Limited Proceedings
2005 No. 11

Integrated Crop-Animal Systems in Southeast Asia: Current Status and Prospects

M.A. Sombilla and B. Hardy, Editors

IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

The International Rice Research Institute (IRRI) was established in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines. Today IRRI is one of 15 nonprofit international research centers supported by the Consultative Group on International Agricultural Research (CGIAR – www.cgiar.org).

IRRI receives support from several CGIAR members, including the World Bank, European Union, Asian Development Bank, International Fund for Agricultural Development, International Development Research Centre, Rockefeller Foundation, and agencies of the following governments: Australia, Belgium, Canada, People's Republic of China, Denmark, France, Germany, India, Islamic Republic of Iran, Japan, Republic of Korea, The Netherlands, Norway, Philippines, Spain, Sweden, Switzerland, Thailand, United Kingdom, United States, and Vietnam.

The responsibility for this publication rests with the International Rice Research Institute.

IRRI Limited Proceedings Series

The series allows IRRI scientists and partners to quickly share information with specialized institutions and individuals. It consists of proceedings from conferences, meetings, and workshops. To permit rapid publication, the review and editing may not be as rigorous as with formal proceedings.

Mailing address: DAPO Box 7777, Metro Manila, Philippines
Phone: +63 (2) 580-5600
Fax: +63 (2) 580-5699
Email: irri@cgiar.org
Home page: www.cgiar.org.irri
Rice Knowledge Bank: www.knowledgebank.irri.org
Courier address: Suite 1009, Pacific Bank Building
6776 Ayala Avenue, Makati City, Philippines
Tel. +63 (2) 891-1236, 891-1174, 891-1258, 891-1303

Suggested citation:
Sombilla MA, Hardy B, editors. 2005. Integrated crop-animal systems in Southeast Asia: current status and prospects. IRRI Limited Proceedings No. 11. Los Baños (Philippines): International Rice Research Institute. 191 p.

ISSN 1607-7776

Contents

Foreword

Integration of rice and livestock production is not new. What have changed over the years are the nature and roles of the crop and animal components and the complexity of their interactions. The relationship between rice production and the raising of carabao and a few other animals approximately 40 years ago was based purely on need for subsistence. This relationship has now evolved into more complex systems, as influenced by various socioeconomic, environmental, and political factors.

This book consists mainly of country monographs that describe the status and direction of development of integrated crop-animal systems in the five main rice-growing countries of Southeast Asia, Cambodia, Vietnam, Indonesia, the Philippines, and Thailand. It emphasizes the growing importance of crop-livestock integration as a path for agricultural intensification, especially among small producers on marginal farm lands.

The publication of these country studies is part of a larger project that provides a more detailed characterization of integrated crop-animal systems on rice farms in Southeast Asia. This project, "Sustainable Food-Feed Systems and Improved Livelihoods of the Poor in Rainfed Lowland Rice Areas," was funded by the CGIAR Systemwide Livestock Program (SLP) convened by the International Livestock Research Institute (ILRI). The project was spearheaded by the International Rice Research Institute (IRRI) under the leadership of Dr. Mercedita A. Sombilla. This project also involved the participation of ILRI and various national institutions in the project areas: the Cambodia Agriculture Research and Development Institute; the Mekong Delta Farming Systems Research and Development Institute, Can Tho University (CTU), South Vietnam, and Vietnam Agricultural Science Institute (VASI) in North Vietnam; the Philippine Rice Research Institute (PhilRice) and Central Luzon State University (CLSU) in the Philippines; the Central Research Institute for Animal Sciences (CRIAS) under the Indonesian Ministry of Agriculture in Indonesia; and the Department of Animal Science, which includes a Farming Systems Unit, in Khon Kaen University in Thailand.

This continued strong partnership with various international and national institutions has enabled the undertaking of other research projects that aim at improving the value of rice as feed for livestock and exploiting synergies and decreasing trade-offs between the need for soil nutrients and livestock feed in rice-based systems.

ROBERT S. ZEIGLER
Director General
IRRI

CARLOS SERÉ
Director General
ILRI

Section 1

Rice and animals in the livelihoods of rural economies in Asia

Mercedita A. Sombilla

In low-income societies in which people spend all their time in subsistence farming, an expanding agricultural sector is important for economic growth and rising income. The livestock sector has a big role to play in this development, especially in many parts of Asia, where rice and wheat production cannot be undertaken without livestock since the fragmentation of land virtually rules out the use of mechanization. For many years, mixed farming systems with a livestock component have been the overriding pattern of agriculture among subsistence and small farm households in the region. These still dominate the agricultural sector, especially among small rice farm households. Whether they continue to do so in the coming decades will depend on the interaction of various factors, such as population growth; rising income; the increasing scarcity of production resources, particularly land, labor, and water; the rate of technological progress; the changing political environment; and the move toward greater globalization.

Rice continues to be the main staple food in Asia, where demand will rise to 680 million tons in 2025. Cultivation of rice will continue in this region, where the scarcity of production resources is becoming a serious threat. At the same time, the region has exhibited a rapid increase in demand for meat, milk, eggs, and other livestock products because of the income growth that brought about changes in dietary patterns. These developments are a cause for concern, particularly with regard to the competing use of production resources and their impact on the poor rural households that are involved in both crops and livestock. Questions emerged on whether the mixed crop-animal systems in Asia will flourish or will be replaced by more specialized production schemes. An ongoing project on "Sustainable Food-Feed Systems and Improved Livelihoods of the Poor in Rainfed Lowland Areas: Socioeconomic Component" aims to shed light on this question by examining studies among rice farm households with animal holdings in five countries to investigate and understand the following:

- The characteristics of the changing role of animals in rice-farming households. Are changes apparent in the relative role of animals in rice-farming households? If yes, in what direction and to what extent?
- Household production decisions and resource allocation. Does animal raising compete with rice cultivation in the use of household resources? What factors influence the allocation of resources, particularly between rice cultivation and animal raising?
- What is the influence of technology development, government programs and policies, and market changes on the growth of rice-animal systems in the area?

This paper provides background to the study. The first section provides a brief overview of the relative importance of rice and livestock in the national economy of Asian countries and presents the emerging trends of demand and the prospects of meeting this demand. The second section gives a brief characterization of mixed crop-animal systems and highlights the important role of livestock among rice farm households. The third section discusses the future development of these systems.

Rice and livestock in the national economy of Asia

Rice occupies a position of overwhelming importance in Asian agriculture. As shown in Table 1, rice constitutes the bulk of the Asian diet. Effective per capita demand of rice ranges from a low of about 60 kg per year in Japan to 208 kg per year in Myanmar. For many of the people in the poorer countries, rice is the main source of energy that enables them to execute their daily chores. It accounts for about 50% of the annual per capita calorie intake in the region, reaching more than 70% in Bangladesh, Cambodia, and Myanmar (FAO database, 2003). Equally important is rice's role in providing livelihood to the Asian population. Rice farming is the single most important source of employment and income for the rural people. Rice-based production systems and their associated postharvest operations employ nearly 1 billion people in the rural areas of developing countries and about four-fifths of the world's rice is grown by small-scale farmers in low-income countries (FAO 2003). This explains the relatively large contribution of rice to agricultural production, particularly in the 1960s and '70s. In countries with per capita income of US$500 or less per

Table 1. Effective demand of various commodities (kg per capita per year) in selected Asian countries, 2000.

Country	Rice (milled)	Wheat	Maize	Roots and tubers	Vegetables	Fruits	Fish	Meat
China	90.1	77.7	18.3	17.4	203.5	61.0	37.6	50.1
Bangladesh	156.5	19.6	0.7	4.2	12.1	13.3	20.4	3.1
India	75.7	57.2	9.1	5.9	62.5	62.4	7.4	4.5
Indonesia	151.1	19.4	34.3	19.9	27.6	44.8	24.1	7.9
Japan	59.4	43.4	12.0	7.6	111.6	61.6	78.7	43.8
South Korea	89.1	53.1	18.9	4.1	232.2	91.5	52.8	46.1
Malaysia	90.5	33.9	4.1	6.4	28.0	69.3	77.8	51.1
Myanmar	207.9	3.8	4.8	1.5	63.6	42.9	30.2	9.3
Philippines	101.8	28.4	4.0	9.6	61.6	148.2	33.8	26.8
Thailand	109.1	10.2	6.4	4.9	37.1	120.4	36.5	24.3
Vietnam	170.3	8.2	6.9	10.3	74.9	73.4	33.6	24.3

Source: FAO (2003).

Table 2. Income elasticity of demand parameters.

Country	Wheat	Rice	Maize	Other coarse grains	Beef	Pork	Sheep/goats	Poultry	Eggs	Milk
India	0.20	0.19	–0.01	–0.03	0.63	0.58	0.58	0.96	0.55	0.58
Pakistan	0.03	0.18	–0.10	–0.10	0.60	0.22	0.38	0.91	0.40	0.35
Bangladesh	0.28	0.21	0.10	0.10	0.55	0.10	0.38	1.01	0.64	0.60
Indonesia	0.26	0.18	0.25	–0.18	0.80	0.72	0.38	0.90	0.55	0.65
Thailand	0.29	–0.02	–0.07	–0.10	0.77	0.75	0.26	0.73	0.40	0.54
Malaysia	0.30	0.06	–0.15	–0.10	0.85	0.55	0.28	0.45	0.31	0.38
Philippines	0.33	0.06	–0.15	–0.08	0.82	0.67	0.31	0.90	0.50	0.60
Vietnam	0.35	0.20	0.25	0.05	0.82	0.60	0.36	0.89	0.53	0.75
Myanmar	0.34	0.30	0.05	0.10	0.82	0.62	0.36	0.94	0.70	0.70
China	0.23	0.10	–0.27	–0.07	0.85	0.48	0.46	0.84	0.31	0.70
South Korea	0.22	–0.05	–0.20	–0.10	0.79	0.50	0.53	0.93	0.40	0.60
Japan	0.25	–0.05	–0.18	–0.10	0.33	0.43	0.13	0.63	0.18	0.20

Source: Parameters in IMPACT (Rosegrant et al 1995, 1997, 2001).

year, rice accounts for 20% to 33% of the gross domestic product (GDP) and 33% to 50% of the agricultural value added (Hossain and Fischer 1995).

The livestock sector has always been an integral component of the agricultural systems in Asia. It has therefore made a significant contribution to economic development. Recent estimates show that livestock contributes from 6% to 20% of agricultural GDP in Southeast Asia and from 10% to 25% in South Asia (Devendra et al 1997, 2000, various country statistical yearbooks). In China, the livestock sector accounts for about 30% of the agricultural GDP (Statistical reports, various years). If the value of animal traction, animal transport, and manure is added, the proportion of the total product contributed by livestock would be much higher. Additionally, animal skins, wool, oil, and other resources are used as inputs in other industries.

The average per capita consumption of meat and other animal products is relatively low (Table 1). The past decades, however, witnessed massive annual increases in the aggregate consumption of animal products, as will be further discussed in the next section. This significant growth in demand led many scientists and experts to predict the advent of a "livestock revolution" that would have profound implications, particularly for the resource base on which the sustainability of production systems depends (Delgado et al 1999).

Emerging trends in the demand for rice and animal food

Income growth, population increases, and changes in life style are key determinants of food demand. Economic theory says that, as per capita income increases, demand for staple foods tends to decrease while demand for high-value products, such as meat, eggs, milk, fruits, and vegetables, tends to increase. This relationship is indicated by the income elasticity of demand, which shows the percentage increase (if positive) or decrease (if negative) in the demand for food with one percentage increase in per capita income. The income elasticity of demand for rice, other staple foods, and meat products in some Asian countries is shown in Table 2. It can be noted from this table that, in the more developed countries, such as Japan and South Korea, the respective income elasticity for rice is negative. This indicates that, as per capita income in these countries rises, further per capita

Table 3. Growth rate (%) in demand for rice and animal products, 1967 to 2000.

Country	Rice	Meat	Eggs	Milk
Bangladesh	2.60	1.95	3.53	3.16
India	2.80	3.06	6.19	4.39
Cambodia	2.20	4.40	2.49	0.45
Indonesia	3.80	5.61	8.56	4.18
Laos	2.00	3.50	5.35	5.43
Malaysia	1.00	7.01	5.51	4.40
Myanmar	3.40	2.38	4.03	3.98
Philippines	2.90	3.93	4.68	2.98
Thailand	0.70	3.53	2.82	5.81
Vietnam	2.70	4.96	3.47	2.06
China	2.40	7.11	8.67	6.49
Japan	–0.80	3.93	1.69	2.26
South Korea	0.40	9.06	5.09	9.3

Source: Estimated using data from FAO.

demand for rice falls. Rapid economic growth in Thailand also influenced the gradual decline in per capita rice demand in recent years and, hence, the country's negative income elasticity. Income elasticity in other countries, particularly that in the low-income group, is still positive but small. As experienced in other countries, these numbers will also gradually diminish as poorer countries continue to prosper and per capita incomes rise. These small numbers account for the much slower growth of demand for rice as shown in Table 3. Population growth has likewise been much slower in many countries in recent years. This additionally explains the slower rates of increase in rice demand.

The picture is different for products of animal origin. The income elasticity is positive and shows relatively large numbers (Table 2). These numbers imply that demand for animal products is expected to further increase in the region with continued economic growth. Increases in demand for these products have been rapid in the past (Table 3). Population growth, changing lifestyle, and other factors are bound to further boost the demand for animal products. Per capita consumption of meat increased more than twofold from 11 kg per year in 1979 to 26 kg in 2000. This huge leap comes primarily from China, where per capita meat consumption rose from 13 kg per year in 1979 to 50 kg in 2000 (Table 4). This is mostly pig meat, thereby keeping China as the biggest consumer of pig meat, with its share ranging from 40% to 45% of total world consumption. Many countries in Southeast Asia (e.g., Malaysia, Cambodia, Laos, Vietnam, Philippines) similarly exhibited a significant per capita increase in meat consumption. In East Asia, Japan's per capita consumption increased from 30 kg per year in 1979 to 44 kg in 2000 and South Korea's leaped from 7 to 46 kg. Growth in per capita meat consumption in South Asia remains almost stagnant. But milk consumption rose in an unprecedented manner, especially in India, where per capita milk consumption increased from 38 kg per year in 1979 to 55 kg in 2000, and in Pakistan it increased from 92 to 150 kg. Even in Bangladesh, where per capita consumption of meat has remained constant over the last two decades, the share of meat in total per capita calorie intake increased as other food intake decreased. Despite this rapid growth, the average per capita consumption in the region remains much lower than the average per capita consumption in the developed world.

Demand projections and implications for production

Baseline projection results show that an additional 104 million metric tons of milled rice (or about 174 million tons of rough rice) will be needed in Asia to meet the projected demand of about 442 million tons, or 734 million tons of rough rice, in 2025 (Fig. 1). About 30% of the projected total demand increase, or about 53 million tons of rough

Table 4. Average per capita consumption (kg per year) in selected Asian countries, 1979 and 2000.

Country	Meat		Milk		Eggs	
	1979	2000	1979	2000	1979	2000
Bangladesh	3.6	3.1	13.5	13.5	0.8	1.0
India	3.6	4.5	38.1	66.0	0.7	1.5
Pakistan	8.6	12.4	92.0	149.8	0.9	2.0
Cambodia	3.8	15.3	10.3	3.9	1.0	1.0
Indonesia	4.4	7.9	5.5	7.6	0.9	2.7
Laos	8.0	15.1	4.8	3.2	0.9	1.7
Malaysia	21.4	51.1	41.2	52.7	9.1	14.4
Myanmar	7.2	9.3	10.5	14.6	0.8	1.5
Philippines	15.8	26.8	22.6	22.6	4.9	6.2
Thailand	20.0	24.3	9.4	21.1	6.7	9.9
Vietnam	9.1	24.3	4.0	4.6	0.9	2.3
China	13.4	50.1	3.0	9.7	2.5	16.1
Japan	30.0	43.8	55.1	67.8	16.5	19.3
South Korea	14.4	46.1	9.4	27.3	6.0	9.5

Source: FAO (2003).

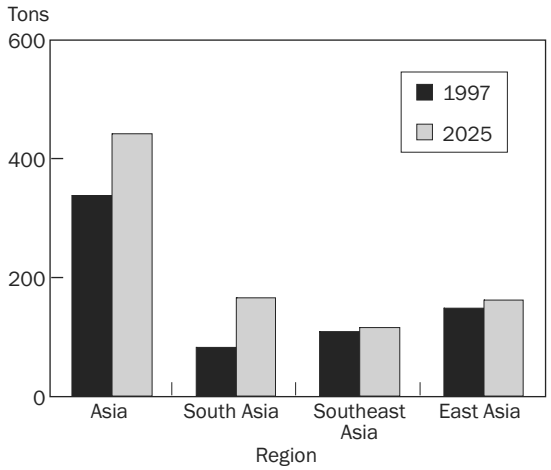


Fig. 1. Projected demand of milled rice in Asia, 1997 and 2025. Source: Rosegrant et al (1995), Sombilla et al (2001).

rice will be accounted for by Southeast Asia, a large percentage of which will be channeled to urban areas where population growth will be rapid. South Asia will need about 95 million tons more to support the demand of its growing population. Rice production in the region has to sustain an average growth rate of at least 1% per year to meet the projected demand for rice in 2025. The annual growth rate in rice production from 1990 to 2000 was estimated at 1.6% (Table 5). This was mainly from growth in yield, which has declined significantly from the 1.8% average growth rate in 1967-80 and the 2.3% average growth rate in 1980-90. The contribution of area growth to total production is shown to have increased in the last decade, but maintaining that level of contribution will be difficult in the region because land is very scarce. Countries such as Myanmar, Cambodia, and Laos have potential for area growth, but much of this will depend on the favorable development of the market policy environment. The 1% annual growth in rice production in the future will most likely come from yield increases; thus, the continued critical role of technology development.

Meat consumption in Asia is projected to increase by more than twofold from 77.2 million tons in 1997 to 164.4 million tons in 2025, whereas milk consumption will rise from 128.6 million tons to 284.8 million tons (Fig. 1). The bulk of this demand will come from China, where the growth rate of meat demand is projected to be around 2.8%, with 3.3% for milk. South Asia's meat consumption is still projected to be low, primarily because of the assumption that this region will continue to be vegetarian. Its milk consumption, however, is expected to almost triple in the next 20 to 25 years. It is in Southeast Asia where the most rapid growth in meat demand will take place, at 3.1% per year, thereby raising the projected total consumption of meat in the subregion from 8.9 million tons in 1997 to 20.9 million tons in 2025.

The past growth performance of different livestock products from 1979 to 2000 is shown in Table 6. The average

Table 5. Trends (in %) in rice production growth in Asia.

Country	1967-80			1981-90			1990-2000		
	Area	Yield	Production	Area	Yield	Production	Area	Yield	Production
Cambodia	–7.55	–3.19	–10.74	2.12	2.64	4.76	1.63	4.42	6.04
Indonesia	1.05	3.54	4.60	1.61	2.29	3.90	1.21	“0.01	1.20
Laos	–1.43	1.48	0.05	–2.65	5.01	2.36	1.45	2.86	4.30
Malaysia	0.49	2.17	2.67	–0.51	–0.72	–1.23	0.11	0.40	0.51
Myanmar	0.15	3.10	3.24	–0.18	–0.03	–0.20	2.35	1.16	3.51
Philippines	0.94	3.25	4.18	0.11	2.28	2.39	1.76	0.09	1.85
Thailand	2.64	-0.06	2.58	0.24	0.73	0.96	1.52	1.23	2.75
Vietnam	1.28	0.52	1.79	0.49	3.86	4.35	2.34	3.03	5.37
Southeast Asia	0.87	2.08	2.95	0.60	2.02	2.62	1.69	1.08	2.76
Bangladesh	0.31	1.32	1.63	0.11	2.42	2.53	0.35	2.19	2.54
Bhutan	2.06	0.00	2.06	–0.45	-2.58	–3.03	1.88	0.13	2.02
India	0.75	1.41	2.16	0.53	3.18	3.71	0.59	1.38	1.98
Nepal	0.84	-0.28	0.56	1.42	2.81	4.23	1.19	1.22	2.41
Pakistan	2.64	1.91	4.55	0.72	–0.96	–0.24	1.79	2.98	4.77
Sri Lanka	2.89	0.21	3.10	–0.75	1.42	0.67	0.20	0.73	0.94
South Asia	0.76	1.37	2.13	0.46	2.83	3.29	0.61	1.57	2.17
China	1.01	2.20	3.21	–0.40	2.64	2.25	–0.55	1.27	0.73
Japan	–2.09	0.22	–1.87	–1.21	1.52	0.30	–1.91	1.15	–0.76
North Korea	2.47	0.71	3.18	0.12	2.11	2.23	–0.93	“9.15	–10.08
South Korea	0.25	3.16	3.42	0.35	2.12	2.48	–1.59	1.22	–0.37
East Asia	0.77	1.88	2.65	–0.41	2.53	2.12	–0.66	1.12	0.46
Asia	0.79	1.77	2.56	0.25	2.33	2.58	0.59	1.01	1.60

Source: Estimated using FAO data.

Table 6. Growth rate (%) in production of meat and other animal products, 1971 to 2000.

Country	1971-85						1986-2000						1971-2000					
	Total meat	Beef	Pig	Poultry	Eggs	Milk	Total meat	Beef	Pig	Poultry	Eggs	Milk	Total meat	Beef	Pig	Poultry	Eggs	Milk
Asia (20)	5.3	3.1	6.1	5.8	4.7	4.3	6.3	6.1	5.5	9.0	8.0	4.7	6.1	4.7	6.2	7.4	6.8	4.6
South Asia																		
Bangladesh	–0.1	–1.0	–	1.4	1.7	0.9	3.7	1.8	–	4.5	7.2	3.5	2.2	0.5	–	3.3	3.6	2.4
India	3.1	3.0	–	4.9	6.4	4.9	2.9	2.5	–	8.2	4.6	4.2	3.3	3.0	–	8.1	6.0	4.6
Pakistan	4.8	3.1	–	14.5	15.6	2.3	3.6	3.5	–	7.9	4.6	7.9	5.1	4.4	–	12.1	8.9	5.1
Others	3.3	3.9	3.1	1.7	3.3	2.4	3.3	3.9	3.1	1.7	3.3	2.4	3.0	2.8	3.7	4.9	3.4	1.9
Southeast Asia																		
Indonesia	5.5	1.7	6.4	11.0	12.2	5.9	3.5	2.9	1.6	6.1	4.0	3.6	5.7	2.1	6.4	9.6	8.2	6.0
Malaysia	6.3	0.6	5.6	7.7	5.6	0.7	7.0	3.7	3.7	8.6	5.4	2.6	7.2	1.2	4.8	9.2	6.2	1.4
Philippines	2.9	–2.1	2.5	6.5	5.0	1.2	6.1	6.4	5.2	8.4	6.0	–8.7	4.2	2.1	4.3	5.4	4.2	–4.5
Thailand	4.2	2.3	4.6	5.5	2.2	16.3	4.2	–1.6	3.9	6.4	3.5	13.8	4.2	0.5	4.0	6.3	3.4	16.8
Vietnam	5.2	3.4	5.7	5.2	1.4	5.7	5.4	1.5	6.0	6.0	6.0	1.8	5.7	3.1	6.5	5.0	4.6	3.6
Others	2.8	1.8	2.0	4.8	4.5	8.5	2.7	2.6	2.4	3.1	2.7	–0.1	2.7	2.5	2.5	3.2	2.1	3.9
East Asia																		
Japan	4.7	5.1	4.2	6.4	1.4	3.5	–1.5	–0.4	–2.0	–1.4	0.7	1.0	1.6	2.5	1.1	2.3	1.5	2.2
China	6.2	5.4	6.4	5.0	6.1	5.9	7.8	15.8	6.0	12.9	10.9	5.6	7.5	12.4	6.8	9.2	9.5	6.8
South Korea	10.8	8.5	13.6	7.2	6.2	19.3	6.7	6.0	7.8	5.5	2.5	3.5	8.4	6.9	9.1	8.7	4.5	12.1
Others	5.0	3.7	5.5	4.0	5.8	11.1	–5.5	–5.8	–5.8	–6.6	–4.0	0.1	0.4	-0.1	0.4	–0.1	1.4	5.3

Source: FAO (2003).

annual growth rates of meat, milk, and egg production in Asia were estimated at 6.2%, 4.1%, and 6.9%, respectively. Meat production from ruminants such as cattle, buffalo, sheep, and goats registered growth rates that slowed down slightly over the years. It is production in nonruminants such as pigs, chickens, and ducks that exhibited tremendous growth as a result of the significant transition in production systems from smallholder/backyard to large commercial-scale, particularly in the wealthier developing countries. The relatively high growth rates in meat production in Indonesia, Malaysia, Philippines, Thailand, Vietnam, South Korea, and China came from the establishment of commercial swine and poultry industries. This same structural change in production system also explains the rapid increase in egg production from the 1980s, when the growth rate was above 7.0% per year. Growth in milk production has also been substantial, ranging from a slightly negative growth rate in the Philippines to huge average growth rates of about 18% per annum in Thailand. High growth rates have been maintained in the two largest milk-producing countries in Asia, India and Pakistan, where the average rate was about 4.7% per annum from 1971 to 2000. Growth rates in other countries such as Thailand, Indonesia, and South Korea were stunning, but their respective volume of production was still small.

The maintenance of these growth rates in meat and other animal products could indeed ensure a sufficient supply to meet the region's future demand for these particular food items. As with crops, sustaining such growth rates will require concerted efforts not only from research institutions but also from all other sectors, including the government. Moreover, growth in the animal sector should proceed judiciously to ensure that poor rural households are not driven out of the development process. The current rapid intensification of animal production provides opportunities for increasing income and comes at a time when small farm households desperately need additional income returns to their shrinking land to supplement income from field crops, particularly rice.

Mixed crop-animal production systems in Asia

Ninety percent of rice production and at least 50% of the meat produced in the world comes from mixed crop-animal production systems (FAO 1995). These areas will most likely continue to be the major supplier of these commodities in the years to come.

The recently completed project conducted by ILRI with funding support from DFID identified nine crop-animal production systems based on land resource use and animal holdings (Thornton et al 2002).[1] Table 7 provides a brief description of these production systems and Figure 2 shows their share in terms of land area in each region. In Asia, particularly in South and Southeast Asia, the dominant pro-

[1]Two additional production systems that cover the landless monogastrics (e.g., pig production in Asia) and ruminant systems (e.g., landless sheep production in WANA) are not shown in the figure. These systems are currently estimated to cover 40% of the total land area, or about 32.6 million km^2.

Table 7. Crop-livestock production systems.

Type	Characteristics	Crop-animal interactions
Grassland-based (LG)		
In temperate and tropical highlands (LGT)	Main resource is the range lands, pastures, and forages. Less than 10 livestock units (LUs)[a]	Very low to low, increasing in areas where crop cultivation is possible
In humid/subhumid subtropics (LGH)		
In arid/semiarid tropics and subtropics (LGA)		
Mixed farming systems (M)	Relatively low land to cattle head ratio. Crop production mostly in rainfed areas.	
Mixed rainfed temperate/tropical highlands (MRT)	More than 10% of dry matter fed to animals comes from crop by-products and stubbles.	
Mixed rainfed humid/subhumid tropics/subtropics (MRH)		
Mixed rainfed arid/semiarid tropics/subtropics (LGA)		
Mixed irrigated temperate/tropical highlands (MIT)	Crop production mainly on irrigated lands. More than 10% of dry matter fed to animals comes from crop by-products and stubbles.	Varies, generally weak to high dependency on intensity of crop cultivation and integration with market.
Mixed irrigated humid/subhumid tropics and subtropics (MIH)		
Mixed irrigated arid/semiarid subtropics (MIA)		

[a]A measure that brings together the distribution of cattle, buffalo, sheep, goats, horses, donkeys, mules, and pigs, using special values of Jahnke (1982).
Source: Thornton et al (2002).

duction systems are those involving mixed crop-animal systems on rainfed and irrigated farms. Most of these farms are predominantly rice-based, with subsidiary food crops such as maize, root crops, pulses, vegetables, etc. (Table 8). In East Asia, a significant portion of the production system is based on grassland and is mostly accounted for by China, where, in the northeast of the country, the communal grazing area of Chinese Merino wool sheep abounds, and, in the southeast, significant cattle raising is found.

The mixed rainfed and irrigated systems are predominantly followed by smallholder farms, where production is highly integrated and diversified and where outputs are partly for sale and partly for own consumption, whereas inputs are partly purchased and partly provided from own resources. It is a long-time tradition that farm animals are used for production and draft power. These include cattle and buffalo, dairy cows, pigs, poultry, goats, and sheep. They are fed by-products and crop residues from the farm and food refuse from the household. They are common sources of protein (meat, eggs, and milk) for farming households. The bigger ruminants are used for power in farm activities. It is estimated that 250 million working animals provide draft power for mixed farms that cover about 28% of the world's arable land (FAO 1995).[2] They are likely to continue to be used as draft animals for some time to come in South Asia (Pingali et al 1987). In East and Southeast Asia, where mechanization is occurring rapidly, animals are now grown more for their food value. The rapid rate of mechanization has made possible the shift from large and small ruminants to animals such as pigs and chickens.

Figure 3 further indicates that it is also in these systems where most of the poor people live. Out of the 6.1 billion people in the world, about 4.7 billion are supported by these production systems, including the landless category that does crop farming and animal raising on rented land or in public areas (Fig. 4). And out of these 4.7 billion people,

[2]The poverty mapping project estimates that mixed cropping systems occupy 30% of global land area (Thornton et al 2002).

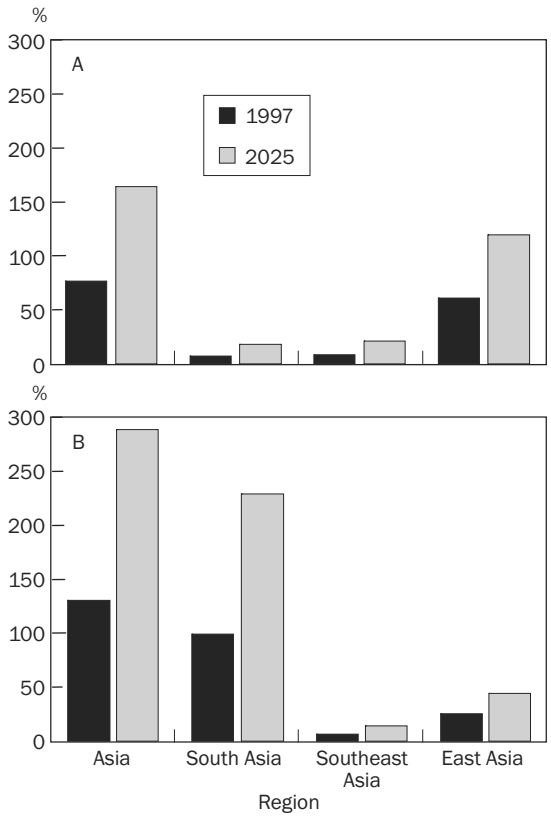


Fig. 2. Projected increase in demand for meat (A) and milk (B), 1997 and 2025. Source: Rosegrant et al (1995), Sombilla et al (2001).

26%, or 1.2 billion, are categorized as poor who live on less than US$1 a day.[3] Seventy-one percent, or about 885 million, of these people are located in the Asian region, most of them in mixed irrigated and rainfed production systems. Mixed crop-animal farming enables poor rural households to maximize the use of their limited resources to increase their income, minimize their production risks, increase their food security, and improve the sustainability of farm enterprises.

Rice cultivation

The importance of rice among rural households pertains to its being the major staple food and to its role as the major source of livelihood. Several in-depth village studies conducted by the International Rice Research Institute in collaboration with policy research institutions in national systems (country studies in David and Otsuka 1993) found that farm household income is at an average level of about $1,000 year^{-1}, of which 36–57% comes from rice cultivation (Table 9). Working on others' rice farms is the main source of employment and livelihood for the landless and marginal farmers that constitute one-third to one-half of rural households.

Rice farm holdings are small and fragmented. The average farm in most countries has no more than 1.5 ha. This area is usually subdivided further into smaller parcels. Farms specializing in a single crop are rare. A typical farm household grows rice along with many other subsistence crops in rice-based farming systems. And, as mentioned earlier, animal raising is almost always a major component of this farming system. Most of the rice produced is consumed by household members. A marketable surplus usually occurs only on irrigated farms of 2 ha or more, where at least two rice crops can be grown (Hossain 1998). Rice farms in upland and rainfed lowland areas are mostly subsistence-oriented.

Livestock and the poor

Livestock are valuable among poor households primarily because they are a quick source of easy cash income, especially for those with limited access to land and capital. Table 10 shows some estimates of household income coming from livestock for households belonging to different income strata, farm holdings, and dietary adequacy. In Pakistan in the mid-1980s, Adams and He (1995) found that about 25% of the poorest rural households' income was derived from livestock compared with only 9% among the richer income group. A similar picture appears in a case study conducted in the Philippines by Bouis (1991) for about the same time period.

Foods that are derived from animal sources have major importance in optimizing human performance in chronically mildly to moderately malnourished populations (Diaz-Briquiets et al 1992). Protein and micronutrient deficiencies remain widespread in developing countries because people subsist on diets that are almost entirely made up of starchy staples. The addition of milk and meat provides protein, calcium, vitamins, and other nutrients that would make a starchy meal more balanced. This explains the apparent importance of livestock among households with a greater incidence of malnourishment compared with households that are well nourished (Table 10).

Small animals that graze on common-property pastures or are fed household waste are an important activity for women. This is also a crucial activity as income earned by women is usually channeled into the family's basic maintenance and nutrition. In India, dairy work is traditionally a women's domain (Rangnekar 1992) as swine raising is in the Philippines and Thailand. Animals provide the micronutrient diversity needed primarily for child health and development.

Livestock income helps decrease inequality

Too little attention has been given to livestock as a means of improving rural equity and overcoming poverty. Rural income collected from sample households in Indonesia and the Philippines is analyzed to determine the contribution of

[3]There are several poverty indicators, but this is the widely cited indicator, hence its adoption here. The data indicate the number of people who cannot purchase a roughly similar basket of commodities.

Table 8. Important crops and cropping patterns in farming systems in Asia.

Country	Important crops	Cropping patterns	Dominant ruminant	Nonruminant	Sources
Cambodia	Rice, maize, roots/tubers, pulses, oilseeds, tobacco, sugarcane, jute	Rice monocrop (lowlands) Rice monocrop (uplands) Rice fallow (uplands) Rice-mungbean or soybean (uplands)	Cattle	Pigs, chickens	ADB (1989) Nesbitt (personal communication)
Indonesia	Rice, maize, cassava, sweet potato, soybean, peanut	Rice/maize intercrop (Java, Sumatera, Sulawesi). Rice/soybean relay crop (Java, lowlands) Rice-fallow-rice (uplands in shifting cultivation) Maize-peanuts/soybean-maize (Madura, lowlands) Cassava/maize/rice/peanut intercrop (Java, Kalimantan, Sumatera in shifting cultivation) (uplands)	Cattle, buffalo, sheep, goats	Chickens, pigs	Imtiaz et al (1978) FAO (1982) ADB (1989) Anwarhan (1995) Devendra (1995)
Laos	Rice, maize, root crops, oilseeds, pulses	Rice-fallow-rice (lowlands; uplands in shifting cultivation) Rice-maize/cassava/sweet potato-rice (uplands in shifting cultivation) Teak/rice intercrop (uplands) Rice/maize intercrop (uplands) Rice monocrop (lowlands)	Cattle, buffalo	Pigs, chickens	ADB (1989) Bouahom (1995) Devendra (1995) Roder et al (1995)
Malaysia	Rice, maize, cassava, peanut, rubber, oil palm, cacao, coffee, pepper, tobacco	Rice monocrop (uplands and lowlands) Oil palm/rubber monocrops (lowlands)	Cattle, buffalo, goats, sheep	Chickens, pigs	FAO (1982) ADB (1989)
Myanmar	Rice, maize, oilseeds, pulses, cotton, vegetables, jute	Rice monocrop (lowlands) Rice-peanut/soybean/sorghum (uplands) Sesame-rice (lowlands) Rice-peanut/mungbean/chili (lowlands) Maize/pea/bean/peanut intercrop Rice-fallow (uplands)	Cattle, buffalo	Pigs, chickens FAO (1982) ADB (1989)	Shim et al (1981)
Philippines	Rice, maize, cassava, pulses, oilseeds, coconut	Rice-fallow-rice Rice-maize-rice (lowlands) Rice-maize/cassava-rice Rice-mungbean-forage legumes-rice (uplands) Maize monocrop (uplands) Maize/leucaena intercrop Coconut monocrop Fruit tree monocrop Rice-maize (uplands) Rice-maize (lowlands) Sugarcane monocrop (lowlands) Coconut/coffee/pineapple (lowlands) Potato/cabbage/rice/legumes, intercrop (uplands)	Buffalo, cattle	Pigs, chickens	Gomez (1980) FAO (1982) ADB (1989) Faylon and Alo (1995) Devendra (1995)

continued on next page...

Table 8 continued.

Country	Important crops	Cropping patterns	Dominant ruminant	Nonruminant	Sources
Thailand	Rice, maize, sorghum, cassava, mungbean, soybean, peanut, kenaf, cotton, sugarcane	Rice monocrop (northeast uplands and lowlands) Rice-fallow-rice (lowlands) Rice-maize/vegetables-rice (uplands) Mungbean-rice-mungbean Maize-mungbean/soybean-maize (central plains) (lowlands) Cassava monocrop (lowlands) Kenaf monocrop (uplands)	Buffalo, cattle	Pigs, chickens	Patanothai and Charoenwatana (1978) FAO (1982) ADB (1989) Devendra (1995)
Vietnam	Rice, maize, roots/tubers, pulses, oilseeds, sugarcane, jute	Rice-fallow-rice (lowlands) Rice cassava/maize/soybean/sugarcane-rice Rice-peanut (lowlands) Rice-fallow (uplands) Rice monocrop (uplands)	Cattle, buffalo	Pigs, chickens	ADB (1989) Xuan et al (1995)
Bangladesh	Rice, wheat, pulses, oilseeds, jute, sugarcane	*Rainfed:* Rice-wheat Rice-rice-barley + chickpea Upland rice-barley Upland rice-barley + chickpea + linseed *Irrigated:* Rice-rice Rice-rice-wheat Jute-mustard Sugarcane-wheat	Cattle	Chickens ADB (1989) Anon (1995) Reynolds et al (1995)	Hoque (1984)
India	Rice, wheat, sorghum, maize, pearl millet, pulses, oilseeds, cotton, sugarcane	*Rainfed:* Rice-wheat Rice-chickpea Rice-lentil Rice-mustard *Irrigated:* Rice-wheat Sugarcane Rice-rapeseed/mustard	Cattle, buffalo, sheep, goats	Low population	Hoque (1984) ADB (1989) Anon (1995) Reynolds et al (1995)

continued on next page...

Table 8 continued.

Country	Important crops	Cropping patterns	Dominant ruminant	Nonruminant	Sources
Nepal	Rice, maize, wheat, finger millet, oilseeds, potato	*Rainfed:* Rice-wheat Rice-finger millet Rice-wheat-fallow Maize/finger millet-wheat *Irrigated:* Rice-rice Rice-potato Rice-rice-wheat Maize-rice-wheat	Cattle, buffalo, sheep, goats	Chickens	Hoque (1984) ADB (1989) Anon (1995) Reynolds et al (1995)
Pakistan	Wheat, rice, maize, sorghum, millet, barley, chickpea, rapeseed, cotton, sugarcane	*Rainfed:* Rice-potato Sorghum-wheat + mustard Groundnut-wheat Maize + beans + potato *Irrigated:* Rice-wheat Maize-wheat Cotton-wheat Rice-chickpea	Sheep, goats	Chickens	Hoque (1984) ADB (1989) Anon (1995) Reynolds et al (1995)
Sri Lanka	Rice, maize, pulses, oilseeds, cassava, chilli	*Rainfed:* Rice-onions Rice-rice Maize-onions Rice-potato *Irrigated:* Rice-rice	Cattle, buffalo	Chickens	Hoque (1984) ADB (1989) Anon (1995) Reynolds et al (1995)

Source: Table 6 in Devendra et al (1997 and 2000).

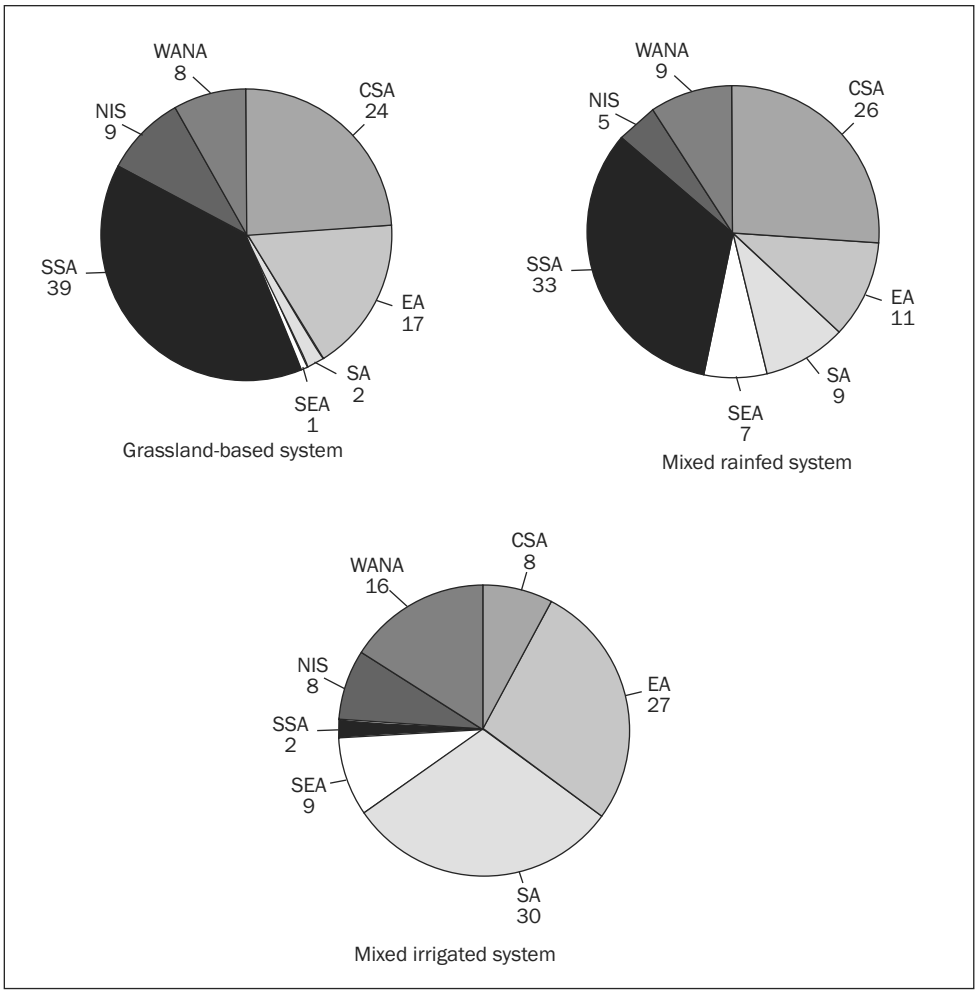


Fig. 3. Crop-livestock production systems: area shares (%) of various regions. CSA = Central and South America; EA = East Asia; SA = South Asia; SEA = Southeast Asia; SSA = Sub-Saharan Africa; NIS = New Independent States; WANA = West Asia/North Africa. Source: Thornton et al (2002).

Table 9. Average farm household income (US$ y^{-1}) in selected Asian countries, by source.

Country	Total household income	Source of income (%)		
		Rice	Nonrice	Nonfarm
Bangladesh	977	38	30	32
China	871	43	30	27
India (Tamil Nadu)	1,010	52	36	12
Indonesia (Lampung)	721	36	44	20
Nepal	1,105	43	46	11
Philippines	1,072	57	18	25
Thailand	1,763	49	20	31

Sources:Compiled from unpublished data collected from household surveys under the collaborative IRRI/NARS project "Differential Impact of Modern Rice Technology in Favorable and Unfavorable Production Environments." For country case studies, see David and Otsuka (1994).

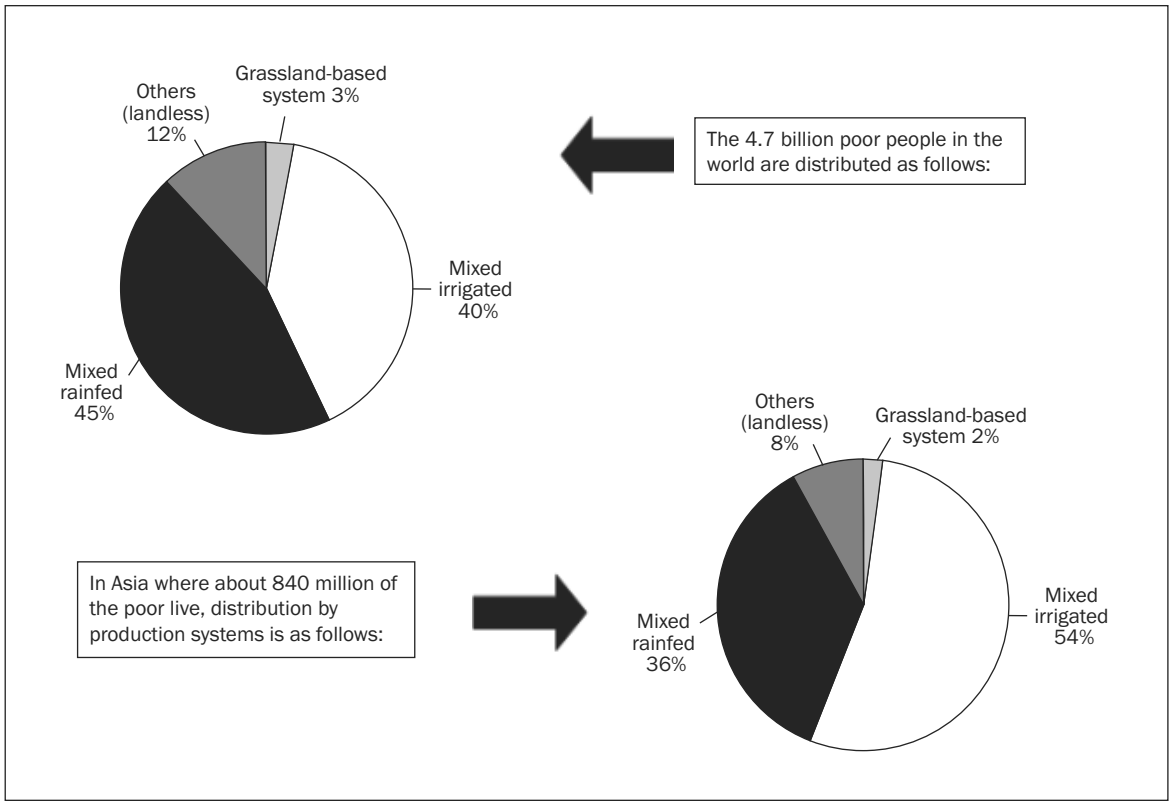


Fig. 4. Where are the poor? Distribution of the poor who live on US$1 a day by production system. Source: Thornton et al (2002).

