VI The Evolution of Cereal and Livestock Supply and Demand: Policies to Meet New Challenges

INTRODUCTION

Recent signs indicate that the phenomenal green-revolution growth in cereal-crop productivity over the past 30 years, particularly for wheat and rice in Asia, is slowing, especially in the intensively cultivated lowlands. Slackening of infrastructure and research investments and reduced policy support partly explain the sluggish growth. Degradation of the lowland resource base due to long-term, intensive use also has contributed to declining productivity growth rates.

Fundamental changes in the diets of the populations in Asian developing economies are also a major factor in the evolution of cereal supply and demand. People with more money to spend on food shift from coarse grains to rice and from cereals to meat and other foods. Cereals that used to feed people now increasingly go to feed animals. Livestock consumption, which until recent years has been small relative to cereal consumption in Asia, has experienced extraordinary growth in demand in much of Asia that is beginning to exert great pressure for expansion in production. Although correction of some policies that have favored crop over livestock production could help, traditional forms of animal husbandry, with their low levels of productivity, cannot meet this new demand. More intensive alternatives hold the promise of greater production, but also a threat of increased environmental damage. In this chapter, the changing trends in cereal and livestock supply and demand are examined; the underlying factors that drive these trends are explored.

EVOLUTION OF CEREAL AND LIVESTOCK DEMAND

Rapid income growth, combined with increasing urbanization and changes in tastes and preferences, has caused a shift in diets from coarse grains to rice and secondary shifts from rice to wheat at the margin, as well as increased consumption of livestock and dairy products, vegetables, and fruits. Huang and Bouis (1996) show that urbanization induces structural shifts in diets: as populations move from rural to urban areas there is a wider choice of foods available in urban markets, as well as an exposure to a wider variety of dietary patterns of foreign cultures. Urban lifestyles place a premium on foods that require less time to prepare (inducing, for example, a shift from rice to wheat bread), as employment opportunities for women improve and the opportunity cost of their time increases. Moreover, urban occupations tend to be more sedentary than rural ones. People engaged in more sedentary occupations require fewer calories to maintain a given body weight. In addition, urban residents typically do not grow their own food. Thus, their consumption choices are not constrained by the potentially high-cost alternative of selling one food item at farm-gate prices (say, rice) to buy another food item at retail prices (say, bread), a choice faced by semisubsistence producers.

In addition, while changes in food demand patterns that cannot be attributed to increases in household incomes and changes in food prices may first be noticed in urban areas, as structural transformation proceeds to a more advanced level these same changes in food demand patterns may eventually occur in rural areas as well (Huang and Bouis 1996). The combination of these structural dietary changes with substantial income growth has brought about rapid changes in consumption patterns in Asian developing economies.

Trends in Cereal Demand

Table VI.1 shows historical growth in per capita food and (animal) feed demand and total demand for cereals in Asia, by region for the periods 1967–82 and 1982–95 (based on centered moving averages). The two subperiods roughly divide the period of 1967 to 1995 into a peak green-revolution period and a late green-revolution period. Growth in per capita cereal food demand declined substantially in Asian developing countries, from 1.2 percent annually during 1967–82 to 0.1 percent during 1982–95. The drop was most dramatic in East Asia, from 1.8 percent per year to –0.4 percent per year. In South Asia, on the other hand, growth in per capita cereal food demand remained virtually constant, at 0.5 percent per year. The fall in the growth rate of per capita food demand has been most rapid for maize, from 0.9 percent per year in 1967–82 to –2.9 percent annually in 1982–95, driven by the dramatic drop in East Asian food demand for maize. The overall decline was also substantial for rice and wheat, from 1.1 percent per year to 0.1 percent annually, and from 3.8 percent per year to 1.6 percent per year, respectively, during the same periods. Negative growth accelerated for other coarse grains, to 4.0 percent per year after 1982.

With both per capita cereal-demand growth and population growth slowing, growth in overall demand for all cereals has also declined over time, from 3.7 percent per year during 1967–82 to 2.8 percent from 1982 to 1995. Rapid shifts in dietary patterns—most apparent in East Asia—show up in a decline in the annual growth of total cereal demand from 4.2 percent during 1967–82 to 2.4 percent after 1982. This drop was mostly accounted for by a halving of the rate of growth of total wheat and rice demand and a reduction of the growth in total maize demand by nearly one third. Moreover, demand for other grains continued to decline sharply, from negative 1.2 to negative 2.3 percent per year over the two subperiods.

In South Asia, a dietary shift has been taking place from other coarse grains to increased consumption of rice. The annual rate of growth of total utilization for rice there remained virtually constant (and the rate of growth of per capita consumption of

Table VI.1: Annual growth in total utilization and per capita food and feed demand for cereal crops, by region, 1967–1995

	1967–82			1982–95		
	Total utilization	Per capita food demand	Per capita feed demand	Total utilization	Per capita food demand	Per capita feed demand
	(percent per year)					
Wheat						
East Asia	6.48	4.95	6.03	2.53	1.23	2.73
Southeast Asia	6.21	3.81	a	5.59	3.40	a
South Asia	4.91	2.27	a	3.59	1.49	a
Asia	5.84	3.75	6.21	3.59	1.60	4.36
Maize						
East Asia	6.01	1.78	6.36	4.42	-5.52	5.70
Southeast Asia	4.43	0.22	5.09	6.02	2.32	6.41
South Asia	1.32	-0.97	a	2.33	0.24	a
Asia	5.21	0.88	6.04	4.47	-2.91	5.27
Milled Rice						
East Asia	3.40	1.44	9.53	1.27	-0.16	5.45
Southeast Asia	3.47	1.10	2.96	2.42	0.49	2.86
South Asia	2.76	0.50	a	2.77	0.69	a
Asia	3.24	1.07	a	2.06	0.13	3.98
Other grains						
East Asia	-1.18	-4.40	2.15	-2.32	-7.54	0.89
Southeast Asia	8.15	a	a	1.76	-0.10	a
South Asia	0.59	-1.73	a	-0.58	-2.57	a
Asia	-0.25	-2.90	1.57	0.20	-3.97	2.80
All cereals						
East Asia	4.22	1.80	5.81	2.39	-0.44	5.11
Southeast Asia	3.81	1.16	4.32	3.32	0.88	5.47
South Asia	2.88	0.50	2.87	2.60	0.53	0.89
Asia	3.73	1.24	5.36	2.82	0.10	4.88

Source of basic data: FAO FAOSTAT 1998.

