Rising Demand for Meat and Milk in Developing Countries: Implications for Grasslands-Based Livestock Production[2]

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The XX International Grassland Congress took place in Ireland and the UK in June-July 2005. The main congress took place in Dublin from 26 June to 1 July and was followed by post congress satellite workshops in Aberystwyth, Belfast, Cork, Glasgow and Oxford. The meeting was hosted by the Irish Grassland Association and the British Grassland Society.

Proceedings Editor: D. A. McGilloway

Publisher: Wageningen Academic Publishers, The Netherlands

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Key points

1. Meat and milk consumption in developing countries has grown three times as fast as in developed countries over the past 30 years.
2. By 2020, developing countries will consume 72 million metric tons (mmt) more meat and 152 mmt more milk compared to 2002/3, dwarfing developed-country increases of 9 mmt for meat and 18 mmt for milk.
3. Ruminant livestock will account for 27% of the increase in global meat consumption between 2003 and 2020, up from 23% over the previous two decades.
4. The inflation-adjusted prices of livestock and feed grains are expected to fall only marginally by 2020, compared to precipitous declines in the past 30 years.
5. Production growth of monogastric livestock in Asia and South America will continue, but at a slower rate as environmental, health, and feed cost problems become more acute.

Keywords: developing countries, ruminants, price projections

Introduction

From the beginning of the 1970s to the mid-1990s, consumption of meat in developing countries increased by 70 million metric tons (mmt), almost triple the increase in developed countries, and consumption of milk by 105 mmt of liquid milk equivalents (LME), more than twice the increase that occurred in developed countries. The market value of that increase in meat and milk consumption totalled approximately $155 billion (1990 US$), more than twice the market value of increased cereal consumption under the better known 'Green Revolution' in *Triticum* spp. (wheat), *Oryza sativa* spp. (rice) and *Zea mays* (maize). The population growth, urbanisation, and income growth that fuelled the increase in meat and milk consumption are expected to continue well into the new millennium, creating a veritable 'livestock revolution'. As these events unfold, the diet for many people will change, some for the better, but others for the worse - especially if food contamination is not controlled. Farm income could rise dramatically, but whether resource-poor smallholders and landless agricultural workers who need it most will share that gain is still undetermined. The environmental, nutritional and public health impact of rapidly rising livestock production in close proximity to population centers also needs attention (Delgado *et al.,* 1999).

[2]This paper draws upon Delgado (2003), which it updates from 1997 to 2003, and for which it also disaggregates the grasslands-relevant livestock commodities, while attempting to address the particular market issues facing grasslands livestock producers. Grateful acknowledgement is made to Mark Rosegrant of IFPRI for the disaggregated July 2002 IMPACT projections model results and of Nancy Morgan of FAO Commodities Division (FAO/ESC) for providing very useful datasheets on updated meat statistics to 2003 on her global list-serve pertaining to meat issues.

The livestock revolution

The livestock revolution is propelled by demand. People in developing countries are increasing their consumption from the low levels of the past have a long way to go before coming near developed country averages. In developing countries people consumed an annual average in 2002/03 of 29 kg/capita meat and 45 kg/capita milk, roughly one-third the meat and one-fifth the milk consumed by people in developed countries. Average meat consumption per capita per annum increased by 263% in developing countries since the early 1970s, but only by 22% in developed countries (Table 1). Nevertheless, the caloric contribution per capita of meat, milk and eggs in developing countries at the start of the new millennium was still only a quarter that of the same absolute figure for developed countries, and at 10% accounted for only half the share of calories from animal sources observed in the developed countries (Delgado, 2003).

Table 1 Annual per capita human food consumption (kg/capita) 1973 and 2003

Commodity	Developed countries		Developing countries	
	1973	2003	1973	2003
Beef	26	23	4	6
Mutton and goat	3	2	1	2
Pork	26	30	4	12
Poultry	11	27	2	8
Four major meats[1]	67	82	11	29
Milk and products excluding butter[2]	188	202	29	45

[1]Four major meats = beef, pork, mutton and goat, and poultry, and may vary slightly from the sum of the individual entries due to rounding; [2]data for milk pertain to 2002.
Source: Values for 1973 are three-year moving averages based on the year shown, from Delgado *et al*. (1999); data for meats are preliminary estimates for 2003 from worksheets obtained from the FAO Commodities Division. Data for milk products are in Liquid Milk Equivalents and are the most recent year available at the time of writing from FAO 2005.

