Meating and Milking Global Demand: Stakes for Small-Scale Farmers in Developing Countries

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The boom in animal product consumption in developing countries

Developing country animal product consumption in context

Consumption of meat in developing countries increased by a factor of five from the early 1970s to the mid-1990s.

This additional 70 million metric tons (mmt) was almost triple the increase in developed countries. Milk consumption in developing countries rose nearly threefold, or by 105 mmt of liquid milk equivalents (LME). This increased milk consumption was more than double the increase in developed countries. The market value of that increase in meat and milk consumption totaled about $155 billion (1990 USD), more than twice the market value of increased cereals consumption during the Green Revolution.

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These trends, taken together, have been dubbed a 'Livestock Revolution' (Delgado *et al.* 1999a).

Although the massive increases in animal product consumption in the developing world are impressive, these countries still have a long way to go before they approach consumption levels in developed countries. Average annual per capita consumption levels in 1997 in developing countries were 25 kg for meat and 44 kg for milk. These levels represent one-third the meat and one-fifth the milk consumed in developed countries. Animal products comprised only 13% of calories consumed in the developing world in 2000, compared to 26% in developing countries, according to the FAO food balance sheet (FAO 2000). Absolute calories derived from animal products were even lower (40% of the developed world total), owing to smaller overall diets. Nonetheless, it is clear that diets are diversifying rapidly, creating a veritable revolution in the consumption and production of animal products in developing regions.

Drivers of increased consumption

For the most part, these increases in meat and milk consumption are propelled by the demand-side factors of population growth, income growth and

This paper is an updating with more recent (July 2002) results from the International Food Policy Research Institute's (IFPRI's) IMPACT global food model for livestock, fish and feeds of the livestock projections and analysis of a paper presented at the World Brahman Congress, Rockhampton, Australia, 16 April 2002 (Delgado *et al.* 2002). It also draws on selected field studies done since then on salient issues with FAO, ILRI and national collaborators. Clare Narrod, until recently at FAO, provided valuable insights on environmental and food safety issues.

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urbanisation. The trends fueling growth in animal product consumption are expected to continue well into the next twenty years. Per capita consumption is rising fastest in regions where rapid income growth and urbanisation result in people adding variety to their diets. Across countries, per capita consumption is significantly determined by average capita income (Cranfield *et al.* 1998). Aggregate consumption grows fastest where rapid population growth augments income and urban growth (Delgado and Courbois 1998; Rae 1998). Since the early 1980s, aggregate global consumption of animal products has grown rapidly, with meat growing at 6% per year and milk at 4%. In East and South East Asia, where population, income and urbanisation grew rapidly from the early 1980s to the late 1990s, meat consumption grew between 4 and 8% per year.

Geographic patterns of growth in animal product consumption

China dominates the overall picture in both production and consumption of meat. Indeed, it is responsible for much of the growth in developing country consumption, as illustrated by per capita figures for China in Table 1. Considerable controversy surrounds the official Chinese meat production figures in the 1990s, and conservative adjustments have been incorporated in the analysis here to the extent feasible. However, even a radical downsizing of the estimates of past Chinese growth in meat consumption puts off by only two or three years the situation that will be projected for 2020 below, and does not change significantly the long-term conclusions of the modelling.

Using the most recent FAO estimates of Chinese consumption, the share of meat and milk consumed in developing countries rose from 37 to 53% and from 34 to 44%, respectively, from 1983 to 1997 (Table 2). Pork and poultry accounted for 76% of the increase in meat consumption. By contrast, both per capita and aggregate milk and meat consumption stagnated in the developed world, where saturation levels of consumption have been reached and population growth is small. Ninety percent of the small net increase in meat consumption in developed countries over the same period came from poultry.

Despite China's clearly dominant role in the production and consumption of meat, trends in consumption extend to other regions and commodities. For example, milk consumption doubled in India from the early 1980s to the late 1990s, now accounting for over 13% of the world's total and over 30% of the milk consumed in developing countries. Heavy urbanisation in Latin America has led to high average levels of milk consumption there (112 kg per capita, compared to 43 kg per capita in the developing world as a whole).