[a] Per capita demand is less than 2 kg. Growth rates are not computed.

rice as food increased slightly), while utilization of coarse grains declined each year after 1982. In Southeast Asia, growth in total cereal utilization of 3.3 percent per year during 1982–95 is driven by maize, which grew at 6.0 percent per year after 1982, closely followed by wheat, which grew at 5.6 percent annually in the same period. While per capita food demand and changing diets lie behind the growth in wheat consumption, it is strong growth in demand for animal feed that lies behind the figure for maize.

This crucial trend, the rapid growth in demand for cereals—in particular maize—as animal feed in Asian developing countries, emerges clearly from Table VI.1. Per capita demand for maize as feed grew at a very rapid 6.0 percent per year during 1967–82, and continued to increase at a strong 5.3 percent annually during 1982–95. Whereas annual growth in per capita feed demand for maize slowed slightly in East Asia (from 6.4 percent to 5.7 percent), it accelerated in the group of Southeast Asian countries (from 5.1 to 6.4 percent). Growth in Asian developing countries was also strong for per capita feed demand of wheat and rice, at 4.4 percent per year and 4.0 percent annually after 1982, respectively. This high growth is due to the rapid expansion of the livestock industry, especially in the more rapidly growing economies where consumption of livestock products has been expanding dramatically.

Growth in Demand for Livestock Products

Table VI.2 summarizes the historical growth in total and per capita demand for livestock products (referred to here as beef, pork, sheep and goat meat, and poultry; dairy products are treated separately in Chapter XII and the Appendix). Growth in meat demand has accelerated in developing Asian countries, with annual per capita food demand growth for all meats of 5.9 percent and total demand growth of a phenomenal 7.9 percent from 1982 to 1995, up from 2.4 percent and 4.6 percent during 1967–82, respectively. For the group of developing Asian economies as a whole, growth was fastest for poultry, with a per capita demand growth of 8.9 percent per year and a total

Table VI.2: Annual growth in total utilization and per capita food demand for livestock products, by region, 1967–1995

	1967–82		1982–95	
	Total utilization	Per capita food demand	Total utilization	Per capita food demand
	(percent per year)			
Beef				
East Asia	5.12	3.10	15.49	13.98
Southeast Asia	1.94	-0.46	3.92	1.96
South Asia	2.52	0.20	3.33	1.21
Asia	2.75	0.58	7.88	5.83
Pork				
East Asia	5.33	3.31	7.22	5.81
Southeast Asia	2.86	0.50	5.68	3.69
South Asia	4.15	a	2.91	a
Asia	5.00	2.78	7.04	5.08
Poultry				
East Asia	5.21	3.19	12.83	11.33
Southeast Asia	6.33	3.89	6.81	4.80
South Asia	4.08	a	10.14	a
Asia	5.50	3.27	10.92	8.86
Sheep and goat				
East Asia	5.95	a	8.96	a
Southeast Asia	5.49	a	4.89	a
South Asia	2.69	a	4.23	a
Asia	3.99	a	7.36	a
All meat				
East Asia	5.33	3.31	8.59	7.16
Southeast Asia	3.67	1.28	5.75	3.74
South Asia	2.77	0.44	4.19	2.06
Asia	4.59	2.38	7.86	5.86

Note: Total utilization for livestock includes food and feed demand, processing, waste and other uses.

Source of basic data: FAO FAOSTAT 1998.

[a] Per capita demand is less than 2 kg. Growth rates are not computed.

demand growth of an extraordinary 10.9 percent per year in 1982–95. These figures basically double the respective annual rates of growth during 1967–82. Moreover, growth in per capita and total utilization of beef overtook growth in per capita and total pork utilization after 1982. Still, growth in total demand for pork and sheep/goat meat was also very rapid, at 7.0 and 7.4 percent per year, respectively, during 1982–95.

Subregional growth among livestock products was highest for beef in East Asia, a per capita food demand growth of a staggering 14.0 percent per year and total demand growth of an even higher 15.5 percent annually—a quadrupling and tripling, respectively, of the rates prevailing in 1967–82. Still, some caution is advised as regards figures for East Asia for the latter period: PRC livestock consumption (as well as production) figures, based on national food balance sheets, may have been overestimated in the 1990s (but not in the 1980s). Independent estimates based on surveys and feed use suggest that actual meat consumption in the early 1990s in the PRC was probably closer to 30 million metric tons in aggregate rather than the 34 to 45 million metric tons (1992–1995 values from FAO 1998) typically shown (Ke 1997; Delgado et al. 1998).

In Southeast Asia, per capita food demand for poultry grew rapidly at 4.8 percent per year during 1982–95, continuing the high growth trend during 1967–82 of 3.9 percent per year. Growth in total utilization grew even more rapidly, at 6.8 percent annually during 1982–95, up from 6.3 percent in the first sub-period. Per capita growth in pork and beef consumption also accelerated during 1982–95, to 3.7 percent per year and 2.0 percent per year, respectively. In South Asia, growth in total utilization of poultry more than doubled between the two sub-periods, from 4.1 percent per year to 10.1 percent per year. Growth continued at a relatively high level for beef (3.3 percent per year, from 2.5 percent annually in the first sub-period) and decelerated slightly for pork, from 4.2 percent per year to 2.9 percent annually after 1982.

EVOLUTION OF CEREAL PRODUCTION: TRENDS, CHALLENGES, AND POLICIES

Growth in cereal production in developing Asian countries slowed for all major cereals, as shown in Table VI.3, from 3.6 percent annually during the first sub-period to 2.4 percent per year thereafter. Maize took over from wheat, exhibiting a growth rate during 1982–95 of 3.9 percent per year, but wheat still showed higher rates of growth in production (2.9 percent per year) than rice (2.0 percent per year), while production growth was negative for other grains in both sub-periods.