Throughout this paper, 'food' will be used to distinguish direct food consumption by humans from uses of animal products as feed, fuel, cosmetics, or coverings.

Per capita consumption is rising fastest in regions where urbanisation and rapid income growth result in people adding variety to their diets. Across countries, per capita consumption is determined by average capita income and whether or not one is living in a city. City life hastens cultural change, increases the frequency of eating outside the home, and increases the choice of foods available locally, all of which are positively associated with meat consumption. Aggregate consumption grows fastest where rapid population growth augments income and urban growth. Since the early 1980s, total meat and milk consumption grew at 6 and 4% per year respectively throughout the developing world. In East and Southeast Asia - where income grew at 4-8% per year between the early 1980s and 1998, population at 2-3% per year, and urbanisation at 4-6% per year -meat consumption grew between 4 and 8% per year (Cranfield *et al*., 1998; Delgado & Courbois, 1998; Rae, 1998).

The Livestock Revolution has been most evident in East Asia, as illustrated by the per capita figures for China in Table 2. The significance of the per capita figures is more striking when

they are multiplied by population, since four-fifths of the latter is in developing countries and their share is growing.

Table 2 Per capita meat and milk consumption (kg) by region, 1982/84 and 2002/03

Region	Meat (kg)		Milk (kg)	
	1983	2003	1983	2002
China	16	54	3	13
India	4	5	46	63
Other South Asia	6	10	47	64
Southeast Asia	11	22	10	13
Latin America	40	62	93	105
WANA*	20	24	86	74
Sub-Saharan Africa	10	14	32	29
Developing world	14	29	35	45
Developed world	74	82	195	202
United States	107	125	237	262
World	30	40	76	79

*WANA = Western Asia and North Africa data

Source: Values for 1983 are three-year moving averages based on the year shown from Delgado *et al*., 1999; data for meats are preliminary estimates as food use for 2003 from worksheets obtained from the FAO Commodities Division; data for milk products in 2002 are in liquid milk equivalents for food use excluding butter and are the most recent year from FAO (2005).

Using current FAO estimates of Chinese consumption in 1982/84 and 2002/03, the share of the world's meat consumed in developing countries rose from 37 to 57%, and their share of the world's milk rose from 34 to 45%. Conversely, 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.

China and Brazil account for a major proportion of the meat component within the Livestock Revolution. However, the doubling of aggregate milk consumption as food in India between the early 1980s and the early 2000s suggests that the Livestock Revolution extends beyond just meat and China and Brazil. At 66 mmt of LME in 2002 (a figure from FAO (2005) - considered low by many Indian dairy analysts), Indian milk consumption amounted to 13.5% of the world's total and 30% of milk consumption in all developing countries. The high milk consumption of Latin America in 2002, at 105 kg/capita, is half way between the developing world as a whole (45 kg/capita) and the developed countries (202 kg/capita), because of the very high level (75%) of urbanisation in Latin America (Table 2).

The share of the developing countries in world use of cereals for feed went from 21% in 1982/84 to 36% in 1996/98. This salient fact has inspired many observers to consider if the rise of production of grain-fed monogastric livestock products for the urban middle class would jack up the price of cereals to the poor in both rural and urban areas of developing countries. A further consideration is whether the trends portrayed above could continue far into the future, without resource scarcities or import constraints raising prices to the point that the growth in consumption would peter out (Delgado *et al*., 1999).

Whether these trends will continue was explored in 1998 with IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), a global food model first reported in Rosegrant *et al*. (1995). Results were put into the context of growing concern about livestock issues in Delgado *et al*. (1999) and updates were reported in 2003.

Rising consumption of meat and milk to 2020

For the 1996/98 to 2020 period, IMPACT predicts developing country aggregate consumption growth rates of meat and milk to be 3.0 and 2.9% per year, respectively, compared to 0.8 and 0.6%, respectively, in developed countries. Aggregate meat consumption in developing countries is projected to grow by 72 mmt between 2003 and 2020, whereas the corresponding figure for developed countries is 9 mmt (Table 3). Similarly, additional milk consumption in the developed countries of 18 mmt of LME will be dwarfed by the additional consumption in developing countries of 152 mmt. Poultry consumption in developing countries is projected to grow at 3.9% per annum through 2020, followed by beef at 2.9% and pork at 2.4%. In the developed countries, poultry consumption is projected to grow at 1.5% per annum through 2020, with other meats growing at 0.5% or less (Table 3).