Table 1. Historical per capita meat and milk consumption by region

Region	Meat		Milk	
	1983	1997	1983	1997
	(kg person^{-1} y^{-1})			
China	16	43	3	8
South East Asia	11	18	10	12
India	4	4	46	62
Other South Asia	6	9	47	63
Latin America	40	54	93	112
WANA	20	21	86	73
SSA	10	10	32	30
United States	107	120	237	257
Developing world	14	25	35	43
Developed world	74	75	195	194
World	30	36	76	77

Source: Values are three-year moving averages centred on the year shown, calculated from data in FAO (2000)

WANA = Western Asia-North Africa

SSA = Sub-Saharan Africa

Table 2. Food consumption trends of various animal products

Region and product	Total consumption		Share of total 1997 (%)	Per capita consumption	
	1983	1997		1983	1997
	(million metric t)			(kg person^{-1} y^{-1})	
Developed world					
Beef	32	30	52	27	23
Pork	34	36	44	29	28
Poultry	19	28	49	16	22
Total meat	88	99	47	74	76
Milk	233	254	56	195	195
Developing world					
Beef	16	27	47	5	6
Pork	20	46	57	6	10
Poultry	10	29	51	3	7
Total meat	50	112	53	14	25
Milk	122	198	44	35	44

Source: Calculated from data in FAO (2000)

Notes: 'Consumption' is direct use as food, uncooked weight bone-in. 'Meat' includes beef, pork, mutton and goat, and poultry. 'Milk' is milk and milk products in liquid milk equivalents. Metric tons and kilograms are three-year moving averages centred on the year shown. Milk consumption as food is less than total milk demand because of use for calves. Milk demand in 1996–98 for developing countries is 228 mmt, and 318 mmt in developed countries.

Table 3. Trends in the use of cereal as feed

Region	Total cereal use as feed			
	1983	1993	1997	2020
	(million metric t)			
China[a]	40–49	78–84	91–111	226
India	2	3	2	4
Other East Asia	3	7	8	12
Other South Asia	1	1	1	3
South East Asia	6	12	15	28
Latin America	40	55	58	101
WANA	24	29	36	61
Sub-Saharan Africa	2	3	4	8
Developing world	128	194	235	444
Developed world	465	442	425	511
World	592	636	660	954

Sources: Calculated from data in FAO (2000). Figures are three-year moving averages centred on year shown. The 2020 projections are from the July 2002 version of the IMPACT model.

Notes: Cereals includes wheat, maize, rice, barley, sorghum, millet, rye and oats. Metric tonnes and kilograms are three-year averages centred on the year shown. WANA is Western Asia and North Africa.

[a]Simpson *et al.* (1994) report 40 mmt from USDA ERS data. That figure is used here because it is more consistent with the feed quantities and feed/meat conversion ratios in Rosegrant *et al.* (1997). FAO (1997) reports 49 mmt. Extrapolations of the lower figure yield the lower bound estimate. FAO data are used on the upper bound and in the totals.

The changing structure of input demand in animal production

The rapid rise in livestock production in developing countries has been confronted in recent years by dwindling grazing resources for ruminant animals and a pattern of effective demand largely centred on rapidly growing mega-cities fuelled by non-agricultural development. The latter increases pressures for rapid industrial approaches to satisfying urban meat demand. Together, these trends help explain the large share of non-ruminants in the production increases in both the North and the South. The feeding of cereals to ruminants in the North has declined, a consequence of increased cattle grazing. This along with the much larger increase in non-ruminant production in the South helps explain a relative shift to the South in the use of feed cereals. This shift is illustrated in Table 3, which includes only cereals used for feed. Cereals feed use in the developed countries has actually declined since the early 1980s, whereas it in-

creased substantially in developing countries. In 1983, developing countries accounted for 21% of cereal feed demand; by 1997, this share had grown to 36%. This trend has sparked concern that increased meat production for the urban middle class could induce higher cereal prices for the poor. Moreover, there is some question as to whether these consumption trends can continue without resource or import constraints causing major increases in meat price.