The contribution of area expansion to growth in cereal production in Asia declined dramatically during the latter sub-period. For the whole region, cereal area growth was virtually stagnant after 1982, dropping from an already slow rate of 0.4 percent per year during 1967–82. Only maize area showed significant expansion after 1982, at nearly one percent per year. Wheat and rice area continued to expand after 1982, but at much

Table VI.3: Annual Growth in Cereal Crop Area, Production, and Yield, by Region, 1967–1995

	1967–82			1982–95		
	Area	**Yield**	**Production**	**Area**	**Yield**	**Production**
	(percent per year)					
Wheat						
East Asia	0.93	5.46	6.45	0.17	2.90	3.07
Southeast Asia	-1.45	5.30	3.72	0.36	-2.60	-2.20
South Asia	3.22	4.12	7.40	0.93	2.52	3.57
Asia	1.30	4.07	5.43	0.15	2.70	2.85
Maize						
East Asia	1.00	4.01	5.05	1.39	3.02	4.47
Southeast Asia	1.45	2.57	4.06	0.34	3.17	3.53
South Asia	0.63	0.88	1.51	0.62	1.68	2.31
Asia	1.09	3.48	4.62	0.95	2.94	3.93
Paddy Rice						
East Asia	0.57	2.78	3.36	-0.65	1.70	1.05
Southeast Asia	0.80	3.07	3.89	1.05	1.65	2.71
South Asia	0.71	1.88	2.60	-0.05	2.92	2.81
Asia	0.70	2.54	3.25	0.13	1.91	2.03
Other grains						
East Asia	-4.44	3.14	-1.43	-4.10	2.23	-1.96
Southeast Asia	5.40	2.85	8.49	-1.02	-0.26	-1.41
South Asia	-0.84	1.92	1.07	-2.35	1.85	-0.55
Asia	-1.76	1.63	-0.15	-1.38	1.05	-0.35
All cereals						
East Asia	0.00	3.84	3.84	-0.20	2.56	2.36
Southeast Asia	0.94	2.97	3.94	0.90	1.90	2.82
South Asia	0.71	2.72	3.44	-0.33	2.94	2.58
Asia	0.42	3.13	3.57	0.02	2.42	2.43

Source of basic data: FAO FAOSTAT 1998.

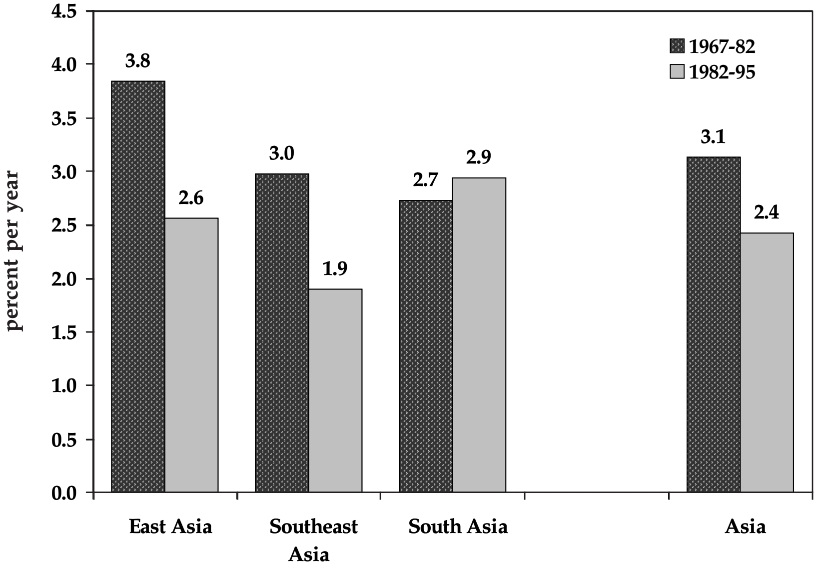
slower rates, and area planted to other grains (including barley, millet, oats, rye, and sorghum) declined sharply. Wheat area grew at only 0.2 percent per year during 1982–95, only about one tenth the rate of growth from 1967 to 1982, while rice area expansion was down from 0.7 percent per year to 0.1 percent. Area growth varied considerably across regions within Asia. East Asia (dominated by the PRC) and South Asia showed a decline in area planted to cereals after 1982, with declines in rice and coarse grain area offsetting the relatively large expansions in maize (East Asia) and wheat (South Asia). Cereal area continued to expand slowly in Southeast Asia, mainly due to growth in rice area.

The pattern of growth of cereal yields in Asia also shows a significant slowdown after 1982 (see also Figure VI.1). Wheat yield growth in Asia declined from 4.1 percent per year in the first sub-period to 2.7 percent in the second, on average, with wheat yield growth in East Asia slowing from 5.5 percent annually to 2.9 percent. Maize yield growth dropped from 3.5 percent annually in 1967–82 to 2.9 percent per year thereafter, on average. Annual yield growth recovered in South Asia, however, from 0.9 percent annually during 1967–82 to 1.7 percent during 1982–95. Rice yield growth exhibits a similar trend, with a drop in annual yield growth from 2.5 percent to 1.9 percent for the region as a whole. Declines in rice yield growth were substantial in most regions, but in South Asia, which was a relatively slow adopter of green-revolution rice technology, yield growth increased from 1.9 percent per year in 1967–82 to 2.9 percent annually in 1982–95. Rice yield growth in South Asia peaked in the late 1980s, at 3.3 percent annually, and slowed to 2.5 percent per year during 1989–95.

Challenges in Sustaining Cereal Production

The slowdown in cereal production growth in developing Asian countries since the early 1980s has been caused by declining world cereal prices and by factors related to the increasing intensification of cereal production. Green-revolution growth in

Figure VI.1: Annual growth in cereals yields, 1967–82 vs. 1982–95



cereal-crop productivity resulted from an increase in land productivity; it occurred in areas of growing land scarcity and/or areas with high land values as a result of good market infrastructure and was associated with strong policy support. High levels of investment in research and infrastructure development, especially irrigation infrastructures, resulted in the rapid intensification of the lowlands. Consequently, the irrigated and the high-rainfall lowland environments became the primary source of food supply for Asia's escalating population.

