is beyond the capacity of most keepers of local livestock in developing countries.

National initiatives on cryopreservation of semen, oocystes and somatic cells are ongoing (Blackburn 2003; Hiemstra *et al.*, 2005). Guidelines for national cryopreservation programmes have been developed by the European Regional Focal Point for the Management of AnGR (Hiemstra, 2004).

Several methods are available to assess genetic diversity at molecular level, using measures of gene diversity or of pair-wise genetic distances between breeds in order to derive individual breed contributions to diversity (Ollivier, 2004). A variety of markers is available to assess different types of diversity (Bruford *et al.*, 2003; Hoffmann *et al.*, 2004; Lenstra *et al.*, 2005; Hiendleder *et al.*, 1998). Molecular methods of structural genome analysis have allowed for the identification of causal genes for defects and monogenic traits, and contributed to the understanding of genetic mechanisms on trait expression and variation. Today a wide range of quantitative trait loci (QTL, loci with significant influence on production performance) have been identified and analysis tests developed (Schwerin, 2004). Use of QTLs is most beneficial for traits that have low heritability and are difficult, expensive or impossible to record in a breeding programme. Use of QTLs could therefore be particularly beneficial in the low to medium input systems of the developing world, where disease resistance and adaptation traits are particularly important. If marker-delimited genome regions that control such traits are identified, the corresponding markers could be used in marker-assisted selection. Although very promising, practical application of marker-assisted selection programmes has as yet been limited (Kuehn *et al.*, 2004, Arias *et al.*, 2004).

There is an increasing discussion in the literature about decision-making for conservation of AnGR, be it in gene banks or in-situ conservation (Weitzman, 1993; Simianer *et al.*, 2003; Bruford *et al.*, 2005). Based on Weitzman (1993), a diversity matrix which is derived from a genetic distance matrix is usually taken as the basis. When the diversity information is combined with extinction probabilities and conservation potential, it is assumed that the expected diversity will be maximized. Between-breed diversity is considered as one major criterion to be taken into account when setting priorities for conservation of domestic animal breeds, but choosing priority breeds with the largest within-breed diversity has also been proposed. Hanotte and Jianlin (2005) propose "livestock diversity hotspots" as priority areas for conservation. Reist-Marti *et al*. (2005) developed first approaches for the optimal allocation of a hypothetical conservation budget under several conservation schemes with known costs.

Genetic improvement

Breeding is the most important component of the management, use and development of animal genetic resources. Livestock breeding starts with planned reproduction, which is difficult to manage in some free-ranging production environments. Breeding has always been influenced by current biological, genetic, technological and statistical knowledge. Systematic breeding requires controlled mating, individual animal identification, progeny and performance testing and recording to identify superior parents (particularly on the male side), and sophisticated data processing. The high-output breeds of today have been selected for at least 20 generations in pure-breeding systems.

Direct or indirect government support to breeding programmes has always taken place, for example through research in genetics. The establishment of breeding organisations in developed countries was state supported in the past in many cases. Today, breeding programmes with established breeds are found in the more favourable parts of the tropics where exotic breeds are well established, whereas indigenous breeds without systematic breeding programmes dominate in regions such as West Africa and large marginal parts of Asia and Latin America.

Private breeding enterprises are fully commercial and invest in those species (dairy cattle, pigs, chicken, turkey) with high technology responsiveness and high returns on investment. Private incentives for animal breeding research are strongest where markets for improved technology are large, advances in husbandry can be implemented relatively easily and quickly, and where knowledge can be protected (Rothschild *et al*., 2004). Private research tends to concentrate on technologies that are likely to result in market applications in the near future. The driving factors are high reproduction rate (at least of the male side), low unit cost, economies of scale in research, the appropriation and control of produce, and uniformity of product to comply with regulations on standards. With emerging possibilities of breeding for disease resistance or specific quality traits, industry may increasingly include genetic material from local breeds in their breeding programmes. Although zoosanitary restrictions are an impediment for the transfer of genetic material from developing countries, new biotechnologies may change this in future.

Subsistence farmers only rarely buy animals but supply their breeding animals from their own herds or through social networks (Blench, 1999). Breeding animals of local breeds are rarely sold. In many pastoral and mixed farming systems, traditional animal exchange systems exist, which are often related to extended human family linkages. Local breeds are 'multi-functional', and breeding goals for such breeds are targetted towards the provision of an array of products and services, and towards adaptation to harsh environments and disease resistance (Tano *et al*., 2003; Wurzinger *et al*., 2005).