The future progress of current trends in increased consumption and production of animal products in developing countries will have large consequences not only for the nutrition of the poor, but also for income growth and opportunities for participation in rapidly growing markets. Shifting patterns of supply and demand will also have major implications for the trade position of countries in both the North and the South. Environmental and public health issues will also be shaped by production and consumption trends in years to come. Moreover, understanding potential price-mediated linkages (such as those involving feed grains) that influence the price of food to poor consumers requires a broad view of the future dynamics of the world food economy. IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) is a global model of food supply and demand well-suited to exploring many of these questions (Rosegrant *et al.* 1995, 2002)[7].

Projections to 2020

Consumption growth

The IMPACT model projects growth in annual aggregate developing country consumption from 1997–2020 to be 3.0% for meat and 2.9% for milk. These increases dwarf the corresponding developed country growth rates of 0.8% and 0.6%. Poultry consumption will grow faster than other meats; the 3.9% per year growth rate in developing countries exceeds that of beef (2.9%) and pork (2.4%). In developed countries, increased poultry consumption (11 mmt) will exceed the combined growth in beef and pork consumption (7 mmt). Aggregate projections of growth in consumption are shown in Table 4.

As the growth rates in Table 5 suggest, high growth in meat and milk consumption is spread throughout the developing world and in no way limited to China, India and Brazil, although the sheer size and vigor of those countries will mean that they will continue to increase their dominance of world markets for livestock products. China will double its consumption of meat by 2020, while India and other South Asian countries will lead the large overall increase in milk consumption.

Projections of per capita consumption are also shown in Table 4. The figures show significant increases in per capita meat consumption in developing countries from 25 kg y^{-1} in 1997 to 36 kg y^{-1} in 2020. Developing country per capita milk consumption, too, shows a large increase from 43 to 62 kg y^{-1} during this time.

Production and feed demand

Production patterns generally follow consumption patterns, as suggested by projected growth rates in production in Table 6 that are similar to growth rates for consumption in Table 4. Because of the relatively high cost of handling perishable final products and taste factors, most meat and milk will be produced where it is consumed, aided by increasing feed imports. Developing countries will account for 63% of meat production and 50% of milk production in 2020. China alone will account for 31% of meat production, but only 3% of milk production.

[7] This paper cannot do justice to the technical aspects of IMPACT; a full exposition by Rosegrant *et al*. of the details of IMPACT and how it works can be found on IFPRI's website at: http://www.ifpri.org/themes/impact/impactmodel.pdf . IMPACT is really a set of country or regional sub-models, within each of which supply, demand and prices for agricultural commodities are determined. The present version of IMPACT (July 2002) covers 36 countries and regions that account for virtually all of world food production and consumption, and up to 28 food commodities. The latter include six fisheries commodities, all cereals, soybeans, roots and tubers, four meats, milk, eggs, oils, oilcakes, meals, sugar, fruits and vegetables. This paper focuses only on results for meat and milk, but it is important to note the major substitutes such as various types of fish, and feeds items such as different cereals and meals.

Table 4. Projected food consumption trends of various livestock products to the year 2020

Region and product	Consumption growth rate 1997–2020 (% y^{-1})	Total consumption		Share of total 2020 (%)	Per capita consumption	
		1997	2020		1997	2020
		(million metric t)			(kg $person^{-1}$ y^{-1})	
Developed world						
Beef	0.5	30	34	40	23	25
Pork	0.4	36	39	33	28	29
Poultry	1.5	28	39	36	22	29
Total meat	0.8	98	117	35	76	87
Milk	0.6	254	286	43	195	210
Developing world						
Beef	2.9	27	52	61	6	9
Pork	2.4	47	81	67	10	13
Poultry	3.9	29	70	64	7	11
Total meat	3.0	111	217	65	25	36
Milk	2.9	198	375	57	44	62

Sources: Total and per capita consumption for 1997 are calculated from FAO (2000) and are three-year moving averages centred on 1997. The 2020 projections are from the July 2002 version of the IMPACT model.