Between 1982 and 1995, however, real world wheat prices declined by 28 percent, rice prices by 42 percent, and corn prices by 43 percent. Declining cereal prices caused a direct shift of land out of cereals and into more profitable cropping alternatives and have slowed the growth in input use and therefore of yields.

Probably more important in the long run, declining world prices have also caused a slowdown in investment in crop research and irrigation infrastructure, with consequent effects on yield growth (Rosegrant and Pingali 1994; Rosegrant and Svendsen 1993). Environmental and resource constraints have also contributed significantly to the slowdown in yield growth. The use of high levels of inputs and the achievement of relatively high cereal yields, particularly for rice and wheat, have made it more difficult in parts of Asia to sustain the same rate of yield gains, as farmer yields in these regions approach the economic optimum yield levels. At the same time, increased intensity of land use has led to the necessity for increasing input requirements in order to sustain current yield gains.

Moreover, Pingali, Hossain, and Gerpacio (1997) argue that the practice of intensive rice monoculture itself contributes to the degradation of the paddy resource base and hence to declining productivities. Declining yield growth trends can be directly associated with the ecological consequences of intensive rice monoculture systems such as buildup of salinity and waterlogging, declining soil nutrient status, increased soil toxicities, and increased pest buildup, especially of soil pests. Many of these degradation problems are also observed in the irrigated lowlands where wheat is grown after rice in rotation (Hobbs and Morris 1996). The nature and magnitude of environmental degradation is described in more detail in Chapter X.

Intensification *per se* is not the root cause of lowland resource base degradation, however, but rather the policy environment that encourages monoculture systems and excessive or unbalanced input use. Trade policies, output price policies, and input subsidies have all contributed to the unsustainable use of the lowlands (for more detail on trade and macroeconomic policies, see Chapter VII). The dual goals of food self-sufficiency and sustainable resource management are often mutually incompatible. Policies designed for achieving food self-sufficiency tend to undervalue goods not traded internationally, especially land and labor resources. As a result, food self-sufficiency in countries with an exhausted land frontier came at a high ecological and environmental cost. Appropriate policy reform, both at the macro as well as at the sector level, will go a long way toward arresting and possibly reversing the current degradation trends, but the degree of degradation in many regions will pose severe challenges to policy (Pingali and Rosegrant 1998).

Policies for the Crop Sector

Ironically, the very policies that encouraged increased food supply through intensive monoculture systems also contributed to the declining sustainability of these systems. Rice policies operated under two presumptions: (i) lowlands are resilient to intensification pressures and sustain productivity growth indefinitely; and (ii) modern technology provides a "silver bullet" solution to food-supply problems of Asia. Traditional farming systems were sustainable because of lower intensities of cultivation and because they benefited from a stock of farmer technical knowledge about the crop and paddy resource base, built up over millenia. Neither science nor farmer knowledge was able to predict the changes imposed by intensification and modern technology use on the biophysical resource base. Learning from the experience of intensification-induced environmental degradation, however, can help to bring this degradation under control, halt it, or possibly even reverse it through appropriate policy and management reforms (Pingali and Rosegrant 1998).

With the progression toward global integration, the competitiveness of domestic cereal agriculture can only be maintained through dramatic reductions in the cost per unit of production. New technologies designed to reduce significantly the cost per unit of output produced, either through a shift in the yield frontier or through an increase in input efficiencies, would substantially enhance farm-level profitability of cereal-crop production systems. Increasing input use efficiency would also contribute significantly to the long-term sustainability of intensive food-crop production and help arrest many of the problems.

Water and Irrigation Policy

Water allocation and water pricing have significantly contributed to the environmental costs of irrigated agriculture. For all practical purposes water has been, and still is, free and is therefore used beyond the social optimum. Two major degradation problems in intensified areas—salinity build-up and waterlogging and excessive reliance on monoculture rice—are directly related to the virtually free provision of water to farmers. When water is provided at no cost, there is no incentive to economize, making rice, a water-intensive crop, artificially more profitable than crops that use less water. Increasing water-use efficiency through opportunity cost pricing or market valuation of water would produce substantial environmental benefits and would not adversely affect yields. Yet this leverage for improving the sustainability of the resource base has been used only in isolated cases in Asia.

Comprehensive reform of water demand management for both groundwater and surface water is essential for increasing the productivity of water in agriculture, by saving water in existing uses and by improving the quality of water and soils. The most significant reforms will involve changing the institutional and legal environment in which water is supplied and used to one that empowers water users to make their own decisions regarding use of the resource, while providing correct signals regarding the real scarcity value of water, including environmental externalities. The combination of reforms that is appropriate will vary, depending on the location, level of institutional and economic development, and degree of water scarcity. Key elements of these reforms should include the establishment of secure water rights of users; decentralization and privatization of water-management functions; and the use of incentives, including markets in tradable property rights, pricing reform and reduction in subsidies, and effluent or pollution charges (Rosegrant 1997).

Principles for groundwater management reform are similar: successful approaches in the western United States, for example, have employed a variety of instruments to influence water demand, including pumping quotas (usually based on some notion of historical use), pumping charges, and transferable rights to groundwater. The governance structure in the groundwater basin establishes water rights, monitoring processes, means for sanctioning violations, representative associations of water users, financing mechanisms for administration and management, and procedures for adapting to changing conditions. Key elements for the success of this governance structure in the U.S. also make it highly appropriate for developing Asia: it is agreed upon and managed by the water users; it is responsive to local conditions; it operates with available information and databases, rather than requiring theoretically better but unavailable information; and it adapts to the evolving environment (Blomquist 1992, 1995; Rosegrant 1997).

Fertilizer and Pesticide Policy

Government intervention in the cereal market, especially through output price support and input subsidies, provided farmers with incentives for increasing cereal productivity. In addition to highly subsidized irrigation water, Asian farmers benefited from "cheap" fertilizers, pesticides, and credit (see Monke and Pearson [1991] for an example of the Indonesian price policy). The net result was that rice monoculture systems and rice-wheat systems were generally profitable through the decades of the 1970s and the 1980s, despite a long-term decline in real world rice and wheat prices through this period.