Better management and breeding may lead to profitability of improved genetics at farm level. Such economic improvement at individual farms may add up to welfare gains and improved food security at the national level. However, public goods benefits from breeding such as maintenance of AnGR for future generations are not usually paid for. An analysis of dairy cattle crossbreeding schemes in Kenya revealed that research and development costs, veterinary costs, foregone non-market benefits from indigenous livestock and overall loss of AnGR biodiversity were not taken into account (Karugia *et al.*, 2000).

FAO (1998a,b,c, 1999, 2000, 2001a) has developed guidelines for the development of national animal genetic resources plans, including the management of small populations at risk and for recording in medium input systems. A comprehensive methodology to define the private and public costs and benefits of sustaining breeding programmes (pure- and cross-breeding) is still lacking, but would be essential to make sensible investments in animal breeding.

While crossbreeding and breed replacement can be effective means for increasing production, their potential in the tropics is limited to benign environments. Unfortunately, introduction of exotic genetic material continues to be seen as a solution to low output of local breeds even in areas where the exotic genotypes are ill adapted (ILRI, 2005a,b). In quantitative terms, most genetic material flows from developed to developing countries. The extension of markets and economic globalization including the global marketing of exotic breeds have contributed significantly to the loss of local breeds through indiscriminate crossbreeding (Tisdell, 2003; Country Reports).

After government breeding stations have not proved successful in most developing countries for a variety of reasons, and breeding programmes have been difficult to implement (Galal *et al.*, 2000), today Open Nucleus Breeding Systems (ONBS) are being developed as one way of community-based AnGR management (Mhlanga, 2002; FAO, 2003; Tempelman and Cardellino, 2005). There is a movement of increasing interest in local breeds and community-based management of AnGR (Köhler-Rollefson, 2003; Mhlanga, 2002, Gondwe and Wollny, 2002; Almekinders, 2002; FAO, 2003; Tempelman and Cardellino, 2005). A few examples show achievements of sustainable genetic gain by selecting within local breeds (FAO, 2001b). With improved management and the inclusion of non-market benefits such as disease and parasite resistance in the productivity assessment local breeds can outperform crossbreds (Setshwaelo, 1989; Ayalew *et al.*, 2003). Some commercial farmers in Zimbabwe and Namibia favour local breeds due to their higher overall productivity.

Matching specific genetics to specific environments

Information about the performance of indigenous or improved breeds and their suitability for specific production systems and environments is very important for farmers to make choices. If exotics and their crossbreds are disseminated to less favourable production environments, the production risk increases and economic loss may occur. The opposite case, that farmers continue to utilize local breeds for too long, seems hardly ever to hardly occur.

After all the progress made in molecular genetics, identifying gene variants that encode breed specific phenotypes remains a challenge (Lenstra *et al.*, 2005). Breed formation and selection are reflected in differences in allele frequencies rather than in breed-specific alleles. Breed is more a cultural than a technical term; therefore the line of argument of breed conservation differs from the one for genetic diversity conservation. Local animal breeds are increasingly recognized as part of culture and landscape, and as attractive for tourism, thus their conservation as a part of habitat conservation is pursued by governments and NGOs equally. Breeds are also conserved because of their historical significance or because of their cultural importance for traditional communities. New developments in "landscape genetics" combining geo-statistics and molecular genetic diversity (Joost and ECONOGENE, 2005, Bruford *et al.*, 2005) will allow for the analysis of gene and environment interaction and its spatial distribution.

There is still a lack of information about existing or potential levels of productivity, production characteristics of local breeds managed in their production system and the genetic make-up of the indigenous breeds. The little research that has been undertaken found that there are highly productive indigenous breeds (e.g. Setshwaelo, 1989; Hossary and Galal 1995; Ramsay 2002; Ayalew *et al.*, 2003; Bester *et al.*, 2003). Several adaptation traits have been documented, such as trypanotolerance, or resistance against parasites, the ability to cope with difficult feed resources or adaptation to extreme climatic conditions. However, hard data are scarce and more research is needed, in particular about the genetic and functional mechanisms of adaptation traits.