Notes: 'Consumption' is direct use as food, uncooked weight bone-in. 'Meat' includes beef, pork, mutton and goat, and poultry. 'Milk' is milk and milk products in liquid milk equivalents. Metric tons and kilograms are three-year moving averages centred on the year shown.

Table 5. Projected food consumption trends of meat and milk, 1997–2020

Region	Projected annual growth 1997–2020		Total consumption in 2020		Per capita consumption in 2020	
	Meat	Milk	Meat	Milk	Meat	Milk
	(%)		(million metric t)		(kg)	
China	3.1	3.8	107	24	73	16
India	3.5	3.5	10	133	8	105
Other East Asia	3.2	2.5	5	2	54	29
Other South Asia	3.5	3.1	7	42	13	82
South East Asia	3.4	3.0	19	12	30	19
Latin America	2.5	1.9	46	85	70	130
of which Brazil	2.4	1.8	20	30	94	145
WANA	2.7	2.3	13	42	26	82
Sub-Saharan Africa	3.2	3.3	11	35	12	37
Developing world	3.0	2.9	217	375	36	62
Developed world	0.8	0.6	117	286	86	210
World	2.1	1.7	334	660	45	89

Sources: Total and per capita meat consumption for 1997 are annual averages of 1996 to 1998 values, calculated from FAO (2000). Projections are from the July 2002 version of IMPACT.

Notes: 'Consumption' is direct use as food, uncooked weight bone-in. 'Meat' includes beef, pork, mutton and goat, and poultry. 'Milk' is milk and milk products in liquid milk equivalents. Metric tons and kilograms are three-year moving averages centred on the year shown. WANA is Western Asia and North Africa. See note in Table 2 concerning total demand for milk.

Table 6. Projected production growth of various animal products to the year 2020

Region and product	Production growth rate, 1997–2020 (% y^{-1})	Total production (million metric t y^{-1})		Share of total in 2020 (%)
		1997	2020	
Developed world				
Beef	0.6	31	35	41
Pork	0.5	36	41	34
Poultry	1.6	30	42	39
Total meat	0.9	100	123	37
Milk	0.6	339	390	50
Developing world				
Beef	2.8	27	51	59
Pork	2.3	47	80	66
Poultry	3.7	29	67	61
Total meat	2.9	110	211	63
Milk	2.8	208	390	50

Sources: Total and per capita production for 1997 are annual averages calculated from FAO (2000). Projections are from the July 2002 version of IMPACT.

Notes: 'Meat' includes beef, pork, mutton and goat, and poultry, carcass weights plus fifth quarter. 'Milk' is milk and milk products in liquid milk equivalents.

The projected rapid expansion in monogastric livestock production implies that feed demand will continue to rise in developing countries. On a global level, the amount of cereals used as feed will rise from 650 mmt in 1997 to 954 mmt in 2020, a net increase larger than the current annual US maize crop. The share of developing countries in feed use is projected to rise from 36 to 46% during this period (Table 3).

Trade

The trade situation for livestock products and feed cereals in 1997, and the projected situation for 2020, are shown in Table 7. Several striking conclusions emerge. First, the big trade flows that equilibrate rapidly-growing livestock demand with supply in developing countries occur primarily in the feed cereals market. Developing countries as a whole increase their net imports of cereals for all purposes by 85%, for a total of 193 mmt. Substantially more than half of the projected increase in annual net imports of cereals to developing countries between 1997 and 2020 is likely to be used for feed[8]. The most impressive increase is projected for China (35 mmt extra net imports of cereals for all purposes), but the rest of South and East Asia will add another 23 mmt in net imports.