Input subsidies that keep input prices low directly affect crop-management practices at the farm level; they reduce farmers' incentives to improve input use efficiency, which often require them to invest in learning about the technology and how best to use it. In addition to inducing increased use—in many regions of Asia considerably in excess of the socially optimal level—subsidized fertilizer prices have tended to favor the use of nitrogen fertilizers over other nutrients, creating soil-fertility imbalances. The reduction and eventual removal of fertilizer-price subsidies would significantly improve the incentives for efficiency of fertilizer use (see also Chapters V and VII for a discussion of costs of input subsidies). Nonprice policies are also important in improving fertilizer-use efficiencies, including location-specific research on soil-fertility constraints and agronomic practices, improvement in extension services, development of improved fertilizer supply and distribution systems, and development of physical and institutional infrastructure (Desai 1986; Desai 1988).

The policy scenario for pesticides is similar to that of fertilizers. Pesticide subsidies provided during the early stage of production-technology adoption have led to indiscriminate pesticide use, resulting in ecological problems including disruption of the pest-predator balance, increased pest resistance, increased pest losses, and human health problems (Pingali and Rosegrant 1998). The design of policies is often based on farmer and policymaker perceptions of pest-related yield losses anchored around exceptionally high losses during major infestations, even when the probability of such infestation is low (Rola and Pingali 1993). For various environmental and human health reasons (see Pingali and Roger [1995] for detailed evidence in Philippine rice ecosystems), Integrated Pest Management (IPM) programs have been vigorously pursued. IPM research results have been translated into usable thresholds, resistant varieties, pest surveillance programs, and identification and definition of the role and importance of natural enemies.

Unless they are spatially and temporally flexible, however, IPM recommendations may overstate the case for applying pesticides and cause increases in applications in cases where a natural control ("do-nothing") strategy would be more effective. IPM will be successful only if farmers participate fully in adapting and using this technology. To make it more attractive, pesticides should never be subsidized since, as in the case of fertilizers, farmers would have no incentive to invest time in acquiring IPM skills. Removing all explicit and implicit subsidies on pesticides is essential to reduce pesticide use on farms. Accelerated IPM program implementation requires local political support and commitment, as well as funds for research and technology dissemination (Pingali and Rosegrant 1998).

Price and Trade Policy and Sustainability

Trade and macroeconomic policies are discussed in detail in Chapter VII, but it must be noted here that the macroeconomic setting has also contributed to unsustainable agricultural management practices. Agricultural price and trade policies in many Asian countries have often been both internally inconsistent and costly for long-term diversified growth. On the one hand, general trade and exchange-rate policies have penalized agriculture across the board, while on the other hand, crop-specific interventions such as output price protection and input subsidies have attempted to favor individual crops, particularly rice and wheat. Continued reform of macroeconomic and price policies to create a level playing field across agricultural commodities would assist in balancing demands on the natural resource base.

Agricultural Research and Extension

Chapter V stressed the critical importance of continued public investment in agricultural research and extension in maintaining productivity growth. Because public resources are scarce, it is also essential that available resources be used more efficiently. Greater emphasis should be placed on raising the competence of scientists and the quality of research management and on providing adequate operating funds and technical support. Oram (1990) suggests that the division of responsibilities and working relationships between the international and national research centers needs to be reexamined with a view to increasing efficiency. He suggests that decentralization of research regionally, to the farmer-participants and based on agro-ecological characterization, may be the most effective approach, because it provides better farmer input and feedback to upstream researchers and policymakers. Improvement in linkages between public agricultural research and small research-based firms and informal farmer research could have high payoffs. Farm-based research often specializes in choosing varieties specific to micro-environments and can be highly complementary with the formal research systems (Lipton 1994).

The importance of effective extension may be even greater in the future, because of the increasing need for efficiency in input use as opposed to input and crop-variety promotion. Technologies to implement IPM and to improve the nutrient balance and the timing and placement of fertilizer applications are highly complex, knowledge-intensive, and location-specific. Because new technologies are more demanding for both the farmer and the extension agent, they require more information and skills for successful adoption compared to the initial adoption of modern varieties and fertilizers. In addition, these improved technologies do not give as clear gains in yield and income as the initial adoption of new technologies. The increase in income from these technologies is in fact highly sensitive to the farmer's skills and efficiency in utilizing them (Byerlee 1987). As a result of the greater complexity of new crop technologies, increased investment in extension, education, and human capital is likely to have high payoffs.

To provide the necessary information dissemination and training for these new technologies, extension services will have to be upgraded. The poor performance of many extension services can be attributed to inadequate training, inappropriate organization, and lack of incentives. Possible options for reform are privatization of extension services, the training and visit extension system, and decentralization of existing public systems. Privatization of extension through contracting to private companies can introduce incentives for higher efficiency. But for much of Asian agriculture, private extension may be difficult to manage and monitor and may not generate adequate profits for the private company, because of the large number of widely dispersed small farmers cultivating many different cropping systems. Privatization of extension is more likely to be successful when extension is linked to delivery of a specific technology, such as hybrid corn, to larger, more homogeneous groups of farmers.

Similar to the case for research systems, decentralization of existing extension services could also help farmers cope with the additional complexity of efficiency-enhancing technology. Thimm (1990) recommends integrated national planning of research and extension to ensure the appropriate budgetary mix for proper operation, regular interdisciplinary evaluation of on-farm benefits of recommended technology, and establishment of a goal-oriented organizational structure that encourages a bottom-up flow from farmers to extension and research. The latter, when combined with adaptive, location-specific research, can facilitate the transfer of complex technologies.

EVOLUTION OF LIVESTOCK PRODUCTION: TRENDS, CHALLENGES, AND POLICIES

The most striking development in the evolution of livestock production is the rapid expansion during 1982–95 in production of poultry in Asia overall (up 10.8 percent per year) and in all regional subgroups (with growth rates ranging from 7.2 percent per year in Southeast Asia to 12.7 percent annually in East Asia). This production growth was only surpassed by the phenomenal growth in beef production in East Asia, mainly the PRC, at 16.0 percent per year during 1982–95, albeit from a relatively low base. These trends in number of livestock slaughtered, carcass weight per animal slaughtered, and meat production are summarized in Table VI.4. Moreover, as has already been noted, production figures for the early 1990s in the PRC might be inflated. Asian production growth was also very rapid for pork (7.1 percent annually) and sheep and goat meat, both again driven by East Asia.