Protection of intellectual property

Increased industrialization has led to heightened interest in protection of intellectual property (Rothschild *et al.*, 2004). The boundaries of the intellectual property system are widened as industries extend their orbit of operation by developing and applying innovative technologies. This expansive process is likely to succeed, except in cases where other interest groups voice their opposition. To date, technological resources and contractual practices, rather than formal intellectual property rights strategies, have been the norm in the livestock industry. In pure-breeding programmes usually the buyer of a breeding animal acquires the right to breed from the animal and its offspring without limitations.

Related to the increasing appreciation of indigenous breeds are efforts for their protection in legal terms. Initiatives of non-governmental or civil society organisations range from the registration and description of local breeds and the traditional knowledge associated with their breeding to the call for unrestricted access, use and exchange of AnGR and the refusal of patenting of indigenous breeds or parts thereof (e.g. in the Karen-Commitment on Pastoralists/Indigenous Livestock Keepers' Rights; LPP and ITDG, 2003). Issues of traditional knowledge, folklore and genetic material, and the rights of the communities where these originate are discussed in the Convention on Biological Diversity (CBD), the TRIPS Council and in the World Intellectual Property Organization (WIPO). Since the continued use of AnGR, in particular in pastoral systems, depends on access to other natural resources, such issues are also discussed in fora such as the International Labour Organisation or the UN Economic and Social Council (ECOSOC).

Conclusion

The Global Databank for Farm Animal Genetic Resources covers more than 30 species used for food and agriculture, with data provided from more than 190 countries. Analysis of the databank suggests that about 30 percent of livestock breeds are close to extinction, with a 13 percent increase in the number of breeds recorded at risk since 1993. Erosion in animal genetic resources is alarming.

Even though data have been collected for more than 10 years, there is still a big gap in information on population sizes and structures. Consistent nation-wide surveys and inventories have not been conducted by most developing countries. The same applies to regular monitoring of threatened breeds. Methods are being developed to assist countries in this task but sufficient capacities and funding are lacking. The lack of information also hinders proper decision-making about what to conserve and how to allocate limited funds available for conservation. Most local breeds, particularly those that have been created in harsh environments of developing countries, have not been sufficiently characterized. If they become extinct, their lost value to humankind will never be known.

The globalization of market chains for livestock and their products is creating a changing market environment in almost all countries that encourages farmers to intensify their production systems or move out of livestock production. Privately funded research and development in support of intensive systems has focused on a very small number of breeds and species and a small number of production traits that offer positive returns to investment. Breeding for low-input production systems will continue to remain a task for the public sector and can be supported by producer cooperatives or community-based breeding programmes. However, given the choices, dynamism and the adaptation inherently embedded in indigenous knowledge on the one side, and the limited availability of resources for conservation in the public sector on the other side, a certain loss of local breeds will be inevitable. The question is: do we know the value of what is getting lost?

Some of the policies directly or indirectly affecting breed choice are well intended and conscious of their impact. Others pursue more general social or economic objectives but distort the playing field on which different genetics compete. While the impacts of such policies are readily discernable in broad terms, little is known about their impact on animal genetic diversity. They may have helped to supply affordable and safe animal products, but they have disadvantaged less intensive production systems and compromised household food security. Where livestock policy changes affect animal genetic resources directly, the net costs and benefits of such policies have usually not been documented, and policy environments or strategies that promote conservation and appropriate utilization have not been defined. The challenge at national, regional and global level is the formulation of policies that consider animal genetic resources and favour their sustainable management.

Market and policy have been identified as the strongest drivers for changes in the livestock sector that may negatively affect animal genetic resources. A reversal of such trends would require putting in place and enforcing national and regional regulatory frameworks that account for externalities of livestock production, e.g. raising taxes or levies on waste disposal, pricing water, imposing sanctions to polluters, charging producers for disease surveillance in the case of intensive production; providing incentives for landscape and agricultural biodiversity management and conservation in the case of extensive production.

Enabling institutions need to be developed. Most countries do not provide a legal framework for the registration of animals of indigenous breeds or the establishment of breeding associations or cooperatives. Particularly in communities without history of systematic breeding, the establishment of breeding programmes requires significant capacity building and training. A conceptual framework taking these factors into consideration has been developed by Dossa and Wollny (2004). Like other community-based natural resources management, community based breeding programmes are not easy to implement because human group development is as important as breed development. Considerable investment is needed for participatory development of the breeding and management protocols, including livestock management protocols, and community participation rules and responsibilities (Wollny *et al*., 2005). The marginalisation of poor farmers or communities may impede community-based AnGR management. If government subsidies are part of the programme, their withdrawal may threaten the sustainability of the programme (Yapi-Gnaoré *et al*., 2003). Decision-makers are also challenged by the choice of technologies required for the management of animal genetic resources in specific socio-economic contexts. Some systems might be currently stable and need to be protected from application of new technologies.