Changes in meat trade to 2020 tend to be more modest, even if adjusted to value terms. Net imports of beef by developing countries are projected to increase by 1.2 mmt by 2020, while the figures for pork and poultry are 1.5 and 2.4 mmt respectively. Latin America is the only developing region projected to increase its net exports of meat. This is especially striking for beef (an additional 1.5 mmt of net exports), but is also the case for pork and poultry. Developing countries are expected to add another 12.3 mmt (LME) in milk imports by 2020, with net imports growing noticeably in most parts of the developing world.

By contrast, India is an exception; despite its size and rapid growth in milk consumption, net imports are projected to grow only by 0.6 mmt (LME) by 2020 because of strong growth in production.

Prices

The overall trend for livestock and feed prices has been downward during the past three decades. Real maize prices, however, did not fall during the 1990s, perhaps reflecting high feed demand under the Livestock Revolution. By contrast, real beef prices fell by a factor of three from 1971 to 1997. Interestingly, real beef prices fell by one-third from 1991 to 1997, but real poultry prices were stable and pork prices actually increased. The monogastrics and milk had real price increases and the real prices for the ruminant meats fell. This probably reflects a combination of consumer problems for the beef market in Europe associated with fears about bovine spongiform encephalopathy (BSE, 'mad-cow disease') and high demand for pork and poultry in Asia over the period. IMPACT projections for price changes from 1997–2020 are shown in Table 8. Meat prices are projected to decline modestly, with real prices of beef, pork and poultry all 3% lower.

[8] Some of the imported maize may be used for human food, and some of the minor cereals for brewing, but quite a bit of the wheat not included in this figure will surely be used for feed.

Table 7. Net exports (imports) of various livestock products by location in 1997 and projected to the year 2020
(thousand metric t; negative numbers indicate net imports)

Region	Beef		Pork		Poultry		Milk		Cereals	
	1997	2020	1997	2020	1997	2020	1997	2020	1997	2020
China	–42	–739	159	–1391	–155	–2358	–1369	–3135	–7721	–42 732
South East Asia	–197	–908	–8	57	158	335	–4663	–8989	–6665	–8088
India	158	–112	0	–60	0	–48	48	–508	1824	–5624
Other South Asia	–1	–129	0	–6	–1	–100	–759	–3006	–4843	–14 124
Latin America	500	1986	–105	111	–60	785	–5767	–5126	–15 262	–3938
WANA	–377	–754	–6	–16	–459	–902	–4885	–6692	–45 080	–74 204
Sub-Saharan Africa	11	–81	–43	–89	–127	–208	–2279	–4101	–12 374	–23 263
United States	–167	302	156	1073	2109	4878	–3269	–3296	76 764	116 594
Developing world	–152	–1307	–7	–1524	–701	–3064	–20 014	–32 355	–104 334	–192 852
Developed world	152	1307	7	1524	701	3064	20 014	32 355	104 334	192 852

Source: Projections are based on production minus consumption in the years shown for the commodity and region shown. Figures for 1997 are annual averages calculated from FAO (2000). Projections are from the July 2002 version of IMPACT.

Notes: Metric tons are carcass weights plus a fifth quarter for meat. 'Milk' is milk and milk products in liquid milk equivalents. Net export (import) figures may not sum to zero overall because of rounding.

Milk prices will decline by 8%, while wheat and rice prices show similar declines (8% and 11%). In contrast, maize prices are projected to increase by 1% while soybean prices decline by 4%. These results indicate that the main effect of the Livestock Revolution on agricultural prices is to stem the fall in feedgrain prices, such that maize and soybeans will increase in value over time compared to rice and wheat. The Livestock Revolution will also cushion if not prevent the further fall in real global livestock prices. IMPACT results do not indicate that increased Asian livestock consumption will push food grain prices beyond the reach of the poor, especially since real maize prices were much higher in the 1980s than they are now, or are projected to be in 2020.