Indeed, production growth accelerated substantially for each of the livestock products between 1967–82 and 1982–95. Growth almost tripled for beef production, from 2.8 percent per year in 1967–82 to 7.7 percent annually in 1982–95; nearly doubled for poultry production, from 5.5 percent per year to 10.8 percent per year; and accelerated substantially for both pork and sheep/goat meat production (from 4.9 to 7.1 percent per year for pork, and 4.0 to 7.2 percent per year for sheep and goat meat).

Growth in production across all these livestock products was driven by growth in numbers, in contrast to developed-country livestock production growth, where growth in carcass weight per animal slaughtered plays a larger role. But the extent to which numbers growth dominated did vary somewhat by product for the region. Growth in numbers accounted for 93 percent of poultry production growth in Asia, on average, during 1967–82, and for 90 percent during 1982–95. For beef production, growth in numbers accounted for 81 percent of growth in the latter sub-period, with the effect particularly strong in East Asia (91 percent). Moreover, numbers growth accounted for 84 percent of sheep and goat meat production and 77 percent of pork production growth (again, from 1982–95).

Table VI.4: Annual growth in livestock number, production, and yield, by region, 1967–1995

	1967–82			1982–95		
	Number	**Yield**	**Production**	**Number**	**Yield**	**Production**
	(percent per year)					
Beef						
East Asia	3.82	0.79	4.65	14.60	1.18	15.98
Southeast Asia	1.80	0.15	1.95	2.86	0.38	3.25
South Asia	2.08	0.56	2.65	2.33	1.12	3.48
Asia	2.26	0.49	2.76	6.25	1.37	7.71
Pork						
East Asia	3.03	2.16	5.26	5.64	1.52	7.24
Southeast Asia	2.55	0.31	2.88	4.47	1.17	5.69
South Asia	4.14	0.02	4.16	2.89	0.03	2.92
Asia	3.01	1.88	4.94	5.46	1.52	7.06
Poultry						
East Asia	4.91	0.26	5.18	10.95	1.55	12.68
Southeast Asia	5.96	0.31	6.49	7.53	0.32	7.18
South Asia	4.03	0.02	4.08	9.37	0.71	10.14
Asia	5.18	1.88	5.54	9.71	1.01	10.83
Sheep and Goat						
East Asia	5.70	0.23	5.94	8.34	0.35	8.71
Southeast Asia	5.55	0.11	5.65	2.71	1.91	4.68
South Asia	2.75	0.02	2.77	2.87	1.28	4.19
Asia	3.87	0.16	4.04	6.04	1.12	7.22

Note: Number is the number of livestock slaughtered, and yield presents the carcass weight per animal slaughtered.

Source of basic data: FAO 1998

Challenges for Increasing Livestock Production

Rapid growth in demand for livestock will put great pressure on production systems in Asia. For the livestock sector in Asia to continue its growth, some major changes in the way livestock is produced—by whom, on what scale, with what technology, and with what quality guarantees for the broader market—will have to take place. The low productivity of traditional smallholder animal husbandry will no longer suffice. Greater industrialization will be required. Some examples of a path for doing so, such as the growth of a commercial sector for poultry production in Thailand and the PRC, do exist. What they indicate about the need to invest in such a commercial sector, to promote a steady transfer of technology for the sector from developed to developing countries, and to institute serious quality control so that production can reach broader markets, has implications for how production of other meats must change in the years ahead. Still, this path does hold greater risk for the environment. Policies to help overcome these challenges must take that threat into account.

Livestock production is influenced by interventions in both the livestock and the feed-crop sectors. The emphasis here will be on the former, since the challenges facing maintenance of cereal yields in the face of environmental degradation and the policy remedies to overcome those challenges, described above, apply to cereal production for the feed sector as well as the basic staple-food sectors.

Traditional Livestock Systems: Limits to Productivity

Of the three major production systems that characterize Asian livestock systems—land-based grazing systems, mixed farming, and industrial farming systems—the first two have historically dominated Asian livestock production. Livestock was traditionally raised using resources that have few alternative uses, such as household food waste or land that was not fertile enough for cropping.

Delgado et al. (1999), based on Carney (1998), summarize the reasons why land-based grazing systems and mixed farming are important to the livelihood of the rural poor in Asian developing countries. First, livestock products are an important source of cash income, particularly for the poorest people. Second, these animals are an important asset, for women in particular. Third, livestock manure and draft power is important for the preservation of soil fertility and the sustainable intensification of farming systems. In addition, livestock allows the rural poor to exploit common property resources, such as open grazing areas. Moreover, livestock products represent a source of income diversification, especially in semi-arid systems characterized by only one cropping season per year. Finally, traditional livestock production is often the only source of income for the most marginal of the rural poor, such as pastoralists, sharecroppers, or widows. Moreover, considerable evidence shows that the rural poor and landless earn a larger share of their income from livestock production than better-off rural people. Thus, livestock production is one of the few rapidly growing markets that the poorest rural people can join even if they lack substantial amounts of capital, land, and training.

At the same time, permanent or seasonal nutritional stress has put at risk production from these traditional systems involving ruminants in pastoral and low-input mixed farming systems. In most Asian countries, it has been possible until now to alleviate such seasonal feed shortages through techniques that rely on feed grains only to a minor degree: conserving and storing forage, treating crop residues, and adding mineral nutrients to feed. But these coping strategies are now falling short as increased specialization in production reduces access to traditional feeds. Scarcity of traditional feeds is just part of a list of woes that Asian smallholders must overcome to boost productivity of their livestock systems, such as high incidence of disease and lack of access to better breeds.

Partial improvement of the system may not have the desired effect. For example, replacing local cattle with improved varieties will not solve the productivity problem without greater feed resources on the farm (see the complimentary volume in this Rural Asia series by Mingsarn and Benjavan [1999]). Even with access to better stock, moreover, higher production often relies on new management practices and farmers typically have limited access to education and training. At the levels of productivity characteristic of the traditional system, much more land would have to come under animal husbandry to meet growth in demand, land that is increasingly not available for this purpose (for more on this, see Chapter X). In short, the pressure that rising demand is now placing on traditional, resource-constrained production systems is rendering these systems increasingly unsustainable and less competitive for the large numbers of Asian poor who rely on them for significant portions of their income (Mingsarn and Benjavan 1999). Thus, there is little doubt that most of the growth in future livestock production will come from industrial farming systems.