Table 10. Livestock income in total household income.

Country	Wealth/poverty indicator	Stratum	Percent of household income from livestock	Period/size of sample	Source
Pakistan	Household income stratum	Lowest 1/5	25	1986-89, 727	Adams and He (1995)
		Highest 1/5	9	rural households	
Pakistan	Household income stratum	Lowest 1/5	22	1986-87 to	Alderman and Garcia
		Highest 1/5	6	1988-89	(1993)
Philippines	Household income stratum	Lowest 1/5	23	1984-85, 500	Bouis (1991)
		Highest 1/5	10	rural households	
India (Andhra Pradesh and Maharashtra)	Landholdings	Lowest 1/5 of land distribution	5	1997, 699 households	
		Highest 1/5 of land distribution	6		
India (Andhra Pradesh and Maharashtra)	Landholdings	Landless	7	1975-78, 240 households	
		Largest landholders	15		
Pakistan	Landholdings	Landless	14	1986-87, 727 landless	Adams and He (1995)
		Largest landholders	11		
Pakistan	Dietary adequacy	Malnourished	16	1986-87, 1,082	Von Braun and
		Not malnourished	14	rural households	Pandya Lorch (1991)
Philippines	Dietary adequacy	Malnourished	10	1983-84, 792	Von Braun and
		Not malnourished	9	rural households	Pandya Lorch (1991)
Sri Lanka	Dietary adequacy	Malnourished	4	1984, 480	Von Braun and
		Not malnourished	1	rural households	Pandya Lorch (1991)

Table 11. Changes in the structure of income.

Activity	Philippines				Indonesia			
	1992		1997		1995		1999	
	% of household earning income from the source	Share of total household income (%)	% of household earning income from the source	Share of total household income (%)	% of household earning income from the source	Share of total household income (%)	% of household earning income from the source	Share of total household income (%)
Agriculture	94.8	35	96.0	40	68.0	33	91.5	55
Rice	45.1	16	45.2	16	49.4	18	37.2	11
Nonrice	84.2	13	87.7	19	–	–	88.3	38
Fish/hunting	–	–	–	–	4.1	2	1.8	5
Livestock	64.8	6	61.9	5	26.8	13	17.2	2
Nonagricultural	79.7	65	87.1	60	63.0	67	81.7	45
Remittances	40.9	21	44.8	17	31.3	18	53.3	9

Source: Household survey data from respective countries, collected by IRRI.

various income sources, including livestock, to overall income inequality. Results from two survey periods are analyzed for each country: for the Philippines, 1992, with a total sample of 772, and 1997, with a total sample of 915; for Indonesia, 1995, with a total sample of 1,158, and 1999, with a total sample of 1,591.[4]

The changes in the structure of rural household income can be gleaned from Table 11. The results show that the number of rural households engaged in agriculture as well as the relative share of income from this sector increased over the survey periods. This is contrary to past trends, in which the contribution of the agricultural sector was supposed to diminish over the years as the country prospered economically. It should be noted that the more recent surveys were conducted during those periods when the financial crisis affected much of Asia. The data seem to indicate, therefore, the tendency of people to go back to agriculture in times of economic slowdown. The data further indicate that they return to agriculture to do more of other nonrice farm activities as the percentage of households that did nonrice farming increased in both countries, and quite significantly in Indonesia. The changes in the share of income from other nonrice crops followed the same trend. The share of income from rice cultivation remained unchanged in the Philippines, whereas it declined in Indonesia.

The percentage of households involved in livestock activities in the Philippines is relatively large at more than 60% but the income share is small and remained almost unchanged over the survey periods. In Indonesia, rural households that reported doing livestock activities comprised only a quarter of the total sample households in 1995 and this decreased to 17% in 1999. The share of livestock income in total rural household income also decreased from 17% in 1995 to a mere 2% in 1999. Table 12 shows the Gini coefficient computed from the income data. The values are almost the same over the survey periods, which indicates that income inequality barely changed.[5] Values are above 0.5 except for the Philippines in 1997, when the Gini coefficient estimate was 0.49. Table 12 also shows two indices that further characterize the Gini coefficient. One is the relative concentration coefficient, which indicates whether a source of income increases or decreases inequality. The other is the factor inequality weight, which indicates the magnitude of the contribution of a particular income source to overall income inequality. The i^{th} source of income is said to increase (decrease) inequality if its concentration coefficient is greater (less) than unity. On the basis of this measure, all nonagricultural sources of income (aggregated by major sectors) in both Indonesia and the Philippines are shown to have increased overall income inequality in the sample rural households. This means that, all things being equal, additional increments of nonagricultural transfers will tend to increase overall income inequality. Income from agriculture helps to decrease income inequality. The relative impact, however, varies with the different income sources. Income from game activities that include fishing and hunting in Indonesia increases income inequality. This is also the case for income from rice in the 1997 survey for the Philippines as the estimated parameter is slightly above 1. For both countries in both survey periods, income from livestock is shown to decrease income inequality rather than income from crops, particularly rice, except in 1995 for Indonesia, when the relative concentration coefficient is 0.75 compared with the 0.48 estimated for crop-based income. The factor inequality weight, on the other hand, indicates the relative contribution of the various income sources to

[4] The surveys involved total household enumeration at the sites covered. The increase in sample respondents indicates the entrance of additional households at the sites.
[5] Results of the estimates should not be interpreted as implying the income inequality situation in the countries covered. The study is based on a nonrepresentative sample of rural households.

Table 12. Decomposition of Gini coefficient: sources of income.[a]

Inequality	Philippines		Indonesia	
	1992	1997	1995	1999
Gini coefficient	0.55	0.49	0.57	0.55
Relative concentration coefficient				
Agriculture	0.66	0.78	0.65	0.90
Rice	1.02	1.10	0.47	0.74
Nonrice	0.22	0.51	–	0.88
Fishing	–	–	1.34	1.69
Livestock	0.56	0.71	0.71	0.79
Nonagriculture	1.19	1.15	1.23	1.12
Factor inequality weight				
Agriculture	0.24	0.32	0.26	0.48
Rice	0.18	0.19	0.10	0.08
Nonrice	0.03	0.09	–	0.33
Fishing	–	–	0.06	0.06
Livestock	0.03	0.04	0.10	0.02
Nonagriculture	0.76	0.68	0.74	0.52

[a]Note: Definition of income sources is as follows: agricultural income includes rice, nonrice, agricultural labor, fishery/hunting, and livestock. In Indonesia, land rental and equipment rental are included. Fishery and hunting: included as nonrice in the Philippines. In Indonesia (1999), the item reflects only fishery. Livestock: in the Philippines, data include labor income from doing livestock-related activities. Nonagricultural income includes government and services (transport, processing, and other service industries). Trade: in Indonesia (1999), this income source includes business. Industry: includes construction. Other income: includes remittances and other income.
Source: Household survey data from respective countries, collected by IRRI.

overall income inequality. And the estimates indicate that income from crop-based activities has contributed much more to overall income inequality than either fishing/hunting or livestock. One major reason for these results is that crop-based farming is very much related to land ownership, which is far more unevenly distributed than income, while fishing, hunting, and livestock raising are not linked with land ownership. Earlier studies show an inverse relationship between farm size and livestock: small farms consistently have more animals per unit of land than large farms (Jabbar and Green 1983).

The contribution of income from agriculture that covers primarily crop income, including rice, as well as income from agricultural labor increased over the two-survey period in both countries. The contribution of livestock to total income decreased substantially in Indonesia and so did the contribution of other nonfarm activities except those coming from trade. The trend was similar in the Philippines, although the decline was milder. These results indicate the continuing predominance of land ownership as a major source of income.

Conclusions

Small farmers continuously face their most important problem in everyday life—survival. Most of these farmers practice mixed crop-animal systems primarily because of the many positive features associated with increased productivity, increased income, and improved sustainability. For regions such as Asia, mixed crop-animal systems can probably be regarded as the foundation for the production increases that improved food security and helped alleviate poverty. Despite the recognized importance of these systems, however, many problems and constraints still hinder their further development. These constraints range from technical to policy-related problems and issues that need immediate attention and support both from governments and international organizations. On the technical side, the most crucial is perhaps the need for a multidisciplinary team of scientists/extension agents in which each one understands another discipline sufficiently to communicate effectively with other scientists/extension agents outside of their own area of expertise. Technologies that would help improve productivity and promote sustainability of the systems are also of great importance. On the policy side, agricultural policies relating to small-farm development must be clearly laid out on a long-term basis, and should not be distorted by policies that promote larger establishments. The proper identification of the specific intervention measures to develop crop-animal systems further is based on a clear understanding of the systems—and where and how they operate.

References

Adams RH, He JJ. 1995. Sources of income inequality and poverty in rural Pakistan. Research Report 102. Washington, D.C. (USA): International Food Policy Research Institute.

Alderman H, Garcia M. 1993. Poverty, household food security and nutrition in rural Pakistan. Research Report 96. Washington, D.C. (USA): International Food Policy Research Institute.

Bouis H. 1991. The determinants of household-level demand for micronutrients: an analysis for Philippine farm households. Washington, D.C. (USA): International Food Policy Research Institute.

David C, Otsuka K. 1993. Differential impact of modern rice varieties in Asia: an overview. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 11-21.

David C, Cordova V, Otsuka K. 1993. Technological change, land reform, and income distribution in the Philippines. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 51-106.

Devendra C, Thomas D, Jabbar MA, Kudo H. 1997. Improvement of livestock production in crop-animal systems in rainfed agro-ecological zones of South-East Asia. Nairobi (Kenya): International Livestock Research Institute.

Devendra C, Thomas D, Jabbar MA, Zerbini E. 2000. Improvement of livestock production in crop-animal systems in agro-ecological zones of South Asia. Nairobi (Kenya): International Livestock Research Institute.

Delgado C, Rosegrant M, Steinfeld H, Ehui S, Courbois C. 1999. Livestock to 2020: the next food revolution. Washington, D.C. (USA): International Food Policy Research Institute, Rome (Italy): Food and Agriculture Organization of the United Nations, Nairobi (Kenya): International Livestock Research Institute.

Diaz-Briquiets S, Cheny CC, Germano S. 1992. Nutrition CRSP feasibility and planning activitiy. Arlington, Va. (USA): Casals and Associates.

FAO. 1995. World animal review, 84/85. Rome (Italy): FAO.

FAO. 2003. International Year of Rice 2004: concept paper. Rome (Italy): Food and Agriculture Organization.

FAOSTAT online database. 2003. Rome (Italy): Food and Agriculture Organization.

Hossain M. 1998. Recent developments in the world rice market and Vietnam rice economy: implications for prioritization of rice research. Paper presented at the Vietnam-IRRI Collaborative Work Plan Meeting, Hanoi, Vietnam, 11-13 November 1998.

Hossain M, Fischer KS. 1995. Rice research for food security and sustainable agricultural development in Asia: achievements and future challenges GeoJournal 35:286-298.

Hossain M, Abdul Quasem A, Jabbar MA, Mokadem Akash M. 1993. Production environments, modern variety adoption, and income distribution in Bangladesh. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 221-280.

Isvilanonda S, Wattanutchariya S. 1993. Modern variety adoption, factor-price differential, and income distribution in Thailand. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 173-220.

Jabbar MA, Green DAG. 1983. The status and potential of livestock within the context of agricultural development policy in Bangladesh. Aberystwyth (UK): The University College of Wales. 113 p.

Jahnke HE. 1982. Livestock production systems and livestock development in tropical Africa. Kiel (Germany): Kieler Wisenschaftsverlag Vauk. 253 p.

Lin JY. 1993. The nature and impact of hybrid rice in China. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 375-408.

Pingali PL, Bigot Y, Binswanger H. 1987. Agricultural mechanization and evaluation of farming system in Sub-Saharan Africa. Baltimore, Md. (USA): Johns Hopkins University Press.

Ramasamy C, Paramasivam P, Kandaswamy A. 1993. Irrigation quality, modern variety adoption, and income distribution: the case of Tamil Nadu in India. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 323-374.

Rangnekar S. 1992. Women in livestock production in rural India: animal production and rural development. In: Proceedings of the Sixth AAAP Animal Science Congress. Vol. I. Bangkok, Thailand.

Rosegrant MW, Sombilla MA, Perez ND. 1995. Global food projection to 2020: implications for investment. Food, Agriculture, and the Environment Discussion Paper No. 5. Washington, D.C. (USA): International Food Policy Research Institute.

Sombilla MA, Hossain M. 2001. Rice and food security in Asia. In: Chern W et al, editors. Food security in Asia: economics and policies. Cheltenham (UK) and Northampton, Mass. (USA): Edward Elgar Publishing.

Sudaryanto T, Kasryno F. 1993. Modern rice variety adoption and factor-market adjustments in Indonesia. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 107-128.

Thornton PK, Kruska RL, Henninger N., Kristjanson PM, Reit RS, Atieno F, Odero AN, Ndegwa T. 2002. Mapping poverty and livestock in the developing world. Nairobi (Kenya): International Livestock Research Institute.

Upadhyaya H, Thapa G. 1993. Modern variety adoption, wage differentials, and income distribution in Nepal. In: David C, Otsuka K. Modern rice technology and income distribution in Asia. Manila (Philippines): International Rice Research Institute. p 281-322.

Von Braun J, Pandya-Lorch R, editors. 1991. Income sources of malnourished people in rural areas: micro-level information and policy implications. Working Paper on Commercialization of Agriculture No. 5. Washington, D.C. (USA): International Food Policy Research Institute.

Notes

Author's address: International Rice Research Institute, DAPO Box 7777, Metro Manila, Philippines.

Improving crop-livestock production systems in rainfed areas of Southeast Asia

Ma. Lucila A. Lapar

Crop-livestock systems are the dominant farming systems in rainfed areas of the humid and subhumid agroecological zones of Southeast Asia. Livestock are an integral, well-established component of these systems, providing greater income stability by acting as a capital reserve and supplying draft power, protein, and fertilizer. The Livestock Revolution predicts increasing demand for food of animal origin (Delgado et al 1999), which necessitates a corresponding supply response in terms of higher animal numbers and outputs. This will require further intensification of both specialized nonruminant industrial systems and smallholder crop-livestock systems that constitute the backbone of small-scale Asian agriculture. It is thus of paramount importance to improve the productivity of crop-livestock systems because of their potential to increase opportunities for improving food security and livelihoods, and thereby reduce poverty for the millions of smallholders in the region. A judicious strategy for the development of crop-livestock systems in rainfed areas would also have implications for natural resource management of the fragile and marginal areas where most of these systems are located. This paper presents some research experience and lessons from an ongoing project being implemented by the International Livestock Research Institute in collaboration with its national partners[1] in Southeast Asia and China.

The Crop-Animal Systems Research Project (CASREN)

Extensive consultations with national partners in Southeast Asia led to the identification of research in crop-livestock systems as a high priority for ILRI in fulfilling its global mandate in Asia. The CASREN Project is a collaborative, multidisciplinary research effort to generate technology and policy options to increase the productivity of smallholder crop-livestock systems in Southeast Asia. It has been supported by the Asian Development Bank (ADB) through a regional technical assistance grant (RETA 5812 during 1999-2001 and RETA 6005 during 2002-04).

The CASREN Project has three overarching objectives: (1) enhance the productivity of crop-livestock systems through improved technologies, (2) improve market participation, competitiveness, and trade of smallholders by identifying appropriate policy options, and (3) strengthen NARES capacity to conduct crop-livestock research.

Crop-livestock interactions at benchmark sites

CASREN started field activities at five benchmark sites (BMS) in five countries in Southeast Asia and South China (see Fig. 1): (1) Kecamatan, Cilau subdistrict, Garut District, West Java, Indonesia; (2) Don Montano village, Umingan, Pangasinan Province, Northern Luzon, Philippines; (3) Amphur Muang District, Mahasarakham Province, northeast Thailand; (4) Dong Tam village, Dong Phu District, Bin Phuoc Province, South Vietnam; and (5) Bixi Xiang, Nanjian County, Yunnan Province, South China. A sixth BMS in Renhe Township in Sichuan Province, South China, was added in 2003. These countries contain ecological environments and production systems representative of many other sites in the region and have varying degrees of system research capacity that needs to be supported for improved effectiveness. Table 1 shows the characteristics of the BMS in the five countries.

Rice-based cropping systems are common in these areas, including other annual crops and tree crops, with a mix of both ruminants and nonruminants present in the continuum of lowland and upland rainfed ecosystems. The presence of both animal and crop diversity thus provides a variety of crop-animal interactions. The effects of this diversity on productivity, livelihoods, and sustainable agriculture provide major opportunities for research and development. Indeed, indications from baseline household surveys show that income from animals contributes 10–25% to total farm income. Feed-supply constraints are critical during the 5–

[1]These partners are the Central Research Institute for Animal Science in Bogor, Indonesia; Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development in Laguna, Philippines; Khon Kaen University in Khon Kaen, Thailand; Institute of Agricultural Sciences of South Vietnam in Ho Chi Minh City, South Vietnam; Yunnan Beef Cattle and Pasture Research Center in Kunming, South China; and the Sichuan Academy of Animal Sciences in Sichuan, South China.

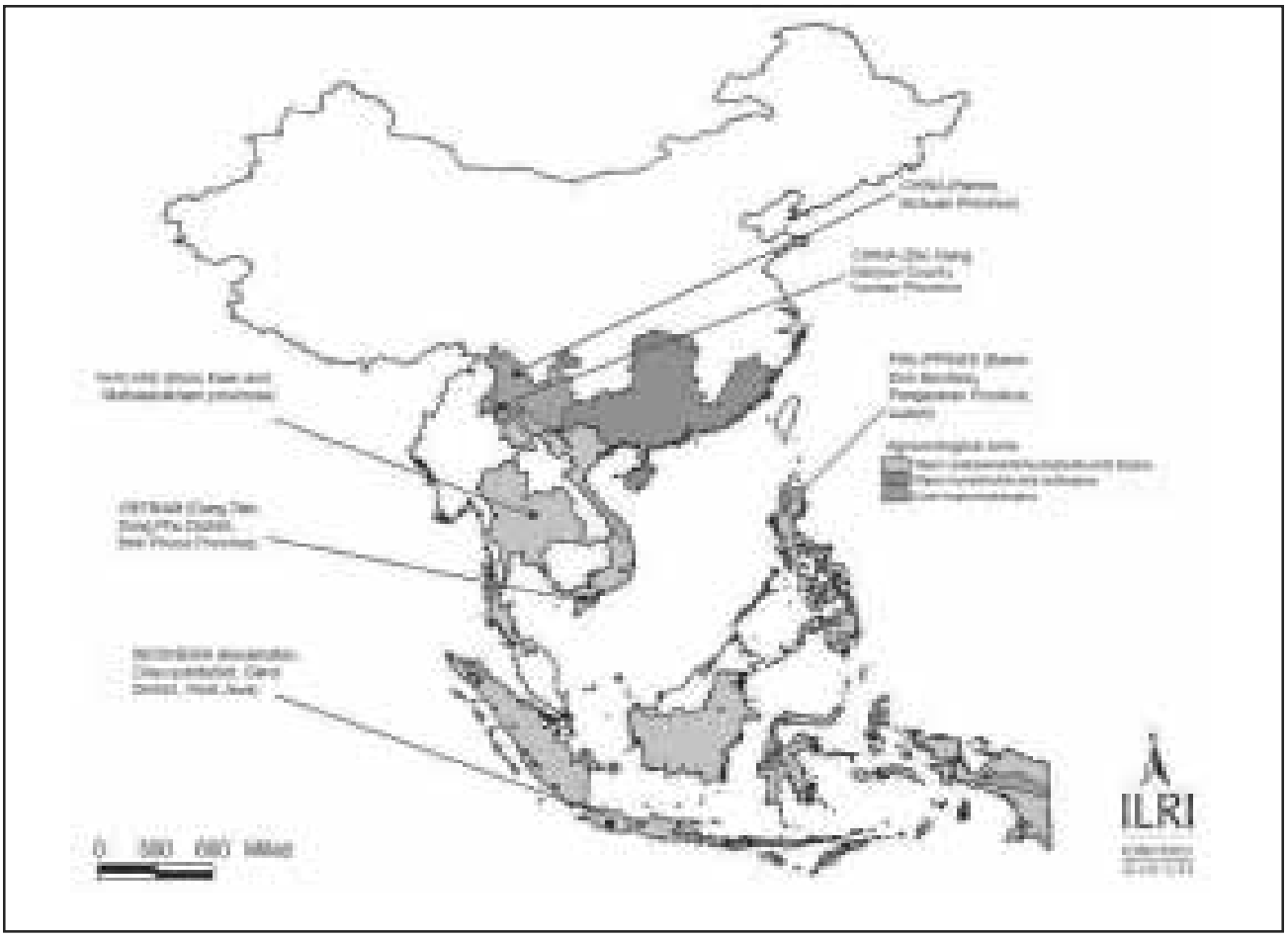


Fig. 1. Location of benchmark sites. Source: Lapar and Jabbar (2003).

7-month dry period at all of the BMS. This presents major challenges for feeds and feeding, and for the efficiency of use and/or protection of natural resources in these environments.

One form of crop-livestock interactions prevalent at the BMS is the use of crop residues as animal feed. In most cases, this competes with other observed uses such as mulching and as raw materials for roofing, particularly in the case of rice straw. The use of rice straw as feed is very common at the Thailand BMS, where farmers are engaged in dairy farming, and in Yunnan Province, where the stocking rate is very high (i.e., greater than 4 TLU[2] ha^{-1}) and pasture areas are limited. In the Philippines, the competing use of rice straw as feed and as mulch has been observed, particularly among households that grow onions as a second crop.

Another form of crop-livestock interactions observed at the BMS is the use of animal manure as fertilizer for crops, particularly in Thailand, Indonesia, and China. In Vietnam, it is common for farmers to sell animal manure that has been collected as well. Cattle manure is also used as feed in crop-livestock-fish systems.

Food-feed crops

Rice straw is definitely the most abundant crop residue for farmers in Southeast Asia and South China (see Fig. 2), but its use as feed is variable, in some cases because of competition for other uses (e.g., mulch) or the lack of knowledge on how to more efficiently use this feed resource. Crop residues from maize are also commonly available. In recent years, there has been a significant increase in the shares of sugarcane residues in Thailand and sweet potato vines in Indonesia and South China relative to other types of crop residues. These respond to shifts in cropping patterns in these areas, which has some implications for the potential use of available feed resources by farmers.

The growing interest in food-feed crops is apparent in the increasing cultivation of sweet potato and, to some extent, maize and sugarcane; their crop residues are used as

[2]Tropical livestock unit

Table 1. General characteristics and types of farming systems at each of the benchmark sites (BMS).

	Vietnam	Thailand	Indonesia	Philippines	China
Location	Dong Tam, Bin Phuoc	Mahasarakham, Khon Kaen	Cilau, Garut	Don Montano, Pangasinan	Bixi Xiang, Nanjian
Distance from major city (km)	Ho Chi Minh City (110)	Khon Kaen (90)	Bogor (180)	Manila (220)	Kunming (380)
Rainfall (mm)	2,170	1,500	2,200	2,300	760
Climate	Subhumid	Subhumid	Subhumid	Subhumid	Subhumid, subtropical
Dry season (months)	6	6–7	5–6	6	7
Agroecological zone	Uplands	Lowlands	Uplands	Lowlands	Uplands
Predominant animal species[a]	BC, Pi, Po	DC, Pi, Po	BC, Bu, S, G, Fi	BC, Bu, G, Pi, Po	BC, Bu, G, Pi, Po
Type of crops	Rice, cash crops, and perennial crops	Annual and cash crops, fruit trees	Rice, cash crops, and fruit trees	Rice, cash crops, and fruit trees	Rice, tea, and fruit trees
Main crop-animal interactions	Crop residues as feed, use of draft animals	Crop residues as feed, manure as fertilizer, use of draft animals	Manure as fertilizer	Crop residues as feed	Farm manure as fertilizer, crop residues as feed, use of draft animals
Main resource degradation problem	Soil mining, erosion, deforestation	Erosion, soil mining	Soil mining, erosion on sloping land, deforestation	Soil mining	Erosion, soil mining due to intensity of crop production, deforestation
% contributions by livestock to total income	13	10–20	10–15	15–20	20–25

[a]BC = beef cattle, DC = dairy cattle, Bu = buffaloes, S = sheep, G = goats, Pi = pigs, Po = poultry, Fi = fish.
Source of Data: Baseline socioeconomic survey of CASREN BMS, 1999.

feed, usually in combination with other types of roughages. Food-feed crops promote increased food production, sustain soil fertility, and provide dietary nutrients for animals (Devendra et al 2001). Thus, the development of food-feed systems represents an important complementary strategy to increase feed availability, food production, and sustainable crop production systems in rainfed areas.

Technological intervention for productivity improvement

The availability of feeds and their efficiency of use throughout the year represent the most important constraint affecting the productivity of animals within crop-animal systems (Devendra et al 2001). Collaborative research in this area is an important strategy in the CASREN project and the development and testing of technologies to improve feed production and use are key ingredients. Within CASREN, the feed production and use technologies developed can be grouped as targeted feed supplements, the use of dual-purpose crops, leguminous forages, and block licks using local resources. Manure and legumes were investigated as important contributors to sustained soil fertility. Table 2 shows a summary of the various technologies tested on-farm at the BMS.

Considerable challenges and opportunities still exist in the region for institutional partnerships and interdisciplinary research aiming to identify appropriate technologies for the improvement of crop-livestock systems. Nevertheless, the participatory approach adopted in technology testing, validation, and diffusion has proved to be effective in scaling up the adoption process.

Studies in economics and policy

Income from market participation is the key to boosting economic growth for nations and reducing poverty for individuals (World Bank 2001). However, participation is not

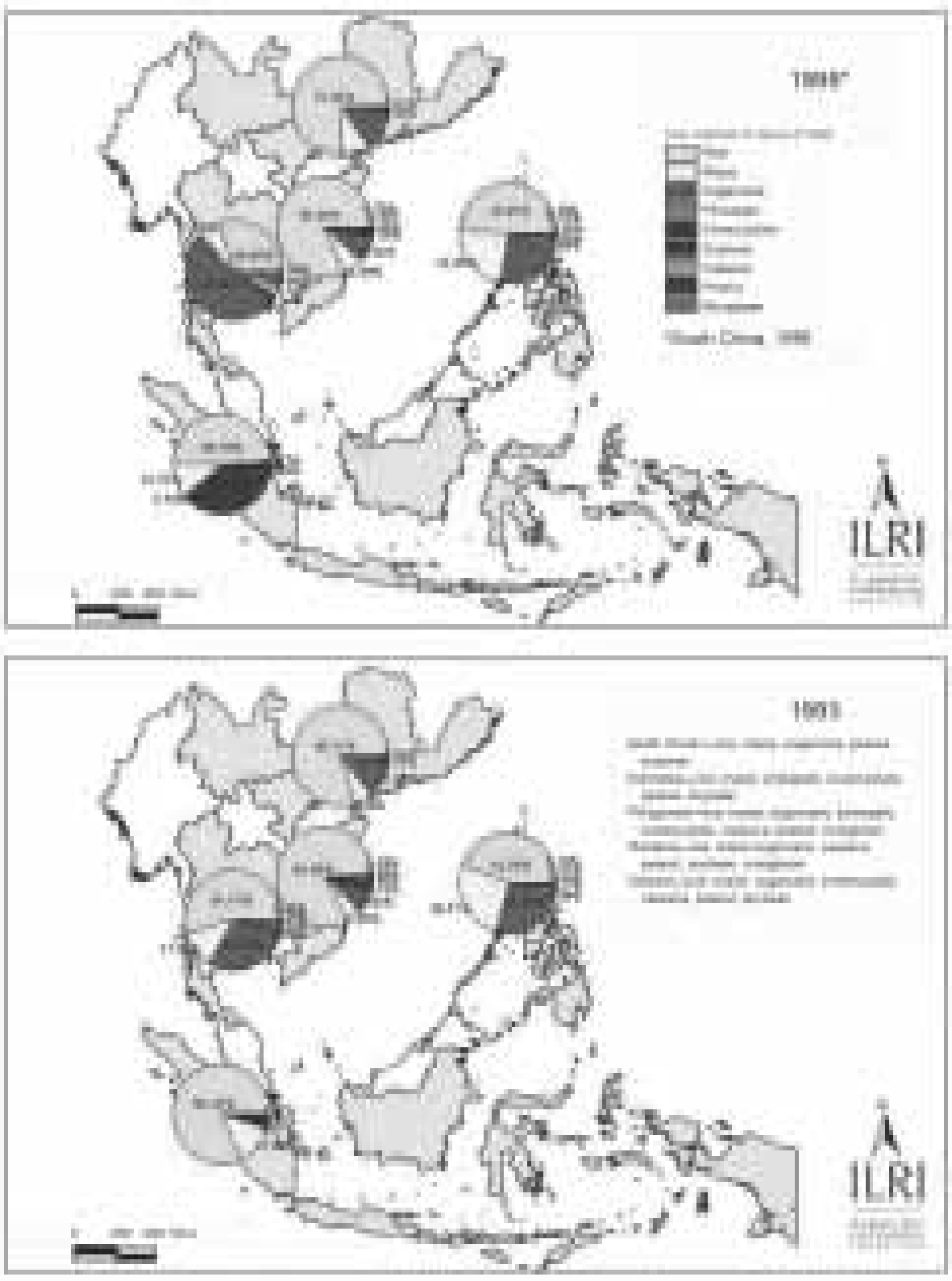


Fig. 2. Relative shares of different types of crop residues in two periods. Source: Lapar and Jabbar (2003).

Table 2. Technology options tested on-farm at the different benchmark sites.

Technology option	Country
Treated rice straw as feed	Thailand, Indonesia
Urea molasses block licks (UMBL) to supplement poor-quality roughages	China, Indonesia, Philippines, Thailand, Vietnam
Use of low-cost concentrates formulated on-farm using locally available feed resources	China, Thailand
Cassava hay production, and use as partial substitute of commercial concentrates	Thailand, Vietnam
High-yielding grasses for cut-and-carry systems	China, Indonesia, Philippines, Thailand, Vietnam
Tree legumes as foliage sources	Indonesia, Philippines, Thailand
Introduction of legumes in food-feed systems	Indonesia, Philippines, Thailand
Use of sweet potato as dual-purpose crop	Indonesia
Use of cassava as dual-purpose crop	Vietnam
Use of grasses in hedgerows to control erosion in cassava plots	Vietnam
Introduction of cool-season legumes	China
Soil-test-based fertilization in rice	Philippines
Treatment of manure (Bokashi system)	Indonesia
New cassava variety and fertilizer management	Vietnam
Development of measuring band to estimate liveweight in cattle	Vietnam

Source: ILRI (2002).

without barriers, given imperfect information and the heterogeneous conditions and characteristics of economic agents. A key policy question then is whether the smallholders, who need it most, will be able to participate in and benefit from the emerging market opportunities. Smallholder participation may be unlikely unless appropriate policies are in place because of some characteristics that are inherent to smallholders, namely, their lack of capital resources, inability to take advantage of economies of scale, and lack of access to information, coupled with the generally poor infrastructure that is prevalent in rural areas where smallholders are largely located.

Studies in economics and policy within CASREN are trying to understand these issues through several country case studies. These studies are aimed at developing and recommending policy changes to improve market participation, competitiveness, and trade for smallholders, and conducting policy dialogues with governments on these policy issues. Brief descriptions of studies conducted from 1999 to 2002 are presented below.

Livestock for rural income diversification

A comprehensive study on policy options for using livestock to promote rural income diversification and growth was undertaken in collaboration with the International Food Policy Research Institute (IFPRI) and the Ministry of Agriculture and Rural Development (MARD).[3] The study identified three priority policy areas in the livestock sector for the short term (next five years):

- The first priority will be to increase productivity to meet the rapid growth of the domestic demand for meat and animal products. The productivity focus in the short term will create the basis for an acceleration of growth and will require the reorganization of the breeding system, additional investment in artificial insemination stations, and expanded commercial credit targeted to breeding. Considerable expansion of investment in capacity and facilities of the research and extension system will also be needed at the same time to support the institutions required to promote the generation and dissemination of improved breeds appropriate to the needs of smallholder producers.
- The second priority is to provide adequate incentives to participants in the livestock system. This will imply maintaining market orientation while at the same time fostering a more competitive environment, and a liberalized trade system, and supporting marketing institutions and facilities. Policies to encourage increased investment in improving market information and setting up appropriate market places will facilitate an increased flow of information between producers and consumers and at the same time improve the bargaining power of smallholder producers. These will potentially result in lower marketing margins, thus expanding production, consumption, and interregional trade.
- The third priority will involve setting up the regulatory and institutional bases for effective health, sanitary, and veterinary services, including an increase in resources devoted to capacity building of the veterinary practitioners, improved facilities for diagnostics and epidemiology, and the privatization of the veterinarian profession. There will also be a need to set up and/or strengthen several inspection systems related to health and environmental control in order to protect both human and animal health.

[3]Details are in IFPRI (2001).

Competitiveness and efficiency of pigs and poultry

A study to investigate the sector competitiveness and efficiency of pig and poultry production was undertaken in Vietnam.[4] Some policy recommendations coming out of the findings of the study include the following:

- Liberalization policy may improve efficiency and competitiveness in both poultry and pig production in North Vietnam because of the economies of scale observed in that region such that flock and herd size may expand because of expectedly lower input prices from liberalization. This policy will create the opposite effect in South Vietnam, where current market conditions and policy are conducive to higher private profits vis-à-vis social profits. With liberalization policy creating pressure for output expansion, pig and poultry farms in the south will lose their cost advantages because of lower technical performance.
- To attain the production potential of improved breeds in smallholder conditions, much can be gained by improving feed quality and management. Policy support for better-quality feeds and better herd management will be important for keeping smallholders out of poverty and for getting them to participate in more market-driven rural development processes.
- Improved access to formal and informal education will help smallholders become more efficient and competitive. Public expenditure on extension and education and specialized training needs to be expanded because of the potential positive impact on smallholder efficiency. Moreover, these are services that only the public sector has the mandate to provide.
- Improved access to credit likewise promotes efficiency by leveraging cash constraints to purchase good-quality inputs and services. Policies to support the expansion of credit access and availability to smallholders will be beneficial in this respect.
- The government should not get involved in the provision of feed, stocks, and drugs because it is shown that doing so will reduce efficiency, likely arising from the poor quality and untimely delivery of such inputs. To optimize the impact of public investments for improving productivity and efficiency, the government should not engage in the business of supplying inputs as dictated by liberalization policy but rather invest in more productive activities such as education and improved delivery of extension services.

A similar study on pigs in the Philippines has highlighted three major issues that constrain smallholder competitiveness and efficiency of smallholder producers: feed quality, animal health services, and genetics.[5] Potentially important policy recommendations arising from these findings include

- Streamlining of the feed control law to ensure proper implementation and enforcement, and subsequently make more transparent the quality classification of feed being sold in the market.
- Institutionalization of mechanisms and an incentive structure for the development of institutional innovations, for example, collective action that will facilitate the mitigation of transaction costs in production and marketing that are stacked against smallholder producers more than commercial ones. Policies to encourage private-public partnerships in livestock production and R&D appear to be promising.
- Policies to improve delivery of extension and animal health services will facilitate increased productivity and improve market participation by smallholder pig producers. This will need to include training and technical support for better management of improved breeds.

Market participation by smallholder livestock producers

A study on market participation decisions by smallholder livestock producers in crop-livestock systems in the Philippines was conducted and came out with the following major findings and policy implications:[6]

- Smallholder livestock producers are consuming almost twice the amount of home-produced livestock products as nonproducers consume on a per household basis. This has important implications for securing the availability and accessibility of better-quality protein for smallholders for improved health and nutrition. Thus, policies to promote the expansion of livestock production by smallholders will help improve food security and the health and nutrition status of smallholders who have less access to better-quality food otherwise.
- Increased animal holdings are important for engendering market access by smallholders. Thus, technology and policy options that will enhance incentives to increase production will have potentially large impacts on engendering market participation. Here, promoting the adoption of animal productivity-improving technologies appears to be the most lucrative among policy options.
- Technology adoption is positively associated with household size (as a proxy for labor resources). On the other hand, the availability of alternative occupational opportunities (which takes labor away from livestock production) affects significantly the potency of so-

[4]Details are in Akter et al (2003).
[5]Details are in Lapar et al (2002a).
[6]Details of the descriptive analysis are in Calara and Lapar (2001). Details of the econometric estimation are in Lapar et al (2002b).

cial and economic prescriptions to facilitate technology adoption and market participation of smallholders. These competing effects, while they may be location-specific, need to be examined very closely when targeting development objectives for smallholders.

In addition to the above findings, it was also shown in a companion study that neighborhood effects are significant in market participation decisions by smallholder farmers at the BMS in the Philippines.[7] This has major implications for the important impacts of knowledge diffusion on farmer decision-making. An understanding of the extent to which pro-active agents influence neighbors and the extent to which this "ripple-effect" is passed on and the range of its geographic dispersion is important for policy-making purposes. Farmers are more likely to imitate their neighbors' success stories, all other things being constant. It is thus well advised to consider this phenomenon in designing policy interventions in order to fine-tune expectations of policy impacts and hence devise more realistic and feasible options.

A similar study on market participation conducted in Vietnam has shown that labor is important in engendering market access, availability of land significantly affects entry into ruminant markets, age (as a proxy for experience) is an important factor for entry into nonruminant markets, and there are differential impacts across regions of policies affecting education, communal grazing land, and access to credit. The latter finding gives emphasis to the need to tailor certain sector policy prescriptions to the requirements and conditions of regions.[8]

Factors affecting technology adoption: the case of dual-purpose forages

Consistent with the objectives of CASREN and the focus on feed technology interventions, a case study to identify the factors that facilitate the adoption of dual-purpose forages in rainfed areas was conducted in the Philippines.[9] An econometric model was estimated to determine the significant factors for adoption. The results of the study showed that, in addition to the biological aspects being critical to the adoption of forage species, the socioeconomic aspects of the farmer and the farm are important factors in engendering the adoption of forages among adopters of contour hedgerows. It was shown that, when a farmer is facing liquidity or a capital constraint, there is less likelihood that adoption of forages will take place because of the accompanying costs of adoption. This suggests that policies that will enhance farmer income and/or facilitate their access to external sources of capital such as credit will promote the adoption of technologies, in this case, forage species. Likewise, the role of education in facilitating the uptake of technologies was shown to be important as implied by the results of this study. Education is not necessarily confined to formal education, but rather could encompass the whole range of training and extension activities that will promote information and knowledge dissemination about a new technology. Thus, programs to promote the adoption of forage species, for example, should emphasize the importance of educating farmers on the benefits of adoption. The implication of the significance of the location dummy is that the promotion of forage species may be more effective if targeted to specific areas or groups of people. In this particular case, forage species for soil conservation and for feed are best targeted to upland areas that are experiencing problems of soil erosion and declining grazing areas. The soil conservation angle could thus be used as another effective avenue for increasing the adoption of forage species among smallholders.

Lessons learned

Some of the valuable lessons learned from the foregoing studies conducted under CASREN are as follows:

- Sector policies that will support the macro-level policies include those that will enhance technology adoption for productivity improvement, facilitate an environment conducive to institutional innovations that will promote market orientation, and provide the right incentives for more equitable participation in and distribution of benefits to the various stakeholders.
- Low levels of productivity are a constraint to livestock-sector development, and increasing adoption rates of productivity-enhancing technologies are worthy objectives of a development initiative. Policy constraints to technology adoption such as limited access to capital, low levels of education and training, inadequate land and labor resources, and ineffective and/or nonexistent regulatory mechanisms for safeguarding producer and consumer welfare, among others, will need to be addressed to engender more adoption and subsequently increase productivity levels. It is also worthwhile to mention that, in some cases, adoption may be constrained by the technology itself, that is, the technology may not be the appropriate one for the types, capabilities, resources, and requirements of the target beneficiaries.
- Increased uptake of productivity-enhancing technologies will likely engender more market participation by smallholder livestock producers. Institutional innovations to promote increased adoption of these technologies as well as to remove bottlenecks in input and output markets are important complementary options to consider.

[7]Details are in Lapar et al (2003).
[8]Details are in Holloway et al (2002).
[9]Details are in Lapar and Ehui (2001).

- Improving farmer capacity through continuous training and enhanced access to information should also be given due consideration in designing development packages to address constraints to smallholder livestock-sector development.

There is no guarantee that governments will immediately or subsequently adopt the policy options identified for recommendation. What will facilitate the increased awareness and improve the likelihood of adoption of these options is to undertake more policy workshops/dialogues to discuss these policy issues and the identified options. Only when governments undertake concrete policy changes as a result of these intensive dialogues and consultations will these initiatives be deemed successful. It will also be useful to increase the level of policy advocacy activities that should ideally be led by national collaborators, with collaboration from international organizations as facilitators.

References

Akter S, Jabbar MA, Ehui SK, Goletti F. 2003. Competitiveness and efficiency in poultry and pig production in Vietnam. Socioeconomics and Policy Research Working Paper No. 57. Nairobi (Kenya): International Livestock Research Institute. 61 p.

Calara A, Lapar MLA. 2001. Policy options for market-oriented livestock production by smallholder producers in the Philippines, final report. Los Baños, Laguna (Philippines): International Livestock Research Institute. 125 p.

Delgado C, Rosegrant M, Steinfeld H, Ehui S, Courbois C. 1999. Livestock to 2020: the next food revolution. Food, Agriculture, and the Environment Discussion Paper 28. IFPRI/FAO/ILRI, Washington, D.C. (USA): International Food Policy Research Institute.

Devendra C, Sevilla C, Pezo D. 2001. Food-feed systems in Asia: review. Asian-Aust. J. Anim. Sci. 14(5):733-745.

Holloway G, Lapar MLA, Ehui S. 2002. Hierarchical modelling of policy options for smallholder entry into emerging markets: evidence from Vietnam. Los Baños, Laguna (Philippines): International Livestock Research Institute. (Draft manuscript.)

IFPRI (International Food Policy Research Institute). 2001. Policy options for using livestock to promote rural income diversification and growth in Vietnam. Final Report, Vols. I and II. Washington, D.C. (USA): IFPRI.

ILRI (International Livestock Research Institute). 2002. Increasing the contribution of livestock to improving productivity of crop-livestock systems in Southeast Asia (RETA 5812). Terminal report prepared for the Asian Development Bank Los Baños, Laguna (Philippines): ILRI.

Lapar MLA, Catelo MA, Aragon C. 2002a. Comparative technologies and performance of smallholder and commercial pig producers: a case study of the Philippines. Paper presented at the workshop "Can Philippine Smallholder Pig Producers Survive: a joint workshop of UPLB-CEM, IFPRI, and ILRI under the CGIAR System-wide Livestock Program," Quezon City, Philippines, 8 November 2002.

Lapar MLA, Ehui S. 2001. Factors affecting adoption of dual-purpose forages in the Philippine uplands. Paper presented at the International Workshop on Forage Demand and Adoption by Smallholder Livestock Keepers, ILRI, Addis Ababa, Ethiopia, 18-20 June 2001. (Recently published in Agric. Syst. 81(2004):95-114.)

Lapar MLA, Holloway G, Ehui S. 2003. How big is your neighborhood?: spatial implications of market participation by smallholder livestock producers. Paper presented at the 25th International Conference of Agricultural Economists, 16-22 August 2003, Durban, South Africa.

Lapar MLA, Holloway G, Ehui S. 2002b. Policy options promoting market participation of smallholder livestock producers: a case study from the Philippines. Socioeconomics and Policy Research Working Paper No. 47. Nairobi (Kenya): International Livestock Research Institute 21 p. (Subsequently published in Food Policy 28(2003):187-211.)

Lapar MLA, Jabbar M. 2003. A GIS-based characterization of livestock and feed resources in the humid and sub-humid zones in five countries in Southeast Asia. Nairobi (Kenya): International Livestock Research Institute. 72 p.

World Bank. 2001. World development report 2002: building institutions for markets. Washington, D.C. (USA): Oxford University Press/World Bank.

Notes

Author's address: International Livestock Research Institute (ILRI), DAPO Box 7777, Metro Manila, Philippines.

Acknowledgment: This paper has benefited from the contributions and support of persons and institutions too many to mention individually. Any errors and/or omissions are the sole responsibility of the author.

Section 2

Sustainable food-feed systems and improved livelihoods of the poor in rainfed lowland areas: socioeconomic components

El Sotheary

Delvert (1961) and Tichit (1981) have described two farming systems that are widely practiced by Cambodian farmers: rice-based farming systems and multiple cropping systems. Rice-based farming systems predominate and occupy around 88% of the total cultivated land (Nesbitt 1997). Rubber and maize, which are the most important crops after rice, have contributed greatly to the national economy. Secondary cash crops consist of mungbean, tobacco, soybean, cassava, sweet potato, and sesame. Vegetable production is important along the Mekong River areas.

Rice-based farming systems vary according to the flooding regime, season, water level, cropping pattern, topography, and soil type. There are five rice ecosystems in Cambodia, but rainfed lowland conditions predominate in the area and contribute 85.7% of the total rice production, which consists mostly of medium- to late-maturing varieties. Some 92% of lowland rice is grown in the wet season as a single crop, with an average yield of 1.3 t ha^{-1}. Rainfed lowland rice is commonly transplanted on bunded fields. The upland rice ecosystem, usually found at an elevation of 200 to 1,000 m, covers only 8.3% of the total rice area. Most upland rice is grown with shifting cultivation in forested areas in the north and northeast of Cambodia. Rice is broadcast on sloping land without bunds for two or five years. Human population densities are low, so fallow periods have not decreased drastically.

Rice farming systems include the household, animals, soil, weeds, insects, and other subsystems. The household, rice, and animal subsystems are integrated and interdependent. The household provides labor and management, while crops provide feed, and the animals produce power, manure, meat, milk, and capital. The farming system is part of an agroecosystem consisting of nonagricultural systems, market and credit systems, and other institutions.

Any strategy for improving the conditions of small rural households must be directed toward increasing the productivity of both crop and animal components of the farming system. To identify such strategies, the nature, extent, and direction of integrated crop-animal systems (ICAS) has to be properly and clearly understood.