Table 3 Projected food consumption trends of various livestock products to the year 2020

Region	Projected growth of consumption 1997-2020 (% per annum)	Total consumption (million mt)			% of world total	Per capita consumption (kg)
		1997	2003	2020	2020	2020
Developed world						
Beef	0.5	30	30	34	40	25
Mutton	0.8	3	3	5	26	3
Pork	0.4	36	39	39	33	29
Poultry	1.5	28	35	39	36	29
Meat	0.8	98	108	117	35	87
Milk	0.6	251	268	286	43	210
Developing world						
Beef	2.9	27	32	52	61	9
Mutton	2.3	8	10	14	74	2
Pork	2.4	47	60	81	67	13
Poultry	3.9	29	41	70	64	11
Meat	3.0	111	145	217	65	36
Milk	2.9	194	223	375	57	62

Sources: Values for 1997 are three-year moving averages based on the year shown from Delgado *et al*. (2003b); data for meats are preliminary estimates for food use for 2003 from worksheets obtained from the FAO commodities division; 'mutton' refers to meat from all sheep and goats; data for milk products pertain to 2002 and are in liquid milk equivalents and are the most recent year from FAO (2005). The 2020 projections are from the July 2002 version of Mark Rosegrant's IMPACT model (Rosegrant *et al*., 2001; Delgado *et al*., 2003b).

In the developing countries, 27% of the additions to meat consumption from the early 1980s to the late 1990s were from ruminant animals; in the developed countries, the comparable figure was 0%. From 1996/98 to 2003, 16% of additions to meat consumption in developing countries were from ruminant animals, whereas absolute consumption of ruminant meat actually declined in the developed countries. The IMPACT projections suggest that over one-

quarter of global additions to meat consumption from the late 1990s to 2020 will involve meats from ruminants, with positive growth in consumption occurring in both the developed an developing world (Table 4).

Table 4 Increase in total annual meat[1] consumption[2] 1982 to 2020, actual and predicted

	Actual 1983 to 1997 (million mt)	Actual 1997 to 2003 (million mt)	Projected 2003 to 2020 (million mt)
Developed countries			
Ruminants	0	-2	+6
Monogastrics	+11	+10	+4
Developing countries			
Ruminants	+17	+5	+14
Monogastrics	+45	+26	+50
World all sources (mmt)	+73	+39	+74
Share of ruminants (%)	23	8	27

[1]Meat = beef, pork, mutton and goat, and poultry; [2]consumption = direct use as food, uncooked weight bone-in.
Sources: Increases in total annual meat consumption between 1983 and 1997 are based on differences between annual three-year annual averages based on the year shown, calculated from FAOStat (FAO, various years). The figures for 2003 are derived from preliminary worksheets obtained form the FAO commodities division. The 2020 projections are from the July 2002 version of Mark Rosegrant's IMPACT model (Rosegrant *et al*., 2001; Delgado *et al*., 2003b).

As the growth rates in Table 5 suggest, high growth in consumption of livestock-source foods is spread throughout the developing world and not limited to China, India and Brazil, although the sheer size and vigour of those countries will mean that they will continue to increase their dominance of world markets for livestock products. Experience for individual commodities will vary widely among different parts of the developing world, with China leading the way on meat with a near-doubling of the total quantity consumed; the increments are primarily poultry and pork. India and the other South Asian countries will drive a large increase in total milk consumption.

Impact on world relative prices of beef and lamb versus pork and chicken

Since so much of the expansion in meat consumption, and thus production, comes from monogastric livestock such as pigs and poultry, effective demand for concentrate feeds in developing countries will continue to increase. Projections from IMPACT suggest a worldwide expansion of an additional 295 mmt of cereals used as feed per year by 2020, compared to the 1996/98 annual average. This can be compared to an average annual US *Zea mays* (corn) crop of about 200 mmt in the 1990s. Developing countries accounted for 36% of cereals feed use in 1996/98, but are projected to account for 46% in 2020. On a human per capita basis, cereals feed use in 2020 in developed countries is projected to be 375 kg, compared to 72 kg in developing countries.