Rapid growth in the demand for livestock products does provide a substantial opportunity for small-scale, rural producers, however. On the one hand, the true economies of scale in livestock production may not always favor industrial production and large-scale producers, once explicit and implicit government subsidies to large-scale producers are accounted for. The phasing out of subsidies and enforcement of pollution and health requirements for large-scale producers or the redirection of subsidies towards small-scale producers could keep a market share open for the poor, with substantial poverty-alleviation benefits. But economies of scale in production facilitate vertical integration from production to the delivery and marketing of these highly perishable products. To overcome this barrier, policymakers need to promote producer cooperatives or other organizational structures to coordinate small producers with processors and distributors. Failure to provide this and other policies targeted carefully towards small-scale producers would not only be a major missed opportunity for the rural poor to share in the gains to be made in the "livestock revolution" in Asia. It could also drive the rural poor out of livestock production (Delgado et al. 1999).

Increasing Industrialization of Livestock Production

Industrial livestock production has seen very high rates of growth in the last decade. Driven by rapid industrial and urban growth, the periurban poultry and pig industries, in particular, expanded. This growth was in response to increased demand as well as to technical changes that resulted in a more favorable feed-conversion ratio with higher returns on investment for these species. This structural shift to more intensive production also reflects the pressure on land from growing populations—part of the trend that has rendered expansion of land-intensive animal husbandry more difficult. These industrial systems are also much more productive and can be competitive in the international marketplace as well, as the case of poultry in Thailand indicates.

There, a commercial sector in poultry evolved from a system previously comprising smallholder producers, starting in the 1970s. Production rose from around 36 million birds in the mid-1970s to more than nine times that, or approximately 338 million birds, by the end of the 1980s. Furthermore, technology was close to United States standards, as measured by market age, average market weight, feed conversion ratio, and mortality, while production costs were actually lower in Thailand (primarily due to differentials in labor costs) (Schwartz and Brooks 1990). The rise of the commercial sector, with ten large firms (vertically integrated) accounting for about 80 percent of production, has meant the decline in importance of independent growers. The low production costs helped attract outside investment to help develop the industry (joint ventures fueled by Japanese investment, which also helped open Japanese markets to Thai chicken exports) (Henry and Rothwell 1996).

Such industrialization is now beginning in the PRC, although most production still comes from traditional animal husbandry. Indeed, the PRC emerged in the 1990s as a competitor to Thailand in chicken, with industrialization spurred by low production costs following market liberalization. Here, too, foreign investment (including technology) played a role. The result has been staggering growth rates in production, over 10 percent per year from 1990 to 1995. Increasingly, then, the commercial sector will need to become the source of production growth for livestock products in developing Asia.

Need for Technology Transfer and Quality Control

These two examples allude to, without underlining the importance of, continued technology transfer if developing Asia is not to lag far behind productivity trends elsewhere. Genetic potential for poultry meat production has vastly improved and continues to do so, but only a handful of companies worldwide supply the genetic material. In fact, the Thai poultry industry relies on imported stock (parent or grandparent) from the developed world (principally the US and UK); the infusion of foreign investment in the PRC also involved improved stock (Henry and Rothwell 1996). At the same time, adequate quality control will be needed to make sure higher production meets quality standards required for export.

Challenges for the Environment

As with intensive crop agriculture, the intensification of livestock production poses potentially severe environmental challenges. Production of livestock generates waste by-products that under some conditions can be recycled but, when animal concentrations are high, can become a serious pollution problem. Livestock and feed production use large quantities of water, not only as a direct input but also for waste disposal. The high concentration of industrial livestock production has the potential to produce organic discharges that can exceed the carrying capacity of the surrounding environment. The intensive production of pigs in the PRC has caused animal waste pollution problems that now need close attention. Malaysia is also experiencing environmental problems arising from the pig sector. Under proper management, these impacts can be alleviated and the environmental costs internalized and charged to producers or consumers so that environmental impacts are mitigated without threatening production. For example, the

Ponggol Pigwaste Plant in Singapore recycles wastewater at the cost of about 8–9 percent of the production cost of pork (Steinfeld et al. 1997). In Malaysia, aerobic treatment increases the cost of production of pork by 6 percent (Mingsarn and Benjavan 1999).

Livestock is a contributor to greenhouse gas emissions and might threaten biodiversity by encroaching on land used by wildlife. Greenhouse gases from livestock are generated from respiration, manure management, and livestock-related activities that utilize fossil fuels. High-intensity animal production has become the biggest consumer of fossil energy in modern agriculture (IPPC 1995). Livestock production is also a source of risk to animal and human health. Risks arise not only from uncontrolled endemic diseases, but also from those that appear when animal concentrations are high or when unconventional feeds are used. Human health can be affected by zoonotic diseases emanating from livestock production facilities and by food contamination resulting from underdeveloped or overwhelmed food monitoring systems (Delgado et al. 1999). Moreover, there are potential negative human and animal health effects when discharges that may contain heavy metals, such as copper, zinc, and cadmium, are not properly discarded, especially under a high-concentration and nutrient-surplus system.

Policies for the Livestock Sector

The ongoing transformation in livestock production creates tremendous policy challenges. A dynamic commercial sector must provide the source of growth and an appropriate policy framework to accompany this transition—one that recognizes the need for continued livestock technology transfer and the likely role of joint ventures in guaranteeing it, plus the regulatory issues, especially pertaining to quality control. At the same time, investment in breeding and research, plus reinforcement of the infrastructure to facilitate the production increases that will be forthcoming, are needed if livestock is to fulfill its potential as a major contributor to overall rural growth and poverty alleviation strategies in Asia (Delgado et al. 1999; Mingsarn and Benjavan 1999).