Profile of the rice and animal sectors

The rice sector's relative performance and contribution to the economy

The Cambodian rice economy in the 1990s. Agriculture's contribution to GDP declined from an estimated 52% in 1990 to 34% in 2002, as agricultural growth lagged behind that of the industrial sector (Table 1). However, agriculture is still by far the most important sector for Cambodia's economy, and will remain so throughout the Socio-Economic Development Plan II (SEDPII) period and beyond.

Table 1. Distribution of GDP by sectors and subsectors in % in constant 2000 prices.

Economic activities	Year				
	1998	1999	2000	2001	2002
Agriculture, fisheries, and forestry	43.7	40.8	37.6	36.4	33.5
Crops	17.6	18.3	17.6	16.7	14.9
Livestock and poultry	7.1	6.3	5.3	5.6	5.4
Fisheries	12.9	11.4	11.3	11.4	11.0
Forestry and logging	6.2	4.8	3.4	2.6	2.2
Industry	16.8	18.1	22.1	23.6	26.3
Services	35.6	35.6	35.2	34.7	34.3

Source: Ministry of Planning (2003).

Table 2. Area planted to rice, grain production, yield, and population, Cambodia, 1900-1999.

Year	Area planted (000 ha)	Rice production (000 t)	Grain yield (t ha^{-1})	Human population (million)	Export rice?
1900[a]	400	560	1.40	2.0	Yes
1950[a]	1,657	1,576	0.95	4.3	Yes
1960[a]	2,150	2,335	1.09	5.5	Yes
1970[a]	2,399	3,184	1.33	7.0	Yes
1980[a]	1,441	1,715	1.19	6.3	No
1990[a]	1,890	2,500	1.32	8.7	No
1999[b]	2,085	4,073	1.95	12.0	Yes

[a]Source: FAO electronic database (2000).
[b]Source: Agricultural statistics (1999-2000).

Table 3. Production area (%) of different rice ecosystems in Cambodia.

Ecosystem	Production area (%)			
	1967[a]	1981[a]	1995[b]	1999[b]
Wet season	93.8	93.4	91.7	88.9
Rainfed lowland	77.9	86.7	85.7	84.0
Early	2.9	15.6	17.4	17.2
Medium	12.4	17.0	35.4	38.9
Late	62.6	54.1	32.9	27.9
Deepwater	15.9	6.7	4.1	2.6
Rainfed upland	–	–	1.9	2.2
Dry season	6.2	6.6	8.3	11.1
Total (000 ha)	2,508.2	1,441.0	2,038.1	2,153.9

Paddy rice is by far the dominant agricultural crop, accounting for 43% of value-added in the crop subsector in 1999. Nonrice crops contributed 29% of value-added, followed closely by livestock with 28%.

Since the reforms of 1989, rice production in Cambodia has been done in a transition market economy. Agriculture is a priority in national development policy. Strategies have been formulated to improve food security, stimulate economic growth, increase rural incomes, and develop agricultural export industries.

Cambodia is close to the center of origin of rice and farmers in the region have grown rice for at least 2,000 years, and possibly longer in the case of upland rice. Natural selection has contributed significantly to the evolution of various rice varietal types for different environments. Irrigated rice production technologies were introduced 15,000 years ago (Chandler 1993) and were widespread during the Angkorian period.

Since 1995, Cambodia has produced a rice surplus each year, although yield averages 1.8 t ha^{-1}. This yield is lower than that of other rice-growing countries because most rice is produced in rainfed lowland ecosystems with climatic constraints. The challenge of increasing rice production remains a major objective of Cambodian agricultural scientists.

Cultivated area, grain production, and average yield in the wet and dry season increased from 1993 to 1999 (Table 2). Cultivated area in the wet season varied from 1.40 million to 1.85 million ha from 1993 to 1999. In 1994, the cultivated area was affected by flood and drought, whereas, in 1998 and 1999, the growth of output may have resulted from cultivating two rice crops (rice-rice). Wet-season rice production increased significantly from 2.0 million tons in 1993 to over 3.4 million t in 1999.

Rice is cultivated in different ecosystems in Cambodia, including rainfed lowlands and uplands, and under flooded and/or deepwater conditions and in dry seasons (Table 3). The highest percentage of the rice-growing area is rainfed lowlands (84% in 1999). Early, intermediate, and late-maturing varieties are located in upper, medium, and lower fields, respectively, to match water depth that is suitable for different varieties. The characteristics of these varieties are well described by Javier (1997). Over the past decades, farmers have steadily shifted away from cultivating late-maturing (flowering after 15 November) rice varieties to growing medium-maturing types (120–150 days if photoperiod-insensitive, and flowering between 15 October and 15 November if photoperiod-sensitive varieties). The cultivation of late-maturing rice decreased from 1.57 million to 0.60 million ha over a 32-year period. A significant increase in area of early and medium-maturing varieties was critical to improving rice production during this period.

Less than 3% of the Cambodian rice area is currently planted to deepwater and/or floating rice. Small areas of

upland rice are found in northeastern Cambodia. Dry-season rice production is increasing in area with better yield. Of dry-season rice production, recession rice is most popular. The other dry-season rice has supplementary irrigation and full irrigation. Although they represent only a small proportion of dry-season rice, contributing only 18% of the nation's total production in 1999, they are of increasing importance to Cambodia's food security and economic growth.

Characteristics of Cambodian rice-farming households. Rural households in Cambodia number 1.5 million and account for 85% of the national population. Eighty-two percent of the rural labor is engaged in agriculture, forestry, and fishing, and the vast majority of this labor is engaged in rice production. The average rural household size is 5.5 persons (range of 3–7). The average age composition of the rural household is 44% age 0–14, 52% age 16–64, and 4% age 65 and above. The average adult labor per household is 2.9 persons. The percentage of rural households headed by a female is estimated at 20% of the total number of households. Heads of farm households tend to be elderly (40–50 years old) and have long farming experience (20–25 years) (Rickman et al 1995).

The average years of education for rural adults are 4.4 years for males and 2.2 years for females. Rural adult literacy rates, assessed at the simplest level of an ability to read and write a simple message, average 79% for men and 51% for women.

Rice farm households in Cambodia are engaged in a range of activities to produce food and income. In addition to rice production, other field crops and vegetable production are undertaken. A fair amount of time is also spent in livestock production, hunting, and fishing. Many households are engaged in wage labor and small business (Helmers 1997, Lando and Mak 1991).

Rice is the staple food for Cambodian people and the most important crop for food security. Rice represents 75% of nutrition intake on average, with per capita consumption needs estimated at 151 kg of milled rice or 250 kg of paddy, an average of 1.4 tons per household annually (MAFF 1996). This figure does not include rice requirements for growing seed, for compensating for postharvest losses, and for basic social and ceremonial purposes, which might easily amount to an additional 500 kg of paddy year^{-1}. Vegetables, other field crops, and wild plants also contribute to the diet, but precise quantities are difficult to measure. The major source of protein in Cambodia is fish, supplemented by smaller quantities of poultry, pork, and beef.

Rice production is one of the major activities undertaken by rural households that require a significant amount of labor. In most cases, the rice crop is grown using labor with simple farming tools. Cattle or buffalo are the major sources of power for plowing and harrowing. However, the use of agricultural machinery in rice production is spreading (Rickman et al 1995). Several studies have been conducted regarding the amount of labor required to cultivate 1 ha of rice. Results indicate large variations in laborers among farm households. Total average person-days ha^{-1} has varied from 85 to 114 days (Tichit 1981, Rickman et al 1995). One study, which involved consecutive surveys of the same households during two seasons, found a mean of 100 person-days ha^{-1}, but the standard deviation of the sample was estimated at 48, which is very high (Pingali 1988).

More than 90% of the labor requirement for rice production permanently involves farming jobs in the wet season, given the dominance of rainfed lowland production. Within this season, labor demand is high for transplanting and harvesting (Nesbitt and Chan 1991). Households frequently experience labor shortages during these periods and they usually hire or exchange labor to meet the peak demand. Different-maturing varieties (early-, medium-, and late-maturing ones) are planted to avoid a labor shortage.

Different cropping operations require different demands on men and women because of common divisions of labor at the farm level. Women make up 60–65% of the agricultural labor. Land preparation and other activities are more often undertaken by men. Transplanting and general animal husbandry are mainly done by women, but harvesting is done by both men and women (Paris 1992). There are, however, exceptions to these patterns according to differences in the availability of household labor.

Rice production in the 1990s. From 1991 to 2000, rice production increased at a remarkable rate of 5.9%, far outstripping the population growth of 2.8%. Average growth in 1996-2000 remained at 3.1% per year. This is mainly attributed to the stronger cultivation of dry-season rice because of the expanded use of high-yielding varieties such as IR66. In 1996-2000, rice production in the dry season grew at an average of 4.8% annually vis-à-vis wet-season rice production, which grew at 2.8% annually. As a result, the share of dry-season rice in total production has increased considerably, from 15% in 1991 to about 20% in 2000. Dry-season rice varieties are cultivated mostly for additional income. Wet-season rice, on the other hand, which is primarily cultivated with traditional varieties, whose taste is reputedly of higher quality than that of modern varieties, is mostly channeled for home consumption.

Increased outputs in dry-season rice are different from wet-season production. Dry-season production is essentially explained by yield improvement, which averages about 3.2 t ha^{-1} versus wet-season rice yield of 1.9 t ha^{-1}. Wet-season rice production comes from an increase in area (74%). In both cases, variability of growth is quite high and much higher than the average growth rate (i.e., standard deviation of 8.5 and 11.5, respectively, for wet- and dry-season rice).

Rice in Cambodia is mainly cultivated under rainfed conditions. Irrigated rice area was estimated at 473,000 ha during 1997 and 1998 (about 23% of total rice area), of which 11% is supplemental wet-season irrigation, 11% is partial dry-season irrigation, and about 1% is fully irrigated. Rice double-cropping area is about 1% of total cultivated area.

Table 4. Economic model of rainfed lowland rice production in Cambodia, 1995.[a]

Item	Inputs		Traditional system		Improved system	
	Unit	Unit price (riels)	Quantity (per ha)	Value (riels)	Quantity (per ha)	Value (riels)
Revenue						
Paddy[b]	kg	368	1,300	478,400	2,000	736,000
Subtotal				478,400		736,000
Cost						
Seed[b]	kg	368	80	29,440	80	64,000
Improved seed[c]	kg	800	0			
Fertilizer						
Urea[b]	kg	680	0		50	34,000
DAP[b]	kg	864	0		75	64,800
Manure	Carts	0	5	0	10	0
Labor						
Family	Person-days	0	110		120	
Hired	Person-days	3,000			0	
Irrigation			0			
Hire draft power[d]		95,650	1	95,650	1	95,650
Equipment and materials[c]		25,800	1	25,800	1	25,800
Miscellaneous			0			
Subtotal				150,890		284,250
Net revenue				327,510		451,750
Returns per person-day				2,977		3,764

[a]Assumptions of improved model: fertilizer and improved seed as shown with minimum water control (supplementary irrigation or good crop/water conditions). Quantities (per ha) based on FAO data. Prices and values in Cambodian riels: US$1 = riels 2,500. [b]FAO (1995) unpublished farm-trial price data. [c]Estimate extrapolated from FAO 1993 data. [d]Rickman et al (1995).

The costs and returns of rainfed lowland and flood recession rice production systems, using existing and improved technologies, are summarized in Table 4.

Rice output in the rainfed lowland is mainly used for consumption. In this situation, input costs are effectively the net expenses of staple food production. In flood recession areas, farmers can produce surplus rice for sale with 1 or more than 1 ha of rice field. With new technologies, rainfed lowland farmers may be able to produce a surplus quantity for sale.

Prospects of rice production in Cambodia. Over the past 10 years, rice production has increased to a level that has made the country self-sufficient and able to export a modest surplus. Even though the exact amount of this surplus is not known because of inaccurate trade statistics and the largely informal nature of rice trade, it is estimated that about 400,000 t of paddy and an additional 50,000 t of milled rice were exported in 2001.

The attainment of this exportable rice surplus could set the basis for a debate about the role of rice in the future of agriculture in Cambodia. One position advocates the need to increase the quality of rice, thus allowing Cambodian rice to be traded at a premium in international markets. This position implies a strict selection of paddy varieties of fragrant rice or local varieties such as Somaly and Phka Malis. Varietal selection, improvement of milling technology, and marketing strategy are part of the approach that sees the future of rice in Cambodia as largely oriented toward fulfilling its internal food requirements first and exporting more quantities of high-quality rice (perhaps in the range of 200,000 to 300,000 t of high-quality rice). The average price of paddy paid to farmers would be about twice the value of high-yielding varieties such as IR66. This strategy implies that only a fraction of the total rice area would be cultivated to these varieties because of the need for adequate soil and agroclimatic conditions. A sophisticated milling and marketing capacity would be developed, and only a relatively small number of farmers would cultivate this rice variety. This strategy implies an emphasis on the postharvest system and variety selection.

The second position advocates the need to increase yield, mostly by disseminating new varieties such as IR66, the intensive application of fertilizers, and irrigated dry-season agriculture. This strategy emphasizes the key role of agricultural extension in intensive agriculture, and the development of a seed system that increases the access of smallholders to improved genetic material. The increased rice surplus would also be exported to world markets (thus still requiring an improvement of postharvest systems) but not to the high-quality segment of the market. Even though the price of paddy would be lower than average prices, the higher yield might still partly compensate farmers for the lower price and higher investment in inputs.

These two positions can be largely interpreted as the "Thai" approach and the "Vietnamese" approach to rice production expansion. One fundamental difference between the two approaches is that the Thai approach will require more private investment and less public investment (in irri-

gation and extension system) than the Vietnamese approach. In terms of income of farmers, it is possible that the Thai approach has better returns than the Vietnamese approach. However, the limitation of the Thai approach is that it is highly dependent on soil and land characteristics and weather pattern, whereas the Vietnamese approach is relatively more stable, given its higher dependence on irrigation.

Currently, Cambodia is following both strategies at the same time. Private investment in high-quality rice mills has occurred over the last two years with some success both with farmers and in terms of exports to international markets (by rice mills such as Angkor Kasekam and Paragon). At the same time, irrigation investment is increasing and, as seen above, dry-season irrigated areas are growing rapidly.

However, for the majority of Cambodian farmers, rice is still cultivated for subsistence reasons. Even with the better cultivars and methods of cultivation, income from rice is likely to be from only $100 to $200 per hectare. Unless farmers own larger fields, rice cultivation alone is unlikely to be the main tool of poverty reduction in Cambodia.

Other constraints to expanding rice production. In addition to the technical constraints identified in previous sections, there are other constraints to further expanding rice production. Marketing of rice is a major economic activity in Cambodia, although comprehensive studies of the rice marketing system are lacking and much rice trade is unrecorded. Rice is imported from and exported to both Vietnam and Thailand. Rice output is marketed for cash and is also traded as an exchange commodity for goods and services in informal markets. It is primarily characterized by a high degree of fragmentation and inefficiency. The causes of fragmentation include poor physical and communication infrastructure, which limits the movement of goods and information. This gives rise to a mismatch between rice supply and demand across the country and over time. Price distortions reflect these imperfections. For example, in September 1994, it was found that rice was selling in Takeo Province for US$160 t^{-1} cheaper than in Phnom Penh, which is only 70 km away, a price differential that is far in excess of the transportation cost. This fragmentation also means that returns to farmers are frequently low, with most profit accruing to traders, wholesalers, and retailers (Cameron 1995).

The rice industry, like the other agricultural subsectors, has a low capital base. This adversely affects the extent of successful marketing. Formal bank credit is unavailable to the small-scale producers and agribusiness workers who are the backbone of the industry. Credit availability in the rice market is dominated by informal moneylenders, who typically charge 20–30% per month on cash loans and 100% interest on loans of rice in-kind over a 6-month period. They remain in business as they provide easy and timely access to capital at the local level and face little competition in local credit markets. In 1995, none of Cambodia's 31 banks were involved in lending to agricultural producers and credit schemes of nongovernment/international organizations have reached only 2.5% of Cambodian villages (Cameron 1995).

Poor postharvest performance also affects the operations of the rice market. The traditional storage method led to grain damage and loss by pests, and poor quality for marketing. Losses in transport are also high due to poor packaging and handling. Finally, rice mills in Cambodia are inefficient, producing milled rice with less than 60% of paddy. This is attributed to the use of low-quality and poorly maintained milling machinery. Efficient milling should yield 70% milled rice of paddy. The current net loss caused by inefficient milling in economic terms is 9% of rough-rice value (Cameron 1995).

Human resources for developing the agricultural sector remain a major constraint. The 36,000 public- and private-sector staff in the agricultural field frequently lack education and training in research, extension, and management. This is especially true of training in important areas such as high-quality technical training suitable to Cambodian conditions, modern modes of extension, and management operations in a market economy. Public-sector performance in agriculture is further constrained by institutional limitations in management, a general lack of resources, and very low salaries.

Animal production systems and demand trends

Animal resources. Animal resources include cattle, buffaloes, pigs, poultry, and ducks that are commonly raised by small households by integrating crop-animal systems. In 1995, there were 2.6 million cattle, 0.9 million buffaloes, 2.2 million pigs, and 10.8 million chickens and ducks. Currently, these are growing annually at 6.8%, 3.9%, 8.5%, and 7.3%, respectively. Because the animal base was devastated by the civil war from 1975 to 1979, these annual growth rates are impressive.

The order of importance of the species is cattle and buffaloes, followed by pigs and poultry. Goats are kept only in small numbers by Muslims in periurban areas. The large ruminants are important for draft power and are thereafter sold for slaughter and use as meat. Buffaloes are used for land preparation on heavy soils and swampy areas. Only male cattle (mostly steers) are used for traction, but, in the case of buffaloes, both males and females are used until they are slaughtered at 12 years of age. Farmers' dependence on large ruminants for draft power is considerable because the traditional systems include manure for crops and also because of their poverty status and lack of access to credit for the purchase of small tractors. Some 1.2 million cattle and 520,000 buffaloes provide 90% of the draft power, which is valued at US$60–80 million annually.

However, the numbers of draft animals are limited because of the illicit trade in live animals abroad. Some 30% of the farmers do not own animals and have to hire them for land preparation or, in the form of exchange labor, farmers provide male labor for rice transplanting and seeding. Milk production is in its infancy, but is likely to become more important in the future with improvements in the living standards of the people and the open-market policy.

Nonruminants are also important, with pigs raised for meat production and income generation, and chickens and ducks for eggs and meat. Pork is the preferred meat in both rural and urban areas. The pig population shows evidence of upgrading through the use of improved European breeds such as the large white.

The government has a 350-ha National Cattle Breeding Station at Phnom Tamao where *Bos indicus* is the next generation of Brahman. Haryana cattle were introduced into Cambodia in the 1960s but their popularity remains mainly in areas close to the Mekong. The unpopularity of Haryana cattle in other regions of the country is due to the poor quality and shortage of feed resources. The size of the former breed is being combined for draft purposes with the height, speed, and greater hardiness of the latter. The crossbreeding program, however, lacks a clear plan.

The great majority of livestock are raised as an integral part of different types of farming systems, most of which have rice production as the major component. Some specialized intensive meat and egg production and pig production are beginning to develop around major cities and towns such as Phnom Penh and Battambang. While still in its infancy, this increasing trend is due primarily to the expected higher income returns.

Animal production systems. Cambodia's animal production systems are mainly extensive. Tethering of animals in the field or close to the homestead is practiced widely to collect dung for crop cultivation. More intensive systems of ruminant production involving stall-feeding are uncommon. Pigs and poultry are fed mainly with kitchen wastes and rice bran; occasionally, limited amounts of purchased concentrates are provided. There is little or no investment in housing. Pigs are slaughtered at 10–12 months of age at weights of 60–70 kg. Although poultry production is based essentially on scavenging flocks, small-scale commercial production is increasing steadily. Production in these more intensive systems is based on home-mixed feeds. Egg production from improved breeds is about 140–170 per bird in two laying periods, compared with 60–70 eggs per year per bird for native birds. There are no specialized duck production systems. However, the meat and egg supply depends on two production systems, the 5–10 ducks per family and rice-duck systems. Ducks for meat consumption are released in paddy fields after harvesting and these ducks are fed paddy rice in the evening. Ducks are kept for two laying seasons, in which they produce 150–180 eggs.

Feed resources. Feed resources in Cambodia are relatively small areas of native grasslands (about 315,000 ha); herbage from roadsides, wasteland, and rice stubble; and crop residues, broken rice, and agro-industry by-products (AIBP) such as rice bran, soybean, and fish meal. The large grassland areas are found in Kampong Thom Province (99,000 ha), with carrying capacity of about 2.5 adult oxen per ha. Most of the AIBP are exported to neighboring countries for local use in pig and poultry production. The availability of rice straw is influenced by the variety used (IRRI cultivars are short-straw types unlike the traditional long-straw Cambodian varieties) and by harvest method (straw is cut relatively close to the ground level). In addition, hand-harvesting takes place over a long period, so that some of the early material would have decayed by the time animals are allowed to graze the stubble.

Grazing for ruminants is severely limited in the dry season and wet season. Both pasture and rice straw are of low nutritive value, particularly in terms of digestibility and protein. Mineral deficiencies, which have not been accurately assessed, may also be a constraint. Very little supplementation is practiced although limited efforts have been made to treat rice straw with urea. The cultivation and use of leguminous forages are minimal. The onset of rains, on the other hand, increases mortality because of the release of large numbers of nematode larvae. Rain also floods much of the area, which, together with the areas brought under cultivation, reduces the availability of herbage.

Feeding strategies. A feeding strategy for cattle and buffalo is one component of an overall management strategy for livestock. As a consequence of the overall strategy, cattle and buffalo are in certain places at certain times, and what they eat is a function of what is available in that place at that time. This is influenced by the following factors:

- Working requirements of the animals for plowing, harrowing, and other work for a crop. For plowing rice fields, or *chamcar*, that are near the house, the working animal needs to be kept near the house.
- Working requirements for other draft work. For this, working animals may be working away from the house for long periods, for example, when they are used to pull carts when cutting wood in forests. This is commonly done at times other than rice-related work.
- Other farming or nonfarming activities of the farmer. In many cases, cattle and buffalo management and movement are not dictated by the needs of the animal, but by the needs of the farmer to carry out certain activities.
- Labor requirements of supervision and care, to avoid livestock grazing or destroying rice fields, and to reduce wandering and chances of theft. Children commonly supervise cattle and buffalo when they are grazing during the day and return to the house during school days. This may mean that the cattle are taken out around 1100-1200 and return late in the afternoon.
- Lack of feed in the wet season (in lowland areas) because of high water levels, and the lack of feed and/or water in the dry season.

Table 5 gives some examples of different feed locations of cattle and buffalo, the feed materials they may get, and the mode of animal supervision.

For a pig feeding strategy, rice bran is the basic ingredient of most pig diets in Cambodia. In fact, the raising of pigs can be viewed partly as a means of adding value to rice bran or just to save daily income when rice bran is purchased. Rice bran is of medium energy and its protein content is in itself a reasonable feed for pigs. It can be estimated that rice

Table 5. Different types of feeding management.

Location of animal	Feed	Supervision
House	Rice straw	Household
House	Cut and carried grass, tree leaves, crop leaves, residue, or other	Household
Daily movement to field and return to house	Varies according to season and farming system	Close or occasional supervision by member of household, usually children, or villager whose animals are joined into the herd. Animals may be tethered, but usually not.
Long-term movement: away from house for a long period of weeks or months	Varies according to season and farming system. Animals are left to the forest after production period.	Close or occasional supervision by member of household, or animals join a larger herd to be supervised by a hired person.No supervision is done but animals are collected back in the early rainy season.

Table 6. Output of rice milling.

Component	%	Range	Owner[a]	Value kg^{-1} (US$)	Value t^{-1} of paddy (US$)
Whole grain (<35% cracked)	54	47–62	Rice grower	0.30	162.00
Cracked grain (noodle)	8	1–17	Miller	0.20	16.00
Fine cracks	3	1.5–5	Miller	0.15	4.50
Bran	11	8–14	Miller	0.10	11.00
Husk	24	21–27	Miller	0.02	4.80
Total					198.50

[a]Some variation occurs, but this seems to be the most common arrangement.
Source: Rickman et al (1995), for ownership of the components and some indicative prices of the components.

bran makes up about 50% of pig feed ingredients in Cambodia, although variation is significant.

A study in sow raising in Prey Veng showed that rice bran made up about 80% of the diet of breeding sows.

Farmers buy rice bran from the rice miller, who collects rice bran as payment for the milling process. The quantity, quality, and cost of rice bran that is available at local rice mills are the major determinants of the number of pigs that are raised in a village, how well they grow, and how profitable the activity is.

The majority of rice grown in Cambodia is taken to local "farmer-supplied" mills. The miller usually takes by-products such as the finest broken rice, bran, and husk as payment for the service of milling. Alternatively, a fee may be charged, which may be 30–40 riels kg^{-1}, at 1997 prices.

Surveys conducted at 10 rice mills showed their average output (Table 6).

Variation is large in the output of whole kernel according to Table 6 and this is attributable to variations in the quality of equipment used by the miller. Mills should be able to produce a "mill-out rate" (the amount of whole grain produced per ton of paddy) of 63% or better. Given the current payment method for milling, there is little incentive for millers to improve their performance above the current level, estimated at 57% in the survey of Rickman et al (1995).

Milling with higher head rice output is achieved by reducing the amount of broken grain. The quality of bran varies greatly according to the amount of husk, which is a function of the quality of the milling machine. This bran is sold in the market as either first, second, or third grade. The third grade has significant amounts of husk. The husk has a large amount of fiber, which pigs cannot digest; therefore, bran with high levels of husk is poor-quality feed.

Farmers readily recognize differences in bran quality and relative price differences of the three types of bran are fairly constant even though the price of rice bran varies.

Rice grain is also commonly fed to pigs. It is cooked before giving it to the pigs, and the rice bran is added so that a kind of soup is made. The water in the soup is usually the only water that the pigs get. Added also may be leaves or stems of water plants such as water convulvulus (or *trachuan*) or duck weed. Banana stems, cut after harvesting fruit, which is usually twice a year, are also commonly fed to pigs. Pigs are also fed household scraps, and many pigs

are left to forage around the village for feed. The type and quantity of feed vary on a seasonal or area basis, and on the labor requirements to collect the feed. For example, the collection of *trachuan* for pig feed ceased during periods when the family was busy with rice-field work. Rice wine producers feed residue to the pigs.

The quality and quantity of feeds given to pigs are not sufficient for them to reach their productive potential. To achieve this, more expensive feeds would be required. Given the price and the risk of pig sickness or death, farmers are usually not willing to invest in these feeds, even if they were available. However, significant improvement could be made in pig nutrition by better use of locally available feeds and targeting protein-rich feeds to young pigs, as part of an overall better management of young pigs to reduce their mortality.

Besides feeding with grain or kitchen wastes, chickens are free-range scavengers that are fed supplements, primarily energy supplements of white rice or paddy, which are usually cast over the ground in the yard of the house. Young chicks may be given a supplement of white rice equivalent to 250 g per day per 10 chicks (an amount equal to one can or *kompong*). An adult hen with her chicks may be given 50–250 g of paddy per day. Some farmers give nothing to the chickens from November to April, considering that there is sufficient rice in the rice fields on which they roam around.

Demand and supply of livestock and livestock products. Livestock products such as meat and eggs are a source of protein, and fat is a source of energy. The demand for consumption of pork (and pork fat), chicken meat, and eggs is the primary driving force for the raising of pigs, chickens, and ducks.

In contrast, the demand for beef consumption is for the most part secondary to the demand for cattle and buffalo for farm operations, such as for soil preparation, for carrying products, and as a source of fertilizer.

Demand for livestock and livestock products comes from two entities of the livestock system: first from farmers who use the animals in farm operations and second from the private sector, namely, the slaughterhouse owners as well as consumers whose interest in the animals is primarily for food. Most of the transactions that take place are carried out through middlemen.

Table 7 gives a summary of the demand for livestock, when they are alive, dead, or slaughtered.

Table 8 gives some indication of the complexity of the marketing processes that occur in the livestock system. The quantity and direction of trade flows of the items listed are as yet poorly defined, although it is possible to make some broad generalizations.

Domestic demand for meat and eggs is strongest in areas where the population is concentrated, particularly Phnom Penh. Therefore, most trade flow of meat and eggs is from different provinces to Phnom Penh.

Annual meat consumption per person in Cambodia has been estimated at 12.4 kg per year, composed of 3.3 kg of ruminant meat (mostly cattle, some buffalo) and 9.1 kg of nonruminant meat (pigs and poultry).

This estimate is in broad agreement with other published estimates. Delvert (1961) quoted Baradat as estimating annual intake of beef at 1.5 kg per person, pork at 6 kg, and chicken at 1–4 kg, making a total of 8.5–11.5 kg per person per year. Tichit (1981) estimated domestic beef consumption in 1967 at an average of 3.27 kg per person per year, with an estimated annual slaughtering of 8.5% (150,000 head) of the national cattle herd of 1,795,000 and 1.7% (12,000 head) of the national buffalo herd (684,000). The same author estimated that clandestine slaughtering was greater than officially declared by a factor of 1.3.

In this document, herd models for cattle and buffalo, and pigs and poultry, are constructed that attempt to give indicative values for the annual average per person intake of the various animal types. Table 8 summarizes the estimated annual average intakes of a variety of foodstuffs and the amount of protein that they represent.

This intake is strongly skewed between rural and urban populations: meat makes up a much smaller percentage of the protein intake among rural populations than urban. Intake of pork, duck meat, and duck eggs is traditionally considered high among Chinese and Chinese-Khmers, who predominantly belong to the merchant class of the towns and cities.

Quantifying the amount and types of food that farmers eat is difficult but a few generalizations can be made. Rice, fish, and green leafy vegetables are the main foods in the rural Cambodian diet. Rice is estimated to make up 70% of the energy requirements of the average Cambodian villager, and up to 90% in poorer families (Mak, personal communication).

Fish, either fresh or in the form of preserved *prahoc*, is the most important source of protein, but intake varies seasonally. Frogs, crabs, shrimp, and birds scavenged from fields are also a major source of protein.

Farmers themselves consume relatively few livestock products. Chickens are commonly slaughtered at around 6 months of age for special occasions. Farmers rarely consume chicken eggs, but this represents a very small part of the protein intake to meet the protein requirements of the family. As a guide, if a family of six raises two hens, and slaughters half of all chickens for home consumption, the protein from the chickens would represent about 5–6% of the family's protein requirements. Cattle, buffalo, and pigs are sold to slaughterhouses but their meat is rarely purchased in return by the farmers. Pork and beef are commonly consumed at ceremonies. Animals that die from an accident or from disease in the village are commonly consumed by the villagers.

Cambodia has long exported live animals to its neighboring countries, a trade flow that has been characterized by large fluctuations in the number of animals exported and changes in destination. This has been largely due to the extraordinary political and economic fluctuations within

Table 7. Demand for livestock and livestock products.

Livestock	Live/dead	Demand from	Demand for
Cattle and buffalo	Live	Farmers	Males for use as draft power, females for breeders
		Farmers	To produce beef for sale
		Slaughterers	For slaughter (domestic)
		Slaughterers	For slaughter (export)
		Farmers outside Cambodia	Export for draft use
	Products	Farmers	Manure for fertilizer
	Dead	Farmers[a]	Eating
	Slaughtered	Domestic consumers	Edible parts
		Consumers outside Cambodia	Edible parts
		Tanneries	Hides (exported)
		Animal feed makers	Bones
Pigs	Live	Rice farmers	Young pigs to fatten or breed
		Merchants	Young pigs to fatten or breed
		Slaughterers	For slaughter (domestic)
		Slaughterers	For slaughter (export)
	Dead[b]	Farmers[b]	Eating
	Slaughtered	Domestic consumers	Edible parts
		Consumers outside Cambodia	Edible parts
		Animal feed makers	Bones
Chickens	Live	Farmers[a]	Eating
		Market sellers	For slaughter and sale
	Products	Farmers[a]	Eggs
	Dead[b]	Farmers[a]	Eating
	Slaughtered	Domestic consumers	Edible parts
		Consumers outside Cambodia	Edible parts
Ducks	Live	Farmers	Young for raising for egg production
		Farmers	Young for raising for meat production
		Market sellers	For slaughter
	Products	Farmers	For eating eggs
		Consumers	For eating eggs and baby duck eggs
	Dead[b]	Farmers	Eating
	Slaughtered	Domestic consumers	Edible parts
		International consumers	Edible parts

[a]Denotes that middlemen are not usually involved. All other transactions are usually carried out with middlemen. [b]Distinction is made between dead animals and slaughtered animals. Dead animals are those that die from disease or accident, usually in the village. It is common for farmers to sell a very sick animal to a middleman or slaughterer when they think it will die soon, for a discounted price. This type of animal may or may not be taken to a slaughterhouse; the meat will be sold at local markets. Animals that die in the village are commonly slaughtered in the village and the meat is sold locally. Farmers bury the bones of the animals in this case.

Table 8. Estimates of intake per person per year and kg of protein consumed per year for various foodstuffs.

Type	kg (person^{-1} year^{-1})	% protein	kg protein person^{-1} year^{-1}
Fish	40	40	16.0
Cattle and buffalo	3	15	0.5
Pigs	8	15	1.2
Poultry	6.5	15	1.0
Rice	150	6	9.0

Cambodia and neighboring countries over the last 40 years, which has created demand for food across porous international boundaries that are no barrier to a black market where trade is unregulated. The export of cattle, particularly breeding females, has at various times been illegal, having been imposed by Cambodian governments at various times to stop the flow of animals that were considered better used for farming, or breed calves to increase livestock numbers. Given the unrest in the region, it is not surprising that such laws are almost impossible to enforce, with the result that exports are not strictly controlled. Nevertheless, the section on cattle and buffalo production contains an estimate of the number of cattle and buffalo exported based on assumptions of domestic beef consumption and the national herd structure.

From 1950 to 1979, war in Vietnam increased demand for rice and livestock for armies and refugees concentrated in the cities. Vietnam has continued its strong demand for

cattle and buffalo not only for meat but also for draft power. Pigs, buffalo, and rice bran were exported to Vietnam in early 1997.

Economic growth in the 1980s in Thailand and Malaysia fueled demand for cattle, among other agricultural products, and informal reports indicate that this trade flow continues despite the recent Asian economic crisis.

Past trends and current performance in livestock. With the exception of poultry, the growth rate of the animal stock has not been particularly strong in Cambodia. Unfortunately, the lack of data on slaughtering and liveweight does not permit drawing clear conclusions as to the growth performance of different species. Large animals in Cambodia (cattle and buffalo) are still used mostly for traction. Their number has declined over the past decades mostly as the result of introducing mechanization. Pigs also declined from 1996 to 2000 because of the adverse effect of floods. Poultry made quite a remarkable growth in production, which reached an average of 8.8% of total livestock in 1996-2000.

Traditionally, large animals (such as cattle and buffalo) are kept for draft power. Older animals are sold for slaughter in urban areas or for local consumption, and trading of live animals among farmers is to replace old draft animals. Movement of live animals across provinces and trade in large live animals are not commercial.

Demand for meat in neighboring countries is projected to increase. Thailand, Indonesia, and Malaysia are already importing large numbers of live animals. In Vietnam, a shortage of meat is expected in the near future as the living standard is improving. The smuggling of live cattle across the border from Cambodia to Vietnam occurs, but the number is still relatively small. Findings from the SEDP (Socio-Economic Development Plan) field survey in the border areas of Thailand confirm that holding pens for live cattle along the border are established, and undeclared exports of live cattle to Thailand have been ongoing for several years.

In 2000, the Mong Rethy Investment Company (MRT), in a joint venture with the Malaysia RML Company, established the MRT-RML Livestock Corp. (Cambodia) Pty. Ltd., based in Prey Nub District, Sihanouk Ville. Their facilities consist of three holding sheds with a capacity of 2,500 head, which are held for 30–60 days for fattening, before they are loaded onto barges destined for Malaysia. Feed is bought locally, except for concentrate that is imported from Malaysia.

To have sufficient live cattle supplies to fill the feedlots, the company is collaborating with private agents in 13 provinces, some of which are working with district agents with private financing. The company provides scales as well as information on quality requirements for the export of live animals, for example, 40% of the supplied animals must be young bulls in good condition, preferably buffalo. Cambodian farmers commonly castrate young bulls for use as draft animals, and supplies of young uncastrated animals are therefore low. The preferred cattle come from Kratie Province; they have better resistance to disease and significantly higher weight gains than cattle from other provinces. Overall, buffalo are the preferred animal because of their good weight gain and resistance to disease.

Since commencing this export two years ago, the company has shipped more than 10,000 head of cattle to Malaysia, of which 20% are buffalo. Small landing facilities, previously used for the export of mineral sand, are used for loading the animals onto barges. Government inspectors are reportedly present when the animals are loaded for shipment. The reported average cattle weight is 200–250 kg and the current company gate price is 3,000 riels per kg liveweight. Trucks with a trailer are provided to the agents by the company for transportation of live animals, and the road tax (e.g., from Kratie Province) is reportedly 80,000 riels one-way.

The traditional pig breed is common in most rural households and is an important source of protein. The introduced improved pig breed is imported from Thailand and Vietnam by farmers located in border areas and Phnom Penh. Improvement to the local breed is taking place in private-sector operations by farmers buying imported boars.

There is an emerging pattern of farmers with improved breeds. These farmers have received training in animal husbandry and veterinary services, becoming village animal health workers and providing services to neighboring smallholders at a low charge. Their farms become the village demonstration unit for improvement of animal husbandry, including pen building and the use of concentrates. Many of the concentrates come from the CP feed mill, but some are prepared by farmers themselves, using local farm outputs or by-products, mainly soybean, maize, rice bran, and dried fish.

Some animal health workers have set up small veterinary drug stores selling raw materials for feed and HIGRO Pokphand concentrates from the CP feed mill. In Kampong Cham, soybean processors use wastes from bean curd processing as pig feed. One farmer has built a biogas arrangement, using the gas as fuel for cooking.

These pig farms provide an increasing supply of pigs to the local markets and to Phnom Penh. The marketing chain in the open-market system is short, both for input supplies and finished products. A 20-kg improved breed piglet currently costs approximately 85,000 riels. After 6 months, the 100-kg pig sells at the farm gate to local collectors at 4,000 riels per kg liveweight. The crossbreed sells at the farm gate at around 3,000 riels per kg. The incentive for farmers to raise improved breeds and application of proper animal husbandry should adequately justify investment in new technologies.

Occasionally, imports of medium-sized pigs from Vietnam cause a drop in the market price and local piggeries encounter losses. For a short period, two to four trucks with 70 pigs weighing 60–80 kg per head make daily deliveries to Phnom Penh. The reason for these occasional imports was reported to be Vietnam's internally distorted market conditions, and this is not related to the supply shortage and high prices in Phnom Penh.

Socioeconomic aspects of animal production in the context of rice-farming systems. Four socioeconomic surveys of agriculture have been undertaken at different times by different agencies. These have been largely of a diagnostic nature, with limited follow-up interventions. Those with specific reference to animals have been undertaken mainly by NGOs and, to a lesser extent, by the German Agency for Technical Cooperation and IRRI. The International Development Research Centre (IDRC) is about to begin a six-month farming systems survey to include animals in the context of natural resource management. Analysis of data collected indicates that the contribution of animals to total farm income is considerably high, but the extent of this depends on the wealth of farmers and their involvement in off-farm activities. Preliminary data from a survey of households by IRRI suggested that animals contributed 29% to total farm income and 75% to agricultural income (Helmers 1997, and personal communication). However, this varies according to the income level of farm households. For poor, middle, and wealthy households, the contribution of animals to total income and agricultural income was 45% and 75%, 25% and 80%, and 18% and 71%, respectively (Helmers 1997, and personal communication).

Constraints to animal production in Cambodia. The three major constraints to livestock production are diseases, feed sources and nutrition, and the low genetic potential of native breeds. However, the low genetic potential of local breeds would probably improve with a better quality of feed. Diseases are problems for both ruminants and nonruminants. Their severity affects productivity and causes high mortalities with consequent loss of cash income. It has been observed that some contagious diseases cause a high rate of mortality. Cattle and buffaloes commonly suffer from hemorrhagic septicemia, blackleg, foot-and-mouth disease, and anthrax. Pigs are affected by swine fever, pasteurellosis and salmonellosis, foot-and-mouth disease, and erysipelas. Newcastle disease and cholera are found in chickens and cholera is a common disease of ducks. Several diseases are found but no specific steps have been taken to overcome these by national organizations with international support. Five NGOs are involved actively in the training of local government agents who undertake vaccination in villages. Diseases arise because of poor veterinary services. However, it is likely that undernutrition and poor management contribute to these problems. Native breeds are perceived to be of low productivity by farmers, and genotype is regarded as a constraint to production. However, the realization of genetic potential may simply be a matter of improving nutrition, management, and disease control rather than the introduction of exotic breeds of often dubious value.

There are clear opportunities to improve the ruminant feed supply and its use. Urea treatment of straw and the use of nutritional blocks of urea, rice bran, and molasses are already being promoted. Grasses such as Napier grass are being sown on paddy bunds, and herbaceous legumes such as species of stylo could be sown on roadsides to be used by animals. Multipurpose trees could also be sown on paddy bunds and around households, while annual legumes could be established as relay crops in lowland rice. Significant developments have been made in the last decade in the selection of legumes adapted to acid, infertile soils and these legumes are more productive than the older Australian cultivars.

The majority of Cambodian farmers are too poor to invest in animal production without any support. The lack of a government assistance project to support the rural poor together with the high interest rate for loans from credit institutions discourage farmers from including animal production in their farming system. Unlike rice production, animal production needs to pay for medical care, including medicines, vaccinations, and veterinary costs, and some material and equipment are also costly. The development of ICAS, which involves different parties, rice and nonrice crops, and animal scientists and extension workers, could face difficulty since crop and livestock specialists usually come from different institutes with different philosophies.

ICAS typology on rice-based farms

Crop-animal interactions benefit small farmers and contribute to the sustainability of mixed farming systems. Draft animals can speed up farming operations such as plowing and cultivating, and increase the land area prepared for cropping. Improved tillage requires extra power, for which resources of male labor are presently inadequate, while soil conservation operations such as terracing and ridging are unlikely to be done by male labor. Animals can provide the required extra power.

The lower compaction resulting from land preparation using animal traction, compared with tractor plowing, also reduces erosion hazards. In Cambodia, hillsides have been leveled into terraces for rice fields, and then re-leveled using draft animal power annually to ensure an even spread of water and its re-distribution to the lower paddies. Without such a system, erosion of rice fields would have made farming unsustainable within a few years. The vast majority of farmers in the region could not afford to buy tractors to replace draft animal power. The use of renewable animal power instead of nonrenewable fossil fuels and tractors has, among other things, reduced carbon dioxide and carbon monoxide emissions into the atmosphere.

There are many interactions between crops and farm animals in Cambodia. At times, livestock may be the only way farmers can benefit from community resources, such as grazing lands or forests. Livestock provide an alternative market for crops with the use of low-quality roughages and poor-quality grains. In addition, livestock ownership provides a safe investment that can be stored and that produces an increased return through reproduction and gain in body weight. This flexibility in marketing and savings adds to the sustainability of farm enterprises and protects against natural calamities.

However, livestock do compete with food crops for land and labor. Forages may occupy land or can be intercropped

Table 9. Main crop-animal interactions in mixed farming systems.

Crop production	Animal production
Crops provide a range of residues and by-products that can be used by ruminants and nonruminants.	Large ruminants provide power for operations such as land preparation and soil conservation practices.
Native pastures, improved pastures, and cover crops growing under perennial tree crops can provide grazing for ruminants.	Both ruminants and nonruminants provide manure for the maintenance and improvement of soil fertility. In many farming systems, manure is the only source of nutrients for cropping. Manure can be applied to the land or, as in nonruminant systems in Cambodia, to the water that is applied to vegetables whose residues are then used by nonruminants.
Cropping systems such as alley-cropping can provide tree forages for ruminants.	The sale of animal products and the hiring out of draft animals can be used for crop production inputs such as fertilizer and pesticides. Animals grazing vegetation under tree crops can control weeds and reduce the use of herbicides in farming systems.
	Animals provide entry-points for the introduction of improved forages into cropping systems. Herbaceous forages can be sown in annual and perennial crops and shrubs or trees established as hedgerows in agroforestry-based cropping systems.

with food crops, planted in hedgerows, or confined to land types that are difficult to manage. Livestock definitely compete for farm labor, which is needed to feed and care for the animals and process the resulting products.

Crop-animal interactions

The integration of crop and animal production is particularly well developed in the rainfed lowland farming systems of Cambodia, particularly those in smallholder agriculture (Table 9).

Animal traction. Draft animal power has a long history of use in smallholder farming systems in Cambodia. Larger ruminants provide power for land preparation, soil conservation practices, and haulage.

Draft animal power is especially important in farming systems that are isolated from infrastructure and have a high land-to-population ratio. Both buffalo and cattle are used for farm power, although buffaloes are the most important draft animal in Cambodia.

Animal feed from crops. Crop production provides a range of residues and agricultural industry by-products (AIBP) that can be used by ruminants and nonruminants. These include cereal straws (e.g., rice and maize), sugarcane tops, grain legume haulms (e.g., peanut and cowpea), root crop tops and vines (e.g., cassava and sweet potato), oilseed cakes and meals (e.g., oil palm kernel cake, cottonseed cake, and copra cake), rice bran, pineapple and citrus pulp, cocoa pod husks, coffee seed pulp, and bagasse.

In Asia as well as in Cambodia, rice straw is the principal fibrous residue fed to more than 90% of the ruminants.

Weed control. Animals grazing vegetation under perennial tree crops such as rubber, oil palm, and coconut can control weeds and reduce the cost of herbicide use. In rubber, the cost of herbicides can be as much as 30% of the total production cost in the early years of the plantation. Most of the native vegetation of grasses, legumes, and broadleaf plants (often 60–70% of floristic composition), found in the interrows of rubber plantations, is acceptable to ruminants such as sheep. Compared to using herbicides, which need protective measures to minimize contamination, the use of sheep is safer for the operator and the environment.

Manure. Both ruminants and nonruminants provide manure for the maintenance and improvement of soil fertility. Manure is used widely throughout Cambodia. Where the use of artificial fertilizers is low, soil fertility depletion is a major constraint to agriculture, particularly in the humid and subhumid climates. Even when inorganic fertilizers are applied, crop yields may not be maintained under continuous cultivation on poor-fertility sandy soils with a low buffering capacity. The use of only mineral fertilizers can decrease soil pH and base-saturation and increase aluminum toxicity. Organic materials applied in bulk can improve soil texture, promote better absorption of moisture, reduce runoff, and prevent crusting of the soil surface. Even small quantities of organic materials can bring about marked improvements in the cation exchange capacity of soils. Manure is also valuable in reversing the deterioration in soil structure in sodic soils, characterized by a high content of exchangeable sodium and low permeability.