Table 5 Projected food consumption[1] trends of meat[2] and milk[3], 1997-2020

Region	Projected annual growth (% per year) 1997-2020		Total consumption (million mt) 2020		Per capita consumption (kg) 2020	
	Meat	Milk	Meat	Milk	Meat	Milk
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
Southeast 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[4]	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

[1]Consumption = direct use as food, uncooked weight bone-in; [2]Meat = beef, pork, mutton and goat, and poultry; [3]milk = milk and milk products in liquid milk equivalents excluding butter; [4]WANA = Western Asia and North Africa data. [Metric tons and kilograms are three-year moving averages based on the year shown].
Sources: Total and per capita meat consumption for 1997 are annual averages of 1996 to 1998 values, calculated from FAO 2005. The 2020 projections are from the July 2002 version of Mark Rosegrant's IMPACT model (Rosegrant *et al*., 2001; and Delgado *et al*., 2003b).

With these large projected increases in animal food product consumption and cereals use as feed, it is interesting to review inflation-adjusted prices of livestock and feed commodities to 2020. Real prices for these items fell sharply from the early 1970s to the early 1990s, in most cases stabilised in the mid 1990s, and fell again thereafter. Real beef prices fell by a factor of three from 1970/72 to 1996/98. Real *Zea mays* prices did not fall over the 1990s, reflecting perhaps high demand for feed under the Livestock Revolution (Delgado *et al*., 2003b). The stability of feed grain prices however was not matched by stable prices for pork and poultry over the 1990s.

Hog producers have had a miserable time since 1991 on the price front, reflecting first rapid growth in supply and later on demand problems (Table 6). Poultry producers also started to suffer after 1997, as a combination of effects of the Asian economic crisis, the Russian financial crisis of 1998, avian influenza, and robust growth in supply from Latin America and China all began to have an impact. Beef on the other hand has seen real price growth since 1997, and overall sheep meat producers have held their own.

Looking to the future, IMPACT projects expected changes in real prices to 2020 relative to 1996/98. The overall picture for 2020 is a noticeable real decline for *Triticum* and *Oryza* spp. (8 and 11%), a similar decline for milk (8%), more modest decreases for meats (3%) and stability or slight increases for feed grains (+11 and –4% for *Zea mays* and *Glycine max* (soybeans), respectively). The results lend support to the view that the main effect of the Livestock Revolution on agricultural prices is to stem the fall in feed grain prices, such that *Zea mays* and *Glycine max* will increase in value over time compared to *Triticum* and *Oryza* spp., whose real prices will fall.

Table 6 Actual and predicted total real price changes for meats 1991 to 2020

	(total % change)			
	Monogastrics		Ruminants	
	Chicken	Pork	Beef	Lamb
1991/93 to 1996/98 (actual)	+11	-30	-41	+10
1996/98 to 2001/03 (actual)	-44	-36	+7	-5
1996/98 to 2020 (predicted)	-2	-3	-3	-3

Source: Actual price changes are computed from worksheets of nominal US dollar prices for benchmark world series obtained form the FAO commodities division and deflated using the US Department of Commerce Seasonally Adjusted Quarterly US GDP deflator. Percentage differences were measured between the midpoints of the annual averages shown. The commodities were represented as follows: chicken - Brazilian free-on-board (f.o.b.) export series for broilers; pork - US frozen pork export unit values; beef - Australian manufacture cow beef charges-interest-freight (c.i.f.) prices to the US; lamb - New Zealand frozen whole carcass sales in London wholesale markets. Projected price changes are from the July 2002 version of Rosegrant's IMPACT model as reported in Delgado *et al*. (2003b).

Cheap feed grains facilitated the rapid expansion of monogastric production in the 1980's and early 1990's, but that situation may have been temporary. In Southwest China, for example, the price of pork increased 25% from June 2003 to June 2004, whereas industrial prices were flat and grain prices rose 32% (Fuller *et al*., 2001). Basically anyone who could produce meat without much grain did very well, and those that could not, did not. The suddenness of the onset of the demand-led Livestock Revolution in the early 1980s led to a rapid market response of investment in short-cycle animals under controlled conditions. Over time, ruminant production for milk and meat may be beginning to catch up in China, South Asia and Africa.