Table 8. Real price change, 1997–2020, of selected commodities under baseline scenario as projected by the IMPACT model

Commodity	Change 1997–2020 (%)
Beef	–3
Pigmeat	–3
Sheepmeat	–3
Poultry meat	–2
Eggs	–3
Milk	–8
Maize	+1
Soybeans	–4
Vegetable meals	–1

Notes: Projections to 2020 are from the July 2002 version of IMPACT

Sensitivity analysis

Any simulation model of IMPACT's size embodies thousands of parameters and basic assumptions about likely economic growth, population growth, urbanisation trends, rates of technological change and so forth. In IMPACT's case, this involves 36 regions of the world and 32 commodities, all with different assumptions. It is not possible to formally test all these, although some of this is always done in model construction.

It is possible, however, to test changes in major assumptions about how the world will evolve, and this helps illustrate the sensitivity of results to model construction as well as provide insights on how the livestock sector relates to the broader economy.

Delgado *et al.* (1999a) tested the sensitivity of projections from the June 1998 version of IMPACT to possible extreme scenarios such as a prolonged and severe economic crisis in Asia, a rapid increase in meat consumption in India, or a global decrease in concentrate feed conversion efficiency stemming from increased use of grain in animal rations under

industrialisation. In all cases, the projected growth of aggregate consumption of livestock products in developing countries remained strong. The projected consumption growth in Asia was lower in the severe economic crisis scenario, and world prices fell further in that scenario than they did in the base projection to 2020. The scenario incorporating a dramatic shift in tastes in India toward meat consumption raised projected world prices. The scenario positing 60% lower feed efficiency in meat and milk production resulted in maize prices only 21% higher than in the original baseline prediction. In real terms, that level was still half the prevailing prices in the early 1980s. Demand increases for meat and milk have historically been met through expansion of feed production or imports at world prices that have declined in real terms over time. Livestock has thus been one of the main factors stabilising world cereal supply. Evidence from years of cereal price shocks in the 1970s and 1980s suggests that reductions in cereal supply were largely absorbed by reductions in feeding to livestock.

The model assumes that the most important forces driving increasing consumption of animal products — population, income growth, and urbanisation — will continue during the next 20 years, albeit at reduced rates compared to the past 20 years. A key conclusion from the model is that even with only modestly increasing productivity, large amounts of additional meat, milk and feed will be supplied without dramatic price increases. If the projected situation is accurate, issues of policy importance will shift away from the net availability of animal products and cereals, and toward the possible impacts of increased production and consumption on the environment, human health and the incomes of the poor. Because developing countries will produce 63% of world meat and 50% of world milk in 2020, the brunt of the benefits and costs will accrue in those regions.

Discussion: opportunities and perils

Conclusions from the projections model

The major result of the projections is to underscore the increasingly important role of developing countries in driving world markets for meat, milk and feed grains. China's role in particular cannot be ignored. As incomes grow and markets liberalise in China, their consumers and producers will be major forces on the world scene.

Growing domestic demand due to increasing population, income and urbanisation in developing countries will translate into impacts on world markets. Saturation levels of consumption have largely been reached in developed countries. As a consequence, net feed and meat imports into developing countries will rise by 2020. Increased livestock consumption is not a particularly large threat to the poor through higher cereals prices, as maize prices increase only modestly to 2020. Meat and milk prices will slightly decline.

Opportunities for poverty reduction and income diversification

The rapidly-growing markets for animal-derived food commodities present a significant opportunity to the rural poor. Aside from improved nutrition resulting from diversified diets, production and processing of animal products can improve the incomes of poor farmers and food processors in developing countries. Household studies in rural Africa and Asia clearly demonstrate that the rural poor and landless derive a higher share of their income from livestock than do rural people with higher incomes (von Braun and Pandya-Lorch 1991; Delgado *et al.* 1999a). In much of the developing world, the asset-poor can benefit greatly from the income supplement provided by a goat, a pig, some chickens or a milking cow.