A framework for describing livestock-rice systems. A farming system can be described by the flows of three quantities: protein, energy, and cash. There are opportunities for exchange among these three categories (for example, energy or protein can be bought or sold). But, in subsistence and semisubsistence systems such as those found in rural Cambodia, these three flows are not well integrated through the cash economy. It makes sense to treat them separately, since all three need to be provided for the maintenance and development of rural households.

If this framework is accepted, the different contributions of livestock and rice to "rice-based farming systems" become more readily apparent.

Protein and energy are the most important components of food. This is not to belittle the importance of the other components of food, such as vitamins and minerals, and a certain amount of fiber. Obviously, water is critical to any form of life also. The use of a protein-energy-cash approach to understanding farming systems is not meant to preclude these other entities; it is intended simply as a framework for understanding and describing the major interactions in rice-livestock farming systems.

An analysis of how these three quantities—energy, protein, and cash—flow within a farming system needs first to consider the nature of the demand for each quantity: how much protein, energy, and cash are needed by a family over a year, when are they needed, and in what quantities?

Second, the analysis needs to consider how and when the quantities are produced, including the amount of each quantity needed as an input to production, and when that input is needed.

Third, the method of storage of each of the quantities needs to be taken into consideration to minimize losses during storage.

Last, there needs to be some consideration of how, within a specific farming system, the three quantities are interchanged, or, in other words, how one quantity is converted to another.

Rice is the major source of energy for Cambodian farming families, and can be considered almost synonymous with the word "energy" in the Cambodian farming system. It is needed every day and the amount needed varies according to the number of family members and the activities they are carrying out. For example, a mother nursing a young baby will need extra rice to produce milk, and any member of the household who is doing hard physical work will need extra rice to eat.

Rice requires labor (energy), which is an important input for production, both human and animal, which may or may not be purchased with cash, depending on the individual situation. Cash is usually required to purchase seed and chemical fertilizer. The amount and availability of labor inputs for rice production depend on the rice production system—wet season, early wet season, dry season, floating. It is hard to set a fixed deadline for rice production because it also obviously depends on the same factors.

Rice is mostly stored as paddy and taken to the mill for milling. Processing is usually a cash-free transaction. Paddy is stored relatively easily, and the risk of wastage from damage or theft can be kept to a minimum. Risks involve drought, flood, pests, or other causes of crop failure or reduced yield.

Rice can be exchanged for cash, which is a long way to say "sold," in cases when there is an excess above home consumption needs, or when cash is needed and rice is the best alternative to sell. An advantage in converting rice to cash is that it is not "lumpy." Small or large quantities of rice can be sold. This is in contrast to the sale of animals, which is lumpy. The minimum you can sell is one head.

Income from rice selling is used to pay debt incurred by the farmer and this is a form of converting rice to cash. Payment with rice to pay back the hiring of animals is a form of converting rice to energy without a cash transaction. The exchange of rice for protein is not a common practice.

An important point about rice production is that, on farms where all the rice is used for human consumption, and cash has been spent on the crop (e.g., for fertilizer), rice is a net cash consumer.

In farming systems where rice is produced largely for sale, such as is often the case with dry-season recession rice, rice should not be considered as an energy source, but rather a cash source. There is obviously a large gray area in between considering rice as a cash source on the one hand or as an energy source on the other: this will vary from farmer to farmer, year to year, and system to system. An understanding of this concept is a key point in understanding a farming system.

Rice straw is a by-product of rice production that provides a major energy source for cattle and buffalo. It is therefore appropriate to consider it as a major energy product of rice production. Rice straw is not needed year-round, but is needed during those periods of the year when grazing is not available, which is usually in the late dry season and wet season. Inputs to the production of rice straw are obviously the same as those for rice. The timing of production also obviously follows that of rice.

Rice straw is stored relatively easily, and losses from damage, usually by water, can be kept to a minimum by good stack design and putting the stack in a place where it will not get flooded. Rice straw can be processed into useful feeds, by combining it with water and other feeds, and into usable energy and protein by being fed to cattle and buffalo. Rice straw is a tradable item: it is converted to energy when it is used to pay laborers, and is converted to cash if sold to other farmers.

Humans need protein every day and, similar to energy, the amount of protein needed by a family will depend on the size, nature, and activities of the family members. Larger families obviously need more protein than smaller families. Growing children need a greater portion of protein in their diet than do adults; a nursing mother needs a high amount of protein also for good milk production.

Protein produced and consumed by farm families is usually in the form of fish and chickens, in some cases also chicken eggs. Variation is large among households in the same farming system. There are various types of fish production: fish can be captured from wet-season canals, wet-season rice fields, lakes, and rivers, or cultivated in ponds. Chicken production varies little, mostly being free-range household scavengers with small amounts of feed supplements.

Inputs to production of fish and chickens vary but are usually relatively low in terms of both energy (labor) and cash. Of these production systems, pond fisheries probably have the highest inputs of labor for constructing ponds and cash for feed.

Wet-season canal fish capture, like dry-season lake or canal capture, has inputs of only some labor and a small amount of cash for equipment. Rice-field fishery capture's only input is some labor to dig a trench. Chicken raising has cost at the start of production for purchasing stock: feeding is mostly a direct conversion of paddy energy stores to protein because the chickens may be fed some paddy.

The period of protein production varies according to the source. Catching of fish is a common dry-season activity for many farmers who travel to areas such as Tonle Sap or other lakes and ponds specifically for this purpose. During the wet season, fish are captured from canals around rice fields. At the end of the wet season, when rice fields are drying out and harvesting approaches, fish are captured from rice fields. During the dry season, ponds dug near the house specifically for fish capture are an important source of fish.

There is no specific seasonality of edible chicken availability. Chickens could bring about disease outbreaks, which seem to commonly occur at the end of the dry season. Though less information is available on chicken disease outbreaks, chickens will be sold or eaten in the face of an outbreak of disease, and availability of edible chickens will increase slowly again over the wet season.

Storage of fish protein is very common in Cambodian villages, in the form of *prahoc*. In many areas, preserved fish is a major source of protein for the family for many months of the year. Digging of ditches near rice fields and of ponds near houses is in effect a form of storing live fish: these practices lead to an extended harvesting period beyond the harvesting date. There is no form of storage of chicken postslaughter. It is unusual to see chickens raised beyond the age of 6 months, which is the optimum time for selling or eating them, except for breeding birds.

It is clear from this discussion that there is considerable interchange between protein and cash. Any of the above protein sources, the various kinds of fish and chickens, can be easily converted to cash, or vice-versa, according to the needs of the family at certain times of the year and according to the type of farming system operated. One common example of conversion of fish protein to cash is the case of fish raised in ponds near houses over the dry season: selling these fish at the end of the dry season earns cash for celebrating the Khmer New Year.

This raises the question, similar to that noted above for rice, as to whether a certain activity in fish or chicken production should be classified as protein-producing or cash-producing. This may vary from farmer to farmer, from year to year, and from farming system to farming system. Again, the understanding of this is a key to understanding the farming system.

Fish and chickens can be sold at a minimum amount of one. It is not appropriate to call them "lumpy" assets since they are so small. Preserved fish can be traded in small quantities.

It may be tempting to attempt to correlate the degree to which cash is generated from each of these individual types of protein production with the degree to which each individual type of production needs cash. This, in fact, is the basic assumption made by those who carry out, for example, a gross margin analysis of any of the individual production types, such as chicken raising or fishpond production. Of course, the subsistence farming system is more complex than that, and this is one more reason to use a protein-energy-cash framework for understanding the farming system, rather than trying to convert all farm interactions to a common denominator of cash.

The nature of a farmer's need for cash is a complex issue: cash is needed to buy food not provided by the farm, for farm operating costs, for clothing and schooling costs, and for fulfillment of social and traditional activities such as weddings or religious festivals. An analysis of a farmer's cash demands can become hopelessly complex to the point where a roomful of sociologists and economists could be employed full-time for years. This is not the aim of those wishing to understand farming systems as a stepping-stone in doing something to help farmers.

Cattle, buffalo, and pigs can be considered primarily as cash producers for the farmer. But it is critical to understand the differences among them.

Pigs are cash producers in the purest form. They are raised in response to a demand from the farmer to generate cash, which occurs whether or not a profit is made.

Production requires cash and a small labor input. A capital cash input is required for the purchase of the pig and for any housing. Cash is needed on a more or less daily basis for feed, since rice bran is a basic feed and it must be bought from the rice-miller. The rice portion of the diet may be considered an investment of energy for a future cash return. Extra cash will be needed for treatment if the pig is sick.

The amounts of inputs for growing fatteners are related to the pig's stage of life: cash to buy the young pig, and an ever-increasing daily amount to buy feed as the pig eats more as it gets older.

The time to sell is also related to the animal's weight. There are two optimum weights for selling fatteners, either 3–4 months after purchase or 6–8 months, which suit the two markets of farmers who wish to buy pigs to "finish" or the slaughterhouse.

Farmers decide when they will buy piglets, and they do not have much leeway in deciding when to sell the pigs, with relatively little regard for seasonal conditions outside their control. This means they can manage the need for inputs and generation of outputs according to their own plan. This is in contrast to rice production, which is seasonally determined.

Fatteners are not the best means to save cash: to keep them beyond the optimum selling weight is very inefficient. A high risk of sickness and death gives pig keepers even more risk.

Breeding sows, on the other hand, because of their longer production cycle, are more useful as cash savings that can be mobilized at a range of times. The optimum sow age is

around 3–4 years, but the sows can be kept even longer if they can produce good litters and do not lose weight; then, they can be considered as efficient producers.

Breeding sows are better producers and stores of cash than fatteners since they have a low sick or death rate. Fatteners have the advantage of less capital cost, and they require less experienced pig keepers.

Cattle are raised by farmers primarily in response to a demand for energy for draft power. However, cattle can generate significant amounts of cash and can be considered as a rich source of income. Breeding animals generate cash through sale or calves, and draft cattle through activities such as transporting logs and draft power in farming.

Cattle production requires minimal cash inputs after the initial investment in stock and equipment, such as plows, harrows, and a cart as well. A purchase of a breeder requires no further cash for equipment. Running costs are mostly family labor and rice straw (energy) inputs, except for the ongoing repair of equipment or treatment of sick animals. Both cattle and buffalo have the advantage of being able to graze in fields. Therefore, cattle can be considered as low-input production but they produce high energy and income.

Inputs are largely seasonally required, but, since these are mostly noncash, the implications are only important insofar as they may divert labor from other tasks. Since children can be responsible for taking care of cattle, there is little effect on key family labor for farm operations.

Cattle are an extremely efficient source of both cash and energy in Cambodian farming systems. Their long productive lifetime of up to 8–10 years means that they maintain their value very well. They can lose weight during periods of poor feed supply and during good times without serious penalty to their own well-being, as long as no severe feed shortage occurs when they are very young. This is in contrast to rice, which, because of its relatively short productive life, can be seriously affected by a range of setbacks. Young animals risk death or sickness as well as theft, whereas rice production does not face this problem.

The value of cattle is partly as a cash source as they can be easily sold to existing markets as breeders, as draft animals, or in terms of beef, either for domestic consumption or for export. There is variation in mobilizing the cash asset according to the proximity to markets. In this aspect, cattle are a lumpy asset: a minimum of one head can be sold. For this reason, they tend to be sold when there is a "lumpy demand" for cash, such as when crop failure occurs.

Draft animals can be cash generators of an extremely "unlumpy" nature. Examples of such cash generation are log transport or farm draft power. These are both examples of converting the energy inside them to cash.

Buffaloes are adapted to soil preparation under wet or heavy soil conditions that do not suit cattle. They represent an efficient storage of energy and cash, with a longer period of productive life than cattle, although their susceptibility to disease when they are young reduces this effectiveness. Because females can be used for plowing also compensates for the drop in cash-generating ability that comes from their poor reproduction and relatively high young mortality rate. Buffaloes are not sold as easily as cattle because their meat is not popular in Cambodia, although there appears to be no such prejudice in neighboring Vietnam.

Competition between crops and livestock

Cambodia has an estimated 1.2–1.3 million farming households. These farmers have been divided into four groups with different agricultural practices and attitudes:

- Rice producers, most of whom produce rainfed lowland rice, own a few animals, and make a small income from sugar-palm tapping. Other rice farmers grow either flood recession paddy rice or floating paddy and earn money with seasonal work in cities and towns or by cutting and selling wood.
- Commercially minded nonrice farmers who produce and sell crops such as tobacco, fruit, and vegetables on river banks, such as vegetable farmers in Kien Svay.
- Upland farmers who make a living from permanent or seasonal crops such as soybean and mungbean, and keep livestock integrated with the rice crop.
- Indigenous farmers who practice swidden agriculture in the northeast of the country.

Livestock and rice-farming systems

At the farmer level, livestock production in most parts of Cambodia is so intimately related to rice production that neither can be studied or understood in isolation from the other. Similarly, in the private sector, activities of those entities involved with processing and marketing of rice and rice by-products have a direct impact on livestock production, since rice by-products such as straw, broken rice, and rice bran are the basis of animal feeds.

Women and children in the crop-livestock system

One of the farming situations in which women and children make a pronounced contribution to on-farm and nonfarm labor is crop-animal production. On such mixed farms, the work is diverse and intensive so that family members (men, women, and children) need to help each other.

Generally, labor is rigidly divided between men and women in agriculture. Men are in charge of land preparation, irrigation, fertilizer application, and mechanical threshing, whereas women are responsible for soaking and broadcasting seeds, pulling seedlings, transplanting, weeding, controlling rats, harvesting, cleaning, drying, storing, animal raising, feeding, purchasing, selling, and also social activities in the village (ceremonies, meetings, and credit). Male children do land preparation whereas female children do harvesting. Both male and female children do transplanting.

For animal care, women and children perform a major role in feeding, watering, and grazing. Furthermore, the control, feeding, and marketing of swine and poultry on a backyard farm are mostly done by women. This demonstrates

that the important contribution of women and children in a crop-livestock enterprise should be incorporated in research methodologies and analysis.

Attitudes toward livestock

Livestock production and marketing are activities generally divided along lines of ethnicity because of the various religious beliefs and customs of the different racial groups in Cambodia.

The majority of Cambodian farmers are Khmers, whose attitude toward livestock is strongly influenced by their Buddhist religion, culture of subsistence, and emphasis on rice production. A Buddhism rule states that Buddhists have to respect all living things and cannot treat animals badly, kill them, or raise them for slaughter. If a person does a bad thing to an animal, that same thing will happen to the person in the future. This is known as committing a sin (*tver barb)*. There is no prohibition, however, on the eating of meat.

Despite these precepts, Khmers commonly raise pigs for slaughter; cattle and buffalo, though raised mainly for draft power, are destined for slaughter; poultry are also raised for slaughter. This shows a certain pragmatism in following precepts when family economic fortunes are at stake. The extreme example of the prohibition of slaughtering seems to largely remain, however, and the slaughtering business is run by others: the Chinese dominate pig slaughtering and the Cham people (Muslim) dominate cattle and buffalo slaughtering.

Chinese populations, who are, generally speaking, city- and rural-based merchants, also dominate the duck production system, and, not surprisingly, they are high consumers of pork, duck meat, and eggs. Cham people do not raise pigs or consume pork. Cham farmers in rice-growing areas often have cattle-raising as a significant enterprise; they also raise some goats and sheep. Many Vietnamese middlemen in the pig industry commonly provide services to farmers such as castration of young male and female pigs.

Ethnic minorities in northeastern Cambodia believe in spirits that inhabit the environment, and that determine the fortunes of the people. As a result, their attitude toward animals is entirely different from that of the Khmers. These minorities readily slaughter animals for sacrificial purposes. In farming practices, they do not use cattle or buffalo for plowing their upland fields, but these animals are highly valued for sacrificial purposes.

Intensification and sustainability of ICAS

Livestock development is foreseen as a potential livelihood in rural areas for improving nutrition and generating income. Providing opportunities for the development of smallholders fits well with the government policy for food security and poverty reduction by supporting service for livestock owners in animal husbandry, disease prevention, credit, and marketing. A medium- and long-term approach is the privatization of the animal health, and production technology and service sectors, which are to be managed and coordinated provincially and nationally by the Department of Animal Health and Production (DAHP), with a mandate from all stakeholders nationally and internationally (National Strategic Plan for Animal Health and Production, DAHP 2000). Improved profitability is needed, however, to encourage investment in livestock production. This is related to the production of better-quality feed, which could increase livestock yield.

Farming systems that are ecologically, biologically, and socioeconomically sound involve crops and animals and also depend on their integration with other farm practices. The integrated crop-livestock farming system can be considered sustainable because it focuses on the use of renewable resources. Consequently, because of the efficient use of solar-energy-based resources (i.e., forages, crop residues, and by-products), there is less use of external inputs, fertilizers, and pesticides that would affect the environment. Crop and animal integration would be an alternative methodology to maintain the environment.

The use of broken grains and by-products of rice and other crop production is a sound economic practice. Crop residues are a major source of feedstuffs for ruminants. Rice straw provides a major source of usable crop residue. The potential value for underused by-products should be fully obtained.

Animal manure is an important source of nutrients to maintain and improve soil fertility and minimize the use of inorganic fertilizer. A major portion of important plant nutrients ingested by ruminants is returned to the soil via feces and urine. Of the plant nitrogen and minerals consumed by grazing cows, 95% of the nitrogen and 96% of the minerals were returned to the soil. Animal traction as a source of farm power reduces the use of petroleum in farm operations, thus minimizing the polluting effect of fuel combustion for machinery. With integrated rice-duck farming, ducks could serve as a biological control for rice pests, including weeds and snails. This would reduce if not eliminate the use of chemical pesticides, which harm both the environment and humans.

These are just some of the sustainable characteristics of the integrated crop-livestock farming system. Conceptual models are needed to study the interrelationships and to identify areas that need further investigation to derive improved alternative production systems.

There is a need for better management of the use of additional sustainable feed resources and credit availability to build stocks. The potential for increasing livestock production is a useful methodology for encouraging national and international investment in commercial livestock farms. This investment could boost local capital/credit and technology transfer, resulting in an improvement of local and household production and processing of raw materials for animal feed such as maize and soybean.

References

Cameron A. 1995. Overview of the marketing of agricultural products in Cambodia. Ministry of Agriculture, Forestry, and Fisheries, Phnom Penh, Cambodia.

Chandler DP. 1993. The beginnings of Cambodian history. In: A history of Cambodia. 2nd ed. Boulder, Col. (USA): Westview Press.

Delvert J. 1961. Le paysan cambodgien. Phnom Penh: Mouton & Co.

Helmers K. 1997. Rice in the Cambodian economy: past and present. In: Nesbitt HJ, editor. Rice production in Cambodia. Manila (Philippines): International Rice Research Institute. p 1-14.

Javier EL. 1997. Rice ecosystems and varieties. In: Nesbitt HJ, editor. Rice production in Cambodia. Manila (Philippines): International Rice Research Institute. p 39-81.

Lando RP, Mak L. 1991. Srey Ampal: a baseline survey of dry season rice in Cambodia. Baseline Survey Report No. 4. Manila (Philippines): International Rice Research Institute.

MAFF (Ministry of Agriculture, Forestry, and Fisheries). 1996. Department of Planning and Statistics. Bulletin of Agricultural Statistics and Studies, No. 2. Phnom Penh, Cambodia.

Ministry of Planning. 2003. National Institute of Statistics. Bulletin of National Accounts of Cambodia 1993-2002, No. 7. Phnom Penh, Cambodia.

Nesbitt HJ, editor. 1997. Rice production in Cambodia. Cambodia-IRRI-Australia Project. Manila (Philippines): International Rice Research Institute. 112 p.

Nesbitt HJ, Chan Phaloeun. 1997. Rice-based farming systems. In: Nesbitt HJ, editor. Rice production in Cambodia. Manila (Philippines): International Rice Research Institute. p 31-37

Paris TR. 1992. Providing a framework for gender impact assessment of CIAP's technologies and identifying strategies to address gender issues in CIAP's research and training activities. Cambodia-IRRI-Australia Project. Phnom Penh, Cambodia.

Pingali PL. 1988. Kampuchean rice economy: an overview of the constraints to output growth. Manila (Philippines): International Rice Research Institute.

Rickman JF, Om S, Khiev CT, Nhem S. 1995. Farm mechanization and crop production in Cambodia. Baseline Survey Report No. 5. Manila (Philippines): International Rice Research Institute.

Tichit L. 1981. L'agriculture au Cambodge. Paris: L'Agence deCooperation Cuturelle e Technique.

Notes

Author's address: Socio-economics Program, Cambodia Agricultural Research and Development Institute (CARDI), Phnom Penh, Cambodia.

Current status of integrated crop-animal systems (ICAS) in Vietnam: a case study in the Mekong Delta

Le Thanh Duong, Nguyen Duy Can, and Tran Thi Phan

Executive summary

Being the main rice bowl of Vietnam, the Mekong Delta region produces more than one half of the total rice production of the country. The Delta currently has about 2 million hectares under rice cultivation. Approximately 70% of the rice area is irrigated or semi-irrigated lowlands and 30% is rainfed lowlands. The Delta has three major rice cropping systems: double, triple, and single rice cropping, of which 80% of the area is cultivated with modern rice varieties. Triple rice cropping is practiced on alluvial soils under irrigation and shallow or noninundated areas. Double rice cropping is most commonly practiced in the Delta and in floodplain areas on slightly and medium acid sulfate soils, and in rainfed coastal areas. Single rice cropping (mainly traditional local rice and medium-duration rice varieties) is practiced in rainfed areas. Crops other than rice are mostly practiced in double and single rice-cropping systems with upland and field crops, or aquaculture with fish and shrimp (both in fresh and brackish water).

Although the Mekong Delta is famous for rice production, it can produce a remarkable amount of different kinds of fruits, fish, and, most recently, brackish-water shrimp (tiger and banana shrimp) for high-value exports. Besides rice and other crops, shrimp, and fish, farmers raise livestock and poultry for family consumption and for cash, of which cattle, pigs, chickens, and ducks are the most common. Results from recent farming systems research projects showed positive responses in farm household livelihoods and economic viability when farmers practiced integrated farming systems. However, small-scale livestock production is most common, and few farmers raise chickens on a large scale. According to the 2000 census, the number of head of major livestock by type are cattle, around 0.2 million head; buffaloes, 0.064 million; and pigs, 2.97 million. Chickens and ducks are mostly for home use, with 20–50 head per household. In addition, the level of integration of livestock and poultry with rice cultivation is different among agroecosystems and depending on household economic situation.

The increase in demand for food, not only for rice but also for other crops and protein products, including fish, shrimp, meat, and milk, is expected to take place with a further expansion of the population in the Delta to about 17.7 million in 2005 and 18.9 million in 2010. As we explain, the growth in the demand for meat and milk is of great importance as daily composition of the diet changes such that people will consume more animal protein and less rice. The role of animals in filling the needed total calorie requirements of the people will become more and more crucial. The largest source of animal protein among the small farm households has been from integrated crop-animal systems (ICAS). These systems have so far been undertaken on a small scale and the types of animals integrated with rice and aquaculture vary by agroecosystem. Intensifying these systems is necessary to prepare for the expected increases in animal requirement for food. Further development of ICAS, however, depends on factors that include technical aspects and agro-physical conditions, socioeconomic conditions, and the political environment.

The project on "Sustainable food-feed systems and improved livelihoods of the poor in rainfed lowland areas" is implemented to understand the dynamic behavior of farm households in the ICAS systems and to determine the ways to further strengthen these systems. This phase aims to provide more detailed characterization of ICAS based on the socioeconomic characteristics of farm households as well as other nontechnical factors that influence these systems in different locations and countries in Southeast Asia. This country monograph provides a backdrop of the project by reviewing the current status of integrated crop-animal systems, particularly focusing on the Mekong Delta of Vietnam, with the following objectives:

1. To describe the evolution of ICAS, especially in rice farming systems.
2. To identify issues and gaps in the intensifications of ICAS.
3. To determine research and policy implications for intensifying and sustaining ICAS.

The entire endeavor aims to identify ways and means to strengthen crop and animal systems to help farmers improve their well-being.

Introduction

Vietnam is situated in Southeast Asia and extends from 104°50′ to 106°50′ E and from 8°40′ to 23°50′ N, with a total area of 32.924 million ha. The country is divided into 61 provinces and cities (Fig. 1). Based on geographic and physical features, Vietnam can be conveniently divided into seven agroecological zones: the midlands and northern mountainous region (MNM), the Red River Delta (RRD), the north-central coastal region (NCC), the south-central coastal region (SCC), the western high plateau (WHP), the southeastern region (SE), and the Mekong Delta (MD) (Xuan V-T et al 1995).

The agricultural land use in 2000 occupied about 9.35 million ha, split into annual crop land (6.13 million ha), perennial crop land (2.18 million ha), pasture land (0.04 million ha), miscellaneous gardens (0.6 million ha), and aquaculture land (0.37 million ha). Forestry occupied about 11.6 million ha of land area. The remaining land has special uses (construction, transportation, irrigation, etc.). Rice-based systems dominate crop production in Vietnam, with paddy land covering about 4.5 million ha (about 14% of the total natural land area of the country). Cultivated rice area has expanded each year, with a growth rate per annum of about 2.5%. However, the trend for expanding rice area in the future is limited because most suitable rice land has been exploited.

In 2002, rice production accounted for about 34.47 million tons, with an average yield of 4.5 t ha^{-1} (Cantho Statistics Office 2003). Rice production in the northern part of Vietnam (the RRD, MNM, and NCC zones) strongly depends on weather conditions, soil type, and availability of water resources. For example, farmers in the RRD have faced unfavorable natural conditions such as low temperature in the winter, degraded soil fertility, typhoons, and floods that are not conducive for growing rice. As a result, monoculture rice cultivation or triple rice cropping is not widely practiced. Two rice crops per year integrated with vegetables, animal production, and fish farming are the most common systems among farmers. These types of rice farming induce the natural integration of rice and livestock with the former providing by-products to feed animals and the latter providing manure to fertilize the rice fields.

In the central and southeastern regions of Vietnam (the WHP, SCC, and SE zones), the conditions for rice production are even more adverse than those in the north. Soils with low fertility, inadequate water for irrigation, drought, typhoons, and even flooding are common problems in growing rice. The increase in rice production in these regions came mainly from expanded area because of the introduction and development of irrigation systems. In the WHP region, some large areas are still not cultivated but are suitable for growing grasses for livestock raising. The vast areas in rainfed ecosystems are more suitable for systems of one paddy crop followed by cash crops. For instance, on the gray and red soils in Dong Nai, Binh Phuoc, and Ho Chi Minh, rainfed lowland rice is grown in rotation with peanut, or in combination with maize, mungbean, or soybean. Other cropping patterns include rice-rice-vegetables, rice-rice-peanut, rice-vegetables-peanut, peanut-peanut-rice, and monoculture rice. Livestock raising, especially cattle, pigs, goats, and chickens, is an important component in the rice-farming systems in these areas.

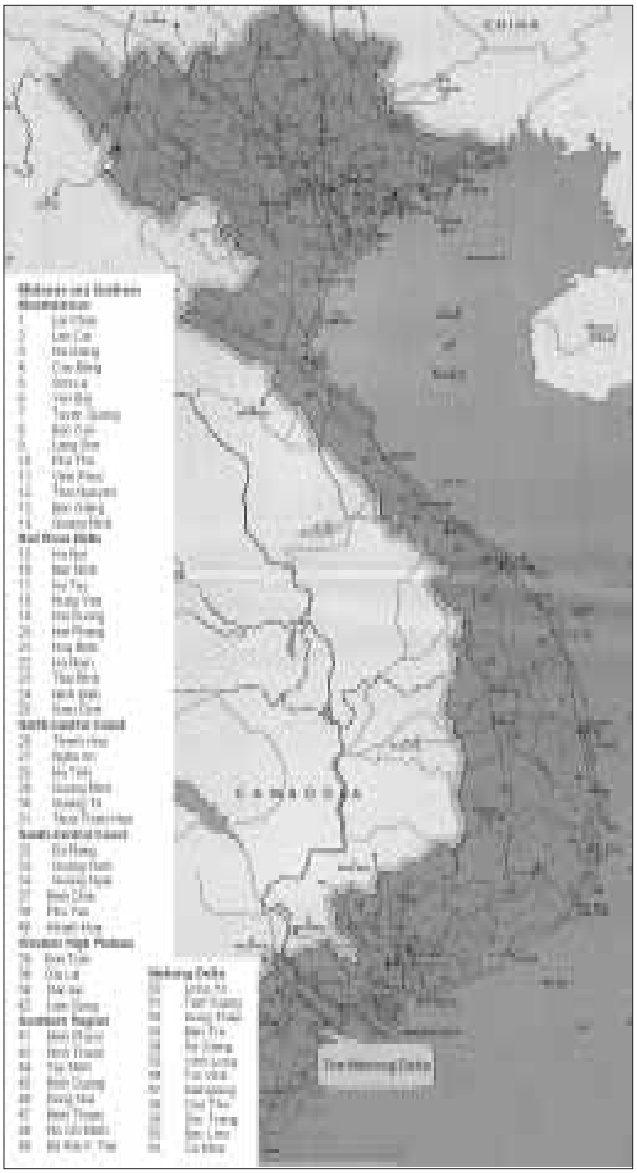


Fig. 1. Agroecological zones and provinces of Vietnam.

The MD is considered as the rice bowl of Vietnam and currently about 2 million ha are under rice. Approximately 70% of the rice area is irrigated or semi-irrigated lowlands and 30% is rainfed lowlands. More than 80% is under modern rice varieties.

The MD has three major rice-cropping systems: triple rice cropping, double rice cropping, and single rice cropping (including *mua* or traditional rice). Triple rice cropping (winter-spring, summer-autumn, and autumn-winter)

is practiced in the alluvial zone where irrigation is available and where there is shallow water but no inundation. Double rice cropping (winter-spring and summer-autumn cropping) is commonly practiced in the flood zone with slightly to medium acid sulfate soils (An Giang and Dong Thap), and in the rainfed coastal zone. Single rice cropping (mainly *mua* and medium-duration rice) followed by the cultivation of other crops or aquaculture is common in rainfed areas. Though the Delta is favorable for rice production, it is also suitable for different fruit trees, aquaculture, etc., all of which have been practiced by MD farmers. For livestock raising, cattle, buffaloes, pigs, goats, chickens, and ducks are the important animals kept by MD rice farmers. However, the level of interaction between crops and animals is different among agroecosystems and the economic situation of households.

Crop and animal production in different regions of the country

The major characteristics of each region and its agricultural situation, with emphasis on rice and animal production, are described below.

The Red River Delta (RRD) region

Geographic and human resources. The RRD zone is composed of 11 provinces (Hanoi, Hai Phong, Ha Tay, Hai Duong, Hung Yen, Ha Nam, Nam Dinh, Thai Binh, Ninh Binh, Vinh Phuc, and Bac Ninh), with a total area of about 1.48 million ha. The RRD in 2000 had about 13.6 million people. About 89.6% of the population lives in rural areas. The population density in the RRD is the highest in Vietnam, with 928 persons km^{-2}. Thus, landholding per household is the smallest.

Physical features. The RRD zone is characterized by four seasons and is primarily influenced by the tropical monsoon and northeastern winds. Average temperature ranges from 16.2 to 29.7 °C, with the coolest months from December to February and warmest months in June and July. Average humidity is 71–86%. Annual rainfall is about 2,400 mm, concentrated during July and August. Flash floods sometimes take place during this period, damaging newly transplanted rice fields. Typhoons often occur in northern Vietnam each year, causing damage to crops.

Soils in the RRD are mostly alluvium but degraded. Because of flood protection structures along the main river course, redeposit of new sediments is minimal. This causes some areas to have low fertility and high acidity. The land is well irrigated and is designed mainly for rice production.

Crop and animal production. The RRD is the second-largest rice-growing region in Vietnam. Most of the rice land is irrigated, with two crops of paddy annually, the winter-spring (WS) and *mua* crops. According to the latest census, the harvested area of rice has not changed much and the growth rate per annum has remained low at 0.3% (Table 1). Rice yield in the RRD region increased from 4.44 t ha^{-1} in 1995 to 5.53 t ha^{-1} in 2000, registering an annual yield growth of 4.4%. In 2000, total rice production in the RRD was about 6.6 million tons of paddy, which is about 22% of the national rice production. Vegetables are grown intensively on a large scale.

Livestock production involves pigs, cattle, buffalo, and poultry. Pig raising is most common among farming households. By 2000, the pig population was 5.4 million head, contributing about 27% of the national pig population (Table 2). The integration of livestock production and rice farming is primarily through the use of animal manure that is composted and incorporated into paddy fields to further enrich the soil. Animals, on the other hand, are fed with crop by-products and crop residues.

The Midlands and Northern Mountainous (MNM) region

Geographic and human resources. The MNM zone stretches from the northeast to the northwest mountainous areas of northern Vietnam. It includes 14 provinces (Ha Giang, Cao Bang, Lao Cai, Bac Can, Lang Son, Tuyen Quang, Yen Bai, Thai Nguyen, Phu Tho, Bac Giang, Quang Ninh, Lai Chau, Son La, and Hoa Binh), with a total area of about 10.09 million ha. The population of the MNM in 2000 was 11.24 million and it is composed of several minorities and ethnic groups. The population density is extremely low, with 111 persons km^{-2}. About 84% of the total population lives in rural areas and the majority of these people pursue subsistence agriculture using traditional practices.

Physical features. The climate is similar to that of the RRD zone, with four seasons. Average temperature ranges from 15.9 to 28.8 °C (the coolest months are from December to February; the warmest months are June and July). Average humidity is 75–86%. Annual rainfall is about 2,200–2,400 mm, concentrated during May and August. Flash floods occur often during the rainy season and likewise damage cultivated crops.

Soils in the MNM are mostly degraded gray soils and are poor in nutrients. Soil erosion is severe during the rainy season because of heavy rains, deforestation, food production practices that cause soils loss, and fertility loss in hills and mountainsides.

Crop and animal production. In the MNM zone, upland rice production is practiced using the slash-and-burn method. Lowland rice is cultivated in watershed areas where there is irrigation. The MNM produces 2.5 million tons of paddy, which was only 7.6% of national rice production in 2000 (Table 1). Yields average 4.0 t ha^{-1} for the northeast areas and 2.9 t ha^{-1} for the northwest areas. Cattle and especially buffalo raising are common in hilly areas. In 2000, there were about 1.63 million head of water buffaloes, some 56% of the national buffalo population. The high population of buffaloes in this region may be due to the animal's importance among farmers primarily for draft power and for meat. The suitable weather conditions in the region allow for the effective use of buffalo for land preparation. The pig

Table 1. Harvested area, yield, and production of paddy by major regions in Vietnam from 1995 to 2000.

Region	Year					Growth rate (%)
	1995	1997	1998	1999	2000	
Whole country						
Harvested area (10^3 ha)	6,765.6	7,099.7	7,362.7	7,653.6	7,654.9	2.5
Yield (t ha^{-1})	3.69	3.88	3.96	4.10	4.25	2.8
Production (10^3 t)	24,963.7	27,523.9	29,145.5	31,393.8	32,554.0	5.3
Red River Delta						
Harvested area (10^3 ha)	1,193.0	1,197.0	1,203.1	1,202.8	1,212.4	0.3
Yield (t ha^{-1})	4.44	4.86	5.13	5.46	5.53	4.4
Production (10^3 t)	5,090.4	5,638.1	5,979.4	6,383.4	6,594.8	5.2
MNM						
Harvested area (10^3 ha)	656.8	664.4	667.4	671.1	686.5	0.9
Yield (t ha^{-1})	2.86	3.32	3.42	3.73	4.04	6.9
Production (10^3 t)	1,786.5	2,057.4	2,098.7	2,283.5	2,487.9	6.6
NCC						
Harvested area (10^3 ha)	682.2	692.0	677.5	677.9	694.7	0.4
Yield (t ha^{-1})	3.14	3.61	3.42	3.89	4.06	5.1
Production (10^3 t)	2,140.8	2,495.5	2,316.3	2,634.6	2,822.3	5.5
SCC						
Harvested area (10^3 ha)	422.5	429.7	424.6	434.8	422.6	0.0
Yield (t ha^{-1})	3.35	3.68	3.68	3.92	3.98	3.4
Production (10^3 t)	1,415.0	1,579.9	1,564.5	1,703.7	1,683.4	3.5
WHP						
Harvested area (10^3 ha)	173.2	170.0	164.7	166.0	175.9	0.3
Yield (t ha^{-1})	2.44	2.81	2.56	3.08	3.33	6.2
Production (10^3 t)	429.5	485.6	436.6	512.4	580.3	6.0
SE						
Harvested area (10^3 ha)	447.3	466.0	464.8	518.8	526.7	3.3
Yield (t ha^{-1})	2.83	3.04	3.08	3.05	3.21	2.5
Production (10^3 t)	1,269.8	1,417.4	1,431.4	1,581.5	1,691.5	5.7
MD						
Harvested area (10^3 ha)	3,190.6	3,480.6	3,760.6	3,986.7	3,921.9	4.2
Yield (t ha^{-1})	4.02	3.98	4.07	4.08	4.36	1.6
Production (10^3 t)	12,831.7	13,850.0	15,318.6	16,280.8	17,106.4	5.9

Source: General Statistics Office (2002) and our calculations.

Table 2. Population of major livestock in different agroecological zones in 2000.

Zone	Cattle (head)	Buffalo (head)	Pigs (head)
Whole country	4,127,900	2,897,200	20,193,800
Red River Delta	488,300	213,600	5,398,600
Midlands & Northern Mountainous area	665,600	1,626,600	4,377,300
North-Central Coast	890,600	679,000	2,944,000
South-Central Coast	937,200	127,700	1,725,000
Western High Plateau	524,900	68,400	1,122,800
Southeastern Region	423,900	118,200	1,649,600
Mekong Delta	197,200	63,700	2,976,600

Source: General Statistics Office (2002).

population is 4.4 million head and this represents 21.7% of the total pig population of the whole country (Table 2).

The North-Central Coastal (NCC) region

Geographic and human resources. The NCC is situated in the central part of Vietnam and contains six provinces (Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, and Thua Thien Hue), with a total area of about 5.15 million ha. The population of the NCC in 2000 was 10.12 million, of which 87.0% lived in rural areas. The population density is about 196 km^{-2}; the tendency of the majority is to concentrate along the coastlines while the ethnic minorities live in small tribes in the mountains.

Physical features. The climate is somehow similar to that of northern Vietnam, with its four seasons, but which are not as distinct. The average temperature is 20 to 28.5 °C. Average humidity is 64–93%. Annual rainfall is about 1,800–2,000 mm, concentrated during September and October. Typhoons and tropical atmospheric depressions occur often during the rainy season.

Soils in the NCC region are classified as moderately eroded hills and mountains on one side and sandy bars along the coast on the other. The arable lands are degraded and sandy, and poor in nutrients.

Crop and animal production. The NCC produces 2.8 million tons of paddy, which was only 8.6% of national rice production in 2000. Yield averages about 4.0 t ha^{-1}. Attempts to develop irrigation systems for rice production have been slow due to inadequate water resources and unsuitable soils. Hilly areas are suitable for growing pasture used for grazing livestock. Cattle raising is common in hilly areas. The cattle population is 0.89 million and constitutes 21.6% of the national cattle population. The pig population is 2.94 million head, which is 14.6% of the total pig population.

The South-Central Coastal (SCC) region

Geographic and human resources. Situated along the coastline in the central part of Vietnam, this region has six provinces (Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, and Khanh Hoa), with a total area of about 3.3 million ha. Arable land is about 0.55 million ha and forest land is 1.16 million ha. The population of the SCC was 6.62 million in 2000, with a population density of about 200 km^{-2}. About 71% of the population lives in rural areas.

Physical features. This zone has mainly two seasons: rainy and dry. Average temperature is 22.5 to 30.4 °C. It is hot during the dry season. Average humidity is 72–87%. The rainy season has less than 1,400 mm of rainfall per annum. Locally, the annual rainfall of Binh Dinh is high, at about 2,400 mm. Typhoons also occur in the region as often as in the NCC region.

Larger deltas in this region with alluvial soils are suitable for rice production. Arable land is almost sandy silt, eroded and poor in nutrients.

Crop and animal production. In the SCC zone, rice production is quite good in major alluvial deltas. The rice land covers about 0.42 million ha. In 2000, the region produced about 1.68 million tons of paddy or 5.2% of national rice production. Average yield is 4.0 t ha^{-1} but in Phu Yen average rice yield is relatively higher at 5.0 t ha^{-1}. Other important crops are coconut, cotton, beans, sesame, sugarcane, fruits, and spices. Cattle are raised in herds of up to a few hundred head. In 2000, the cattle population was about 0.937 million head and represented about 23% of the national cattle population. The pig population is 1.7 million, representing 8.5% of the national pig population. Household farming systems include poultry production, which provides extra income to small-scale farmers.

The Western High Plateau (WHP) region

Geographic and human resources. This region has four provinces (Kom Tum, Gia Lai, Dac Lac, and Lam Dong), with a total land area of about 5.45 million ha, of which arable land is about 1.23 million ha and forest land 2.99 million ha. The region contained 4.24 million inhabitants (in 2000), with a population density of about 77 km^{-2}. There is a close integration of lowland Vietnamese people and several ethnic minorities in this zone, where 73.5% of the population lives in rural areas.

Physical features. This region has mild temperature and high humidity. The temperature average 20.0–24.0 °C and humidity 80–95%. The coolest months are December and January, with a temperature of 15–17 °C. Annual rainfall is 1,800–2,400 mm, concentrated in the rainy season.

Most of the soils are characterized as reddish brown basalt rich in nutrients. In recent years, however, significant soil damage (soil erosion, soil loss, fertility loss, increased acidity) has taken place because of the overexploitation by new settlers of food production and coffee production, extensive deforestation, and other economic activities deemed harmful to the environment.

Crop and animal production. The WHP has a large area covered with forest. Rice has been cultivated in valleys with irrigation, but upland rice is grown at higher elevation via the shifting cultivation system. In 2000, the region produced only 1.8% of the national rice production and yield averaged 3.3 t ha^{-1}. The region has potential for producing industrial crops such as rubber, coffee, tea, and fruit trees. Livestock production is mainly cattle, pigs, and chickens. In 2000, livestock production increased to 0.525 million head of cattle and 1.12 million head of pigs. In general, the climatic and natural conditions of this zone are suitable for dairy cattle and chicken production.

The Southeastern (SE) region

Geographic and human resources. The SE region contains eight provinces (Ninh Thuan, Binh Thuan, Dong Nai, Binh Phuoc, Ho Chi Minh, Tay Ninh, Binh Duong, and Ba Ria-Vung Tau), with a total natural area of about 3.47 million ha, of which arable land is 1.71 million ha and forest land 1.02 million ha. The population in 2000 was 12.07 million, with a relatively high density of about 347 km^{-2} because of the population concentration in Ho Chi Minh City. Excluding Ho Chi Minh, 72.2% of the region's population lives in rural areas.

Physical features. The climate in the SE region is warm, with average temperature of 26.4 to 28.8 °C (the coolest months are December-January, the warmest months April-May). Annual rainfall is 1,400–2,200 mm with rainfall concentrated in May to August.

The soils in the region are classified into two major groups: reddish brown basaltic soils and degraded gray soils with patches of acid sulfate soils adjacent to the Mekong Delta.

Crop and animal production. In the SE region, the conditions for growing rice are unfavorable. In recent years, attempts have been made to install irrigation systems for rice production. As a result, the cultivated area of winter-spring paddy increased to 117,500 ha in 2000 vis-à-vis 73,500 ha in 1995, with a growth rate of 3.3% per annum. Rice production in the SE region accounted for 1.27 million tons in 1995, which increased to 1.69 million tons in 2000, with a current share of 5.2% of national rice production. The SE region is more suitable for growing industrial crops. Rubber, coffee, tea, cashew, sugarcane, black pepper, and other high-value fruit trees grow well here. Other crops such as peanut, soybean, mungbean, sweet potato, cassava, etc., are also found. The region is also suitable for livestock production such as cattle, pigs, goats, and poultry. Various farming systems with the integration of crops and animals have been practiced in the region. In 2000, the animal population was 0.42 million head of cattle, 0.12 million head of buffalo, and 1.65 million head of pigs.

The Mekong Delta (MD) region

Geographic and human resources. The MD consists of 12 provinces (Long An, Dong Thap, An Giang, Tien Giang, Vinh Long, Ben Tre, Kien Giang, Can Tho, Tra Vinh, Soc Trang, Bac Lieu, and Ca Mau) that cover about 3.97 million ha, representing about 12% of the total area of the country. The region lies at 104°50′ to 106°50′ E and 8°40′ to 10°55′ N. The region is settled by major groups of Vietnamese, Cambodians, Chinese, and a small number of Cham people, an ethnic group with a population of 16.36 million. The population density is high, about 409 km^{-2} (in 2000). Some 82.5% of the population lives in rural areas.

Physical features. The climate in the MD is warm and belongs to monsoon tropical climate. Average temperature is 26.4 to 28.8 °C. The MD region has two well-defined seasons: rainy and dry. The rainy season lasts from May to November (providing 80% of the rainfall) and the dry season from December to April. The average rainfall is 1,000–2,000 mm. The rainfall distribution among the areas in the region is different (a high of 2,000–2,400 mm in the forest areas and a low of 1,400–1,600 mm in the northeast). The Mekong Delta is influenced by the flow of the Mekong River, the diurnal tidal movement of the East Sea (also known as the South China Sea), and the semidiurnal tidal movement of the Gulf of Thailand. The high rainfall combined with a high water discharge of about 40,000 $m^3 s^{-1}$ of the Mekong River results in regular floods of 0.5 to 3.0 m deep during August to December on the poorly drained and depressed areas. Serious flood damage occurs annually in these areas.

The MD is a flat and low-lying region, which was formed through slow alluvial depositions. According to Sanh et al (1998), the major soil types of the MD include alluvial soils that cover about 28% of the Delta, acid sulfate soils that cover 41%, and saline soils that cover 21%. The remaining soils are mountainous soils and peat soils.