In summary, the Livestock Revolution will cushion if not prevent the further fall in real global livestock prices, and also ensure that the costs of production of monogastric livestock (about two-thirds of which are concentrate feed costs) will remain stable if feed conversion ratios do not decline further. Technical progress in lowering feed conversion ratios for monogastric livestock in developing countries has been spectacular over the last 30 years due to both scientific advances and catch-up with the industrial world. However, biological limits to further scientific advances may be coming nearer for poultry at least, and the rapidly expanding industrial livestock sectors of Asia are already approaching the productivity levels of the industrial countries (Delgado *et al.*, 2003a).

Furthermore, based on the comparison of the long-term price projections (over 23 years from 1996/98 to 2020) to the medium-term actuals (5 years from 1996/98 to 2003) in Table 6, readers could be pardoned for wondering if the long-term projections for monogastric prices were too optimistic from a producer standpoint, even though the ones for ruminants seem about right. The price and cost conditions that favoured rapid responses by the monogastric sectors over the past two decades may be less evident in the next twenty years. Furthermore, other events not factored explicitly into the projections suggest that limits to the continued rapid expansion of monogastric livestock production compared to ruminants are in sight (Delgado *et al*., 2003a).

Factors other than relative prices that will favour grasslands production over monogastrics

On the supply side, there is increased awareness in developing countries of the environmental and public health issues raised by increasing monogastric animal densities. Major attention is now being devoted to observed nutrient loading of nitrogen and phosphorous in the soils of many emerging environmental 'hot spots' in zones of high production of pigs and poultry, especially in the East coast provinces of China, large parts of Southeast Asia, Central America, Southern Brazil, Northern Europe and the Middle Atlantic region of North America (de Haan *et al.*, 1997).

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 (primarily monogastric) 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.,* 2003a).

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, especially monogastrics, has caused a build-up of pesticides and antibiotics in the food chain in both the developed and developing world.

There is mounting evidence from around the world that governments are moving to have producers internalise (i.e. pay the cost of) negative environmental externalities that they are creating. Animal disease outbreaks and issues with chemical residues in the context of expanding world trade are also leading many governments to enforcing previous lax regulations with respect to the pig and poultry sectors (Delgado *et al*., 2003a).

On the demand-side, evidence has yet to be generated that large numbers of people in developing countries are prepared to pay a premium for red meat that is both more tender and leaner. However, history elsewhere suggests that this trend will be observable in important markets such as the major urban markets of the faster growing countries, e.g. China. Consumers also tend to place a premium on diversity of diet as they become wealthier, which may help explain why China went from 0 to 5% of world beef production in less than 20 years. Demand for improved qualities of livestock products from grasslands is likely to be added to continued demand for higher quantities of meat and milk in developing countries over the next two decades, at a time that traditional competition from monogastric livestock will become more constrained by cost and side-effect factors than it was in the past.

Conclusions: opportunities for poverty alleviation through ruminant livestock systems

The principal conclusion of the IMPACT projections is to confirm the view that the Livestock Revolution in developing countries will continue at least through the arbitrary horizon of 2020 and will increasingly drive world markets for meat, milk and feed grains. The main trade implication predicted by IMPACT is that developing countries will increase their already

large net imports of cereals to an annual amount in 2020 of approximately the same magnitude as the annual US corn crop (193 mmt). About half (92 mmt) of these net imports will be *Zea mays* and cereals other than *Triticum* and *Oryza* spp.; most of the coarse grains will probably go to feeding, as may some of the *Triticum*. Meat and milk production increases in developing countries will largely match the big consumption increases, and meat exports from Latin America to Asia will soar.

The projections suggest relatively little change in 2020 inflation-adjusted prices relative to real price levels in the base years 1996/98. This is principally because of the propping-up effect of net import demand from developing countries; feed grain prices will remain at about 1996/98 average levels. Meat prices as a whole will fall in the range of 3%, whereas the milk price is projected to fall 8%. These falls would be substantially higher without the livestock revolution. Experience since the late 1990s may prompt one to wonder whether the real prices of pigs will not decline even more over time relative to other meat animals, and what the net impacts of this will be on feed grains and other markets. Part of the answer will depend on imponderables such as biotechnology (for both feed and swine) and consumer acceptance of GMO products in major markets.