Industrialisation of pig and poultry production is occurring rapidly in many parts of Asia and Latin America. Much of this development is based on technology transfer through joint ventures and direct importation of parent and grandparent stock. Although the possibilities for doing this feasibly have been around in many of the same countries since the late 1940s, the process really took off only in the late 1970s and early 1980s, when the demand surge in developing countries made a supply response so profitable (Delgado *et al.* 2003).

The poor may not benefit in a widespread manner from these changes, however, unless specific policies are enacted. Market distortions that favor large producers, often in the form of input subsidies, can create artificial economies of scale in production that discriminate against smallholders. Policy research is only now beginning to focus on the separate and interacting roles of overt policy distortions, scale-related differences in 'transactions

costs'[9] and basic differences in technical and managerial efficiency in explaining why larger farms are out-competing smaller ones for poultry, pigs and increasingly milk in developing countries.

Policies that promote the integration of small producers with larger production chains are essential to keeping the poor involved in these rapidly growing markets. Contract farming schemes or participatory producer cooperatives may help prevent the poor from being driven out of the one growing market they presently supply. Policies affect the costs of livestock production, and thus the location and type of production at home and abroad. Policies toward infrastructure, pollution, access to capital and rural organisation will affect the comparative advantage of smallholders versus large industrial enterprises.

Environmental issues

The expansion of animal production will likely put stress on the environment (de Haan *et al.* 1997). Growth in food production from livestock in developing countries until recently came primarily from rapidly increasing numbers of animals rather than from higher carcass weights. This increase contributed to large concentrations of animals and people in urban environments in many cities of developing countries with weak regulations governing livestock production (such as in Beijing, Mumbai, Lima and Dar-es-Salaam). Over-stocking has also occurred in places where land is 'free' (such as most of the African Sahel); more intensive use of the land without additional inputs could further degrade its productivity. Work by the Livestock, the Environment and Development initiative (LEAD) secretariat housed in FAO shows that the accumulation of excess nitrogen and phosphorus in coastal areas of Asia is becoming a very serious problem (see maps by Gerber in Delgado *et al.* 2003).

Property rights systems that do not internalise externalities (where private costs do not adequately reflect true social costs) are responsible for most problems of this kind. Recent research shows that larger livestock farms in India, the Philippines, Thailand and Brazil tend to create larger nutrient surpluses per unit of land than do small farmers, implying a strong probability that they pollute more. Separate calculations by the same authors show that larger farms also tend to spend less per unit output on mitigating the negative effects of pollution by livestock waste than do small farms in the same areas (Delgado *et al.* 2003)[10].

Animals have tended to be produced more intensively in places where financial capital is cheap relative to land (such as the Netherlands), worsening waste and air problems. Nutrient loading has occurred where the social cost has not been fully passed on to the producers and through them to the consumers. Distortions in domestic capital markets, such as subsidised lending to influential organisations, can promote inefficient, large-scale pig, milk and poultry production in the peri-urban areas of developing countries. These policies distort the pattern of livestock development and ultimately cannot be sustained. Further, poor infrastructure and distortions in the marketing chain, such as extortionate police road stops that prevent competition from rural areas, poor environmental regulation, and lack of legal accountability for pollution promote urban piggeries and dairies that cannot adequately dispose of waste materials.

Growing concentrations of animals and people in the major cities of developing countries also notably increased the incidence of zoonotic diseases such as infections from *Salmonella*, *E. coli*, and avian flu — diseases that can only be controlled through enforcement of zoning and health regulations. Greater intensification of livestock production has caused a build-up of pesticides and antibiotics in the food chain in both the developed and developing world. Furthermore, as the consumption of animal products increases in tropical climates, food safety risks from microbial contamination become more prevalent.