Crop and animal production. The MD is the most important rice production area in Vietnam. In 2000, MD rice production reached about 17.0 million tons, with average yield of 4.36 t ha^{-1}. Rice-based systems with fruit trees, pineapple, sugarcane, maize, and soybean are practiced. Integration of livestock with rice-based farming systems takes place in rainfed areas as well as in irrigated areas. In the mountainous areas of Tri Ton, Tinh Bien, and Moc Hoa, in Duc Hoa and Duc Hue, which are adjacent to Cambodia, and in the high-elevation areas of Tra Vinh and Soc Trang, local cattle are a predominant component of the Khmer farm household. Traditionally, the Khmer people keep cattle for both draft and for entering into the livestock market at the border with Cambodia. According to the 2000 census, the number of major livestock by type were cattle about 0.2 million head, buffaloes about 0.064 million head, and pigs about 2.98 million head. Chickens and ducks are also kept by rice farmers where the combined number of chickens and ducks is 10–20 head per household and these are often used for home consumption.

General trends of rice and animal production and demand in the Mekong Delta region

Vietnam agriculture has undergone tremendous changes during the last two decades. These changes were accelerated in 1986 after the policy reform, often known as "Renovation." In 1998, Vietnam became the world's second-largest rice exporter. The rice surpluses that have entered the world market came mainly from the Mekong Delta. As mentioned earlier, the MD is the most important region for agricultural production in Vietnam. Because of this, the monograph focuses on the MD and characterizes the region in terms of its rice and animal production activities.

Changes in rice production and demand trends

Agricultural production, especially rice production, continues to play a dominant role in the economy, accounting for over 23% of GDP. Attempts to produce more rice are still the main focus of the government as well as farmers in the Mekong Delta.

Table 3 shows rice production performance in 1995-2000 and the projected growth of demand for rice up to 2010 in the MD. The harvested area in the MD increased by 4.21% in five years, from about 3.2 million ha in 1995 to 3.9 million ha in 2000. However, area is expected to decrease by 2010. Rice yield and production increased at 1.6% and 5.9% per annum, respectively, in 1995-2000. The increase in rice production in this period is a result of increases in both harvested area and yield. However, trends in rice yield and production are estimated to slow down in the future as indicated in Table 3.

Table 3 also compares the growth performance of rice in 1990-95 and 1995-2001 across the provinces constituting the MD. Geographically, the MD consists of 12 provinces but only 7 are considered to have great potential for

Table 3.1. Trends in cultivated area, yield, and production of rice in the Mekong Delta.

Item	Year								Growth rate (% y^{-1})		
	1995	1996	1997	1998	1999	2000	2005	2010	1995-00	2000-05	2005-10
Whole year											
Cultivated area (10^3 ha)	3,190.60	3,445.58	3,480.00	3,760.6	3,986.7	3,921.89	3,933.6	3,898.8	4.21	0.06	–0.18
Yield (t ha^{-1})	4.02	4.21	3.98	4.07	4.08	4.36	4.72	4.96	1.64	1.58	1.01
Production (10^3 t)	12,831.7	14,511.3	13,850.0	15,318.6	16,280.8	17,106.4	18,555.9	19,343.4	5.92	1.64	0.83
Winter-summer paddy											
Cultivated area (10^3 ha)	1,035.7	1,162.6	1,254.0	1,349.0	1,449.9	1,482.9	1,579.3	1,595.3	7.44	1.27	0.20
Yield (t ha^{-1})	5.16	5.48	5.33	5.30	5.00	5.27	5.61	5.80	0.40	1.28	0.66
Production (10^3 t)	5,348.5	63,63.7.3	6,689.8	7,148.0	7,251.5	7,811.3	8,865.5	9,255.7	7.87	2.56	0.87
Summer-autumn paddy											
Cultivated area (10^3 ha)	1,397.6	1,491.3	1,510.2	1,776.0	1,933.9	1,843.0	1,972.5	1,953.7	5.69	1.37	–0.19
Yield (t ha^{-1})	3.79	3.94	3.48	3.53	3.72	3.96	4.24	4.48	0.91	1.37	1.08
Production (10^3 t)	5,296.4	5,883.1	5,250.1	6,275.9	7,200.9	7,306.9	8,370.4	8,747.7	6.65	2.75	0.89
Mua or autumn-winter paddy											
Cultivated area (10^3 ha)	757.3	791.0	716.4	635.6	602.9	595.9	381.8	349.8	–4.68	–8.52	–1.74
Yield (t ha^{-1})	2.89	2.86	2.67	2.98	3.03	3.34	3.46	3.83	2.93	0.71	2.07
Production (10^3 t)	2,186.7	2,260.8	1,910.1	1,894.7	1,828.4	1,988.1	1,320.0	1,340.0	–1.89	–7.86	0.30

Table 3.2. Harvested area, production, and rice yield growth rates in selected MD provinces, 1990-95 and 1995-2001.

Province	Growth rate in harvested area (% y^{-1})		Growth rate in production (% y^{-1})		Growth rate in yield (%y^{-1})	
	1990-95	1995-2001	1990-95	1995-2001	1990-95	1995-2001
Can Tho	4.6	2.4	8.8	2.3	4.2	–0.2
Long An	3.2	4.3	6.6	5.6	3.4	1.4
Tien Giang	1.9	0.1	4.7	0.3	2.8	0.2
Dong Thap	6.4	1.0	7.2	1.6	0.7	0.6
An Giang	4.5	1.7	7.8	–0.7	3.2	–2.3
Kien Giang	8.6	4.5	13.4	4.3	4.8	–0.3
Soc Trang	–	3.0	–	5.5	–	2.5

Table 3.3. Prediction in food consumption pattern (kg $capita^{-1}$ $year^{-1}$).

Food item	2000	2005	2010
Paddy (rough rice)	257	250	246
Oils	4	5	6
Soybean	4	5	6
Fish	18	20	24
Fruits	36	45	60
Sugar	12	14	15
Vegetables	50	50	60
Meat	15	16	18
Eggs	40	50	60

Table 4. Trends of population growth and rice consumption demand.

Item	2000	2005	2010
Population (million people):			
Whole country	77.69	83.74	89.81
Mekong Delta	16.38	17.67	18.90
Consumption (million tons, rough rice)			
Whole country	20.00	21.00	22.00
Mekong Delta	4.21	4.41	4.64

Source: Statistical yearbook (2001) and our calculations.

Table 5. Rice production (milled rice) and exports from Vietnam from 1998 to 2002.

Item	Year			
	1998	1999	2000	2001
Production (million t)	18.65	20.11	20.75	21.10
Exports (million t)	2.7	4.56	3.37	4.00

rice production. Relatively high growth rates per annum were exhibited in rice harvested area, yield, and production in 1990-95, but later slowed down during 1995-2001.

Population trends and food demand. The Vietnamese people eat rice as a staple food. On average, rice consumption is about 422 grams capita^{-1} day^{-1} or 257 kg (rough rice) per year. Table 3 presents some figures that indicate the expected food consumption pattern in Vietnam. The demand for rice in the daily meal will decrease but other food nutrients, particularly those from animal origin, will increase. This trend is based on an economic principle. When income is low, people obtain most of their nutrients from starchy foods (mainly rice) and per capita demand for rice is high. When income improves, per capita rice consumption as food either declines or becomes stagnant, and consumption of other foods, particularly livestock products, tends to increase (Ohga 1999 and Hossain 1999).

Table 4 shows the trends of population growth and projected rice demand for 2005 and 2010. Rice consumption shows an increase and parallels the growth in population. Rice consumption of the country was about 20 million tons (rough rice) in 2000 but is expected to increase to 21 million tons in 2005 and about 22 million tons in 2010. In the Mekong Delta, the rice bowl of the country, rice consumption was about 4.21 tons in 2000 and is projected to increase to 4.41 tons and 4.64 tons in 2005 and 2010, respectively.

Demand of rice for export. As the rice belt of Vietnam, the Mekong Delta has produced rice not only for meeting domestic demand for food in the country but also for export. Almost all of the country's rice exported to the world market comes from the Mekong Delta. The amount of milled rice for export has increased year by year. It was about 2.7 million tons in 1998 and 4.0 million tons in 2001 (Table 5). Growing rice for export continues to be the major focus of Mekong Delta farmers. According to rice researchers, for Vietnam rice exports to increase, the nation needs to pay more attention to improving the quality of exported rice rather than increasing its quantity.

Changes in the animal production sector and demand trends

In general, livestock production systems in the MD are largely traditional. These systems cater primarily to the immediate needs of farming households. For instance, farmers often keep animals to be used for special purposes (usually planned) or just for home consumption. There is really no long-term strategy for animal production among households. Changes are taking place now, however. Three major types of animal production systems have emerged: semi-industrial or industrial farms, medium-size commercial farms, and small-scale household or backyard farms. The semi-industrial or industrial farms are often state-run with large herds. These state-run farms usually raise 500–1,000 pigs, 200–500 cows, or 20,000–30,000 head of poultry. The medium commercial farms (mostly privately owned) usually raise 100–300 pigs, 1,000–10,000 chickens (layers), and 10–100 cows. Small-scale farms usually consist of 2–4 pigs, 2–5 cows, and 40–50 head of poultry, and are the backyard type that still largely prevails among small households.

Tables 6 and 7 show the trends in livestock production in 1990-95 and 1995-2001. Generally, animal production in the MD has undergone a rapid change since 1990. The cattle population decreased during 1990 to 1995 at –4.3% per annum. It again exhibited significant growth of about 5% per annum from 1995 to 2000 in response to increased demand for beef as well as dairy products. For pigs and poultry production, the growth rates per annum were relatively high in 1990 to 1995 at 15.3% and 12.6%, respectively. Growth rates were lower, however, in 1995-2001 at

Table 6. Trends in livestock production in the Mekong Delta, 1990-95 and 1995-2001.

Animals	Growth rate in production (% y^{-1})	
	1990-95	1995-2001
Buffaloes	–4.2	–12.3
Draft buffaloes	–3.9	–17.5
Cattle	–4.3	5.1
Draft cattle	–10.6	–0.6
Pigs	15.3	3.1
Poultry	12.6	4.9

Table 7. Livestock growth rates in selected Mekong Delta provinces, 1990-95 and 1995-2001.

Province	Growth rate in buffalo (% y^{-1})		Growth rate in cattle (% y^{-1})		Growth rate in pigs (% y^{-1})		Growth rate in poultry (% y^{-1})	
	1990-95	1995-2001	1990-95	1995-2001	1990-95	1995-2001	1990-95	1995-2001
Can Tho	–28.5	–11.8	–48.7	13.4	2.9	2.8	–2.8	2.7
Long An	–11.4	–4.5	–7.2	5.3	2.4	2.2	8.1	1.7
Tien Giang	–19.5	–28.9	–12.3	4.4	11.2	2.7	9.5	0.4
Ben Tre	–9.8	–13.2	–1.8	7.0	7.5	3.7	1.8	8.4
Dong Thap	–27.3	–12.8	–31.0	3.5	–0.1	4.9	8.0	6.5
An Giang	–2.0	–7.8	–16.0	1.8	7.8	1.2	–1.6	5.3
Kien Giang	–17.0	–11.9	–10.7	2.7	3.1	4.0	–5.2	12.7
Soc Trang	–	–27.2	–	–7.8	–	3.9	–	5.8

Source: Data from Can Tho Statistical Department (2002) and our calculations.

3.1% and 4.9%, respectively. The slower growth rates of pig and poultry production in 1995-2001 came primarily from the reduction in the number of farmers keeping and raising these animals as profits were eroded because of declining market prices while prices of production inputs remained high.

Starting in 1990, the population of buffaloes and draft cattle decreased significantly because of the introduction of tractors for land preparation in rice farming. Only in a few swampy areas or areas with low elevation were buffaloes and cattle kept for plowing or for transport.

Locally, types and numbers of animals raised vary from location to location (Table 7). Cattle raising is rapidly being developed in almost all provinces, but especially in Long An, Ben Tre, An Giang, Tra Vinh, Dong Than, and Tien Giang. Recently, some new breeds of dairy cattle such as Holstein-Friesan, Lai Sind, Charolaise, and Sahiwal have been introduced to the MD primarily because of government initiatives. At the early stage of this program, dairy cows were kept on intensive state farms. In 2000, Song Hau farm of Can Tho Province and Luong An Tra farm of An Giang Province started raising about 1,170 dairy cows, which can produce 1,000 good calves for the province and other farms in the region (Nghia 2002, Chi 2002).

Pig production, on the other hand, continued to grow, but at lower rates. Pig farms are found mostly in Tien Giang Province, which accounts for 15% of the MD pig population. Buffaloes are mainly raised in Long An Province, with the current population at 22,000 head. This accounts for 37% of the MD buffalo population. The lowest buffalo population is in Vinh Long Province, with only 351 buffaloes.

Development of livestock production to supply meat and other livestock products for food consumption continues to be the major focus of leaders and farmers alike in the Mekong Delta. The major activities that the government has recommended to further develop the livestock sector in the region includes further development of pig farms, increasing the number of poultry farms, and development of cattle herds, especially dairy cows, to supply milk for dairy factories in the region.

Crop-animal systems in rice-based farms in the Mekong Delta

A hypothetical ICAS typology

In general, integrated rice-livestock farming systems are quite popular in the MD. They are found to some extent in all agroecological zones. Rice is grown for both family consumption and marketing. Rice by-products such as rice bran and rice straw are used for livestock production. Livestock themselves play an important role in the economy and social life of the farmers. Livestock are kept as a form of sav-

ings that can easily be converted to cash in times of need, and they also make full use of family labor in the rural areas of the MD.

Based on data and information collected from a primary survey at the provincial level, a typical ICAS has rice-based farms classified into seven types. One farm type is without any livestock holding, whereas the other six farm types have a livestock component. The six types are defined based on (1) economic status of rice farm households, that is, rich versus average/poor households, (2) the use of crop residues for animal feeding, and (3) the application of manure in fields. The most dominant farm types in the rainfed areas of the MD are types 5 and 6, described as follows:

Type 5: Rice household with animals and that uses crop by-products and residues for feed but which does not use manure in fields as fertilizer.

Type 6: Rice household with animals and that uses crop by-products and residues for feed and applies manure in fields as fertilizer.

Farm types 4 and 7, in which households do not use crop residues and other by-products, including manure, appear to be nonexistent in this region. Cases of farm types 2 and 3 are very few because the rich farm households often feed their animals with concentrated feed or grasses that are purchased in the city or at big business centers. Rich farm households have also used contract caretakers to take care of their animals and caretakers use manure.

In terms of ownership, the principal aspect identified is that not all rice farmers own livestock, and the type of livestock keeping is also different from farm to farm. Sanh et al (1998), in the results of a survey on the management practices of crop-animal integration in the MD, showed that backyard animal raising is predominant; about 82% of the farmers raised pigs while only 15% of them raised chickens, and some farmers raised ducks. In rainfed hilly and mountainous areas of An Giang Province, where cattle raising of Khmer farm households is predominant, there are two ways of cattle keeping:

1. The owner himself takes care of his cattle.
2. The owner shares taking care of his animals with another farmer (caretaker), who does not own cattle by himself. In this case, the owner and caretaker have an agreement in which all activities such as management and feeding of cattle are the duties of the caretaker, and the sharing arrangement is as follows: (a) the first offspring (calf) is for the owner and the second one for the caretaker, which allows the caretaker to start his own cattle production; or (b) the caretaker receives a previously agreed upon amount of money in return for his services. However, many poor caretakers often sell their share because of a lack of money for daily activities, even before the calf is born.

ICAS among rice farm households in the Mekong Delta

In the Mekong Delta, farm types 5 and 6 usually consist of four components: (1) a homestead with animal husbandry and a garden, (2) a fish pond for aquaculture and household water use, (3) dikes and orchards for perennial trees, and (4) cash crops and a paddy field for rice cultivation (Fig. 1).

The various components of the system interact with each other. The greater these interactions are, the more viable or sustainable the system is. The main interaction between livestock and the crop is in the form of livestock feeding on crop residues or by-products and animal traction or animal manure use for fields. Supplementary feeding of livestock, especially cattle and buffaloes, with rice straw and crop residues is an important interaction. Large-scale pig and chicken raising is usually supplemented with purchased concentrated feeds. Cattle and buffaloes are used occasionally for land preparation and for transport. Very few cases of animal manure application in rice fields are recorded. Animal manure is applied mostly in orchards and sometimes in fish pens or bio-gas processes.

The level of integration of ICAS also varies depending on the physical environmental conditions. In freshwater alluvial areas, rice-based farming systems are the most diversified. Results from a survey in Tan Phu Thanh village of Can Tho Province showed that about 70% of the households apply integrated farming systems with a combination of 2–5 components (Dung et al 2000). Some integrated rice-based farming systems include

- Pigs + poultry + vegetables + fruit + aquaculture
- Pigs and bio-gas digester + vegetables + fruit + aquaculture + rice
- Pigs and bio-gas digester + fruit + aquaculture + rice

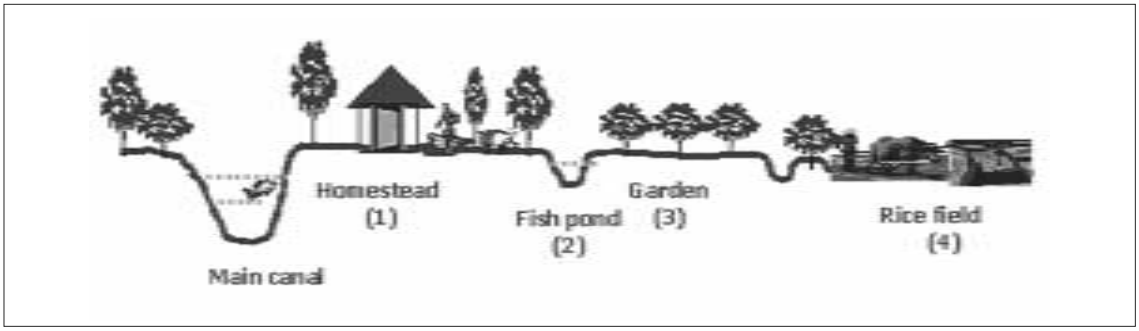


Fig. 1. Typical rice farm in the Mekong Delta.

- Ducks + rice
- Cattle + earthworms + chickens + rice

In these systems, livestock are fed mainly with by-products from the farms (rice bran, broken rice), agro-industrial by-products (such as concentrated feeds from Con Co Ltd. company), aquatic plants collected from rice fields or ponds, and mixes with concentrated feeds that are purchased from local markets. The manure from livestock raising is used as feed for fish, fertilizer for fruit trees, or to produce bio-gas for fuel. Nowadays, some farmers use livestock manure (especially cow dung) to culture earthworms to feed poultry or fish.

Crop-animal systems by agroecological zones of the MD

There are some degrees of difference in ICAS among agroecological zones in the MD. According to Sanh et al (1998), based on major agroecological characteristics such as rainfall, temperature, soil type, topography, water resources, and vegetation, the Mekong Delta can be easily divided into seven major "micro-zones" (agroecological zones): the freshwater alluvial areas, the Plain of Reeds, the Long Xuyen-Ha Tien quadrangle, hills and mountainous areas, the Trans-Bassac depression, Ca Mau Peninsula, and the coastal zones (Fig. 2).

The freshwater alluvial zone. This zone is situated along the Trans-Bassac and Mekong rivers of the central parts of the Mekong Delta, covering about 900,000 ha. This zone is well known as the most suitable area for rice and fruit production. The common rice-based farming systems are rice-rice-rice, rice-rice-upland crops, rice-rice-aquaculture, and rice-rice-rice + ducks. Figure 3 shows the rice-cropping calendar in some major zones of the Delta. Other combinations between livestock and rice farming are also found in this zone. The major types of livestock in this zone are water buffaloes, cattle, pigs, ducks, chickens, and some goats. Farmers use rice straw, grass, and maize culms to feed cattle. Some farmers in Long An Province use rice straw treated with urea fertilizer, rice bran, and native grasses to feed cattle. Pigs are often fed rice bran and concentrated feed, whereas chickens and ducks are fed with half-filled rice grains, rice bran, and some concentrates.

The Plain of Reeds. This area comprises a large part of Dong Thap Province and some parts of Long An Province, covering about 500,000 ha. This is the lowest place in the Delta (0.5 m below mean sea level). The soil is acid sulfate. Rice is cultivated where freshwater irrigation is available. The rice-rice system predominates. Some farmers practice the integration of livestock and rice fields such as the rice-rice + duck system. Other farmers raise ducks by the thousands, herding from an already harvested rice field to another one and ducks can feed on dropped rice grains. Cattle and pig raising are not common in the area. Only in a few places with higher elevation in Long An can some cattle and buffaloes be found.

The Long Xuyen-Ha Tien quadrangle. This zone is located in parts of An Giang and Kien Giang provinces, covering about 400,000 ha. It is also dominated by acid sulfate

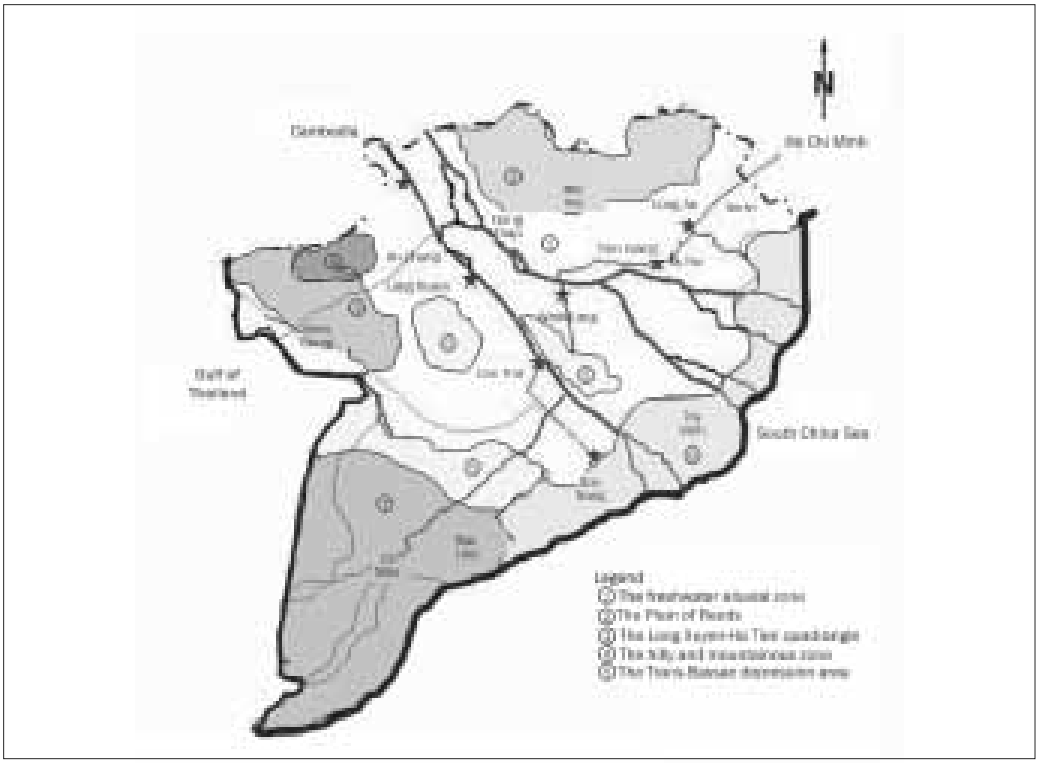


Fig. 2. Agroecological zones of the Mekong Delta.

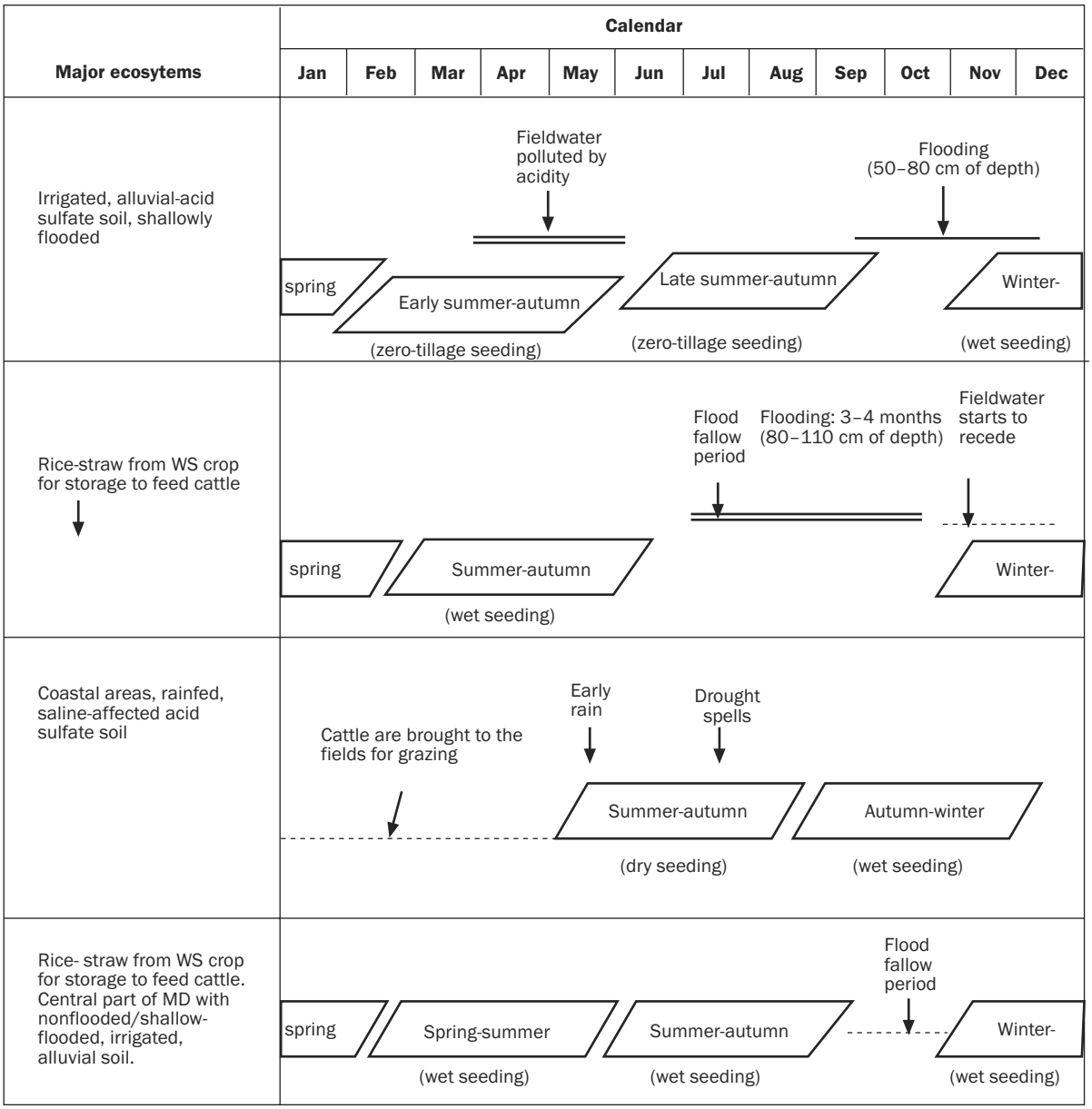


Fig. 3. Cropping calendar of rice in various ecosystems in the Mekong Delta, Vietnam.

soils. Two rice crops are grown in areas with freshwater irrigation. Integration between livestock and rice farming is not popular in this zone. Some farmers raise a few chickens, ducks, and pigs for home consumption and local markets.

The hilly and mountainous zone. The hilly and mountainous zone is located in An Giang and Kien Giang provinces, covering about 200,000 ha. The Khmer people predominate in this area. Where irrigation systems are available, farmers grow two rice crops per year; otherwise they grow only one rice crop with local upland rice varieties. Native cattle raising is common in Khmer farm households. Traditionally, the Khmer raise cattle not only for draft use or as a form of saving money but also for entering into the livestock market at the border with Cambodia. Cattle are often fed rice straw and native grasses. Some households also keep 1 to 2 local pigs and about 20 chickens and ducks mainly for home consumption.

The Trans-Bassac depression area. This zone covers about 600,000 ha, with common rice-based farming systems such as rice-rice, rice-rice-upland crop, rice-rice-aquaculture, and rice-rice + ducks. Most farm households raise pigs for sale and about 20 native chickens and ducks for family consumption or for local markets. Pigs are fed rice bran, broken rice, water spinach, and concentrates, whereas native chickens and ducks are fed half-filled rice grains or graze in homestead orchards. Some farmers keep water buf-

faloes and use them as draft power for land preparation. Rice straw and native grasses are common feeds for buffaloes.

The coastal area. This zone covers about 600,000 ha. Rice production depends on rainwater. The major rice-based farming systems are rice-rice and rice-upland crop. There is a low use of crop by-products and crop residues for animals and only rice straw is used to feed cattle during the dry season. In higher elevation areas of Tra Vinh and Soc Trang, native cattle are an important component of Khmer farm households. Households with cattle often keep from 2 to 10 for meat products and for draft use. Cattle are fed mainly rice straw in the dry season and grasses, maize stems, groundnut stems, and sweet potato leaves. Several rice farm households also keep pigs and about 20–30 chickens and ducks for both family consumption and local markets.

Ca Mau Peninsula. Ca Mau Peninsula covers about 800,000 ha of three provinces: Kien Giang, Bac Lieu, and Ca Mau. This zone is characterized by seasonally saline-affected soils and various rice-based farming systems under rainfed conditions. The common rice-based farming systems are rice-aquaculture (shrimp/fish) and rice-rice. Most farmers often keep some pigs and poultry for family consumption and for local markets. Pigs are fed rice bran and concentrates, whereas chickens and ducks are fed half-filled rice grains mixed with rice grains. Ducks are sometimes allowed to graze along the canals and paddy fields.

Reciprocity of animal raising and rice farming

The MD is an important region for both rice production and livestock production. Like in other regions, farmers in the MD raise livestock in a traditional manner. It is estimated that about 80% of the population is engaged in raising livestock, which are considered to be an important component of rice farming. In particular, small farmers often keep livestock to supply food (meat, eggs), to use as draft power (cattle and buffaloes) to use manure as fertilizer for crops, and for use as savings that can easily be converted into cash for purchasing fertilizer, pesticides, and other inputs for rice production. Livestock are also kept as a form of security against uncertainties.

The following crop-animal interactions are common among rice farm households in the MD.

Use of crop residues to feed animals and animal manure as fertilizer in crops. The principal characteristic of rice-based farming systems is the intensive use of land for rice and cash crop production. For that reason, farmers grow high-yielding early-maturing rice varieties (IR64, MTL250, OMCS-2000, etc.), which can be harvested twice per year. Later, farmers rotate the land with mostly leguminous crops (groundnut, soybean, mungbean) or maize that can generate income for households. Farmers use rice straw and groundnut stems to feed their animals. Animal manure, on the other hand, is applied to rice fields and/or groundnut to enrich the soil.

Contribution of rice farming to the sustainability of animal raising. Small-scale farmers produce rice mostly for home consumption; only a small part of this production is sold to middlemen who process it at local rice mills. By-products such as rice bran are used to feed pigs, and half-filled rice grains are used to feed chickens and ducks. Rice straw, which comes from the rice harvested in the winter-spring rice crop (dry season), is stored and used to feed animals during the dry season. In the wet season, animals are fed mainly with natural grasses. Supplementary feeds such as rice bran and other crop residues (groundnut stems, maize stems, etc.) are also provided. The crop by-products are a contribution of rice farming to the sustainability of animal raising. The current system is different from the past when farmers practiced monoculture rice and thus avoided production diversity.

Using animals as draft power. Rice production in the MD uses farm machines, especially for land preparation. Using animals as draft power for plowing and leveling fields takes place in some areas where field conditions are difficult for tractors to operate or the fields are small. Off-farm activities from using animals as draft power or for transportation can generate income for rice households.

Factors influencing changes in the direction of ICAS

The following factors could influence the possible direction of ICAS.

Socioeconomic factors

Better-off farmers tend to use chemical fertilizer and concentrated feeds as they have enough money to purchase them. Applying chemical fertilizers is a common practice at high levels of 180–300 kg N per ha per annum, whereas the application of manure is not common for better-off farmers. There are some constraints to the wider application of manure in paddy fields. Farmers are not aware of or lack knowledge on the importance of these organic materials. The use of manure as fertilizer is labor-intensive and time-consuming. Currently, the process of efficiently making and using compost needs to be investigated and results disseminated rapidly to farmers. All these research results still need to reach farmers.

Where growing rice is not very profitable because of poor soil conditions, rich farmers convert rice lands to grow forage. At present, few better-off farmers have forage land that was originally paddy land. To support animal raising, the proportion of paddy land and forage should be considered within the rice farm household level. From the economic aspect, land use for either paddy or forage is profitable and this is also the question farmers raise.

Geographic characteristics

Different geographic characteristics (agroecological zones) can lead to different development of ICAS. For instance, in the rainfed zones of the MD, the rice-cattle system is more

common, whereas, in the alluvial and irrigated zones, intensive rice farming, fruit trees, and poultry raising are popular. In the hilly and mountainous zone, where the Khmer mostly live, the integrated rice-native cattle system is practiced as a traditional custom.

Government policy

In recent years, the Vietnamese government has had a policy to support resource-poor farmers in order to improve the living standards of rural people under a national program called "Hunger alleviation and poverty reduction." Low-interest credit is granted to poor farmers, especially credit to purchase piglets, beef cattle, and dairy cows. As an outcome of this policy, several small farmers have started to raise pigs and even beef cattle and dairy cows. The government is now geared toward promoting intensification of crop and animal production. These measures encourage rice farmers to diversify their rice-based farming systems, including livestock integrated with rice farming. This policy especially supports the future integration of crop-animal systems in the MD.

Technical aspects

For rice production, direct seeding is replacing transplanting and improved rice is replacing local rice varieties in the MD. Farmers also practice row seeding, use of the leaf color chart for more effective application of fertilizer, and integrated pest management. These technologies support rice farmers in increasing yield and income from rice.

For animals, on the contrary, low-productivity breeds are predominant for all animal types kept by small-scale farmers. These breeds are characterized by low genetic potential for meat and egg production and they have small body sizes and slow growth. In particular, some species such as local cattle (in Tra Vinh, Long An, An Giang) and buffaloes are late maturing and have small body size. Local pigs (*heo co, heo moi*) and native chickens grow slowly and have low productivity; it takes about 8 months for pigs and 4 months for chickens to be sold. These factors limit the expansion of livestock raising, especially among poor farmers.

Extension and veterinary services

Although the extension network has been established up to the village level, its activities are more addressed to rice and crop issues than to livestock. The "top-down" approach in extension also limits the dissemination of new technologies, including ICAS. The new participatory extension approach could support ICAS development.

Women contribute most of their time to taking care of livestock but they have less opportunity to use new techniques since they are rarely invited to attend workshops or extension clubs where they can get information to improve their knowledge and thus their farming potential. For instance, results from a survey of 277 households with animal production in three villages of Can Tho Province showed that women contribute 95% of the labor in animal production, but only 33% have knowledge on animal care and animal diseases (Phan 1999). The credit and savings groups of women that have been organized by the Women's Union showed good results in supporting resource-poor farmers in credit management, using improved technologies, and generating income.

Veterinary services are unable to cover all smallholders of livestock in rural areas because of a lack of manpower, equipment, and facilities. As a result, animal diseases and illegal imports of livestock from neighboring countries across borders are uncontrolled. This is one reason for outbreaks of disease that occur every year, and the risk of animal death is high.

Market opportunities and prices

Market opportunities and prices of both animal products and rice have remained unstable. Rice and animal production strongly depend on market demand and prices. Sometimes, farmers have to reduce their animal population to avoid risk from low prices of animal products. ICAS supports an increase in the use of by-products and crop residues, which improves household income.

Natural disasters

Serious flooding affects a large part of the MD every year. Raising livestock is difficult, and sometimes flood damages all crops and animals. Animal diseases occur often during and after flood, which influences the development of crop and animal production in some Delta areas.

Management of livestock and rice production systems

Management of livestock

Animal resources. The major livestock raised in the MD are ruminants (cattle, buffaloes, goats) and nonruminants (pigs, chickens, ducks), even though types of animal holdings vary from location to location. Raising of nonruminants is very significant in the area. Most farmers raise crossbreed pigs (crossbreeds from Large White, Landrace, and Duroc). Local breeds such as Ba Xuyen and Thuoc Nhieu are still used by many farmers, especial in remote areas (Manh 2002). Native chickens and imported species such as Tam Hoang and Luong Phuong chicken (from China) are commonly raised on a small scale by rice farm households. For ducks, some of the more common varieties such as Muscovy duck are kept for meat, whereas Peking, CV2000, Khaki Campell, and Cherry Valley ducks are kept for both meat and eggs. These different types require different management techniques, and only professional farmers may be able to raise ducks or chickens. Today, many farmers raise ducks or chickens by contract with private companies. Farmers often receive all inputs from the company such as seeds, feed, and even extension services.

Feeding. Animals are fed with what is available from farms in terms of by-products (crop residues, rice straw, etc.). Supplementary feed is provided by concentrated feed. Cattle

are fed grasses and even rice straw during the dry season. More often, these are sufficient for animal holdings. Farmers now pay more attention to the quantity rather than quality of feed for their animals.

Animal health care and diseases. Although the veterinary network was organized at the village level to help farmers in vaccination against common animal diseases, some endemic outbreaks still occur throughout the year. The common disease in cattle and buffaloes is hemorrhagic septicemia, which usually occurs at the onset of the rainy season. Common diseases in pigs are swine fever, salmonellosis, pasteurellosis, colibacillosis, and edema disease of young pigs, and reproductive disorders of sows. Common diseases of chickens are Newcastle, gumboro, pasteurellosis, variola, and coccidiosis, while those of ducks are duck plague, pasteurellosis, and duckling influenza. Many farmers lack knowledge and information on veterinary issues, especially on the prevention of animal diseases.

Major constraints to animal production. Several factors influence the production of livestock in the MD: (1) the economic status of farmers (the poorer and landless may not have capital to invest in animals, which affects the number of the animal population); (2) the market for products (low prices of local market, lack of processing); (3) the availability of feed resources (rice straw; crop by-products insufficient; growth affected by type of feed); and (4) veterinary services. Small farm households in remote areas usually lack capital and therefore are unable to take advantage of integrating livestock with other farming activities. In many cases, the poor kept livestock as a form of savings that can easily be converted to cash at short notice, and, especially, small farmers often kept poultry for household consumption. The market for products and feed resources are two important factors that have influenced livestock production in the MD. The number and type of livestock strongly depend on the market prices of outputs and inputs. For instance, pork production, which plays an important role in livestock production in the MD, increases when the price of pork is rising and the price of feed (mainly rice bran) is kept constant and low.

Management of rice production

Rice ecosystems. The MD region is the rice bowl of Vietnam, with about 2.0 million ha devoted to growing rice. Rice production in the region accounts for 52% of national rice production, with yield averaging 5.27 t ha^{-1} for winter-spring (W-S) paddy and 3.96 t ha^{-1} for the summer-autumn (S-A) crop. Although a large part of MD land is suitable for rice, this has not been very profitable because of the high production cost while the farm-gate price is low. Rice farmers earn additional income through crop diversification. As a result, various rice-based farming systems involving cash crops, livestock, aquaculture, and fruit trees have proven to be more profitable than monoculture of rice and are thus widely practiced in the region.

The Mekong Delta has three major rice cropping seasons: winter-spring (W-S), summer-autumn (S-A), and wet season or autumn-winter (A-W).

About 70% of the rice is grown on irrigated and/or semi-irrigated lowlands, and 30% is grown under rainfed lowland conditions. More than 80% of the area is under modern rice varieties. Average yield is 4.0–5.5 t ha^{-1}. *Mua* or A-W rice yield is 2.5–3.5 t ha^{-1}. Direct seeding is the most common crop establishment practice in the Delta.

Fertilizer application. Farmers often apply a high level of chemical fertilizer (90–120 kg N ha^{-1}) and use less organic fertilizer. Farmers apply animal manure in rainfed rice fields. A few farmers use the leaf color chart to apply fertilizer in order to reduce production costs.

Pest and disease control. More than 90% of the farmers in the MD use pesticides, and farmers use them quite heavily, averaging 1,081 g of active ingredient per ha. A consequence of this profuse use of pesticides is that it limits the use of rice straw to feed animals, especial for dairy cows.

Constraints to rice production. The major constraints to rice production in the Mekong Delta are flooding during the rainy season, drought in the dry season, and extensive areas with soil problems. Soil stresses affect more than half of the rice land, especially in rainfed and nonirrigated areas in the Delta. As discussed earlier, the problem soils are mainly saline and acid sulfate soils. Saline soils mainly in the coastal region occupy about 0.8 million ha. Acid sulfate soils occupy about 1.6 million ha, mainly in the Plain of Reeds and Long Xuyen-Ha Tien quadrangle. Rice yield varies greatly, depending on the degree of seriousness of soil problems. Average rice yield in areas with high acid sulfate is 2.6–3.6 t ha^{-1} and in areas affected by salt is 2.4–3.5 t ha^{-1}. In the more favorable areas, rice yield is 4.5–6.5 t ha^{-1}.

Mekong Delta farmers face low income from rice production because of inappropriate government policy for the sector, unstable and low farm-gate prices, high production costs, an inefficient marketing system, and a lack of market information.

The current level of infrastructure is inadequate to support increases in agricultural production. Postharvest facilities are inadequate. For instance, storage space and rice-processing factories are not enough, and about two-thirds of the farms have no access to drying areas.

Many small farmers in marginal areas in the Mekong Delta live with great variability in their environment. They lack the technical, economic, and institutional resources to overcome problems related to the environment and to improve rice cultivation and increase yield.

Potential for further development with ICAS in rice farming

The integrated crop-animal system is an effective means to promote economic security and rural welfare improvement among small-scale rice farmers. It also helps safeguard the

environment and is central to strengthening biodiversity in rice-based farming systems that cover the majority of the present government policy on "Change in the economic structure of agricultural systems." For these reasons, ICAS must be strengthened and promoted, not only at the level of the farm household but also on a wider regional scale. Promotion of ICAS should be a key component in government development policy. Along with this should be strong support from national agricultural scientists and/or the international community, particularly for research and technology development.

Small-scale rice-based farming systems still play an important role in the development of agriculture in the Mekong Delta. The integration of livestock into the rice-based farming system could be seen as a way of improving livelihood and generating income for farmers. Observations made by several researchers as well as by farmers point to the fact that rice monoculture among small farm households is not profitable. Supplemental economic activities on the farm or in other landholdings such as growing vegetables and other cash crops or raising animals or fish can indeed raise household income. Raising livestock is also not profitable without the integration of the crop component and/or other farm resources. Thus, more diversification of rice-based farming systems in combination with livestock raising is a major priority of small-scale farmers in the MD.

In rainfed areas, especially in more remote areas, livestock production systems are mainly backyard growing systems with extensive management (no concentrated feeds are fed to animals). On these farms, the combination of animals and rice fields shows some degrees of integration as crop residues and by-products are used as the main supplementary feed. Native cattle are often fed rice straw and rice bran as a major supplemental feed in the dry season. Pigs and poultry are also fed rice bran, broken rice, and unfilled rice grains. These systems continue to be the most appropriate farming systems for small farmers, although the number of backyard farms may decline further in the future, but the quantity of animals kept per household will increase.

Current trends likewise indicate that some farming households are gradually being transformed from subsistence livestock husbandry into commercial livestock production with semi-intensive or intensive systems. However, these types of farms occupy 10–20% of the total animal production of the Delta and are categorized as semi-intensive or intensive farms located close to the city. They keep large animals and practice more intensive management (such as the primary use of concentrated feed and vaccination service). These types of farms exhibit very low interaction between crop and animal components.

In line with the current situation of animal production and potential of ICAS in the region, commercial farms (these farms also exhibit very low interaction between crops and animals) should be encouraged to meet the increasing market demand for meat and other animal products. At the same time, however, ICAS should be developed further as a potential and effective measure of sustaining food production among small farm households to fight rural poverty and improve rural living standards.

Issues/gaps for ICAS success and sustainability in rice ecosystems

Considering the current situation of the livestock production sector and in line with the intensification and sustainability of ICAS, key research issues are identified below that should be considered priorities in the region:

- Based on the comparative advantages of each agroecosystem and its potential, identifying suitable types of animals and crops that can promote appropriate ICAS in each agroecological zone.
- Conducting a socioeconomic analysis for ICAS, including studying the social-cultural acceptability of ICAS, using farm resources, using manure, the labor requirement, and cost-benefit analysis (also to compare whether to grow forage or rice on some unfavorable rice lands).
- Promotion of ICAS as the best approach to eliminating rural poverty among rural poor farmers, especially in rainfed areas. A form of "farmer field school on ICAS technologies" may be essential to introduce both crop production and animal husbandry skills to these resource-poor farmers.
- Improving transfer of knowledge to farmers and veterinary services. From our findings, certain new potential technological innovations, which are beneficial to farmers, have yet to reach them. Small-scale farmers often follow traditional practices and extensive management systems, especially backyard growers, who do not pay attention to husbandry skills, sanitation, feed composition, and vaccination. Usually, extension agents have provided only "what they have and not what farmers need." Linkages among extension, research, veterinary services, and farmers need to be studied further.
- Supporting credit to farmers to develop ICAS. Almost all small farmers in remote areas have a lack of capital and credit, and they are unable to take advantage of integrating animals into their farming system. Experiences from certain projects with credit support to small farmers in the region (women's savings and credit groups, a heifer project, etc.) showed a positive effect. A study on how to strengthen "micro-credit systems" to support ICAS in the region could be valuable.

References

Chi HH. 2002. Results of dairy cattle production in Song Hau state farm. Paper presented at the Workshop on the Development of Ruminant Production in the Mekong Delta, 9-11 April 2002. (In Vietnamese.)

Dung LC, Tuyen NQ, Yamada R, Can ND. 2000. Farm household status in Tan Phu Thanh village: results from the benchmark survey in 2000. Proceedings of the 2000 Annual Workshop of JIRCAS Mekong Delta Project. Can Tho University, Can Tho, Vietnam.

Hossain M. 1999. Long-term perspective of the demand-supply balance for rice in Asia: implications for technological challenges. In: Proceedings of the International Symposium on World Food Security, Kyoto, Japan. p 31-39.

Manh LH, Xuan Dung NN, Thanh VC, Hirata Y, Hayashidani H. 2002. The distribution and genetic diversity of local pig varieties in the Mekong Delta, Vietnam. Bulletin of research reports on environmental and agricultural sciences (1999-2001), Can Tho University, Can Tho, Vietnam.

Nghia NV. 2002. An outline of cattle breeding of Luong An Tra farm. Paper presented in the Workshop on the Development of Ruminant Production in the Mekong Delta, 9-11 April 2002. (In Vietnamese.)

Ohga K. 1999. World's food supply and demand prospects in 21st century. In: Proceedings of the International Symposium on World Food Security, Kyoto, Japan. p 9-15.