Even as price and cost trends over the past three decades favored production response to the demand surges through large-scale farming, particularly of monogastric livestock, price trends over the next two decades are likely to be more encouraging for producers of ruminant livestock. Even without projecting changes in relative output price trends, projections suggest that while meat from ruminants accounted for 23% of global increases in meat consumption from 1982/84, the share from 2003 to 2020 is likely to be 27%. Furthermore, the absolute increases in consumption of ruminant meat in developing countries will be substantially more than twice as large in developing countries than in developed.

The rapid rise in aggregate consumption of meat and milk is propelled by (literally) billions of people diversifying primarily starch-based diets into a small amount of milk and meat, and this fundamental structural shift is not likely to be policy-changeable. Nor should it be, at least not for human nutrition reasons, as average per capita consumption in developing countries is still in most cases far below what is desirable. In any event, whether it is a good thing is not the issue; it is a phenomenon that will occur. What is much less certain is who will produce the extra meat and milk, what share of the meat will be from ruminants, and what proportion will be through large-scale or industrial methods.

Increased consumption of meat and milk will offer a major opportunity to improve the incomes per capita of resource-poor farmers and food processors in developing countries. Considerable evidence from in-depth field studies of rural households in Africa and Asia shows that the rural poor and landless traditionally receive a higher share of their income from livestock than do better-off rural people (von Braun & Pandya-Lorch 1991; Delgado *et al.,* 1999). The exception tends to be in Latin America, where relative rural wealth correlates more clearly with cattle holdings. In Africa, there is an overwhelming correlation between poverty and ruminant livestock keeping (Thornton *et al*., 2002). Since Africa also contains most of the world's under-used grazing land, a bright future for products of ruminant livestock is helpful in thinking about how to best assist one of the world's poorest regions.

In most of the developing world, a goat, a pig, some chickens, or a milking cow can provide a key income supplement for the landless and otherwise asset-poor. Ruminants in particular offer the poor of the world a path for improving their livelihoods. Smallholder dairy operations are

thriving in many areas around the world, and are growing in importance as a livelihood source for the poor in East Africa and South Asia. There are virtually no economies of scale in production in this activity, although the organisation of post-harvest support systems is critical to the expanded participation of smallholders (Rangnekar & Thorpe, 2002). There are large economies of scale in processing livestock-origin food products and perhaps in input supply, but far less in production itself if market-distortions are removed.

The prospects for using monogastric livestock production as an engine for poverty alleviation are still being debated. Clearly the magnitude of production increases suggest that every effort should be devoted to keeping small-scale and resource-poor producers in developing countries engaged in that sector. Policy reforms that help create a more level playing field by forcing the internalisation of the unpaid costs of pollution (which are larger per unit output for larger operations) will help, as will institutional innovations such as contract farming that help overcome economies of scale in input supply. However, the best scope for using the demand surge from the livestock revolution to help the poor directly is likely to be in the ruminant sectors in many cases.

Grassland and ruminant livestock sciences can serve the cause of poverty alleviation in developing countries in two main ways, depending on whether the zone in question is favorable (or not) to increased intensification of mixed crop-livestock systems. On a global basis, livestock use 3.4 billion hectares of grazing land, in addition to the production of about a quarter of the land under crops (FAO, 2005).

Access by resource-poor people to common lands for grazing or fodder production in large parts of Africa, the Middle East, and Central Asia is shrinking over time, and feed is a growing constraint for many livestock keepers in low potential areas worldwide. Crop farming increasingly impinges on pastureland, and herd transhumance that was traditionally used to optimise pastures under climatic changes has become less viable. Pastoralists have become increasingly dependent on marginal lands, leading to overgrazing and land degradation. Insecure land rights and regular periods of severe drought often exacerbate these processes. In such lower potential zones, there is above all a need for institutional innovations to protect common property resources as a major asset of resource-poor people. Science on both the livestock and pasture side can then help maintain and possibly enhance the productivity of a fragile resource base.

Where there is both market and agronomic potential for further sustainable intensification of farming systems, ruminant livestock play a key role in increasing the overall productivity of small farms. The demand surge for milk and meat, especially within 100 km of cities, provides a growing outlet for products, and helps ensure impact for the combined efforts of crop and livestock scientists whose objective is to increase the productivity and sustainability of the crop-livestock system as a whole. The scope for doing this is much better in a world where both meat and grain prices are rising, which gives an added advantage to ruminant livestock production on pastures, forages and crop by-products. The overall message is that the livestock revolution is changing the context for success in our work: although we may picture a sea of grass, no producer or consumer is an island.

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