In broad terms, policies for the livestock sector are similar to those presented for the crop sector and agricultural production, especially the abandonment of distortional policies in favor of a market-oriented framework. While intensification of production means less land needed for production of livestock, environmental sustainability and human health will only be guaranteed by policies that monitor and prevent damaging by-products of the industrialization of livestock production.

Facilitation of Technology Transfer

As the Thai and PRC examples in the poultry industry described above make evident, the industrialization of the livestock sector in Asia implies the need to import the advanced technology already developed and in development. As they also show, the unimpeded flow of technology is just one aspect of the globalization that will affect the sector: joint ventures and competition for export markets are others. In demand-driven production systems in developing countries, such as in East Asia and periurban India, adoption of intensification technologies patterned on those in developed countries will probably be rapid. Where the livestock sector is demand-driven, adoption can and will occur through market forces. In particular, technologies for increased production of pork, poultry and dairy products will be largely transferable from developed countries. Technology transfer will drive a trend (similar to that for the crop sector described above) toward knowledge-intensive systems; smart technologies, supported by astute policies, can help to meet future demands while maintaining the integrity of the natural resource base. Better information on which to base decision-making is, therefore, urgently required (Mingsarn and Benjavan 1999; Delgado et al. 1999).

Even with the direct import of technology, however, it will be necessary to develop policies that facilitate a market-oriented environment; key research issues will remain in the livestock policy area for production, processing and marketing. Moreover, issues relating to livestock and the environment cannot be solved with technical innovations alone, but will require an enabling environment in which effective technologies can be introduced. In addition, the quality of extension services and of the livestock producers in general is of particular importance. In the PRC, for example, productivity increased by 41 percent in animal production, but low educational levels of the producers and weak extension systems hinder increased technology adoption (Liu 1995).

Livestock Research

In addition to direct transfer of technology, the Asian livestock industry can be expected to benefit substantially from progress in biotechnology. Embryo technology could lead to the replacement of conventional breeding. This could lower the cost of importing individual animals and remove the challenges of their environmental adjustment. Biotechnology could also be used to identify genetically superior individuals for particular traits, like resistance to specific diseases. Specifically tailored vaccines could increase the effectiveness and reduce the risk of industrial livestock production. There is also considerable potential for increasing control over endemic diseases (Mingsarn and Benjavan 1999). Further livestock research in Asian developing countries should also focus on the development and adaptation of nonconventional feeds; improved storage, preservation, and processing technologies; improved breeding programs; and better disease controls (Devendra, Smalley, and Li Pun 1998).

Integration of Crop and Livestock Policies

Although technology will be adopted in demand-driven areas, in regions where demand is growing less quickly, such as in most of South Asia, technology uptake will be slower; important pockets of stagnant technology are likely to remain. In order to facilitate this transformation, livestock and feed (that is, crop-sector) policies that are closely related in these economies should be established in an integrated way with regard to achieving livestock objectives (Rae 1992). Historically, though, livestock-sector and crop-sector policies have often pursued diverging objectives in Asian developing countries, with negative effects on livestock production. In the Philippines, for example, while livestock has historically received high levels of protection through import tariffs, the price of corn and soybeans has simultaneously been greatly increased through tariffs and import quotas, the net result being a tax on the livestock sector (Dimaranan, Rosegrant, and Unnevehr 1996).

Livestock policies include subsidies for credit, breeding stock, and slaughter services. Moreover, in some Association of Southeast Asian Nations (ASEAN) countries, production units must be licensed and environmental regulation might constrain production activities. Tariffs have been levied on imported medicines, baby chicks, and feeds. And both tariffs and quantitative controls have been imposed on the importation of livestock products. Research and development policies focus on breeding improvements, extension and training programs, animal inspection, and vaccination and artificial insemination programs. Moreover, livestock production is affected by policies related to the investment or regulation of slaughterhouses (Rae 1992).

Rae (1992), citing a study by Kasryno et al. (1989), states that livestock policies in Indonesia have forced domestic prices below border values by 20 percent to 40 percent, at the same time that other policies raised the price of feeds by 20 percent to 75 percent above border values. Dairy products, however, receive government support that more than offsets the policy-induced increase in feed prices. In Malaysia, product-price supports in the dairy industry offset the slight distortions in the feed prices, and the effective protection rates in poultry and pig protection are close to zero, since the effects of product and feed policies basically offset each other. In Thailand, distortions in feed prices contribute little to effective protection rates. The Government controls the pork market via ownership of slaughterhouses and influences overall domestic processing and trading. Both beef and dairy production are protected through tariffs on imports of beef and quantitative import controls on dairy products, reducing the incentives for efficient production (Rae 1992).

Policies Protecting the Environment

Policies to maintain the nutrient balance in nutrient-deficit mixed farming in developing countries should focus on providing incentives and services for technology uptake to preserve and enhance crop-livestock integration. For nutrient-surplus industrial and mixed farming systems, a mixture of regulations to control animal densities and waste discharge and incentives for waste reduction is required, including the removal of subsidies on concentrate feed and on inputs used in the production of feed.

Policies to address environmental degradation in grazing areas of developing countries need to include elements of institutional development through local empowerment and property-rights instruments. Incentive policies may help to reduce grazing pressure in the semi-arid zones through, for example, the introduction of full cost recovery for water and animal health services or for grazing fees. Similarly, taxation of pasture and cropland in rainforest areas can discourage forest conversion.

CONCLUSIONS

Intensification of agricultural production, combined with wrong incentive structures from past or present policies, has caused substantial environmental degradation in the crop sector. With rapidly increasing demand for feed, pressure for livestock production could cause similar or even more severe environmental degradation. Policies that mitigate or even reverse negative environmental effects in the crop sector and help preempt larger problems in the livestock sector include the removal of trade, macroeconomic, and price distortions on input and output markets (see also Chapter VII), and the establishment of price incentives and regulations to reduce the production of environmental externalities in both sectors. Modernizing the aging livestock production systems in many Asian countries will require substantial investments to improve the feeding potential, ensure a suitable animal environment, and provide other modern production and processing technology. Moreover, the increasing importance of new, knowledge-intensive technology in both sectors requires a market-friendly environment for the adoption and adaptation of new technologies, the removal of restrictions on technology imports, and, in particular, a better and more decentralized research and extension system.