Phan TT. 1999. Roles of women in animal production in some provinces in the Mekong Delta. Project report on "Revolving loan for agricultural production of poor women in rural areas."

Sanh NV, Xuan V-T, Phong TA. 1998. History and future of farming systems in the Mekong Delta. In: Xuan V-T, Matsui S, editors. Development of farming systems in the Mekong Delta of Vietnam. JIRCAS, CTU, and CLRRI, Ho Chi Minh City, Vietnam. p 16-80.

Xuan V-T, Hai LT, Loc CB. 1995. Research priorities for improving animal production by agro-ecological zone in Vietnam. In: Global agenda for livestock research. Proceedings of the consultation for the Southeast Asia Region, International Rice Research Institute, Los Baños, Philippines, 10-13 May 1995. p 197-213.

Notes

Authors' address: Mekong Delta Farming Systems Research and Development Institute, University Campus II, 3/2 Street, Can Tho City, Can Tho, Vietnam.

Acknowledgments: The authors would like to express thanks to SLP/ILRI for funding this study and to IRRI for extending the invitation to us to participate in this project. Our special thanks go to Mercedita A. Sombilla and Violeta G. Cordova from IRRI for their support for and advice on this study.

We would also like to express our appreciation and sincere thanks to all organizations and individuals for their collaboration and providing information for this study. In particular, we give our sincere thanks to L.L. Dung, Agricultural Extension Department of Long An Province; H.H. Thanh, Agricultural Extension Department of An Giang Province; P.T. Tai, Agricultural Extension Department of Vinh Long Province; P.V. Nghi, Agricultural Extension Department of Tien Giang Province; D.V. Chuong, Agricultural Extension Department of Tien Giang Province; Hua Quang Tang, Department of Agricultural and Rural Development of Tien Giang Province; and N.T.Viet Nga, Veterinary Department of Tien Giang Province.

Without their help, this monograph could never have been completed. We hope that the monograph will help people to understand better the evolution of integrated crop and animal systems, especially among rice-based farm households in the Mekong Delta of Vietnam.

Evolution of integrated crop-animal systems in northern Vietnam

Dao The Anh, Pham Thi Hanh Tho, Vu Trong Binh, and Nguyen Ngoc Luan

Crop production and animal husbandry are the two main branches of Vietnamese agriculture since they contribute the most agricultural revenue. For the agricultural sector, particularly in North Vietnam, animal raising has always played an important supplementary role to crop cultivation. For many years, production systems among rural households have been characterized by the close integration of crop cultivation and animal raising. These production systems consist of a combination of a garden, a pond, and/or a cage and are commonly referred to as the "VAC" system. The garden includes all areas where crops such as rice, roots and tubers, vegetables, trees, and other plants are cultivated; the pond is the place where fish and other aquatic animals are grown; and the cage refers to all activities that have something to do with animal raising for own consumption as well as for livelihood purposes. These activities represent a closed ecosystem in which animal raising provides extra revenue as well as organic fertilizer for crop cultivation, while crop production provides food for both the household and the animals.

Production systems change over time and they differ across each region. In this report, the characterization of production systems focuses on two contrasting areas: the Red River Delta, where agriculture is highly intensive, and the North Mountainous region, where agriculture is more extensive and where problems are more multifaceted and serious.

Because of the growth in population and increasing trend toward urbanization, cultivated land per capita in the Red River Delta has gradually decreased. Population density is approximately 1,000 people per km^2, whereas cultivated land is only about 0.25 to 0.3 ha per household. Because of this limited land resource, increasing income from agriculture is more difficult. Farmers therefore have to look for new opportunities outside the farm, such as working in small handicraft production, processing agricultural products, getting engaged in the service sector, or working as an employee in established businesses. But, such opportunities are greatly hampered by a lack of capital, inadequate technical skills, and weak markets. The majority of farmers have found one solution with livestock production to supplement income from crop cultivation, especially among small households that primarily consume most of their production and sell the surplus to fulfill other needs. In contrast to the delta, the mountainous area faces many constraints related to the economic well-being of households, such as the low availability of production technology and difficulty to gain access to larger markets. Crop-animal production in this area still follows the old local systems as it is still considered to be a safe strategy for raising household income.

Promotion of a closer relation between crop cultivation and animal production in North Vietnam came largely from the passing of Resolution 10 (1988) for farming households to be a self-contained unit such that each household would produce mainly for consumption and sell production surpluses if these were available. This concept is a divergence from the long period of the collective production concept in which households are part of cooperatives. The system typifies the basic characteristic of small-scale production in both delta areas and mountainous areas where some outputs from crop cultivation serve as inputs in animal production and vice versa.

As Vietnam's economy further developed, additional policy reforms were adopted that aimed to slowly change the agricultural and rural structure toward greater industrialization and modernization. Now, in the more progressive areas, farm households have been gradually expanding production structures from self-contained and subsistence operations to operations that are more commercially oriented. This trend has been indicated by the increased rate of specialization in animal production. The emerging trend caters to the increasing demand for highly nutritious and better-quality food.

But, for a greater part of Vietnam, traditional agricultural production methods characterized by poor economic efficiency and the use of backward methods still abound. This will not be easy to overcome over a short period of time. Thus, the integrated crop-animal system (ICAS) among small rural households remains the most appropriate means of livelihood to improve rural welfare in the next few years. It is the key to achieving the main objective of agriculture,

which is to stabilize rural livelihood by increasing potential sources of household income, creating jobs, improving nutritional well-being, and contributing to a better and more sustainable environment. ICAS is also a tool to reduce the risk of both natural calamities and the unstable agricultural product markets. As the role of the government in agricultural product markets diminishes and effective regulatory institutions are still not in place, the domestic market for food in Vietnam has been very unstable.

Research purpose and method

This monograph is a part of a socioeconomic study that intends to understand the multifactoral and changing role of animals in rice farm households of Vietnam, specifically in the Red River Delta and North Mountainous areas. The monograph aims to present a general picture of the agroecological conditions, characteristics, evolution, and trend of crop-animal systems, especially in the light of a changing economic environment as well as technology development in Vietnam. It also aims to identify more specific issues and gaps that could be further examined in subsequent studies. More specifically, this monograph has the following objectives:

- Describe trends in rice, food crop, and livestock production and demand.
- Describe the evolution of ICAS, especially in rice farm areas.
- Identify issues/gaps that hinder further intensification of ICAS.
- Determine research and policy implications for sustainable ICAS.

Evolution of the main rice-based production systems at the regional level

Red River Delta area

Natural, social, and economic conditions. Land surface in the Red River Delta is 12,614 km^2. This is only 5% of the total surface area of the country, which is 330,900 km^2. The total delta surface covers more than 20% of the nation's surface area, most of which is concentrated in the delta of the Mekong River in southern Vietnam.

Most of the area in the Red River Delta is agricultural land (857,515 ha or 58.6% of the total natural land as shown in Figure 1). However, the surface area of agricultural land per farming household or per capita is small and has gradually decreased over time because of the high rate of urbanization and population growth (Fig. 2).

From 1991 to 1998, the ratio of the average agricultural land per household decreased from 0.29 to 0.25 ha; agricultural land per capita also decreased from about 720 to 630 m^2. On the contrary, in the Mekong River Delta, the average agricultural land was more than 1 ha per household and 0.2 ha per capita. As in the Red River Delta, these ratios are declining over time.

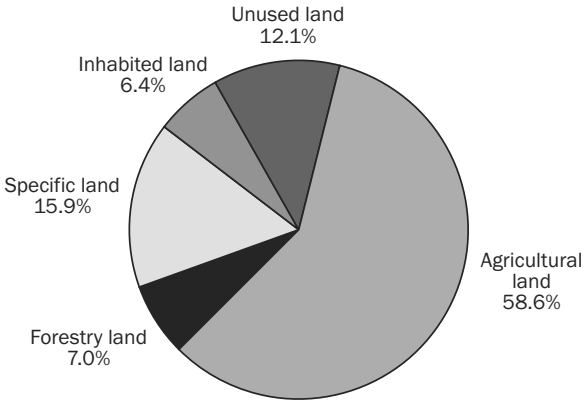


Fig. 1. Land-use status in the Red River Delta in 2000. Specific lands are public areas used for nonagricultural production, such as a cemetery, etc. Source: GSO (2001).

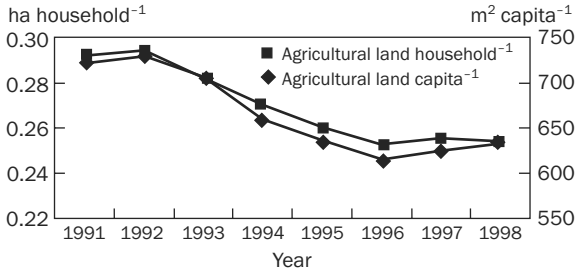


Fig. 2. Evolution of agricultural land per capita and per household. Source: GSO (2000).

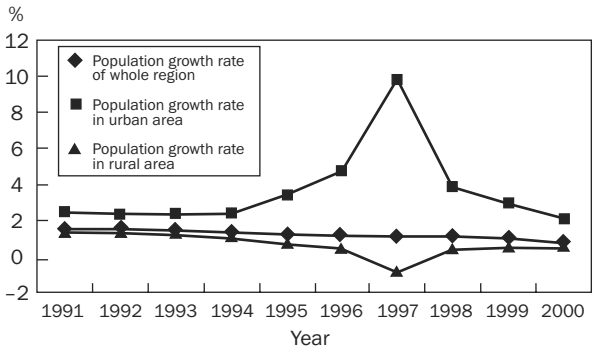


Fig. 3. Population growth rate of the Red River Delta. Source: GSO (2001).

Population in the Red River Delta increased from about 13.1 million in 1991 to nearly 15 million in 2000, an average growth rate of 1.3% per year (Fig. 3). About 80% of the population is in rural areas. At the same time, the urban population increased from about 2.2 million to more than 3.2 million (average growth of 3.6% per year), while the rural population increased from nearly 11 million to more than 11.7 million (average growth of 0.7% per year). In 1997,

the urban population in the Red River Delta suddenly increased, with an annual growth rate of 9.7%, while the rural population decreased at 0.8%. This was also when the urban and rural population in the whole country exhibited similar growth trends, with the urban population growth rate estimated at 9.2% per year and rural growth rate at –0.5% per year (Fig. 4). These data partly reflect the strong urbanization process starting in 1997. In recent years, the population growth rate in the Red River Delta has decreased. This also explains the decrease in agricultural landholding per household over time as well as the high and increasing population density. From 1991 to 2000, population density increased from about 1,000 people km^{-2} to more than 1,100 people km^{-2}.

In 2000, the gross domestic product (GDP) of the Red River Delta was more than US$3.8 billion. Agricultural, forestry, and aquatic products contributed 25% of the GDP; industry, 31%; and services, 44% (Fig. 5). Agricultural products accounted for 90% of the GDP for agricultural, forestry, and aquatic products, and 80% of the total GDP. The contribution of agricultural, forestry, and aquatic products has decreased in recent years while that from the industrial sector has increased. The contribution of the services sector remained constant and fluctuated around 44% to 45%.

In 1997, GDP in the Red River Delta grew at 11.2%, in which agricultural, forestry, and aquatic products grew at 8.9%. This growth was particularly impressive vis-à-vis the growth rate of 0.1% in 1996. However, from 1997 to 2000, the growth rate of agricultural, forestry, and aquatic products gradually decreased.

GDP per capita in the Red River Delta increased year by year. From 1996 to 2000, it increased from US$173.30 per capita per year to $213.30.

Agriculture in the Red River Delta has three major sectors: crop cultivation, animal production, and agricultural services. Crop cultivation has always contributed the most to the gross value of agricultural production. However, from 1996 to 2000, the structure of agricultural value added started to change; the contribution of the animal sector to the gross value added has increased from 16% to more than 25% (Fig. 6). The contribution of crop cultivation decreased from more than 80% to nearly 75%.

The average value of the supply of food per capita in the Red River Delta increased gradually from 1996 to 2000, from $36.60 to $45.[1] Thai Binh Province had the highest average supply of food per capita, estimated at about $66.70 per year for 1996-2000. This province also had the highest value of food productivity, followed by Nam Dinh and Ha Tay provinces. However, this value has decreased gradually in Thai Binh because of its overcrowding.

The top of the Red River Delta is located near Viet Tri City (Phu Tho Province) and the bottom is situated along the seaside of the West Sea, from Hai Phong Province to Ninh Binh Province. Before 1995, the Red River Delta included 58 districts and towns belonging to six provinces (Ha Tay, Hai Duong, Hung Yen, Ha Nam, Ninh Binh, and Thai Binh) and to three cities (Ha Noi, Hai Phong, and Nam Dinh). Starting in 1996, two more provinces were added, Vinh Phuc and Bac Ninh.[2] Overall, the Red River Delta

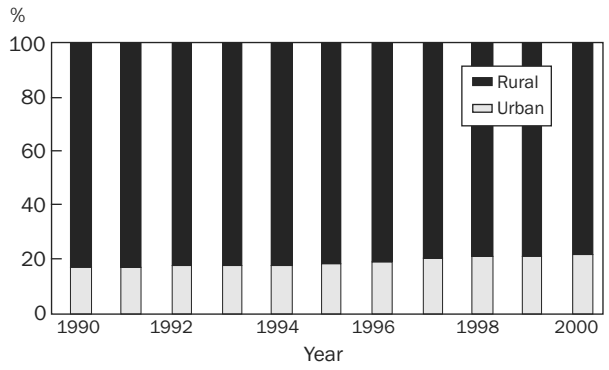


Fig. 4. Evolution of rural-urban population in the Red River Delta. Source: GSO (2001).

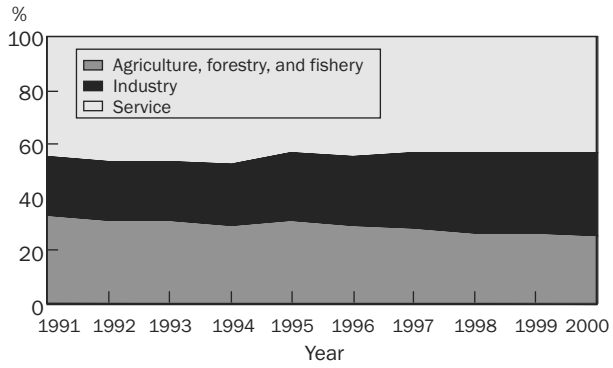


Fig. 5. GDP structure in the Red River Delta. Source: GSO (2001).

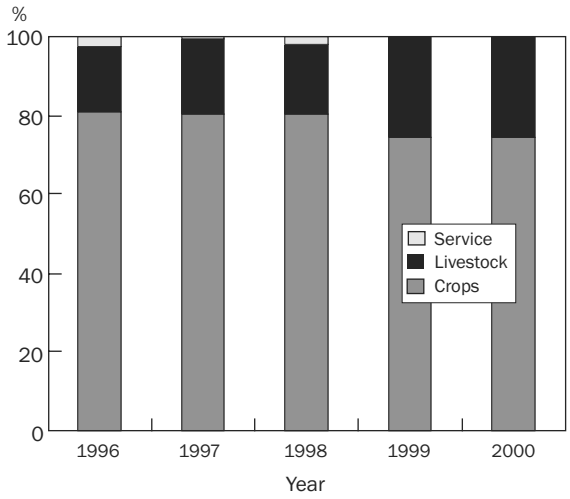


Fig. 6. Evolution of the agricultural value structure in the Red River Delta. Source: GSO (2001).

[1]US$1 is equivalent to VN dong 15,000.

[2]Because of this change, statistics in Bac Ninh and Vinh Phuc provinces from 1991 to 1995 are not available. Thus, for 1991-2000, we analyzed and compared only statistics of the original nine provinces in the Red River Delta.

consists of 11 provincial areas with more than 80 districts and 2,000 communes.

The Red River Delta has a dense river network that extends widely over the entire surface of the area. All the river systems of the Red River Delta are now protected by a full dike system that efficiently drains water from the two big river systems: the Red River and Thai Binh River.

The Red River Delta is located in the monsoon climate zone. The climate is divided into two distinct seasons: the dry season and the rainy season. The dry season starts in November and ends in April and the rainy season goes from May to October. This region has alluvial deposits and rugged terrain (alternately high, low, and middle).

The Red River Delta is divided into three ranges:

- The northeast range toward the southwest.
- The central range: this structure is the deepest and thus becomes the hollow places of the Red River Delta.
- The southwest range.

Agroecological areas in the Red River Delta. The Red River Delta is divided into four agroecological areas (Fig. 7):

1. Lowland area: This area is usually flooded and it is difficult to diversify crop cultivation. It is located in Nam Dinh, Nam Ha, and Ninh Binh provinces.
2. Dry crop area: This area is not flooded or irrigated. It is easy to diversify crop plants but the area has low productivity.
3. Coastal area: This area is difficult to diversify but it has high productivity (Thai Binh Province).
4. Intensive area: This area has the highest productivity per unit surface, with strong diversification and high yield (Hai Duong Province).

Most of the provinces that are included in the lowland and dry crop areas have poor soils and thus low productivity. Enriching these lands by applying fertilizer and other inputs has been difficult because of farmers being unable to gain extra income from off-farm activities as they are quite far from markets and business centers. The coastal and intensive areas have rich soils that help in achieving higher productivity. The potential for developing off-farm activities in these areas is also greater.

Physical and climatic conditions, agroecological characteristics, and some socioeconomic variables have had much influence on the farming households' production systems.

According to Table 1, six types of households are defined by combinations of several factors, including the size of land owned, income, and agroecological characteristics. The integration of crops and animals is different for each household category. Pigs are the most popular but other animals such as cattle and poultry are also present among a few households but in not enough number to make any significant contribution to household income. Pig production is the most developed in two types of households: those belonging to groups C and F. Households in group C, compared with the other groups of households with small land area, are engaged in more diversified activities, both on-farm and off-farm, and have performed relatively well in these activities. Pig raising has been one activity they have been able to develop more successfully. The large involvement in pig raising of households in group F, on the other hand, is very clear. These households not only possess relatively large land areas but most of them are also more experienced in animal breeding. Unlike group C, whose members are actively involved in off-farm work that provides the capital for pig raising, those in group F mostly derive their financial support from pensions, money sent by relatives working abroad, etc. They are very successful in their crop production, which is quite intensive. They use pig manure in production, and hence incur some savings on fertilizer expenditures. These two groups are the more well-to-do households compared with the other households in their respective groups. It is clear from the table that what gives the income edge to these groups is their involvement in pig raising. Other households have either not ventured

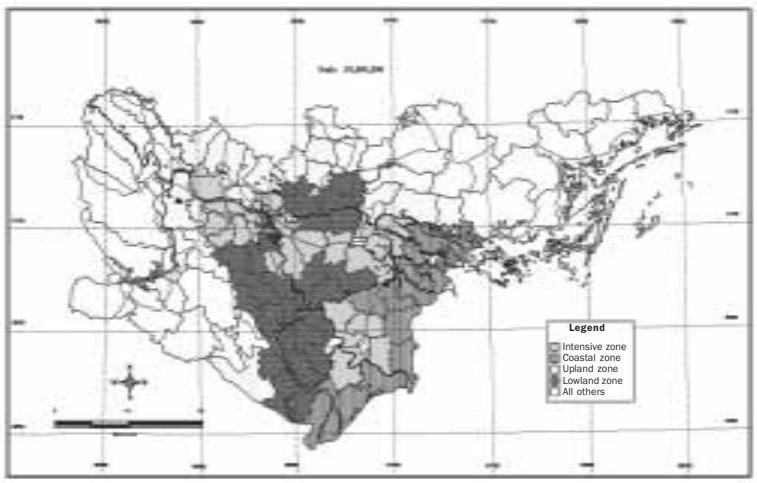


Fig. 7. Agroecological zoning map of Red River Delta.

Table 1. Main household types in the Red River Delta.

Item	Cultivated area					
	Small land area			Large land area		
Income without labor	Low	Medium	High	Low	Medium	High
Type of land	Lowland and dry land	Intensive and coastal	Intensive and low	Lowland and dry land	Intensive and coastal	Intensive and low
Type of household	(A) Small land area, poor	(B) Small land area, diversified agriculture	(C) Small land area, diversified economics	(D) Poor farmers	(E) Middle farmers	(F) Breeders
Productivity of plants[a]	–	–	++	–	–	++
Off-farm activities	– –	=	++	– –	–	–
Pig production	– –	–	+	=	+	++
Percent of total respondents (%)	15	21	5	24	33	2
Average surface (m^2 $person^{-1}$)	350–500	350–400	400–500	550–1,000	600–900	550–900
Average income $year^{-1}$ (US$ $person^{-1}$)	40–50	70–100	130	60–70	80–100	120–200

[a]Bad development: –, very bad development: – –, normal development: =, good development: +, very good development: ++.
Source: Dao The Anh and Jesus (1997). Classifying from data of VLSS (1993).

into pig raising or have not been successful with this activity.

Characteristics of cropping systems in the Red River Delta. Cropping patterns in the Red River Delta closely follow those in other Southeast Asian countries with monsoon climate. The climatic conditions and diverse soil characteristics have influenced the crop combination and cropping schedule as follows:

- The spring rice crop is started in January and harvested at the beginning of June.
- The autumn rice crop is started at the beginning of July and harvested in October.
- Vegetables or winter plants are cultivated from October to January.

Crops usually consist of rice, vegetables, fruit trees, and annual industrial crops. Rice is cropped in most farm areas. Most of the irrigated lands are used for growing rice, vegetables, and fast-growing industrial trees. Highland or alluvial land is used for cultivating vegetables, fast-growing industrial trees, and fruit trees. The cropping system is highly intensive and involves cultivation of several crops within a year. Popular crop combinations include the following:

- One rice crop with one spring rice crop or one summer crop
- Two rice crops, usually spring rice and summer rice
- Two rice crops and one winter crop: spring rice, summer rice, and a winter crop
- One rice crop and one dry crop: a spring dry crop followed by summer rice
- One rice crop and two dry crops: a spring dry crop followed by summer rice and then a winter dry crop
- Dry-crop specialization in rainfed area: spring, summer, and winter seasons have dry crops
- Four crops: spring rice, summer dry crop, summer rice, winter dry crop
- Spring rice, fish in summer, fruit trees on the farm border

(Note: The spring rice crop covers the period of February to June; the summer rice crop, from July to October; the winter rice crop, from October to January; the summer dry crop, from June to August. The spring dry crops usually consist of peanut, soybean, green bean; summer dry crops are soybean; and winter dry crops are potato, maize, sweet potato, and vegetables.)

The intensiveness of land use has necessitated the application of fertilizer to satisfy plant requirements. Fertilizer supplements usually come from livestock manure.

Since 1991, the annual sown area of rice in the Red River area has increased very slowly and has fluctuated around 1 million ha (Fig. 8). Compared with the whole country, the contribution of annual sown area of rice in the Red

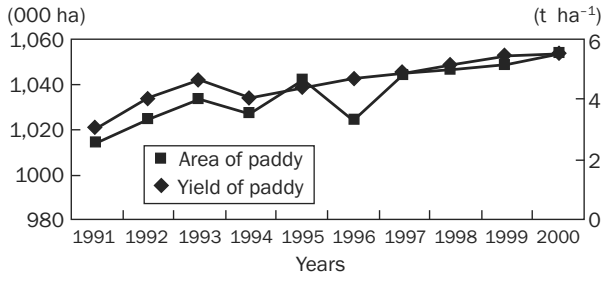


Fig. 8. Paddy production in the Red River Delta. Source: GSO (2001).

River area has decreased from 16% to 14% of the total-country sown area. The Red River Delta ranks second in terms of rice sown area, after the Mekong River Delta, where cultivated rice reached 3.9 million ha in 2000.

Although the sown area of rice has decreased, rice production in the Red River Delta still increased from 15% of the total-country area in 1991 to 18% in 2000 because of the relatively high yield performance achieved. Rice yield increased from 3 t ha^{-1} in 1991 to 5.5 t ha^{-1} in 2000, which is the highest gain in the country, even higher than that achieved in the Mekong River Delta, which had an average yield of 4.2 t ha^{-1} in 2000. Total rice production was more than 5.8 million t in 2000, whereas in 1991 it was only 3 million t. This increase has resulted in the average rice supply per capita increasing from nearly 230 kg $capita^{-1}$ $year^{-1}$ in 1991 to 390 kg $capita^{-1}$ $year^{-1}$ in 2000.

The cultivated area of maize in the Red River Delta represented about 10% of the total cultivated area of maize in the whole country in 2000. It increased steadily from 69,000 ha in 1991 to 89,000 ha in 1996, then decreased gradually to 68,000 ha in 2000 (Fig. 9).

Maize yield has increased from about 1.8 t ha^{-1} to more than 3 t ha^{-1} during 1991-2000 (Fig. 9). This compensated for the significant decrease in maize sown area starting in 1996; hence, the impact on total production was low. Production was recorded to have increased in 1996-97 and 1998-99. But, in 2000, maize production dropped to only 200,000 t, necessitating maize imports into the Red River Delta from other areas or countries to meet local demand for animal feed.

The sown area of sweet potato decreased from about 78,000 ha in 1991 to 53,000 ha in 2000 (Fig. 10). This trend is connected to the increase in rice production that ensured greater food security in the Red River Delta; sweet potato was mainly channeled to the demand for feed by the animal sector. In addition, demand for sweet potato has been low as farm households use more and more mixed feed for their animals.

The yield of sweet potato has not improved much because stagnant demand has not been enough of an incentive for further development in crop performance. The average yield of sweet potato was around 8 t ha^{-1} (Fig. 10). Production of sweet potato has also decreased over time, from nearly 600,000 t in 1991 to 440,000 t in 2000, reflecting the decline in cultivated area and unchangeable yield.

Crop diversification in the Red River Delta in 1996-2000 tended to decrease, as indicated by the diversity coefficient for agricultural activities, which fell from 0.56 to 0.43 (GSO 2001). While rice continued to be cultivated as the dominant food crop, the cultivation of other food crops such as maize and sweet potato decreased. The production of high-value crops such as vegetables increased, on the other hand, as their demand strengthened with income growth. Maize production continued to cater to pig production, which was developing rapidly. The crop production pattern was observed to have become more specialized as cultivation became concentrated on a limited number of crops.

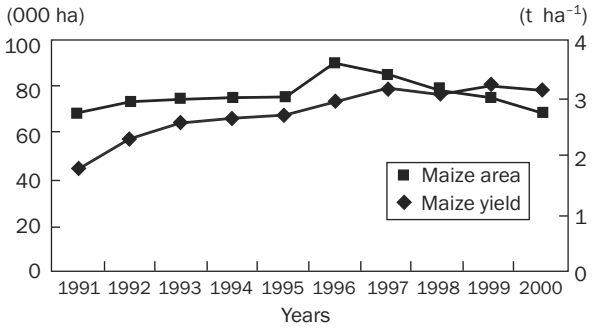


Fig. 9. Maize production in the Red River Delta. Source: GSO (2001).

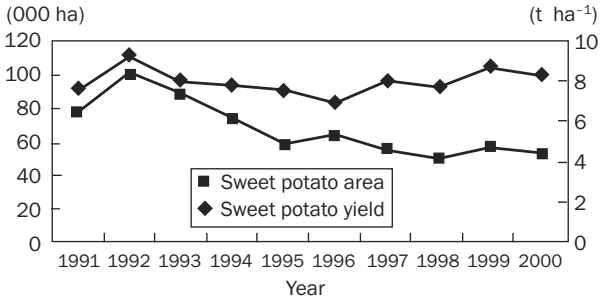


Fig. 10. Sweet potato production in the Red River Delta. Source: GSO (2001).

Animal production situation in the Red River Delta. During 1991-2000, the production performance of different types of livestock in the Red River Delta changed. Cow, pig, and poultry production increased significantly, whereas buffalo production decreased (Fig. 11). In earlier years, farmers raised cows and buffaloes not only for food but also for labor. However, with the rapid rate of mechanization in agriculture, raising cows or buffaloes is now mainly for food. Consumers like to eat beef much more than buffalo meat. Hence, buffalo production has gradually decreased in the Red River Delta. Cattle production, on the other hand, has continued to develop, mostly at dike edge areas because farmers can graze animals on pasture. Pig production, in contrast, has always been part of the small farm household production system. However, its role as a supplier of manure for rice cultivation is now gradually decreasing as production has become more and more specialized.

The rate of livestock production in the Red River Delta has increased over the years. In 1996-2000, the production value of livestock breeding increased at about 17% (Fig. 12).

North Mountainous area

Natural, social, and economic conditions. The North Mountainous area of Vietnam consists of two regions: the north-

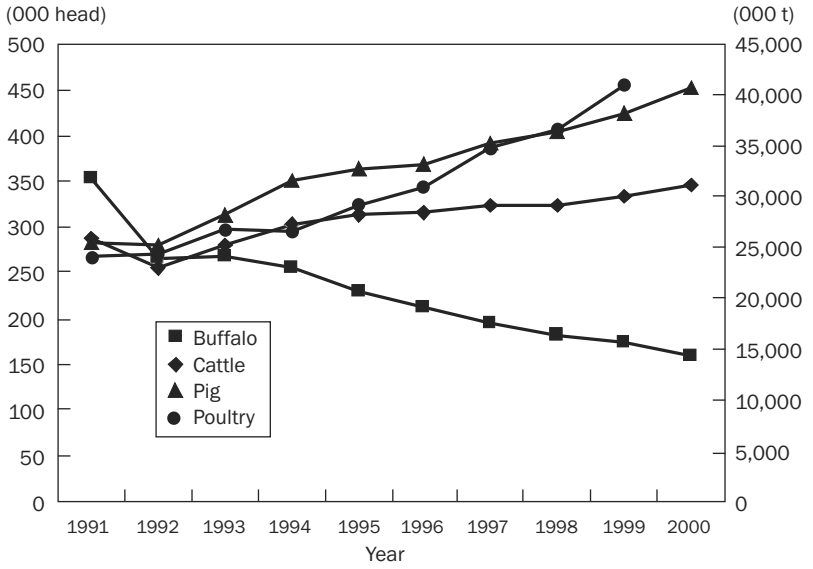


Fig. 11. Animal population and poultry production in the Red River Delta. Source: GSO (2001).

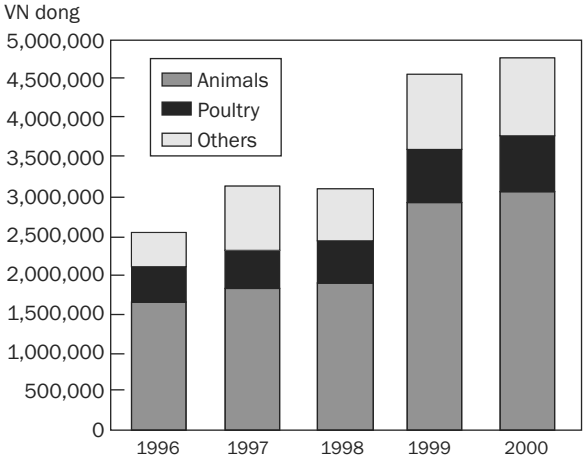


Fig. 12. Value of animal production in the Red River Delta. Source: GSO (2001).

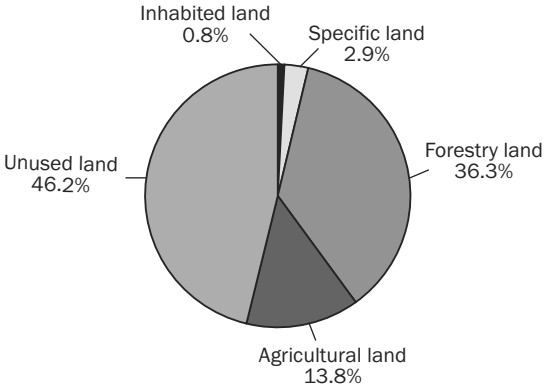


Fig. 13. Land use in the North Mountainous area in 2000. Note: Specific land consists of public areas used for nonagricultural activities such as a cemetery, etc. Source: GSO (2001).

east and northwest. There are 13 provinces in the northeast—Ha Giang, Cao Bang, Lao Cai, Lang Son, Tuyen Quang, Yen Bai, Bac Kan, Thai Nguyen, Phu Tho, Vinh Phuc, Bac Giang, Bac Ninh, and Quang Ninh—and three provinces in the northwest—Lai Chau, Son La, and Hoa Binh.

The climate in the North Mountainous area is also divided into two distinct seasons, the dry and rainy seasons. The dry season starts in October to November and ends in March to April of the next year. During the dry season, the climate of Bac Kan Province is cold and dry and the average temperature is 18 °C. Monthly rainfall during this season ranges from 13.0 to 70.5 mm. The bulk of the rainfall (average of about 82% of the total yearly rainfall) takes place during the rainy season. The maximum rainfall is in July, with 263 mm. The temperature during this season ranges from 22.9 to 27.3 °C.

Total natural land in the North Mountainous area is 103,106 km^2. Agricultural land occupies approximately 14%, whereas unused land occupies more than 45% (Fig. 13).

Despite its small share, agricultural land per household and per capita are 0.6 ha and 0.13 ha, respectively, which are relatively higher than those reported in the Red River Delta of 0.08 ha per capita on average (Fig. 14). The average landholdings in this area have also decreased over the years.

From 1991 to 2000, the population in the North Mountainous area increased from 11 million to more than 13 million, with an average growth of 1.6% per year. The population is made up of various ethnic groups who live mainly in

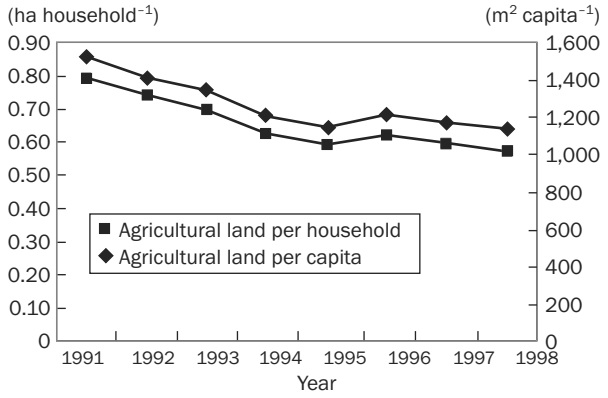


Fig. 14. Evolution of agricultural land in the North Mountainous area. Source: GSO (2000).

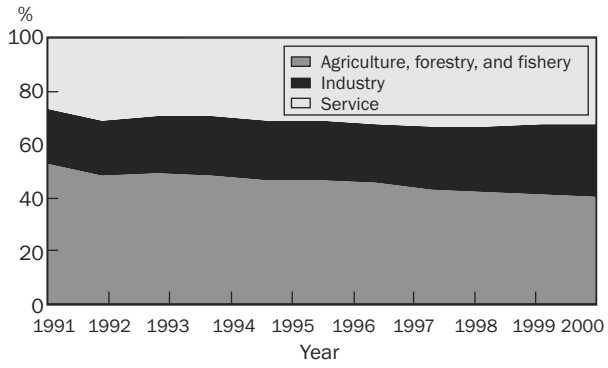


Fig. 15. Evolution of GDP structure in the North Mountainous area. Source: GSO (2001).

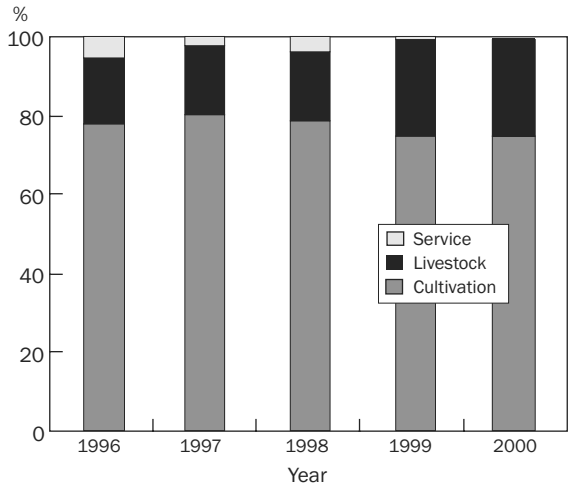


Fig. 16. Evolution of agricultural value structure in the North Mountainous area. Source: GSO (2001).

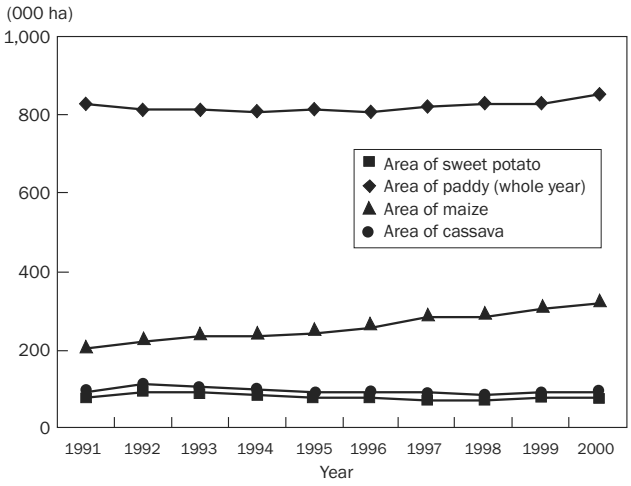


Fig. 17. Evolution of some main crop areas in the North Mountainous area. Source: GSO (2001).

the rural areas. The rural population still accounts for about 85% of the area's total population. Over the years, the urban population increased, with the highest growth rate at 8% in 1997.

In 2000, GDP of the North Mountainous area was more than $2,000 (Fig. 15). Agriculture had the largest percentage contribution at 40%. During 1996-2000, GDP increased at 9%, with industry averaging 15%, service 10%, and agricultural, forestry, and aquatic products combined at 6%. GDP per capita also increased from more than $100 in 1996 to more than $133 in 2000. Despite this significant rise, per capita GDP in the North Mountainous area is still lower than in other areas.

The structure of agriculture in the North Mountainous area has moved from crop cultivation and agricultural services toward animal production. Over 1996-2000, the production value of crop cultivation decreased from 78% to nearly 75% of the total production value of agriculture and so did the value of the agricultural service sector, from 5.2% to 0.2%. But, animal production increased from 16% to 25% (Fig. 16).

The average value of food supply per capita in the North Mountainous area increased from about $25 in 1996 to more than $32 in 2000. This number did not vary substantially between provinces in the area. In this period, the northeast provinces increased their percentage of food cultivation area from 61% to 65% vis-à-vis total cultivation area. However, the northwest provinces did not increase this share.

Characteristics of cropping systems in the North Mountainous area. During 1991-2000, the sown area of rice in the North Mountainous area increased only a small amount from 820,000 to 845,000 ha (Fig. 17). But, from 2000 up to now, the rate of growth has fallen even lower.

Total rice production increased year by year (from about 1,600,000 t in 1991 to more than 3,200,000 t in 2000) despite cultivated area remaining at almost the same size. This was due to the rapid increase in rice yield (from nearly 2 t ha^{-1} in 1992 to nearly 4 t ha^{-1} in 2000; Fig. 19).

With the increase in rice production, paddy supply per capita also increased (from more than 135 kg capita^{-1} in

1991 to 245 kg capita^{-1} in 2000 on average); however, it was still smaller than in other areas of the country.

For households at some locations in the North Mountainous area, maize was still considered the staple food. In addition, maize is the main feed for animals in various localities. Cultivated area dedicated to maize increased gradually (from nearly 200,000 ha to more than 300,000 ha over 1991-2000). Following the increase in sown area, yield and production of maize also increased. In 2000, maize production reached nearly 700,000 t, with yield of about 2.3 t ha^{-1} (Figs. 17 and 18).

Sown area of sweet potato has not changed much. It fluctuated around 70,000 ha during 1991 to 2000. The highest sown area recorded was 85,000 ha in 1993. From 1994 to 1998, sown area of sweet potato decreased and its yield was low and unstable, only 5–6 t ha^{-1}. Production of sweet potato in the area in 2000 reached only 400,000 t (lower than in 1991-93, especially in 1992, which was more than 540,000 t).

In the North Mountainous area, cassava was primarily cultivated only after rice. It played an important role in supplying feed for animal production. The sown area of cassava reached 85,000 ha in 2000 and occupied more than 35% of the sown area of cassava in the whole country. From 1991 to 2000, the sown area of cassava was unchanged (Fig. 17). It fluctuated from 85,000 to 90,000 ha and reached a high of a little more than 100,000 ha in 1992. Yield of cassava is now even lower than previous levels, and it has also been unstable over the years (about 8 t ha^{-1}; Fig. 18).

The production of cows, buffaloes, pigs, and poultry in the North Mountainous area all increased during 1991 to 2000 (Figs. 19 and 20). While buffalo production in the whole country decreased, buffalo production in the North Mountainous area still increased to become the largest buffalo meat-producing area (about 60% of buffalo production of the country). The main reason for this situation is that there is still a strong demand for buffaloes for use as draft power and transportation. Cow breeding in the North Mountainous area is mainly channeled only to meet beef demand from the local people or from people in nearby areas. Farmers raised cows and buffaloes by taking advantage of the rich grazing pastures that are still abundant in the area. Households therefore did not have to spend much money on feed. Thus, the percentage of benefits in raising cows and buffaloes was relatively high and has increased over time.

The total value of animal production has increased more than 1.9 times from 1996 to 2000, in which domestic animals such as cows or buffaloes occupied nearly 70% (Fig. 20).

Meat consumption in Vietnam

Consumption of meat per capita has increased rapidly in recent years. Although the gap in consumption between urban and rural areas is still high, it is decreasing because of the strong growth in consumption in rural areas from 1992

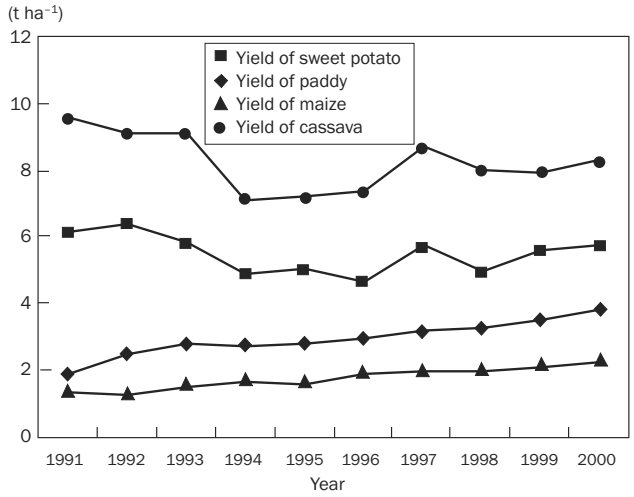


Fig. 18. Evolution of some main crop yields in the North Mountainous area. Source: GSO (2001).

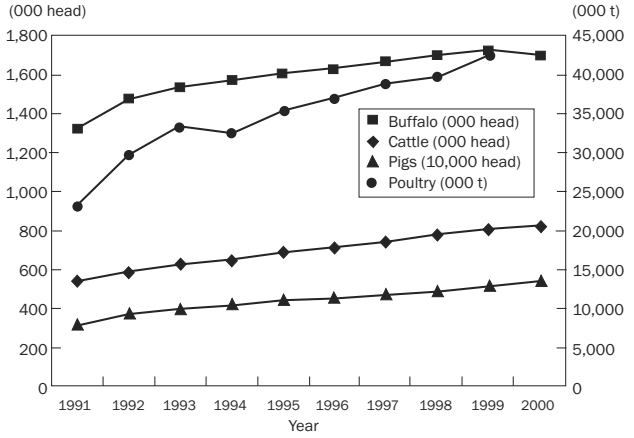


Fig. 19. Animal population and poultry production in the North Mountainous area. Source: GSO (2001).

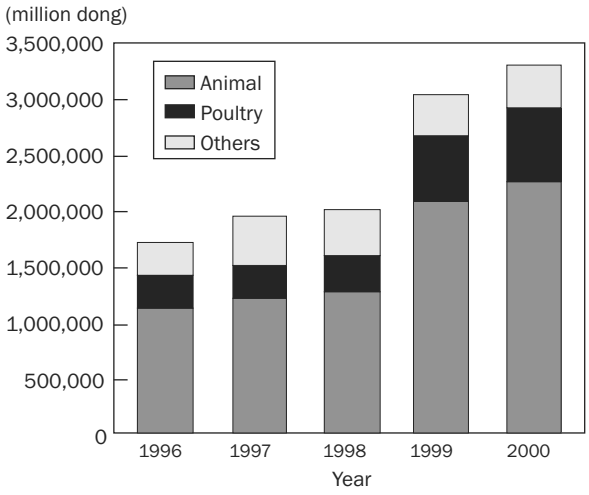


Fig. 20. Value of animal production in the North Mountainous area. Source: GSO (2001).

to 1997 (10% per year). Moreover, the increase in meat consumption is relatively equal at all levels of the population.

According to a survey on living standards of the Vietnamese people, foodstuffs that were made available in the market were valued at about $3,343 billion in the Vietnam Living Standard Survey (VLSS) for 1992-93 and increased to $4,998 billion in the VLSS for 1997-98 (Moustier et al 2003). In urban areas, consumption increased by 25% and in rural areas it was slightly lower at 23%. The urban market showed a much faster increase in consumption compared with the rural market, from 38% (1992-93) to 40% (1997-98). According to the FAO food balance sheet, while growth in overall food consumption fell, that for meat and vegetable consumption increased. Meat consumption increased from nearly 1 million t in 1985 to nearly 2 million t in 2000. According to Dang Tinh,[3] domestic demand for milk has also increased rapidly, but the national capacity of the milk supply applied only 8% to the demand for consumption. Vietnam needed to import about $230 million worth of milk powder every year.

Table 2. Meat consumption in some areas of Vietnam (kg person^{-1} year^{-1})

Site	Medium-income household	Rich (higher-income) household
Rural area (Hai Duong Province)	12	36
City: Ha Noi, Hai Phong	30–35	80–90

Source: Vu Trong Binh (2002).

Economic development led to an increase in average income per capita in both urban and rural areas and increases in demand for rich protein products, especially pork products. Pork consumption per head alone in the Red River Delta is about 8–9 kg capita^{-1} year^{-1} (IFPRI-MARD 1999-2001). Meat consumption differs across areas (Table 2). In Hai Duong Province, according to Vu Trong Binh's survey in 1998 (Vu Trong Binh 2002), meat consumption was about 12 kg capita^{-1} year^{-1} among medium-income households in rural areas, while the more affluent households had total consumption of rich protein food at 36 kg capita^{-1} year^{-1}. In Hai Phong and Ha Noi, meat consumption was about 30–35 kg capita^{-1} year^{-1} among medium-income households, while total rich protein food consumption was 80–90 kg capita^{-1} year^{-1} among the richer group. Based on statistics provided by Moustier (2003), egg consumption was about 2 kg head^{-1} year^{-1} in 1997.