It is certainly high time to worry about our breeds of livestock, our common heritage and basis for food security and increased production of the wide range of products of animal origin. Appropriate measures to halt erosion in our animal genetic resources and most effectively use our heritage for future generations and human wellbeing have to be taken at all levels ranging from farmers and herdsmen to the international level.

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regional perspective

Asian Livestock benefiting from innovation

David Hall

Introduction

The concept of innovation often generates thoughts of high-technology interventions, with sophisticated scientific discoveries applied to solve sometimes generations-old problems. This article demonstrates that in the smallholder livestock sector of Asia, innovation from low-technology approaches and new ways of thinking about problems plays as important a role as advanced science. The examples described here show that more efficient and more profitable ways of raising livestock can be found using low level technology and low costs, and can also be generated from creative thinking about the use of established tools and technology.

Innovation is the introduction of something new such as an idea, method, process, or device, which is used in solving a problem. High-technology innovations might include the use of new computer assisted solutions to generate faster and more accurate results to a question or problem involving information management. There is no shortage of such hi-tech solutions applied to small scale livestock problems in Asia. For example, in India, small scale enterprises (SMEs) have been developing computer access points in remote area communities to provide farmers with access to market prices for grains and other crops, complete with training and other needed support. New and cheaper vaccines and the use of inexpensive feed additives to promote feed efficiency or reduce parasite burden are other high-tech examples of innovation, although the practicality of such interventions for the typical small scale system may be open to question.

In contrast to these high-tech approaches, decidedly low-tech innovative solutions extend access for small scale farmers to improved production techniques which increase household profits. This increases the likelihood of adoption and sustainability. Furthermore, low-tech solutions tend to favour the use of renewable resources while promoting integrated farming techniques amenable to community led decision making. Examples of low-tech innovation in the livestock sector can be found in situations as diverse as smallholder dairy production in South Asia, community managed solutions addressing the use of micro-credit and animal health, indigenous and appropriate low input types of livestock in Bali and Bangladesh, and innovative fodder techniques in Vietnam.

Yet another form of innovation is creative thinking to use existing and well known technology and tools in a new way. One topical example in Asia is the concept of compartmentalisation, which classifies livestock systems by management system and scale of production to help fight avian influenza in the region.

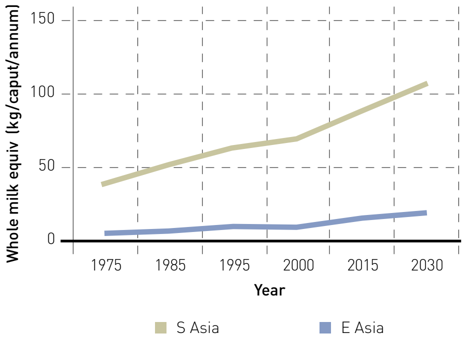
Community managed solutions

Dairy communities

Communities are playing an ever greater role in managing innovative solutions to livestock production. This is particularly so for dairy production in Asia, which has grown significantly in the last two decades. Consumption of milk and dairy products in many countries in Asia has risen tremendously since the 1980s following increased incomes and populations and changes in tastes and preferences, prompting a rise in the number of dairy cattle. Despite increases in production, demand is increasing at such a rate that imports of powdered milk are expected to continue in all countries in Asia for the next twenty years.

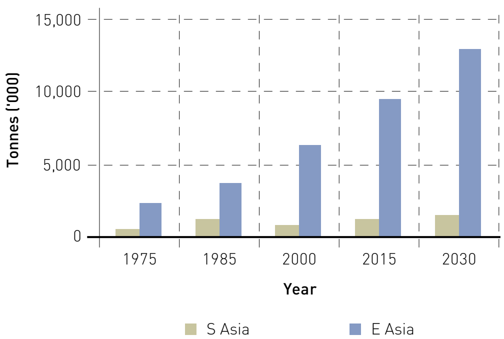
Much of the success of small scale dairying has been due to the presence of dairy co-operatives, often based on the success of Operation Flood in

MILK CONSUMED IN ASIA (KG/CAPUT/ANNUM)



Source: FAOSTAT (2005)

NET IMPORTS OF DAIRY PRODUCTS IN ASIA



Source: FAOSTAT (2005)

Gujarat, India, which set an example for further success stories in countries such as Thailand. Benefits that have been well documented include a system of regular collection and distribution, and a reliable price for milk produced. But more recently, communities have developed innovative approaches to expanding milk sales and increasing profit margins.