[9] Transactions costs are the costs of search and monitoring bound up in transactions between two economic agents, and fundamentally arise because of asymmetries in the information available to both sides of a bargain. They are a particular problem for smallholders in developing countries. Simply put, if you are not a regular and large supplier with a stake in continuing to sell to me in particular, I cannot trust you not to water down the milk you sell me or not to use poor feed that will produce off-flavors in the meat I buy from you. Therefore, I will pay you less than a large producer, whose product I know and trust. In the Philippines, the margin in live-weight producer prices for hogs in Southern Luzon attributable to differential transactions costs by scale is about 8%. Smallholders who sell through a contract farming scheme and large independent farmers get about that much more per kilogram than independent smallholders, *ceteris paribus* (Costales *et al.* 2003).

[10] Bearing in mind that part of the 'spending' is the value of time spreading manure on one's own fields, whatever the motive.

A rare opportunity

The global boom in consumption of animal products is a rare opportunity for poor people in rural areas to benefit from a rapidly-growing market for items they either already produce or could. Policymakers and development partners who wish to help the poor should pay close attention to these trends. Policy needs to focus on removing the overt distortions that produce problems, while promoting institutional change in property rights in commercialising smallholder areas. The trends underlying increased animal consumption will almost certainly continue into the future, but the form taken by the growing markets is far from certain. Public investment in small-operator forms of market-oriented animal production is essential for shaping these trends in a way that is beneficial to the poor and to the environment.

Perhaps surprisingly to some, detailed cost-route surveys and analysis in the Philippines, India, Brazil and Thailand shows that as long as smallholders value their own labor at less than market wage rates, small family farms are typically more efficient at generating profits per unit of output than are large production operations, sometimes even in items such as poultry, which are often thought to be subject to large 'economies of scale' (Delgado *et al.* 2003). Smallholders have a chance, but they do need to move to minimal production levels (say 500 layers instead of 6), and they need to be involved in some form of vertical coordination with processors and input suppliers; otherwise their cost advantage will be destroyed by the market problems of trust and reputation and difficulties in ensuring access to credit, extension information and a secure market. Improved policies and institutions in partnerships with private and public sector stakeholders are key to moving in this direction.

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Appendix: Regional classification of countries used in this paper

China: Mainland China, Taiwan, Hong Kong

Other East Asia excluding Japan: Macau, Mongolia, North Korea, South Korea

India: India

Other South Asia: Afghanistan, Bangladesh, Maldives, Nepal, Pakistan, Sri Lanka

South East Asia: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, Vietnam

Latin America: Antigua & Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Dominica, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, St. Lucia, St. Kitts & Nevis, St. Vincent & Grenadines, Suriname, Trinidad & Tobago, Uruguay, Venezuela

Western Asia and North Africa (WANA): Algeria, Cyprus, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Saudi Arabia, Syria, Tunisia, Turkey, United Arab Emirates, Yemen

Sub-Saharan Africa (SSA): Angola, Botswana, Burkina Faso, Benin, Burundi, Cameroon, Central African Republic, Chad, Comoros Islands, Democratic Republic of the Congo, Cote d'Ivoire, Djibouti, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Republic of the Congo, Reunion, Rwanda, Sao-Tome & Principe, Senegal, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe

United States: United States of America

Japan: Japan

Europe (EC-15): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom

Developed World: 'United States,' 'EC-15,' 'Japan,' Albania, Armenia, Australia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Canada, Croatia, Czech Republic, Czechoslovakia, Estonia, Georgia, Hungary, Iceland, Israel, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Malta, Moldova, New Zealand, Norway, Poland, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Switzerland, Tajikistan, Turkmenistan, Ukraine, USSR, Uzbekhistan, Yugoslavia, Yugoslavia (former)

Developing World: 'China,' 'Other East Asia,' 'India,' 'Other South Asia,' 'South East Asia,' 'Latin America,' 'WANA,' 'SSA,' Cape Verde, Fiji, French Polynesia, Kiribati, New Caledonia, Papua New Guinea, Seychelles, Vanuatu

World: 'Developed World,' 'Developing World'

Sources: Regional groupings were chosen based on Delgado *et al.* (1999a).

Note: Data from some small countries were not available in all series in all years. Missing values for very small countries are ignored without note.