The increase in pork consumption in rural areas was more rapid between the survey periods covering 1992-93 and 1997-98 (Table 3). Also indicated for the same period was the much bigger magnitude of increase among the rural population. Table 4 indicates that the rate of increase in meat consumption among individuals in the low-income group was more rapid than that exhibited by the richer-income group.

The rapid development of consumption demand in urban areas shows that many households, primarily those with high-income levels, have reached their saturation point for particular food products, especially products of lower quality. This pattern is no different from that experienced in more advanced countries in Asia. Consumers in urban areas

Table 3. Growth rate of pork consumption in urban and rural areas.

Item	Urban	Rural	Rural/urban ratio
Consumption (1992-93) in kg person^{-1} year^{-1}	14.7	8.3	77%
Consumption (1997-98) in kg person^{-1} year^{-1}	18.9	12.5	51%
% change	28.6	50.6	
Annual growth rate (% year^{-1})	5.7	10.0	

Source: Vietnam Living Standard Survey for 1993 and 1998 in GSO (2000).

Table 4. Growth rate of pork consumption by income of different population levels.

Item	Income quintile					Average
	1	2	3	4	5	
Consumption (1992-93) in kg person^{-1} year^{-1}	3.7	6.1	8.2	10.7	19.2	9.6
Consumption(1997-98) in kg person^{-1} year^{-1}	5.9	9.7	12.4	17.3	24.7	14.0
% change	59.8	59.9	50.5	61.5	28.8	46.1
Annual growth rate (% year^{-1})	12.0	12.0	10.1	12.3	5.8	9.2

Source: VLSS 1993 and 1998 in GSO (2000).

[3]Vietnam Agricultural Newspaper, Tuesday, No. 113, 25 June 2002.

tend to diversify their food intake and demand products of higher quality. This demand surpasses our present agricultural production ability as demonstrated by the market share of high-quality foreign products.

Product quality

In general, consumers are likely to use high-quality products, but there is a clear difference in demand between urban and rural areas. In urban areas, 86% of households are now more prepared to buy better-quality meat at a relatively higher price and 54% are more inclined to replace pig fat with vegetable oil. Thus, it is difficult to sell pigs that have a thick layer of fat in urban areas. In rural areas, demand for high-quality meat is lower, and pig fat for cooking is still very much used, although recent trends have also indicated its gradual substitution by vegetable oil.

The requirement for hygiene quality of meat in cities is clearly expressed in Table 5. Actually, if the products are clean and safe, consumers are prepared to pay higher prices, perhaps from 6% to 16% more than the basic price, depending on their level of income.

Although Vietnam's consumers are rapidly increasing the quantity of pork they eat, they also require higher-quality pork, such as a higher proportion of lean meat and hygiene control. However, the domestic pork market poorly signals these consumer preferences to producers. The pig meat distribution process is scattered, with too many agents that do not specialize in product distribution. Agents that retail to consumers are only interested in quality aspects that consumers are able to identify. Other quality aspects, such as hygiene, cannot yet be identified because of the absence of product trademarks or government controls, and therefore some meat quality aspects that cannot be identified do not receive a price premium. On the other hand, producers face higher costs from increasing meat quality because of the small scale of high-quality meat production. In this environment, producers have little incentive to increase the quality of their product.

Achieving economies of scale in the production of high-quality meat would be an important step in reducing the costs of breeding, animal collection, meat distribution, and quality control. Currently, the small scale of production means that the risks of participating in the commodity chain are high and this is reflected in high transaction costs among commodity agents (Vu Trong Binh and Casabianca 1996). If the domestic market is not reorganized to ensure that product quality becomes an important factor in the price determination process, consumer demand will never be met by domestic production and the domestic market will risk being dominated by foreign companies.

Policy reforms and the development of agriculture

It was primarily in the rural areas where the transition from collective agriculture to the household economy took place. Because of difficulties in the management of upland nonrice food crops and animal production, it was decided that these activities should also be given to the household economy in addition to cultivation and home gardening. So, income from households increased and surpassed that from the cooperatives. In some areas, peasants practiced the "underground contract" (*khoan chui*), in which paddy land was leased to farmers for a fixed contribution to the cooperative. In these villages, production increased. In 1981, Directive No. 100 was passed and adopted to legalize this institution, which was kept informal and hidden for some time. Viewed from an institutional perspective, this directive gave farmers the right to decide on use and return. In 1981, the household started to be reconstituted as the major unit of agricultural production in place of the farm cooperatives. Households were allotted specific plots of land for management under a contract system. The cooperatives still held a monopoly over the provision of inputs and the marketing of output (Dao The Anh and Jesus 1998).

But farmers were not fully satisfied with the new system. In many villages where the "full contract" (*khoan trang*) was practiced, farm households seemed to be more satisfied cultivating paddy fields that were leased to them and at the same time were free from any responsibility to the cooperatives. This initiative was the basis of Resolution No. 10 that initially established farmers' right to decide their use of capital. Together with the abolition of the state procurement and supply system, the household economy system

Table 5. Requirement of hygiene quality of meat in Hai Phong.

Item	Percent of people who take notice	Good signal
Butcher	73.6	Clean, shows no disease
Position of store	34.0	Clean, far from road
Height of meat table	71.7	>1 m
Cleanliness of meat table	62.3	Clean, made of concrete or tile
Cleanliness of tools	34.0	Clean
Washing water	1.9	Using tap water
Package	43.4	Made of plastic
Don't buy if not clean	47.2	

Source: Vu Trong Binh (2002).

was almost resuscitated. But control over the land was still under the cooperatives. In 1988, Resolution No. 10 was reenacted and strengthened, giving households decision rights over the use of their resources, including land, although the state retained ownership of the latter. Households' right to use their land was in exchange for a land tax. By 1992, 6 million of the 7 million hectares of agricultural land were farmed under direct household-use rights, although the specific arrangement varied from place to place (Dao The Anh and Jesus 1998).

Despite the existence of the 1987 land law that prohibited the sale of the land, an underground land market was forming. The 1993 land law legalized this situation only under a formal right of transfer of the land-use rights. In July 1993, a revision of the land law allowed for the extension of tenure of use rights to 20 years and more importantly provided for the transfer of use rights.

So, after three consecutive reforms, full rights regarding the main factors of production had been returned to the household and the collective farming system had been completely dismantled. This process occurred over 12 years and, during this time, the peasant household economy was being reinforced to take full responsibility for agricultural production in the whole country.

These reforms had a positive impact on rice production in the entire country. Vietnam quickly transformed itself from a rice importation situation to rice exportation.

Toward a greater focus on development of the livestock sector

With rice now in surplus, the new challenge for agricultural policy is to promote agricultural diversification in which the livestock sector would play a crucial role. Closer scrutiny of policy for the livestock sector will help us understand how ICAS will fare in the coming years.

The Vietnamese government has always focused on the policy objective of promoting animal production and pushing this subsector to become a principal production activity. But the government has had difficulties in realizing this promotion policy. Every year, the state has a budget for agricultural research and development. Extension programs are often spread from the top to the bottom in the extension network. In general, extension programs on animal production are rather small in comparison with crop cultivation activities. Nonetheless, the increase in budget for extension in the last 10 years has proved that the government has been paying attention to agricultural development activities (Table 6).

The government extension system in the delta areas pays much more attention than in the mountainous areas to breeding foreign pigs and dairy cows. In contrast, the local budget of mountainous areas allocates only a small amount of the budget to animal development (Table 7).

Besides extension stations, other government actors in the pig commodity chain play a role in preventing epidemic diseases, such as veterinary networks from the central level to the commune level (in delta areas) or district level (in mountainous areas). The salary of these veterinary networks is paid by the government. These networks are responsible for abattoir quarantine in order to be able to help meet export demand.

Moreover, local breeding conservation and multiplication centers have been set up all over the country. These centers play an important role in introducing new breeds to farmers/pig raisers.

In conclusion, the pig and poultry commodity chain includes actors such as producers, middlemen, traders, market vendors, external stakeholders, etc. The government is also an actor with the tasks of investigating, supervising, and promoting commodity chains. Government policies often concentrate on quarantine, breed, and development projects. Tax policies are also considered as a barrier to entry to the market. Many actors in the commodity chain are a nonstate institution, that is, the government does not

Table 6. Budget for governmental extension programs (US$).

Year		Cultivation	Animal husbandry	Information and extension	Total
1993	$	27,333	8,600	60,200	99,467
	%	27.5	8.6	60.5	100.0
1994	$	574,400	187,933	98,667	861,000
	%	66.7	21.8	11.4	100.0
1995	$	666,667	240,000	73,333	1,000,000
	%	66.6	24. 0	7.3	100.0
1996	$	1,020,800	277,333	54,667	1,594,133
	%	66.0	17.9	3.5	100.0
1997	$	1,226,667	326,667	93,333	1,900,000
	%	64.5	17.2	4.9	100.0
1998	$	957,400	413,333	167,467	1,750,200
	%	54.7	23.7	9.5	100.0
1999	$	825,067	397,800	160,867	1,777,733
	%	46.4	22.4	9.0	100.0

Source: Department of Agriculture-Forestry Extension (Ministry of Agriculture and Rural Development 2000).

Table 7. Local budget for extension programs and local development projects in 1999 (US$).

Region	Province level	District level	Projects	Total
Red River Delta	299,333	32,667	–	332,000
Northeast	402,600	135,600	309,400	847,600
Northwest	51,000	23,467	140,667	215,134
North-central coast	370,467	66,000	40,000	476,467
South-central coast	322,133	143,267	100,333	565,733
Central highland	133,733	–	15,333	149,066
Northeast south	455,360	16,000	–	471,360
Mekong River Delta	633,867	157,333	–	791,200

Source: Department of Agriculture-Forestry Extension (Ministry of Agriculture and Rural Development 2000).

have a supervisory role or the institution is beyond the government's control. Actually, these unofficial institutions control most activities of the pig and poultry commodity chain.

Problems in the animal sector drawn from experiences of some development projects and programs

Although the government has had many polices of pursuing the development of pig breeding through extension programs (e.g., increasing the rate of lean meat), in many cases the results did not meet expectations. The following examples from projects carried out in Vietnam illustrate the nature of some problems encountered.

Extension and market development support. In 1990, the Vietnam Agricultural Science Institute (VASI) undertook a project on the introduction of exotic pig breeding in Yen So (Hanoi). Though this project involved a substantial investment and effort by many specialists in the field of livestock raising, the result was that households would not introduce exotic pigs into their breeding decisions.

In 1990, the Hai Duong Science Committee (now named the Hai Duong Science, Technology, and Environment Department), in collaboration with VASI, carried out breeding 3/4 hybrid pigs in Hong Lac commune, Thanh Ha District. However, after their introduction, peasants turned back to breeding crossbred F_1 pigs as before.

Following the high rate of growth in production of exotic pig breeds, Hai Duong Province started a program in 1999 of breeding exotic sows. The program involved the investment in hundreds of exotic sows for Nam Hung commune (Nam Sach District) together with supplies of feed and other breeding requirements. But, the exotic sow herds were eliminated gradually. By 2000, only 20 sows remained. These sows were used mainly as reproduction sows, supplying piglets to newly formed livestock groups with the support of the Red River program and VASI.

An important reason that contributed to the failure of these programs was that they focused only on technical aspects of pig breeding rather than difficulties concerning the market.

Fund support for further development and proper dissemination of new technology. Ha Tay is one province that has achieved some success in implementing technological progress in pig raising. The Department of Agriculture and Rural Development (DARD) and an animal breeding company indicated that, from 1993 up to now, Ha Tay has been one of the main provinces exporting a very large number of piglets. Many communes in Ha Tay have become leaders in improving the quality of pork and the breeding of foreign sows, such as Trung Chau commune (Dan Phuong District).

To obtain these results, the provincial and district governments cooperated with research institutes to support the dissemination of livestock technology from different capital sources. A major source of capital has been the $2.2 million invested by the government to improve the lean-meat content of pigs throughout the country. In addition, Ha Tay Province has provided billions of VND not only for the development of lean-meat pigs but also for centers specializing in particular pig breeds. Besides the support of capital, pig breeds, or pig-pen infrastructure, the DARD has provided technicians to help farmers in practicing new techniques and using veterinary methods.[4]

Stronger domestic market. Although there has been much success in the development of foreign pig raising in Ha Tay, substantial problems remain to be overcome. The models of exotic pig breeding have not yet multiplied and those that exist are unstable. In Trung Chau commune, only some peasant households breed piglets for export. The other households breed only some sows, supplying piglets for these families. So, targets for exotic pig development were not reached. In other districts, such as Quoc Oai, some households also breed exotic pig sows. However, in Quoc Oai, a livestock association of 10 persons was established, but now only three households have been breeding exotic pig sows.

Although some projects were extended to introduce exotic sows into production, projects have not focused on development of the domestic market. Actually, the breed-

[4]According to Mr. Duc, vice director of the Department of Agriculture and Rural Development of Ha Tay.

ing of exotic sows by household farmers mainly serves export-oriented activities because funding sources are primarily concerned with the export market.

For poultry, the projects focused on the development of this sector had the most success on large farms with a strong domestic market linkage. There are only some regions where small and large farms benefited from development projects in the poultry sector. The main example of this was the introduction of new poultry strains such as Super C.V. and Super M, which were imported into Vietnam starting in 1989 under the framework of a project titled "Research and Development of Duck Raising—VIE 86/007," supported by the United Nations Development Programme (UNDP). In 1993, duck breeding developed strongly, to the point that the female duck population in the country is now about 75,000. Afterward, many breeds of water birds were placed into production. In addition to this, some projects have introduced specific chicken strains with a twofold purpose (meat and eggs) into production in many regions of the country.

Some conclusions from these projects

The main reason for the ineffectiveness of many government policies and projects seems to be constraints within the projects, such as the following:

- Exotic pig breeds require livestock conditions that are much more demanding on peasants than local pig breeds in households at present. For requirements concerning hygiene, nutrition, breeding facilities, and the prevention and treatment of epidemics and diseases, exotic breeds often surpass the ability of most peasants. The shift from breeding traditional breeds to exotic breeds requires a learning process to accumulate experiences. Many peasants were not yet prepared thoroughly and many projects did not have suitable training and guiding methods. Naturally, the absence of appropriate breeding conditions and learning processes led to high risks. At the end of these projects, some peasants could not continue raising the new breeds.
- Presently, breeding high-productivity animals requires a good understanding of the necessary breeding conditions and a basic level of investment; otherwise, product costs would increase substantially. However, most research on these conditions was based on theoretical requirements from a biological perspective rather than from the poor-farmer environment. To promote high-productivity breeds, experiments in poor-farmer environments need to be conducted. But, up to now, it is rare to see research institutes conducting such experiments because they often put out technological regulations that were built from experiments at stations; therefore, extension service offices find it very difficult to find and give suitable recommendations for poor farmers. The scale of breeding by poor farmers is still small and no institutions are able to provide linkages between these farmers and institutions. In addition to the inability of small producers to gain economies of scale in production costs, they have some problems in gaining access to markets. Thus, while the quality of exotic pig products is higher, the small level of production means that it is very difficult for poor farmers to negotiate higher selling prices that reflect the quality of the product. Collectors have to spend a substantial amount of time collecting just a small amount of high-quality products that in many cases results in their inability to offer a higher price for these products. This problem alone is substantial enough to remove the benefits to peasants from taking up the production of exotic breeds.
- Projects are often only interested in technical factors of production, with almost no studies concerning economic and social factors. For this reason, many technical studies have dealt with factors to promote the economic effectiveness that is expected of the project.

Constraints to the further development of livestock

Constraints related to input markets

Price and quality of animal feed. According to IFPRI and the MARD survey, the difference in the quality of animal feed is reflected partly in its price. Animal feed produced by the private sector in Vietnam is much less expensive than feed produced by foreign and government enterprises, but it has a lower quality. These private producers have a strategy of maximizing profit by concentrating on quantity rather than quality. This is also true for most livestock producers that are focused on the quantity of their breeding rather than the quality of the meat they produce. In contrast, foreign enterprises concentrate their efforts on products with a higher quality that command higher prices. However, the time will come when demand for high-quality meat products will increase to the point where domestic livestock producers will also have to provide high-quality animal feed. Current producers of cheap animal feed need to invest soon in their capacity to produce with higher quality, improve their reputation for producing a consistent quality, and develop their trademark products. Only then will these producers be able to compete successfully with large foreign enterprises that have positioned themselves well for future growth of the livestock industry.

Feed for exotic pigs requires industrial feed rich in protein. The rate of raw protein in pig feed is still very low, only 13.6% for fattening pigs (Table 8). The Vietnamese animal feed industry is still in its infancy and product quality is often inconsistent, even products made by large foreign enterprises such as CP from Thailand, Proconco, American Feed (AF), and Cargill. The inconsistency of quality is largely due to the inability of small livestock breeders to monitor the quality of feed over time and organize themselves in such a way that their grievances are addressed if feed quality lapses. There is also little pressure from the government for animal feed producers to meet quality stan-

Table 8. Rate of raw protein, classified by kind of feed and form of owners' production base (%).

Item	Enterprise		
	State	Private	Foreign
Feed for pregnant sows	19.1	14.4	22.7
Feed for suckling pigs	19.2	16.5	19.5
Feed for sows, waiting to be pregnant	15.0	13.0	13.0
Feed for piglets	17.0	14.3	24.8
Feed for fattening pigs	16.9	12.5	13.0
Condensed feed for pigs	36.6	28.0	34.0
Feed for egg-laying chickens	17.1	17.0	22.2
Feed for pullets	18.4	17.0	31.5
Feed for infant chickens	22.2	20.5	20.3
Feed for not fully grown chickens	18.5	18.0	19.5
Condensed feed for poultry	38.0	–	25.5
Feed for dairy breeding	15.2	15.2	15.0

Source: IFPRI-MARD (1999-2001).

dards because of the lack of control of the sector. An example of this occurred in 2002 when a French company, Proconco, was discovered to have used animal protein imported from Europe into Vietnam for feed products. Regulations prohibit the use of such products because of the threat of mad cow disease.

The price of animal feed in Vietnam is relatively high in comparison with that in other countries in the region. This is one factor that raises the production cost of pigs and poultry.

The price of animal feed is high not only for mixed feed but also for raw materials such as maize and soybean, which often have higher prices than the world market price. The large difference in prices between Vietnam and the world market is mainly due to the government's policy of protectionism for agricultural products. While this protectionism is supposed to benefit the poor farmers, many of them suffer from this policy. There is only an advantage for processing companies, especially for foreign companies, which receive quotas for imported products. The artificially high cost of animal feed obstructs efforts to improve the quality and competitiveness of the livestock commodity chain. If the government wants to improve the competitiveness of all agricultural branches, it is necessary to have a strategy of reducing the cost price of products in both livestock and crop production. The way to assess changes to government policy is to determine the costs and benefits for all stakeholders affected by this change. From this perspective, the decision to stimulate the livestock sector by removing protectionist policies will also have to take into account the costs imposed on the cultivation sector. In any case, Vietnam will have to consider such issues as part of its preparation for joining the ASEAN Free Trade Agreement (AFTA) and World Trade Organization (WTO) by around 2006.

Unstable quality and high price of animal breeds. A majority of the pig breeds are produced and marketed by farm families, primarily on a small scale (Table 9). Farm families undertaking pig breeding on a larger scale are also substantial, and about 75% of the total supply originates from them. Although most pig breeds are supplied by farm households from small-scale production, only a few have a good understanding of crossbreed formulas. Consequently, knowledge of the advantages of a particular breed is limited. For government-owned companies, the production cost and selling price of a particular breed are often too high and prohibitive for household breeding. For exotic pig breeds, only in Ho Chi Minh City and Dong Nai Province can households be found with these breeds. The Red River Delta now has only a few households with exotic pig breeds. In general, the use of exotic breeds depends on the scale of livestock production. Big households raise many more exotic breeds than small households (Table 10). Producing exotic pig breeds on government farms is often very expensive, and is not suited for poor farmers. Many breeds that were raised for lean meat were not successful, either in terms of the quality achieved or to the extent to which farmers were able to increase the weight of these pigs at the time of slaughter. The main reason for this was poor nutritional diets.

Lack of capital for investment. According to Hoang Vu Quang (1996), the agricultural communes in the Red River Delta were developing livestock and improving their orchards. Thirty-five percent of the peasants borrowed capital from official credit organizations such as banks or credit funds and the remaining 65% did not borrow capital from any source. Nonetheless, private borrowed capital still plays an important role in supplying capital for pig and poultry breeding, given that 60% of medium households and 50% of poor households borrow capital from private sources. The reason for this is because breeding domestic animals and poultry is more capital-intensive than crop cultivation. In particular, pig breeding involves a long cycle of up to some years for sows and yearly for meat pigs. However, a cycle for borrowed capital is around 1 year for a short-term loan facil-

Table 9. Proportion of purchased pig breeds by farm type (%).

Sources of pig race	Farmers/ merchants	Government	Other private	Others
Small scale	93.0	5.0	1.8	0.2
Large scale	74.0	16.0	5.6	4.4

Source: IFPRI-MARD (1999-2001).

Table 10. Proportion of producers breeding partial- or full-blooded foreign strains (%).

Type of household	Pigs	Chickens	Ducks
Small	10.0	22.0	21.3
Big	55.0	70.0	42.9

Source: IFPRI-MARD (1999-2001).

ity. There are many difficulties for households to shift from combining livestock production with subordinate agricultural products to specialize in livestock production. These households typically lack access to finance to repair and upgrade breeding facilities and buy new breeds.

The conditions offered by financial institutions are now insufficient for households that want to achieve large-scale pig farming, in terms of both the amount of the loan available and the time required to repay it. This problem is particularly the case with the Agricultural Bank. On the other hand, loans available to poor households are too large for their purposes. Many poor households require only a very small amount of capital to buy new breeds. However, small credit funds do not exist and the larger lending institutions will not cater to them.

Small-scale production. According to the research carried out in Ha Tay, Nam Dinh, and Hai Duong provinces (all located in the Red River Delta) by VASI and the French Scientific Organization for Tropical Agriculture (CIRAD), the livestock sector as a whole has not yet become specialized and it has a tight relationship with other production branches, especially crop production.

However, the high capital intensity of pig breeding lends itself to specialization because of the benefits of economies of scale. Economies of scale imply that the incremental cost of production decreases as the total production of pigs increases. As participants in the pig commodity chain take advantage of economies of scale, it is expected that producers will become more concentrated and production prices will decline. Similarly, intermediate agents, such as distributors, can also take advantage of economies of scale. For example, the cost of distribution per unit of meat generally decreases as the number of units distributed by a particular agent increases.

To benefit from economies of scale, it is necessary to remove the constraints faced by households in increasing their level of production, such as the lack of money available for investments. Another important step would be to search for the most appropriate means for small-farmer households to form organizations such as associations or cooperatives that are able to obtain benefits of economies of scale.

Risk from epidemics and disease. The potential threat of epidemics and disease is increasing day by day, especially for imported breeds. These risks are great among livestock producers and pose big constraints to households increasing their production scale.

Most veterinary services are provided by private individuals who have shops only to sell veterinary medicine and animal feed. These shops do not provide animal maintenance advice and care services and, if they do, they are poorly managed and very deficient, resulting in poor medicine prescriptions and treatment quality. Farmers' employment of these services only results in increased production and transaction costs, and hence ignores the importance of animal care and maintenance. Furthermore, this deficiency and the weak system discourage small livestock producers from using new pig breeds. Table 11 compares the losses of pig raisers who do not have veterinary consultation with those who do. This research conducted by the Agrarian Systems Department of VASI in Hai Duong Province indicates that farming households could substantially reduce the risks associated with epidemics and disease when veterinary consultation takes place.

Constraints related to output markets

Capital for investment. A lack of capital is the factor preventing many farmers from taking part in the market. These farmers are not able to achieve a sufficient scale of production to take advantage of economies of scale as well as opportunities from the government to be able to borrow money (as owners of farms) or to participate in meat export programs subsidized by the government. Poor households are unable to produce pigs with a high percentage of lean meat as they do not have enough capital to ensure appropriate breeding conditions. Households face great difficulty borrowing a sum exceeding about $700 over the medium to long term.

High costs of production. The costs of pig and poultry production in Vietnam are much higher than in most other countries, even in Southeast Asia. Production costs are important mainly because input costs are high, the production scale is small, and new technology is lacking. This situation led the government to subsidize the production of meat

Table 11. Comparison of economic and technical efficiency of veterinary consultations.

Monitoring items	Households didn't take part in veterinary consultation	Households took part in veterinary consultation
Number of pigs monitored	1,317	1,421
Number of pigs with disease	266	191
Number of pigs that died because of disease	106	35
Rate of pigs being contamintaed by disease (%)	20.2	13.4
Rate pigs die/rate pigs get the disease (%)	39.8	18.3
Veterinary expenses pig^{-1} $month^{-1}$ when disease occurs (US$)	0.33	0.18
Loss because of death and/or cheap selling ($)	1.37	0.42
Total loss pig^{-1} ($)	2.36	1.15

Source: Survey of Agrarian Systems Department (2001).

for export over many years, which has diverted funds away from programs that could have focused on lowering production costs.

Quality and hygiene of pig production. The quality of pig meat depends on the particular pig breeds used and breeding conditions. Because these factors differ across farming households, quality varies substantially. However, on the whole, the quality of pig meat is low in Vietnam. Hygiene quality is not controlled tightly from the place of production to the retail trade area. On the other hand, imported meat has a reputation for good hygiene and this will be an important factor that drives the consumption of imported meat in Vietnam as its availability increases over time. Vietnamese exporters of pork now face substantial difficulties in passing the control barriers of many countries.

Economies of scale. The low scale of production by most pig and poultry farmers is the main factor that explains the difference in production costs in Vietnam compared with those in other countries. The inability to take advantage of economies of scale is also present in the transportation and distribution sector of the livestock commodity chain, which largely explains the high transaction costs involved in moving products to local and export markets. On the whole, if Vietnam does not overcome shortcomings of the lack of economies of scale, it will probably lose its market share when admitted to AFTA and the WTO.

Incomplete legal system. The government does not yet have clear standards and enforceable regulations concerning the transportation and slaughter of livestock. Private or government agents acting in this field pay almost no attention to quality standards. For example, abattoirs in Ha Noi are not subject to any hygiene standards. There is no definition of what is an abattoir, where they are allowed to be built, and the infrastructure and operating conditions that must be met. The lack of effectiveness of governmental institutions in this field has made the slaughter of livestock disorderly and the offices for controlling epidemics unable to fulfill their duties. In this environment, efforts by producers to improve the quality of their products are largely wasted given the poor treatment of livestock from the farm gate to the retail sector. These factors demonstrate the production problems faced by different agents throughout the commodity chain.

Communication obstacles. Many regions, especially the mountainous regions, face substantial communication difficulties, largely because of geographic and cultural divisions combined with poor infrastructure and a lack of technology. For example, there is a clear division of markets between North and South Vietnam. Divisions also exist on a much smaller scale, such as communities in mountainous regions that simply do not interact with other nearby communities and have very limited access to large markets. The price of pork is much higher in these communities than in Ha Noi and Ho Chi Minh City. Also, at present, many road systems were financed by foreign loans, which has increased the tax burden faced by many households. This situation means that poor farmers are not able to afford communication costs that increase day by day. Another constraint to distribution is police activities. According to the results of studies undertaken by IFPRI and the MARD as part of the DANIDA project in 2000, 20% to 30% of traders thought that the police were the main obstruction they faced, and up to 70% of traders thought that the police obstructed their trade activity.

Limited information. Traders represent the main source of market information for poor-farmer households. The government's role in providing market information is poor because of a disjointed communication network and its responsibilities overlap among offices. Because of the extent of market divisions and differences in prices among regions, farmers cannot make informed production decisions that would maximize their income. Poor farmers do not know the destination of their products and therefore have little information on the activities of the distribution agents they deal with. The activities of many export programs are also kept secret from producers. The shortage of information makes poor farmers unable to be active in their production decisions and they therefore become dependent on output agents.

Development trends of crop-animal systems

Integrated crop-animal systems have been practiced by farmers in many areas across the country. In this paper, the main areas identified are the Red River Delta and North Mountainous area. Each area has several differences in the form of the ICAS used.

Integrated crop-animal systems in North Vietnam

Red River Delta. Since the beginning of the disbanding of state cooperatives in 1988, households in the Red River Delta tended to diversify their products; however, they were still mainly based on a small scale of production. In 1988-93, most of the households concentrated on intensive rice production to reach the target of food self-sufficiency. In 1993, the Red River Delta was able to satisfy household food demand. Since then, farm production has continued to diversify and intensify the practice of ICAS based primarily on dictates of the market.

Animal production has played a different role through the period as well as across geographic areas. Even at the beginning of the reform (1988-93) toward greater emphasis on household economics, subsistence agriculture expanded such that households also aimed at producing goods to trade. Quoc Tuan and Thai Tan communes showed that, from 1988 to 1993, the number of households that produced purely for own consumption decreased in Thai Tan commune while there were none in Quoc Tuan commune. This meant that the process of producing goods for trade was strong in rural areas even though no government action encouraged this. This was due to the ability of households to choose their economic activities to maximize their income.

Animal production systems during the self-sufficiency period had the following characteristics:

- Animal production mainly took advantage of cultivated crops. Livestock partially supplied the required fertilizer for plants, especially for rice and vegetables.
- Animal production combined with off-farm activities such as producing soya curd or wine supplied feed for animal raising. Moreover, these activities created a large resource of capital to promote the development of animal breeding.
- Households that derived a significant income from pensions had sufficient capital to invest in animal breeding.
- This type of breeding was combined with another household-based activity such as "bonsai" growing or the cultivation of ornamental plants that are sold to supplement income.

Several advantages and disadvantages were found. Households chose pig raising because problems entailed in marketing pigs were minimal. Pig prices in the market were somewhat stable and did not experience decreases. Likewise, pig raising did not face much rigid competition. There were, however, some disadvantages. The biggest one was the capital-intensive nature of pig raising as well as the need for technical skills that were very much lacking during that time because of the weak government extension service.

Crop-animal systems in the period of diversification had the following characteristics:

- Households diversified income by combining animal production and crop cultivation: diversification was mainly toward maintenance of the rice crop but greatly supplemented with pig production and vegetable growing such as onions or garlic. The goal was to produce goods to participate in the market. Diversification of production activities continued as households tried to find an appropriate activity on which to concentrate and specialize.
- Households combined animal production with off-farm activities: focused efforts to stabilize commercial activity by steadily expanding animal production by increasing the number of animals regardless of meat quality. This type of animal raising took advantage of feed resources from off-farm activities (soya curd and wine production) as practiced during the self-sufficiency period, and the opportunity to use industrial feed and investments in good-quality pig breeds.
- Households produced bonsai (and other ornamental plants) while maintaining a diversified production mixture of crops and animals: this type of production aimed at protecting against market difficulties (such as in 2000, when the price of bonsai went down). However, bonsai have a long production cycle so it is difficult to react to changes in the market.
- Some households planted bonsai or specialized in animal raising to compensate for difficulties in the bonsai market. Many of them specialized in poultry raising.
- Some households that have been undertaking pig production started to target a more specialized market for high-quality meat. These households invested in obtaining pigs from foreign breeds that yielded a higher percentage of lean meat. In 1988, income from pig production accounted for nearly 40% of total income. In 2000, income from pig production accounted for more than 85% of total household income.
- Households that derived a significant portion of their household income from pensions: pig raising was the main production activity and rice continued on a much smaller scale because the income from pigs was better than that from rice.

The rice production of all types of households did not decrease, but the relative proportion of rice in the total income did decrease.

Some advantages and disadvantages were found.

- Farmers received more scientific and technical knowledge and benefited from a more effective production system from many national and international offices and organizations.
- From 1993 to 1997, the price of liveweight pork was relatively high while rice prices fell and animal feed prices were stable because of the stable supply of mixed industrial feed and maize.
- Demand for meat increased.

However, farmers still faced disadvantages such as

- A poor ability of poor farmers to be active in the market, which has led to a reduction in the competitiveness of their products.
- A lack of market information provided to farmers by intermediary actors.
- A lack of capital, which has limited gains from economies of scale.

North mountainous area. For integrated crop-animal systems,

- The Tay people diversify production to attain the self-sufficiency objective.
- Because the Kinh people do not have rice fields, they enhance pig raising to produce lean meat. They also produce other goods for trading, using capital accumulated and taking advantage of good relationships with lowlanders.
- Since 1998, these types of integrated crop-animal systems have remained relatively unchanged. However, livestock decreased because of a decline in the production of animal feed (cassava and maize).

Several factors strengthened crop-animal integration: agroecological conditions, market demand and farmers' ability to approach the market, household income and the structure of income, and the ethnic factor.

Samples of crop-animal systems by agroecological areas in the Red River Delta

In the Red River Delta, Nam Thanh District (Hai Duong Province; after that, divided into two districts: Nam Sach and Thanh Ha) represents the delta area while Cho Don District (Bac Kan Province) represents the mountainous area.

On the basis of its agroecological characteristics, Nam Thanh District is divided into four zones—lowland dike edge, intensive area (winter crops), diversification area, and litchi gardens. In this paper, only the two first zones are discussed. The characteristics of these two agroecological zones are described in Table 12. These zones have potential area for winter crops that contribute the quantity necessary for livestock feed.

Intensive agriculture (winter-crop area). Quoc Tuan is one of the communes that is distinctly characterized as an intensive area because it lies near highway No. 183 to Quang Ninh Province and its location is therefore convenient for circulation and market access for winter crops. The winter-crop surface occupies a large area in the commune (65% of the whole cultivated area in 1993). Farmers' capacity for intensive cultivation is well developed since the beginning of the cooperative period. Cultivated land is located inside fields as there is no dike edge land. The main crops are rice, onion, garlic, potato, sweet potato, maize, cucumber, etc. The land-use coefficient is rather high at about 2.4 (Table 13).

Rice, onion, and garlic provided, on average, about 7% to 10% of total household income. From 1988 to 2000, the income structure of households in Quoc Tuan changed. The contribution from rice fell and the contribution from livestock breeding increased, especially in pig breeding (Table 14). In 2000, livestock breeding provided more than 32% of household income, in which the part from pigs was 20%. The location nearby the pig market is an important factor that explained the growth in pig breeding in many households in Quoc Tuan commune. In 2000, several households obtained income of about $1,200 from breeding pigs. Cows were not developed because farmers had no alluvial land; thus, income from cows contributed only a small amount to total income.

Lowland and dike edge area. Thai Tan commune (Nam Sach District, Hai Duong Province) is characterized by lowland and dike edge areas because it is located on an alluvial area along the Thai Binh River, which is situated southwest of the commune. Thai Tan is located far from transportation infrastructure so farmers have difficulty engaging in trade. The surface of cultivated land per capita is high because of the dike edge land (Table 15).

Table 12. Agroecological areas in Nam Thanh District.

Item	Area	
	Lowland, dike edge	Intensive
Population density (people km^{-2})	973.6	1055.2
Crop surface capita^{-1} (m^2)	529.4	546.2
Outside dike surface capita^{-1} (m^2)	99.8	8.5
Low rice-field surface capita^{-1} (m^2)	25.1	12.5
Number of cows ha^{-1}	1.36	1.27
Rate of commercial households (%)	0.9	1.8
Winter crop surface capita^{-1} (1995-97) (m^2)	269.1	330.5

Source: Dao The Anh et al (1997).

Table 13. Rice field surface and land use in Quoc Tuan commune by household economic class (1995).

Item	Household class		
	Rich	Middle	Poor
Cultivated land surface (m^2 capita^{-1})	544	605	598
Rice field surface (m^2 head^{-1})	972	1,220	1,181
Winter-crop surface (m^2 head^{-1})	346	227	227
Land-use coefficient	2.4	2.4	2.4

Source: Dao The Anh et al (1997).

Table 14. Structure of average household income in Quoc Tuan commune from 1988 to 2000 (%).

Source of income	Year			
	1988	1993	1997	2000
Rice	32.3	27.1	21.3	20.4
Animal husbandry	19.6	17.2	32.6	32.3
Pigs	–	–	28.9	20.2
Poultry	–	–	3.7	11.8
Cows	–	–	–	0.3
Off-farm activities	12.5	13.9	14.7	15.1
Other income (retail, remittance, etc.)	35.6	41.8	31.4	32.2
Total	100.0	100.0	100.0	100.0

Source: Dao The Anh (2003).

Table 15. Rice field surface and land use in Thai Tan commune in 1995 by household economic class.

Item	Household class		
	Rich	Middle	Poor
Surface of cropped land inside field (m^2 $capita^{-1}$)	547	644	590
Surface of cropped dike edge land (m^2 $capita^{-1}$)	205	360	238
Surface of rice field (m^2 $capita^{-1}$)	1,044	1,094	1,181
Surface of winter-crop plants inside field (m^2 $capita^{-1}$)	43	108	79
Surface of winter-crop plants at dike edge (m^2 $capita^{-1}$)	205	360	238
Total square of winter-crop plants (m^2 $capita^{-1}$)	248	468	317
Coefficient of inside field use	1.99	1.87	2.13
Coefficient of outside field use	2.14	1.71	1.80

Source: Dao The Anh et al (1997).

Table 16. Structure of average household income in Thai Tan commune from 1988 to 2000 (%)

Source of income	Year			
	1988	1993	1997	2000
Rice	28.2	30.6	31.7	22.6
Animal husbandry	39.3	32.0	26.0	33.1
Pigs	–	–	18.9	19.9
Poultry	–	–	7.1	11.0
Cows	–	–		2.2
Off-farm activities	12.2	11.6	5.6	9.0
Other income (retail, remittance, etc.)	20.3	25.9	36.7	35.3
Total	100.0	100.0	100.0	100.0

Source: Dao The Anh (2003).

Although Thai Tan commune occupies a large surface area of the district, it has not yet exploited its maximum potential as reflected by the low coefficient of land use. The surface of cultivated land inside the fields is actively watered but cultivated land at dike edges is nonirrigated and is often submerged from March to September so that only spring plants, vegetables, and beans are cultivated.

With a large surface of alluvial land, farmers here have developed cow production. According to our household surveys in Thai Tan in 2000, the highest income gained by households reached $120 per capita (while in Quoc Tuan it was only $26.70 per capita). Pig production represented 20% of total income. In crop cultivation, rice was still the main crop. Income from rice in Thai Tan increased considerably during 1988-2000, from nearly $33 per capita in 1988 to more than $60 per capita in 2000 (Dao The Anh 2003). But, the share of rice in total income decreased because of the diversification of household activities (Table 16).

Samples of specific crop-animal systems in the North Mountainous area

Dong Vien commune is located in the North Mountainous area (northeast), in Cho Don District, Bac Kan Province. This commune is one of the richest because of its relatively significant rice cultivation and greater integration to markets and business centers of Cho Don and the provincial capital of Bac Kan. The Tay people and the Kinh people dominate the ethnic groups in Dong Vien commune. In this agrarian system, rice is now a surplus commodity, with greater production intensification in the rice fields of the valley (Table 17).

Table 17. Main characteristics of Dong Vien commune, Cho Don District, Bac Kan Province.

Item	Year	
	1993	1998
Rice-field surface (ha)	134	155
Hilly surface (ha)	456	17
Forest surface (ha)	550	382
Balance of rice production-consumption (t)	–190	95
Population density (people km^{-2})	106	107

Source: Dao The Anh (2001).

The traditional livestock production system in the commune is closely connected with crop cultivation, but it has some characteristics that are different from those of delta areas. Pigs, buffaloes, cows, and poultry are the main livestock, but they are bred on a small scale. In 1993, income

Table 18. Diversification of production systems among the ethnic groups (%).

Ethnic group	System			
	Cultivation	Livestock	Nonfarm activities	Forestry product
Tay	50.6	19.5	28.4	1.5
Dao	65.5	26.7	6.2	1.6
Kinh	45.7	29.3	16.7	8.3
H'mong	80.4	18.7	0.4	0.5

Source: Duong Duc Vinh (2001).

from animal production averaged 25% of total household income, with pig production accounting for 20%. Pig production was almost entirely dependent on cultivated crops such as cassava, maize, etc. This implies that livestock production could only be undertaken on a small scale. Animal production involved a long cycle and hence was not very efficient. Only a small percentage of households now practice highly intensive pig production.

Only the Kinh people go directly to the field to apply animal and green manure to serve as fertilizer in rice fields. The other ethnic groups stock the manure in the village, close to where the irrigation water flows. They also use animal manure to fertilize rice fields but, unlike the Kihn people, they do not take the manure to the fields and directly spread it on the soil; they use the water flow from irrigation to do the work. This is the traditional way of fertilizer application.

Ethnic groups have diversified production activities (Table 18). Crop cultivation is still practiced by a majority, especially among the H'mong. The Dao and the Kinh show the greatest number of households engaged in livestock raising. Almost all households in the commune raise animals, primarily pigs, to meet local demand, especially for special occasions related to religious ceremonies or festivals.

Table 19 compares production systems between the Kinh and Tay groups and shows how these systems have changed over time. Several factors influenced the changes, such as the deterioration of the landscape, lack of capital, and lack of market prospects for commodities. The slash-and-burn practice strongly decreased the cultivation of rainfed rice, cassava, and maize as land degradation intensified from 1992 to 1998. Areas for maize and cassava decreased substantially or were wiped out, while rice cultivation shifted from the rainfed system to irrigated system. This was the general trend observed among the Tay groups, who are primarily engaged in rice production, especially households that have cultivated smaller areas of rice. Among the very big Tay rice cultivators, however, the trend was a decrease in rice cultivation as households became engaged in other activities, particularly those outside the farm.

Animal production became more significant among the ethnic groups with the increase in animal holdings, especially cows. Cattle production was more favorable for the Tays, who had access to remaining sloping areas that were still good for grazing. Likewise, the market for cattle was becoming better with the cattle meat price rising. Cattle, as well as buffalo, are means for this group to accumulate capital. Pig raising decreased, however, because of the lack of feed. The decrease in production of maize and cassava affected pig feed. Rice was also used as feed but its use as a staple food rather than as feed became especially intense, especially with the decrease in rainfed areas that used to be cultivated to these crops.

The Kihn people are generally nonrice cultivators. They get rice as a share for rendering labor in rice cultivation. They are pig raisers but this activity was also affected by the scarcity of maize, cassava, and rice as feed. They were more heavily engaged in nonfarm activities, especially in 1998, because of the existence of a closer family relationship with the people in the Red River Delta.

Apricot plantations declined for all ethnic groups because of the low commodity price caused by poor market access. Other activities related to the forest emerged, however, especially with the implementation of plantation projects in these areas.

Determinants of crop-animal typology for livelihood strategies

Household livelihood strategies in this region consist of one or more crop cultivation or livestock production systems, sometimes combined with nonfarm income. Household activities can be classified into categories defined by a combination of crop cultivation and animal production. For instance, when a household grows rice in the lowlands, grows maize and apricots on the slopes, and raises pigs for selling and buffaloes for land preparation, three interrelated production systems can be identified: (1) a rice production system comprising rice cultivation and buffalo raising, (2) a pig production system including maize cultivation for feed, and (3) an apricot tree cultivation system.

The rice-based production systems are

- Animal-rice system, including buffalo raising for draft power.
- Mechanized rice cultivation, using own machines, which could also be rented out to other households.
- Manual rice cultivation, with mutual aid among households in the same village.

Table 19. Typology of production systems in Dong Vien commune in 1992 and 1998.

Item	Type of household						
	1	2	3	4	5	6	7
Percentage	7	8	8	36	11	23	7
Ethnic group	Kinh	Kinh	Tay	Tay	Tay	Tay	Tay
1992							
Production system in 1992	No paddy field, sell labor in paddy fields	No paddy field, pig business, nonfarm activities developed	No irrigated paddy field,cultivated 2 seasons of rice	Small irrigated paddy field	Intensive paddy cultivation, self-sufficiency in rice	Big paddy field, livestock developed	Very big paddy field
Paddy produced capita^{-1} (kg)	37.5	0.0	156.1	224.3	399.1	457.2	758.1
Pigs (average kg per household)	90.6	569.0	94.0	150.8	192.9	231.2	125.8
Cattle (average no. of head per household)	0.0	0.0	1.4	1.4	3.2	2.4	1.5
Fruits (VND 1,000 capita^{-1})[a]	69.6	420.0	75.8	48.0	154.0	168.9	248.7
Nonfarm activities (VND 1,000 capita^{-1})	277.0	722.3	153.5	252.4	231.8	238.6	297.0
1998							
Production system in 1998	No paddy field, sell labor, other activities developed	No paddy field, forest, pig business decreased, nonfarm activities developed	Irrigated paddy field, cultivated 2 seasons of rice, other activities	Irrigated paddy field increasing, forest	Intensive paddy cultivation, self-sufficiency in rice, forest	Big paddy field, cattle increased, pigs decreased	Paddy field decreasing, cattle increased
Paddy produced capita^{-1} (kg)	33.3	0.0	173.3	353.2	366.4	622.1	471.3
Pigs (average kg per household)	80.0	250.0	60.0	82.2	100.0	84.2	65.0
Cattle (average no. of head per household)	0	0	3.7	4.3	3.0	5.8	3.0
Fruits (VND 1,000 capita^{-1})	100.0	75.0	50.0	2.1	30.6	77.3	10.0
Plantation project (VND 1,000 capita^{-1})	177.8	0.0	50.0	111.2	130.0	114.1	175.0
Forest (VND 1,000 capita^{-1})	46.7	30.0	7.1	11.8	11.9	5.3	22.1
Nonfarm activities (VND 1,000 capita^{-1})	266.7	1433.5	362.3	609.3	457.6	584	890

[a]US$1 = VND 15,000. Source: Dao The Anh (2001).

On the hillsides, the following systems are found:

- Maize cultivation primarily for sales.
- Maize cultivation for pig farming combined with the purchase of supplementary feed.
- Apricot tree cultivation, intercropped with maize for two to three years.
- Manglieta timber plantation, subsidized by the World Food Program.

Factors influencing the specific crop-animal system adopted. Farmers decide about the amount of land and labor devoted to each system based on their access to means of production, the relative profitability of production systems, and the timing of competing peaks of labor requirements.

Table 20 shows the advantages and constraints of typical production systems that are available to farmers.

Profitability of production systems. The relative profitability, capital needs, and labor requirements of the different production systems in the commune appear in Table 21. Rice, the staple food of most families, continues to be of strategic importance, with relatively stable yield, although generating only an average income of $1.33 per working day. The maize-pig system offers high profits without initial investment because the maize is on sloping land. This system is used by farmers having smaller rice fields. Pig farming is most commonly practiced by households that lack paddy areas but nevertheless have access to capital.

Timing of peak labor requirements. There are two peak periods for labor demand: from March to April and from June to July. At the time of planting a given crop and then during each peak period, the most important factor in the decision made by farmers is marginal income per working day (Table 22). In March to April, rice production is the highest priority, both because it is profitable and because it ensures household food security. Maize and apricots are the second priority. Rice and maize are rarely produced by the same household on large areas because their demand for labor would occur in the same period.