In South Asia, communities have modified the concept of milk producers' marketing co-operatives to increase access to vertically integrated markets. Rather than relying on sales of fluid milk alone, much of which is purchased for further processing by local co-operatives, farmers have developed community networks of input and output suppliers and processors with the end purpose of generating greater sales of processed dairy products such as yoghurt and soft cheeses. Even modest small scale processing of milk into yoghurt can significantly increase the value of the product sold, generating extra income for producers. Model small scale community dairy processing plants have been set up in several communities in Bangladesh, India, and Pakistan, demonstrating to local farmers how milk can be transformed into yoghurt and soft cheeses for sale locally and at nearby markets. A few such small scale processing plants are now fully operational, typically serving up to several hundred producers. The innovation introduced is not so much the methodology used, which has been available for many years, but the concept that local communities can take charge of collection and processing of their milk with support from co-operatives. Profits are directly absorbed by the producers as they are paid for their milk on arrival at milk collection centres which double as processing centres.

Small scale dairy farm communities have also become more integrated with other farming systems. Reliance on dairy as a sole means of income is risky, as for any farm product. More farm villages in South Asia are integrating activities to spread risk and to increase efficiency of production systems. In Bangladesh, the Community Livestock and Dairy Development Project (Mitra, 2005), a UNDP funded project with technical assistance from FAO, has demonstrated that by developing opportunities for community managed decision making in mixed crop-fisheries-livestock production systems, communities can help themselves to reduce poverty and enhance livelihoods. Based around village micro-credit and investment in agriculture, the innovative features of the CLDDP project that could be emulated elsewhere include: emphasis on diversified community activities with household specialization; integration of complementary agricultural activities such as dairy cattle and forage crops; and, creation of special development and insurance funds to reduce start up costs and minimize financial risk of failure. The CLDDP project also has an emphasis on the enhancement of development opportunities for women.

Community animal health workers

Another example of innovative community managed approaches to livestock production has been practiced in Myanmar, Nepal, and the Philippines, where women are trained as part-time community animal health workers (CAHWs). Women who participate in training as CAHWs in such programs are not encouraged to rely on animal health work as their sole activity, but rather to act as resource persons with potential for earning extra income from animal health work. Furthermore, unlike previous CAHW programs, women enrolled in newer programs are encouraged to remain within their communities and act as resource points, attend to local concerns rather than national programs, and engage in joint analysis of problems and solutions. This encourages two fundamental but essential elements of the new approach to training CAHWs. Firstly, CAHWs should be members of the community who are also dependent on livestock for their income and who understand the local nature of livestock production constraints and problems. Secondly, CAHWs are not a replacement for technical services but provide a stop-gap particularly in areas where veterinarians or extension workers rarely travel. The innovative approach here has been to reject the notion that the only successful model of an extension worker is a university educated individual based in a provincial office serving many communities; instead, CAHWs have shown that locally recruited and trained individuals with basic education can prevent 15-25% of herd losses annually (McCorkle, 2003), providing a needed service to communities that public veterinary service either cannot or will not provide.

Management of animal waste

In many countries the trend in livestock production over the last 15-20 years has been for increasing numbers of large scale operations, an increase in the concentration of production, and a reduction in the amount of land and water available for treatment of animal waste. Backyard and small scale producers of pigs and poultry now regard pollution from livestock as a serious concern, particularly in peri-urban settings and areas where water is a scarce resource. In the Philippines this concern has slowed the rate of intensification of livestock production systems in areas already intensifying (Rola *et al.*, 2003), following the trend of larger scale producers to either maintain or reduce the number of livestock raised. One response has been to establish lagoons for waste collection, while another has been to adjust feed formulae in order to minimize waste odours from livestock farms. But these measures have not by themselves been sufficient to allow farm expansion while meeting the requirements of new environmental laws and regulations, many of which are enforced with increasing frequency.

The concern for proper management of animal waste has led producers in South Asia and China to develop innovative ways of storing and removing animal waste. Biogas production units are being re-investigated on small to large scale farms as waste disposal presents increasing problems. Bio-solids broken down in underground fermentation units produce gas for cooking, lighting, and as an energy source for on-farm activities. Modelled after larger scale units on commercial farms, small scale units suitable to smallholder production systems can serve the energy needs of two or more houses while recycling poultry, dairy, and pig waste. Solids broken down in fermentation units are used as fertilizer for crop production, sometimes being sold for cash. The innovative changes in designing specific bio-gas units for small-scale and large-scale production as well as the rising cost of fuels has made biogas units more cost effective while providing a method for handling livestock waste.

Small scale producers are also being brought into discussions regarding planning and policy formulation as it pertains to local environmental guidelines and regulations for waste management. Issues such as zoning, bans on discharge, manure and manure product marketing, nature of storage, use of taxes and subsidies to enforce and encourage waste management, and appropriate mix of crops and livestock to facilitate waste management are important to small holders as well as larger scale producers. Further efforts to encourage small scale farmers to use innovative techniques for waste management are being encouraged. For example, in the Philippines small scale farmers are joining larger scale producers in learning of ways to evaluate and adopt practical techniques that reflect nutrient mass balance calculations and evaluation of environmental mitigation efforts on a per kg of output basis. Recent studies have shown that small scale farmers in fact spend more in environmental mitigation per unit of output than do large scale producers, indicating that small scale farmers have a less negative impact on the environment than do large farms (Catelo, 2004).

Appropriate breeds of livestock

In the area of livestock genetics, attitudes to indigenous breeds are slowly changing. While the offtake (milk, meat, etc.) from indigenous livestock is usually less than that of imported breeds, local types of livestock fare better under systems of minimal input typical of small scale production. Indigenous animals tend to be hardier and more disease resistant, and less demanding of high energy/protein diets for metabolic and reproductive functions.

While there is much room for improvement in the preservation of indigenous breeds in Asia through breeding programs and breed promotion, there are good examples of the preferred use of indigenous livestock. In Bali, Indonesia, for example, the primary breed of cattle is the *Bos javanicus* (also erroneously known as *Bos banteng*), a banteng type of cattle that is listed by the International Union for Conservation of Nature and Natural Resources (IUCN) as endangered. The Bali Banteng is preferred for its ability to graze on minimal roughage sources such as roadsides, areas under palm and other trees, and unimproved pasture. Used primarily for meat, the Bali Banteng is also used to produce small amounts of milk and for traction. Regrettably, the purity of the genepool of Bali Banteng cattle has decreased considerably due to cross breeding programs throughout South-East Asia. Aware of the threat of extinction of the breed, the island of Bali has taken the innovative step of banning other cattle types on the island in order to conserve the purity of the Bali Banteng (NRC, 1991), confirmed by recent informal discussion with veterinary officers from Bali. Until greater efforts are made to secure the biodiversity of indigenous livestock such strict and innovative breed preservation measures may be necessary to ensure that breeds such as the Bali Banteng do not disappear forever.

While the Bali Banteng is an example of a locally preserved indigenous breed, a different approach to innovation in breeding has been adopted in Bangaldesh, where crossbreeding has been used to produce a low input chicken for small scale farming. Egyptian Fayoumi cockerels from imported stock are crossed with Rhode Island Red hens on government farms to produce a local bird known as Sonali, suitable for semi-scavenging production (Rahman *et al.*, 2004). The Sonali is extremely popular with small holders and the meat and eggs fetch a premium in local markets. The birds require little supplementation and lay large numbers of eggs per year (up to 200 per annum), three to four times higher than local hens. Although not a native bird to Bangladesh, the innovative use of a low input indigenous breed from Egypt in a native cross-breeding program has worked extremely well for Bangladeshi poultry farmers. In contrast to more expensive

PHOTO: D. HALL

Sonali type birds are extremely popular in Bangladesh for their hardiness and high egg laying ability.

imported poultry such as the white leghorn which requires high feed and management inputs, the Sonali breed has proved a hardy semi-scavenging type of bird that has generated cash, meat, and eggs for millions of Bangladeshi rural families.

Forages

Typically one thinks of grasses and shrubs as a source of fodder for small ruminants and monogastrics, but it is now common to see the use of food industry by-products such as rejected parts and residues of pineapple and baby corn crops. In Vietnam and China, innovative ideas regarding sources of roughage are leading researchers to develop methods of preparing and feeding alternative crops to livestock that are already in use for human food, such as cassava and rice. For example, cassava is an essential tuber crop grown in China and Vietnam; in Vietnam it is second in use to rice as a cash crop for small scale farmers (Khang *et al.*, 2000). As a roughage source, fresh cassava leaves have been used with varying results in ruminants, and one hectare of cassava can yield 3000 kg of protein.

Part of the constraint to greater use has been potential cyanide toxicity and unfavourable tannin content of the leaves, reducing palatability. To overcome these problems, researchers in Vietnam (Ly and Ngoan, 2005) have shown that by wilting cassava leaves in a simple manner following a prescribed process, the cyanic acid content of the leaves not only had reduced to negligible levels but the addition of small amounts of rice bran or cassava root meal resulted in good quality silage that reduced feed costs. Cassava leaves have also been shown to have good potential as bypass ruminant protein for use in dairy cow rations (Khang *et al.*, 2000). Other examples include further processing of tofu waste to avoid spoilage for duck feed and ensiling of fish by-products for protein supplementation in fattening pigs.

Compartmentalization and controlling livestock disease

In the last two years the outbreaks of bird flu in Asia, or avian influenza as it is properly termed, has caused the deaths of more than 65 humans, the deaths of birds, and billions of dollars in direct economic damage and lost trade. It has been recognised that eradicating the disease from entire countries, or even geographic zones, is a major challenge.

Recently countries in the region have begun discussing details of an innovative approach to containing and defeating avian influenza which is adaptable to other livestock diseases as well. The premise of the new approach, called compartmentalization, is to identify "compartments" of farms or processing units based on the scale of production and other shared characteristics in order that approaches to controlling disease are geared to compartments rather than the entire poultry industry. For example, farms with low input low output management such as households rearing backyard native chickens could be classed in a completely separate compartment to that of a high bio-secure intensive operation raising thousands of broilers for international markets. The grouping is not based directly on geographic location but rather on characteristics such as scale of production and inputs, and particularly on a common bio-security system within a compartment, and degree of traceability of animals and products along the market chain.

Compartmentalisation can only be effective when seen as part of a well designed national disease control strategy, requiring surveillance and monitoring activities, stamping out of outbreaks and on-farm biosecurity, and protection for the compartment from incursion of disease agents. In this respect, it shares common features with progressive zoning. The valuable innovation that it offers, however, is the possibility that the geographic space occupied by a compartment need not be continuous, provided that biosecurity is maintained. All of the operations within one vertically integrated poultry market chain might be considered a compartment, even if they are physically separated.

Under a compartmentalization system, if avian influenza breaks out in an isolated area and is confined to small holder backyard farms, disease control efforts could be focused on that compartment rather than the entire sub-sector or a geographic zone. Large scale highly bio-secure units could continue production of chicks, meat, and eggs, and exports could continue subject to trading partner agreements. Resources currently directed to the entire sub-sector could be focused on problem elements that are most at risk for entry and spread of the avian influenza virus, increasing the efficiency of response and containment.

If compartmentalization is adopted, it is almost certain that there will be changes in the management systems of the various potential compartments. Producers of small scale backyard flocks will likely come under pressure to contain their birds with netting or fencing, and techniques such as vaccination may or may not be mandatory depending on the nature of confinement and housing used.

The World Organisation for Animal Health (OIE) recently included the use of compartments in its guidelines on avian influenza control (OIE, 2005). It has been stressed that compartmentalization is a strategy that needs to be adopted by countries with particular attention to country level production characteristics and features. Furthermore, trade agreements between countries that use or do not use compartmentalization will be worked out between those trading countries, as has always been the case in bilateral trading agreements.

Conclusions

Innovation in the livestock sub-sector does not have to rely on new high-tech inputs in order to be successful. The examples presented in this article demonstrate that simple local application of innovative ideas can result in cost savings with increased output and reduced disease and environmental risk. Furthermore, low-tech innovations can be a part of sustainable community-led mixed crop-livestock production systems. For farmers with limited access to financial and other resources, low-tech innovation provides small scale farmers with advanced applications in animal production and health, increasing the role of livestock in providing household nutrition and financial security. For problems on a larger scale, new ways of applying existing technology may provide effective solutions where previous approaches have failed.

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