In June and July, labor is divided between maize and rice cultivation. If time is insufficient, families do not plant a second maize cycle. For households with small rice-field areas, the high profitability of the maize-pig system makes it a common choice.

Quoc Tuan, Thai Tan, and Dong Vien are three communes with different agroecological conditions but all have integrated crop-animal systems in which rice plays an important role in producing income and supplying feed for livestock breeding, especially pig breeding.

The agroecological conditions have influenced the structure of livestock production as well as methods of production, especially in taking advantage of natural resources appropriate for grazing cows and buffaloes.

Developing technology to support growth of the livestock industry

Vietnamese traditional livestock breeds often have low productivity in breeding and at slaughter. According to Molenat and Tran The Thong (1991), the most popular breeds were Mong Cai, Muong Khuong, Lang Hong, Meo,

Table 20. Factors explaining the production combinations observed in Cho Don District.

Production system	Advantages	Constraints
Rice + buffalo	Food security Buffalo care maximizes labor use (employing both children and elderly people)	Limited by the available paddy-field area
Rice + hand tractor	Food security Good return on investment	Large areas required to ensure investment profitability
Rice (hired labor)	Eases pressure on family labor during labor peaks	Low return on labor Food security less assured
Maize for sale	No investment required	Very low profitability Minimal available area and low return per unit of land
Maize + pigs	Return on labor comparable to rice fields	Labor competition, especially during harvesting periods
Maize + pigs with additional feed	Substantial return on labor Regular work throughout year	Significant initial investment Labor competition, especially during harvesting season
Apricots	Potential good profit	Unstable income

Source: Dang Dinh Quang (2002).

Table 21. Relative profits and requirements of production systems.

Production system	Profits (VND 000)[a]		Capital needs (VND 000)		Labor requirements	
	Per working day	Per 1,000 m^2 cultivated	Rotated capital per 1,000 m^2 cultivated (e.g., inputs, hired labor)	Initial investment required per 1,000 m^2	Maximum area per laborer (m^2) (larger areas indicate lower labor requirement)	Peak
Rice + buffalo	20	1,700	250	1,500	1,200	March and June-July
Rice + hand tractor	21	2,100	250	1,000	1,200	
Rice + hired labor	15	1,300	600	7,000	2,000	
Maize for sale	13	120	–	–	2,500	July
Maize for pigs	19	2,300	120	–	1,500	
Maize for pigs with additional feed	23	1,140	450	–	2,000	
Apricots	150	900	–	–	6,000	March-April

[a]US$1 = VND 15,000.
Source: Dang Dinh Quang and Castella (2002).

Table 22. Income (in VND) of a working day during labor peaks.[a]

Period	Apricots	Rice double-cropping	Maize + labor-intensive pig farming	Maize + capital-intensive pig farming	Maize for sale
March-April	150,000	120,000	88,000	90,000	78,000
June-July	–	74,000	135,000	60,000	47,000

[a]The income of a working day is equal to the ratio of the income per ha to the working time per ha during the peak labor period.
Source: Dang Dinh Quang and Castella (2002).

and some crossbred races such as Ba Xuyen, Thuoc Nhieu, Ba Tri, Nghia Binh's white pig, etc. However, only Mong Cai have been popular in the northern and central regions up to now. In fact, in the southern region, the Ba Xuyen and Thuoc Nhieu are also crossbred between domestic and imported breeds developed from the end of the 19th century to the beginning of the 20th century. In addition, many local pig breeds have not yet been thoroughly investigated to identify their genetic characteristics. In general, information on types of breeds and geographic dispersion is very limited. In the delta regions, sows of domestic breeds are usually raised with foreign boars to produce piglets for the supply of meat. According to our research in Hai Duong Province, 100% of the pigs for meat supply were crossbred pigs, and up to 50–60% of the sows were of Mong Cai I breeds. However, this proportion has been decreasing gradually and is around only 20–30%. According to VASI research results in the framework of the Red River program, the proportion of crossbred pigs was around 30–45% in mountain region communes of Bac Can Province, and the remainder were local pig breeds. In the North Midland regions, the proportion of Mong Cai pigs was around 63%. In the Central region, the proportion of domestic pigs is still higher than in the Red River Delta, but, in the southern region, few pure domestic breed pigs are raised.

Mong Cai I pigs have relatively large litter sizes of around 12 piglets. However, the number of piglets varies according to the number of farrows. In particular, some sows can produce 16 piglets per farrow for up to 14 years. When litter sizes are large, the quality and quantity of meat from the Mong Cai I sow is poor. It takes around 7 to 8 months to raise these pigs to a weight of about 40 kg. Compared with foreign breeds, the domestic ones have lower carcass quality.

Changes in feed composition. Table 23 shows that the composition of pig feed changed substantially from 1993 to 1997. There was a trend of increasing rice and decreasing rice bran in the diet composition. Maize was used only in a small amount in 1993 but was always used by households located at dike edges, where it was cultivated in large quantities. From 1993 to 1997, the maize component increased considerably and became the main component of the feed formula. Feed from winter plants such as sweet potato or potato was often used by households that cultivated these winter crops.

However, most farmers have still used rice products as the main component of pig feed up to now. In 1998-2000 in some provinces in the Red River Delta, rice was used for feed (Table 24).

Table 23. Changes in the composition of pig feed in Cong Hoa commune from 1993 to 1997 (%).

Type of food	Year	
	1993	1997
Rice bran	49.2	24.6
Rice	14.7	21.5
Maize	8.3	33.8
Solid food	0.0	5.4
Other by-products	27.8	14.7

Source: Pham Van Duy et al (1998).

Table 24. Rice use by farming households.

Item	Province			
	Ha Tay		Nam Dinh	
	Phu Xuyen District	Hoai Duc District	Vu Ban District	Hai Hau District
Proportion of paddy production sold (%)	42	33	33	33
Proportion of paddy production for human self-consumption (%)	33	53	38	25
Proportion of paddy production for animal feed (%)	25	14	29	42

Source: Jésus et al (2002).

Changes in pig breeds. The average number of pigs per household in 1988 was only 3.7 per year; in 1998, this number increased to 6.8.

Before 1962, pig breeds in Nam Thanh District were only two: Mong Cai and fat pigs. Since 1962, artificial insemination methods began to develop in Nam Thanh, establishing a movement of breeding of Mong Cai pigs. Genetically, pigs in Nam Thanh were crossbred with other breeds such as Mong Cai, Y, Dai Bach (large and white pig), and Landrace. Farmers tended to change from breeds with a low percentage of lean meat to ones with a high percentage (change from Mong Cai × Yorkshire to Mong Cai × Landrace).

Changes in the production structure. Farmers need to have better knowledge about livestock production as well as market characteristics when they expand the number of pigs from around 30 to 100 per year. To minimize risk, farmers have changed from single production to group production (high-quality production group) with support from the Red River program. By organizing meeting groups, farmers have the opportunity to exchange technical information, increase product quality, reduce production costs (by jointly purchasing animal feed), and be able to approach the market better.

In mountainous provinces such as Cho Don District, the structure of pig breeds has changed from breeding local pigs to crossbred pigs. Crossbred pigs have occupied a high rate in areas that have much contact with large markets and technical research organizations. For communes that were at more remote locations, local pigs were much more common. However, across the whole district, local pigs still occupied a high percentage of the total (77% in 1997).

During recent years, feed for animal production improved somewhat, but it is still mainly based on food crops such as maize or cassava. Supplement feeds are used only to a small degree in these areas.

Farmer organizations have been established with the support of some projects or programs but they involve only technical exchanges, rather than other activities such as joint marketing or combined veterinary support as in delta areas.

Conclusions

The integrated crop-animal system (ICAS) in northern Vietnam, represented here by the Red River Delta and the North Mountainous areas, is a popular system with a long-standing development process. It can be considered as a habit of the agricultural production of Vietnamese farmers.

This system has many different characteristics, depending on factors such as agroecological area, population dynamics, market evolution, farming household conditions, institutional support, etc. However, the system is mainly the integration between rice cultivation and pig production.

The system has evolved over time:

- Continued integration of crop-animal production by diversifying to a small scale to take advantage of food complementation.
- Integrating crop-animal production on a larger scale and applying more intensive techniques to promote production efficiency of livestock and market integration.
- Strengthening the specialization of cultivation, with livestock breeding playing only a supplemental role. Contrary to this trend, farmers in some areas specialize in breeding (pigs), with little cultivation. These trends rely on collective action among farmers to create economies of scale. Household specialization in livestock or crops needs a diversification between crops and animals at the regional level to avoid market risk.

However, the integration of crop-animal production in a small-scale household is most common in North Vietnam. This system will play a role in income diversification for poor and middle-class people in the near future. Rich households will specialize in different ways as with high added-value crops or pigs to intensify. The manure market in the Red River Delta is being built up because of this specialization tendency. In the North Mountainous area, the production system of diversification will be developed with a strong contribution of ICAS in the near future.

The evolution of ICAS has been mostly driven by farmers themselves, without influence by the state. This evolution was clearly a reflection of supply and demand forced by the market and its competitive nature. Especially, output markets are an important factor in the development process of ICAS. Food crop prices are decreasing for all crops and diversification has some difficulties. In this context, animal products have a good price, but only for ones of higher quality. Thus, techniques applied in breeding were different among areas to meet market demand. In the delta, livestock need to be more specialized to improve their quality. But, generally, because of small-scale production, ICAS will still play a major role in sustaining household income.

Policies for promoting this integrated system are the same as for agricultural diversification. Actually, these policies lack a support role for households. Policies could promote changes in land-use regulations, market liberalization, or the allocation of land-use certificates. Public investments could include road construction, electrification, or the provision of other infrastructure. Institutional innovations could include the development of cooperatives or farmer associations, contract farming, improved market information, quality control, or origin identity for agricultural products. Income diversification that is sustainable in the long term and does not depend on government subsidies for inputs, or marketing costs, is promising for Vietnamese households.

References

ASD-VASI (Agrarian Systems Department-VASI). 2001. Survey on eco-pathology of pig livestock in Nam Sach Dictrict, Hai Duong Province.

Dao The Anh, Jesus F. 1997. L'agriculture du delta du Fleuve Rouge face aux réformes économiques. Cahiers Agriculture. Sept-Oct 1997. p 67-73.

Dao The Anh, Du Van Chau, Le Hoai Thanh. 1997. Approche micro-économique de la différenciation des exploitations agricoles dans le delta du Fleuve Rouge au Nord Vietnam. Cahiers Agriculture. Sept-Oct 1997. p 27-34.

Dao The Anh, Jesus F. 1998. Les réformes au Vietnam depuis 1979 et leurs effets sur les ménages agricoles. ECOPOL-CIRAD. CIRAD Working Document no. 28.

Dao The Anh. 2001. Transition of household economics at Cho Don area. In: Research and development agriculture at mountainous area, summary record of the conference of five years of activities (1995-99) in Cho Don District, Bac Kan Province. Red River Program, Agricultural Publishing House. 135 p.

Dao The Anh. 2003. Les réformes socio-économiques et l'adaptation par le choix d'activité des ménages ruraux dans le delta du Fleuve Rouge. Thèse de doctorat. Economie agricole, du développement rural et agro-alimentaire, Ecole national supérieur d' agriculture de Montpellier (ENSAM). 400 p.

Dang Dinh Quang, Castella J.-C. 2002. Doi Moi in the mountains: land use changes and farmers' livelihood strategies in Bac Kan Province, Vietnam. Hanoi (Vietnam): Agricultural Publishing House. 281 p.

Duong Duc Vinh. 2001. Principal characteristics of production systems in Cho Don District and Red River program activities. In: Research and development agriculture at mountainous area, summary record of the conference of five years of activities (1995-99) in Cho Don District, Bac Kan Province. Red River Program, Agricultural Publishing House. 135 p.

GSO. 2000. Statistical yearbook. Hanoi (Vietnam): General Statistical Office.

GSO. 2001. Statistical yearbook. Hanoi (Vietnam): General Statistical Office.

Hoang Vu Quang. 1996. The forms of peasant credit at Thanh Xa commune, Nam Thanh, Hai Hung. VASI Working Document. 80 p.

IFPRI–MARD. 1999-2001. Policy options for livestock in order to promote agricultural diversification in Vietnam. Hanoi.

MARD. 2000. Department of Agriculture forestry extension data.

Molenat M, Tran The Thong. 1991. Genetic and pig livestock in Vietnam. IEMVT Working Document. CIRAD, Montpellier. 107 p.

Moustier P, Dao The Anh, Figuié M. 2003. Food market and agricultural development in Vietnam 2003. MALICA (CIRAD-IOS-RIFAV-VASI). 108 p.

Pham Van Duy, Nguyen Xuan Hoan, Vu Trong Binh. 1998. Results of alimentation supply and its impact on family livestock. VASI Working Document. 49 p.

Vu Trong Binh, Casabianca F. 1996. La commercialisation de la viande porcine dans le district de Nam Thanh: actes du séminaire: “Agriculture familiale et gestion des ressources naturelles dans le bassin du Fleuve Rouge,” Hanoi, 9-12 April 1996. p 81-91.

Vu Trong Binh. 2002. La qualité des porcs dans le Nord du Vietnam (Delta du Fleuve Rouge) entre organisation des producteurs et évolution des systèmes de production. INA-PG. Paris, INA-PG. 300 p.

Notes

Authors' address: Agrarian Systems Department (ASD), Vietnam Agricultural Sciences Institute (VASI).

A review of integrated crop-livestock (animal) systems in Indonesia

Sri Nastiti Jarmani, Arti Djatiharti, and Budi Haryanto

Indonesia is an agriculture-based country with rice as the primary source of carbohydrate for the major portion of the population. Rice farming has thus become the predominant way of living, especially for those who live in suburban villages. Livestock, primarily cattle, and buffaloes are important components of the farming household because of their important role in providing draft power for land preparation and other farm activities. The Green Revolution technology that made possible the more intensive cultivation of land through the use of modern rice varieties, fertilizer, and irrigation brought about changes in agricultural practices that affected both the rice and livestock production systems. As farmers continued to practice rice monoculture to increase production and adopted three cropping seasons,[1] the use of mechanical power became more and more practical to facilitate land preparation. Less attention was given to livestock raising, particularly to cattle and buffaloes, which therefore resulted in a decline in their population. This trend is apparent in the northern areas of Java Island, specifically in West Java. The growing popularity of machinery for farm use was not the only reason for the decline in draft animal resources. Even farmers that continued traditional agricultural systems in which animal traction for land preparation was employed were gradually shifting to mechanical traction because of the difficulty in keeping animals with the increasing contraction of area for grazing and for forage production.

Over the last five years, however, growth in rice productivity was observed to be leveling off. Agricultural experts believe that the diminishing trend was due to the deterioration in soil quality because of organic matter content depletion with the intensive application of inorganic fertilizers for a long period of time. They also believe that the use of animal manure could help enrich the soil again and improve its fertility. Concerns about environmental degradation and its effect on production provide a strong basis for bringing livestock back as a major component in rice areas. Crop-animal integration is thus once again being considered not only as a means of promoting more sustainable production growth but also as a means of improving food security and farmer welfare. As such, the concept of crop-animal systems has now expanded to include both cattle and buffaloes and other animals such as chickens, ducks, pigs, sheep, and goats. In Indonesia, the raising of ducks and native chickens is a common sight among farm households, even though at a small scale. Small ruminants, such as sheep and goats, are almost always present in Indonesian villages.

This monograph has two objectives: (1) to describe the development of crop-animal systems in Indonesia and (2) to assess existing models of crop-animal (livestock) systems in rice and rice-based production areas with the aim of identifying components that would improve farmers' welfare and promote sustainable increases in rice production.

The rice and livestock sectors

Profile of the rice economy

The rice sector in Indonesia remains the backbone of most rural economies. Approximately 15 million farm families in Indonesia are cultivating more than 10 million ha of harvested rice area. About 50% of the total rice area and about 60% of the farm families are situated on the island of Java. Each farm household owns around 0.3 ha of land, on which 4 to 5 family members depend for subsistence. The average rice yield of 4 to 5 t ha^{-1} translates into an average income from rice that ranges from 1 to 3 million rupiah (US$125–375 ha^{-1} or a monthly income of $25–75). On a per family basis, production is much less because of the small landholdings. Hence, rice is basically for home consumption. Only 30% of local production enters the market, whereas 70% is retained by farm households. Out of the 30% marketed, a major part (80%) is traded through private channels, whereas only 20% or less is traded through govern-

[1]Three cropping seasons are very common in Indonesia, particularly in Java. The first cropping season is cultivated to rice and usually starts during the wet season in October. This is followed by another rice crop that starts immediately after the first rice crop harvest around January. The third cropping season is the dry-season crop, which begins in June and is planted to maize or to other horticultural crops.

ment channels (Arifin et al 2002). This situation has not been beneficial to farmers as they remain at the mercy of unscrupulous traders.

Data from the Social Accounting Matrix (CBS 2001) indicated that the lowest income per capita was that from agricultural employee households, followed by agricultural households with landholdings of less than 0.5 ha. The majority of rice farm households fall under the second category. Moreover, rural households in the wetland ecosystem that primarily derive their main source of income from rice are the poorest vis-à-vis those in the dryland and coastal areas as indicated by the study of Adnyana et al (2000). Thus, the continued support of the government is essential to further develop the rice sector because of the role it plays in promoting food security and in improving the well-being of the rural economy, which is dominated by poor rice farm households.

Rice production and demand trends

The national government has always deemed the achievement of rice self-sufficiency to be of strategic importance, hence, its all-out support to increase production. From 1970 to 1984, rice production (in milled form) increased from 11.8 million to 23.7 million t, at an average annual growth of 5.23% (Sudaryanto et al 2002). This growth was more than the average growth in population during that same period, which was 2.22% per annum. This enabled the country to achieve rice self-sufficiency.

Average yield growth declined drastically in the 1980s to about 2.4% per year, with a negative growth rate of –0.13% per annum in the 1990s. Yield growth in the 1980s and 1990s thus averaged only about 1.18% per year, which was much lower than the population growth rate, which was still estimated at 1.75% per year. The slight increase in rice-harvest area was not enough to compensate for the reduction in yield growth. The average growth rate in production during the 1990s was estimated at only 1.28%, which was also below the population growth rate estimate. These declining growth rates in yield and production may constitute a partial response to the diminishing demand for the staple food with economic progress and to farmers losing interest in rice production because of inadequate returns. The decline in yield growth rate may result from several causes, such as a lessening of input application as farmers respond to falling rice prices in the world market, the maintenance of input use as farmers have already optimized their input applications, or because yield gaps across provinces are progressively being closed.

Table 1 shows rice production statistics for 1990-2001. Total domestic rice production reached 50.46 million t in 2001. As can be noted, this has come more from expansion of the irrigated area than from yield improvement. Yield levels have remained almost constant and currently average around 4.5 t ha^{-1}. Recent results of the application of integrated crop management in several provinces indicated an increase in rice yield of 10–20% compared with that obtained with farmers' traditional practices, even though the costs of inputs were higher. The increase in rice yield resulted in an increase in net income of around $125 per hectare per season (Nur et al 2003, Sembiring et al 2003). On a per family basis, however, this is much less because the average area cultivated is less than 1 ha.

Despite the increases in production, substantial imports of rice were still needed to meet domestic demand, which grew at about 3.07% per year from 1981 to 1991. Official records show that imports as high as 6 million t were reported in 1998 (Table 2; Sudaryanto et al 2002). The continued strong growth in demand came from the use of rice other than as a direct food. Rice demand for direct food consumption was reported to have increased at only 0.21% annually (Sudaryanto et al 2002). This is due to the decline in per capita consumption that follows from sustained eco-

Table 1. Harvested area and production of rice in 1990-2001.

Year	Rainfed rice			Irrigated rice		
	Harvested area (000 ha)	Production (000 t)	Average production (t ha^{-1})	Harvested area (000 ha)	Production (000 t)	Average production (t ha^{-1})
1990	1,125	2,353	2.09	9,377	42,825	4.57
1991	1,113	2,357	2.12	9,168	42,331	4.62
1992	1,304	2,826	2.17	9,799	45,414	4.63
1993	1,206	2,622	2.17	9,807	45,559	4.65
1994	1,240	2,682	2.16	9,494	43,959	4.63
1995	1,358	2,938	2.17	10,081	46,806	4.64
1996	1,318	2,913	2.21	10,251	48,488	4.70
1997	1,259	2,785	2.21	9,882	46,592	4.71
1998	1,255	2,754	2.20	10,476	46,483	4.44
1999	1,169	2,665	2.28	10,794	48,201	4.47
2000	1,176	2,692	2.30	10,618	49,207	4.63
2001	1,081	2,565	2.37	10,419	47,896	4.60

Source: CBS (2000, 2001).

Table 2. Rice production, consumption, and imports during 1995-2001.

Year	Production (000 t)	Consumption (000 t)	Imports(000 t)	Relative imports to consumption (%)
1995	32,334	35,348	3,014	8.53
1996	33,216	34,306	1,090	3.18
1997	31,206	31,612	406	1.28
1998	31,118	37,195	6,077	16.34
1999	32,148	36,331	4,183	11.51
2000	32,040	33,552	1,512	4.51
2001	31,651	32,951	1,300	3.95
Av	31,959	34,471	2,511	7.28

Source: Kariyasa (2003).

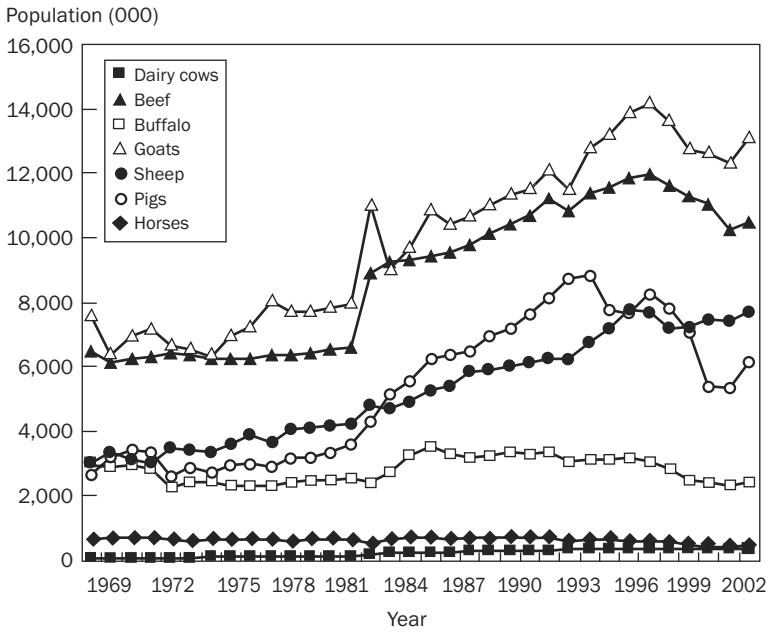


Fig. 1. Evolution of the livestock population. (Source: Directorate General of Livestock Services 2003.) Note: Beef includes bulls of both dairy and beef breeds.

nomic growth and increases in per capita income. Table 2 indicates the level of production, consumption, and imports of rice during 1995-2001 (Kariyasa 2003).

Trends in livestock production and demand

Figure 1 shows the trends in livestock population by animal type. Up to the mid-1990s, animal numbers were generally increasing. The rates of increase are shown to be relatively more rapid from the 1970s up to the mid-1990s, when the rate started to go downward. The recent downward trend is possibly because animal development has been somewhat neglected, with continued government focus on the development of crop production, primarily rice. It is also explained by the continued rise in meat production (Fig. 2) because of strong demand. The growth in animal population obviously did not match the rate at which animals were slaughtered, hence, the downward trend in animal population. The small attention afforded to animal development was exacerbated by the introduction of farm machinery that facilitated land preparation. In a study undertaken in Central Java, Soeharto et al (1981) stressed the observation about the negative effect of farm mechanization on the growth in buffalo population. Hence, as Figure 1 confirms, the number of buffaloes in the country started to diminish much earlier than did the number of other animals.

The goat population constitutes the largest number, increasing from 7 million in the 1970s to around 12 million in 2000. Currently, goats are around 13 million. The cattle

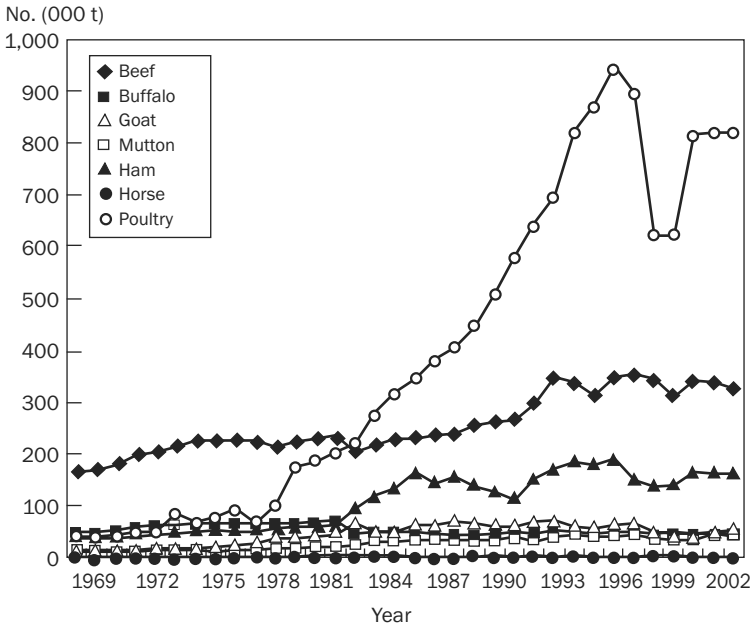


Fig. 2. Meat production from 1969 to 2002. (Source: Directorate General of Livestock Services 2003.)

Table 3. Meat production (t year^{-1}).

Year	Beef	Buffalo	Goat	Sheep	Pig	Horse	Poultry
1990	259.2	44.3	58.3	31.7	123.8	1.7	508.7
1991	262.2	47.5	57.0	37.4	110.0	1.5	583.5
1992	297.0	45.0	68.8	30.2	149.9	1.8	646.6
1993	346.3	51.2	71.2	40.1	169.3	1.6	698.6
1994	336.5	48.2	57.1	42.6	183.6	2.3	822.6
1995	312.0	46.2	55.9	38.4	177.8	1.2	875.7
1996	347.2	48.7	59.6	39.0	189.5	1.2	947.0
1997	353.7	47.4	65.5	41.7	146.8	1.5	898.5
1998	342.6	46.3	47.5	34.2	134.8	1.9	621.2
1999	308.8	48.1	45.0	32.3	136.8	2.3	620.3
2000	339.9	45.9	44.9	33.4	162.4	1.0	817.7
2001	338.7	43.6	48.7	44.8	160.1	1.1	821.1
2002	323.9	43.9	51.0	37.3	161.7	1.1	821.1

Source: Directorate General of Livestock Services (2003).

population comes next after goats in terms of size. It increased from 6 million head to 10 million head from 1971 to 2000. Cattle are currently around 11 million head. The dairy cow population, on the other hand, is smallest, as its number became conspicuous only in the 1970s. Its number, however, has shown steady growth over the years. The trend in the growth of the pig population follows that of cattle and goats, but at a lower level. The buffalo population is lower than its number in the 1960s. What is not illustrated in the figure is the significant increase in the poultry population with the rapid development of the poultry industry.

Figure 2 includes poultry meat and apparently shows the rapid rise in poultry meat. It increased to a peak of 950 t in 1996, declined for a couple of years as demand slackened because of the financial crisis in 1997-98, and then rose again to its current level of 821 t (Table 3). Next to chicken and other poultry meat is beef production, but this has not increased much as a more rapid rate of animal slaughter could not be obtained because of the dwindling cattle population. Pig production is also shown to have risen, especially among the non-Muslim population and in areas where tourism is high.

Figure 3 shows how beef and poultry meat reversed their position in terms of their contribution to total meat production over time. In the late 1960s, beef represented about 50% of total meat production, whereas chicken contributed only a mere 12%. Current statistics show that poultry meat now represents close to 60% of meat production,

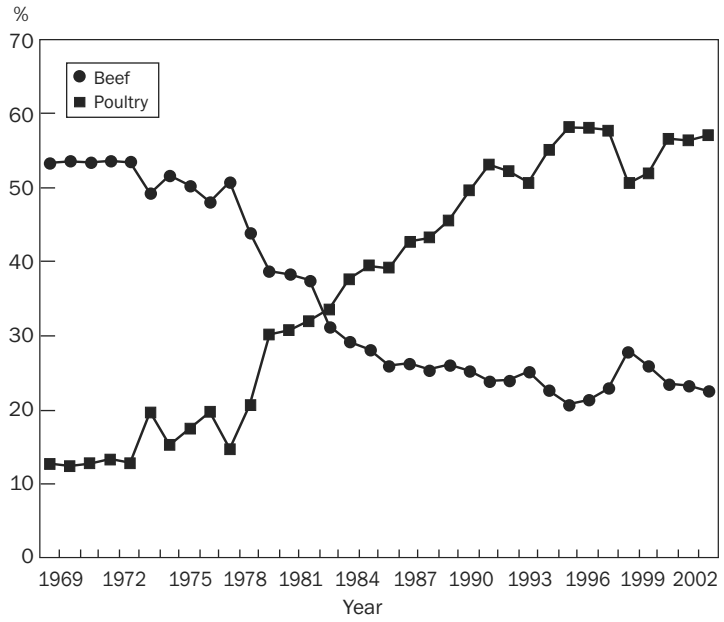


Fig. 3. Contribution of beef and poultry meat to total meat production. (Source: Directorate General of Livestock Services 2003.)

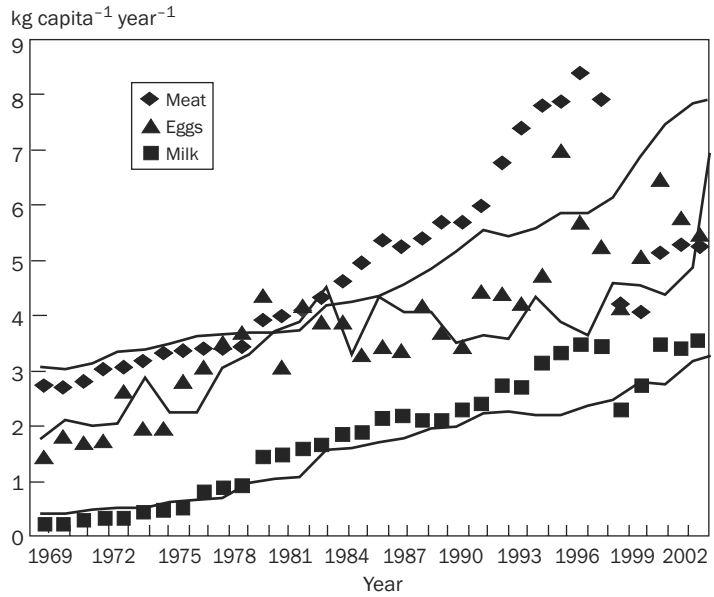


Fig 4. Consumption of meat, eggs, and milk per capita per year. (Source: Directorate General of Livestock Services 2003.)

whereas the contribution of beef is down to about 20%. Production of the other kinds of meat has also risen, also at a gradual rate for exactly the same reason as in beef production.

Meat consumption per capita rose quite significantly from 1981 to 1997 (Fig. 4), primarily because of the rapid expansion of demand for poultry meat. Red meat consumption also increased but not as rapidly as did chicken and other poultry meat. The rise in poultry demand was fully met domestically with the rapid development of the poultry industry. In the case of red meat, however, increased demand was partially met by meat imports from other countries as the domestic stock of animals was limited. In the case of cattle, for example, the continued rise in demand for beef affected the cattle population as productive cows were slaughtered, making it rather difficult to find young calves or yearlings for fattening purposes. Per capita consumption of other livestock products such as eggs and milk is also

shown in Figure 4. Demand for these products has also been on the rise.

Figure 4 also indicates how demand for meat was affected by the financial crisis in 1997 as consumers' capacity to buy was affected. Meat consumption per capita dropped to 4 kg per year in 1997 to 2000 (Directorate General of Livestock Services 2003). This indicates that demand for meat responds strongly to changes in income. As the economy recovered from the financial crisis, meat demand rose. Indonesia must be prepared for this trend in meat demand with a stable and sustained economic growth.

Contribution of rice and the livestock sector to gross domestic product

The Central Bureau of Statistics (2001) indicated that the contribution of food crops (e.g., rice, maize, and other grain crops) still constitutes the biggest share of the country's GDP. This is followed by fisheries, livestock, and forestry, as can be noted in Figure 5. Rice still accounts for the bulk of the food crop contribution, but it is no longer the major single contributor to GDP as it used to be prior to the massive industrialization of the Indonesian economy in the 1990s (Sudaryanto et al 2002). With income growth, the population changed from working in the agricultural sector to the nonagricultural sector since 1991, which resulted in the increased contribution of the nonagricultural sector to GDP (CBS 2001). The contribution of the livestock sector, on the other hand, increased only slightly.

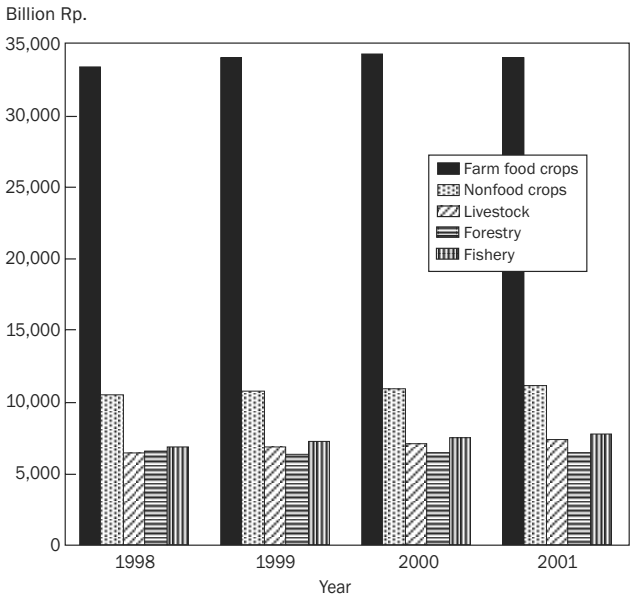


Fig. 5. Contribution of agriculture to GDP. (Source: Central Bureau of Statistics 2001.)

Extent of crop-animal integration

The role of livestock in rice production systems

In earlier times, livestock were farmers' primary assistants in rice cultivation. Animal traction, provided by cattle and buffaloes, was used a lot for land preparation. Nowadays, such use of these animals has tended to diminish with the greater availability of machinery that is more convenient and practical for farmers to use, especially on the vast and flat irrigated farms where intensive planting is practiced and labor availability is low. As animal use in land preparation slowly diminished, many families still continued to keep animals because these were considered as a form of savings and as a social indicator of welfare status in rural areas. A study conducted by Suradisastra (1984) found that 79% of the farmers in a village in Bogor, West Java, indicated that they raised animals to be able to save money for future use, 3% responded that they kept animals for immediate cash during emergencies, and 18% indicated that they kept livestock only as a hobby or because they inherited the animals from their elders (Suradisastra 1984).

Richer farmers generally owned more animals, whereas poorer families tended to keep animals through tenancy. Animal ownership was also related to the availability and accessibility of feed. Most farmers obtained feed such as grasses and forages outside of their own farms on estate crop lands or other public land areas (Sabrani 1981). Animals that are not used for land preparation are kept and taken care of and then sold when farmers need cash.

Transmigration areas, especially those located in Sumatra, have generally employed cattle to prepare the land for food crop production, particularly for rice. Many of these areas, however, have now been developed into estate plantations such as rubber and oil palm, where animal traction is seldom used (Santoso and Prawiradiputra 1981). Recently, the government started to encourage the integration of cattle into the plantation areas to promote and strengthen more sustainable production systems.

The role of nonruminants among rice farm households

It is also common for rice farm households to keep and raise nonruminant animals around their homestead and in areas close by their fields. Such animals include Kampong chickens, ducks, and pigs. The motivation for keeping Kampong chickens is not financial in nature but more related to noneconomic reasons such as for filling leisure time or for self-consumption. In general, 86% of the farmers in a village would have these animals primarily for their own family consumption. Only 14% raise Kampong chickens for economic reasons (Martojoedo et al 1982). This explains why it has been difficult to develop Kampong chicken production on a much larger scale. In rice-producing areas, Kampong chickens are more predominantly available than in non-rice-producing areas.

Duck raising is also a traditional practice and has been well adopted by farmers. The social motives of raising ducks are to optimize the resource availability. Releasing them in rice fields after harvest and prior to planting helps reduce

snail infestation as ducks feed on snails. Moreover, their wastes serve to enrich the soil in rice fields. The management system basically consists of (1) those individuals maintaining a small holding of ducks (around 20) with intensive rice farming, (2) those individuals herding from 50 to 150 ducks in rice fields after or during the time of harvest, and (3) individuals maintaining their ducks in confinement after herding and giving them supplemental feed when they are not herded. An observation of duck raisers in Cirebon (West Java) and Banyuasin (South Sumatra) indicated that most duck raisers cultivate food crops and additionally keep other livestock such as goats (Siregar and Sabrani 1981). Ducks are also raised to enhance farm household income. Different types of ducks are raised depending on the urgency of households to meet economic needs. Tegal ducks reach productive age earlier than crossbred or Khaki Campbell or Bali ducks. Under an intensive management system, the ducks start to produce eggs at 6 to 8 months of age. However, Khaki Campbell ducks produce more eggs than the other strains. The only constraint of the Khaki Campbell ducks is that the egg color is white, which is not preferred by consumers and therefore is more difficult to market (Hetzel 1981). Cost and return estimates show that duck raising can give farmers net income of roughly $5 per bird over a 47-week period (Gunawan and Hetzel 1981). Farmers are also raising swan, turkey, and quail, even though in limited numbers. These poultry, except for quail, are not common in the villages. They are kept only as hobbies rather than for economic purposes.

Pigs are found in a limited number of villages, mostly in North Sumatra, Bali, South Sulawesi, and West Kalimantan. Pigs are raised in backyards by small farmers as well as in large-scale enterprises. Local breeds of pig are common in the backyards of farm households in Bali (Bali pig) and the Nias Islands (North Sumatra). They are fed rice leftovers and other crop residues and are raised primarily for home or ceremonial use. The large-scale pig enterprises usually keep and raise exotic breeds, such as Hampshire, Yorkshire, Duroc, etc., which are sold in markets, mainly to resident foreigners or visitors. However, interaction between pigs raised in large-scale systems and rice production does not exist because pigs are usually raised in a separate area far from rice fields and are fed with rice residues or leftovers.

Feed resources from rice areas

In the intensively managed rice production areas, most of the lands are cultivated three times in a year. Feed resources, in the form of grasses or shrubs, for animals kept and raised become very limited from farmers' own fields. And, because of their tight schedule in rice production, farmers do not usually have the time to find fresh forages for their cattle. Hence, livestock in these areas are usually tethered at roadsides or in vacant arable areas. Rice straw as animal feed is not a common practice, especially among traditional farmers that use grasses and other foliages for their cattle. Only a few farmers use this residue for additional feed. It is burned after the grain is harvested, a habit that has not helped improve rice productivity because organic materials from rice straw are lost and not put back into the soil.

Altering a cropping pattern in intensive rice production areas can be a means to produce more crop residue (waste) that can be used as animal feed and at the same time enhance soil fertility. A cropping sequence of maize, dryland rice, cassava, peanuts, and red bean on a 1-ha farm can produce 814 kg of dry matter of residue that can provide additional feed for 3.71 head of goats (Sudaryanto et al 1982) to fulfill a year-round requirement. An issue that arises, however, relates to the provision of feed for the animals on a continuous basis. The availability of a single type of agricultural residue at a certain time may not be appropriate as a sole source of feed. Therefore, the formulation of several agricultural residues into a complete feed should be considered.

Promoting more sustainable production systems

Small-scale livestock holders are generally subsistent and "zero-cost" producers. Animals are fed with natural grasses taken from roadsides, riverbanks, idle public lands, and crop residues. Accounting for the costs and returns among these farmers is quite difficult. Family labor is usually not counted as a production cost, whereas noncash benefits derived from the use of animals in fields, animal manure, animals consumed at home, the elevation of social status, and leisure-time activities are rarely valued for inclusion in evaluating the relative returns of the production system (Mulyadi 1986). What these small farmers desire most is stability. Hence, adding animals to mixed cropping systems has been prevalent, particularly in the tropical regions of the world.

The practice of mixed animal-crop systems has not only enabled farmers to achieve the most out of their production resources but also has helped promote more sustainable farming. Animals consume crop residues or vegetative matter that would just be thrown away as waste because of being unfit for human consumption. In rice, the presence of livestock will increase the use of rice straw rather than it just being burned. At the same time, the livestock will produce manure for organic fertilizers. The existing conditions of agricultural land, with special reference to that used for rice production, tended to decrease its productivity because of the degradation of soil fertility and its physical structure. The lack of organic matter is considered as the main factor for the reduction in soil productivity. The long-term effects of the application of inorganic fertilizers have resulted in changes in soil physical structure and texture, which brings about the inefficient absorption of soil plant nutrients. It is assumed that some plant nutrients are available adequately in the soil, but they are not readily available for absorption by the plant. The addition of organic matter into the soil has been one possibility for remedying the sick soil. The government has tried to develop the crop-livestock system as the primary means to supply adequate organic matter by

using livestock manure as the main source of material for organic fertilizer. Results of this initiative are discussed in the next section of this paper.

Small ruminants such as goats and sheep are an extremely valuable source of cash income and hence they help stabilize total farm income, especially when calamities hit the areas, as these animals are sturdy and can usually survive more difficult situations better than other types of animals (Gaylord 1986).

Types of crop-animal systems and their impact

Several models of crop-livestock system (CLS) can be observed around the country. The type of interaction between animals and the land is largely determined by the biological adaptation of the animals to existing conditions as these should complement rather than compete with crop production in terms of land, water, and energy use, and nutrient uptake from the soil, as well as in helping to reduce disease or plant pests (Siregar et al 1981). The carrying capacity of land as well as its potential for producing animal feed also determine the types and quantities of livestock to be raised. Land area ownership is likewise related to the species of livestock being kept by farmers. Therefore, it is uncommon to see farmers with 0.3 ha of land ownership keeping cattle at the same time.

The three-strata forage production system

The use of livestock as a component in an integrated farming system (food crops and livestock) was tried in South Sumatra (Batumarta) in the 1980s (Ismail et al 1985). The model introduced involved keeping cattle, goats, and chickens and the cultivation of food crops. The model enabled farmers' income to increase by $1,500 per year. Subsequent trials of the same model were carried out in other areas, which gradually led to the development of the three-strata forage production system (Nitis et al 1985). In this system, forages and the cash crop are cultivated after rice. Forage provides a year-round supply of livestock feed while the cash crop is sold to augment income. This system helped reduce soil erosion while increasing the carrying capacity of the area and increasing farmers' income.

Yogyakarta livestock model

The predominant crop-livestock model is the one that can be found in Yogyakarta, in which the farmers have developed a community of cattle shelters and used rice straw as the main source of feed, with supplementation of rice bran or cassava in limited amounts. The adoption of collective shelters has been advantageous for health care and artificial insemination purposes. In this location, however, manure has not been processed into organic fertilizer. The manure is only collected and allowed to stand for several months before being taken out to other areas, usually to the higher plain, and used for horticultural production. Therefore, the system has not been a full closed cycle of nutrients, in which the source of cattle feed came from the rice field, and the manure being produced by the cattle should be applied back into the rice field to maintain its soil productivity. Exactly the same model was also developed in Nusa Tenggara Barat (West Nusa Tenggara) and East Java, but, in these areas, animal manure was also processed for organic fertilizer. The model developed in Central Java (Grobogan District) involved the government, which provided the cattle through a credit scheme. Farmer participation in the development of the model was a necessity. The cattle were for breeding purposes to increase the cattle population.

Iteration of the Yogyakarta model continued. A more recent one was introduced in an intensive irrigated rice-producing area (Diwyanto and Haryanto 2003), in which rice straw, after being treated by a fermentative process, was used as the main source of fibrous feed for cattle. Concentrated feed was given to fulfill the total nutrient requirement. In the present model, the shelter system was a group model in which sawdust was used as bedding material, mixed with cattle manure and urine, and it was not replaced until 3–4 weeks later. The collected cattle feces and urine combined with the bedding material were used as the main material for making organic fertilizer after being processed through a fermentative treatment. The process takes about 4 weeks, with weekly piling up of the materials as needed.

Synergistic effects of crops and livestock on total agricultural production: experience from various trial sites

As indicated earlier, the effect of keeping livestock as a component of the agricultural system, in addition to the main cash crop, will be able to increase farmers' income. An increase in efficiency of fertilizer use because of the use of organic fertilizer from cattle manure has been observed at some experiment stations.

Results of trials on the model crop-livestock system carried out in the eight provinces as reported by the Assessment Institute for Agricultural Technology (AIAT) are as follows.

Lampung area. Lampung used to be one of the suppliers of livestock for meat to Jakarta and other areas; however, the cattle population decreased significantly because of the high rate of animal slaughter compared with the rate of increase in animal population. The population in 1996 was more than 520,000, but decreased to only 372,000 in 2000. With an area of 3,301,784 ha, 47.8% is used for agricultural and estate crops. Agricultural residues have not been used optimally for feeding animals. Even residues such as rice straw are burned in the field. The availability of phosphorus and potassium in the rice field is quite high, but these have not become easily available for the plants because of their slow absorption rate. The benefits of the rice straw have therefore not been tapped fully. Neither was the cattle manure fully used as organic fertilizer, even though traditionally some farmers have already applied the manure on their rice crop.

Table 4. Results of organic fertilizer use in rice production, Lampung, Indonesia.

Variable	Treatment[a]	
	Plus organic fertilizer	Control
Rice grain production (t ha^{-1}), dry-harvest	7.38 ± 0.921	6.16 ± 0.848
Input production (Rp.)	1,160,500 ± 102,122	554,143 ± 172,897
Manpower (Rp.)	1,469.700 ± 180,700	1,333,600 ± 153,300
Total input cost (Rp.)	2,630,300 ± 255,650	1,887,750 ± 237,000
Gross output (Rp.)	8,118,000 ± 1,012,800	6,774,400 ± 932,400
Net output (Rp.)	5,487,750 ± 827,160	4,886.700 ± 816,200

[a]Some values are rounded up. Rp. 8,500 = US$1.

Technology application was assessed in the area where animal manure was incorporated in the rice fields with burned straw. Results of these trials indicated an increase in rice production at 5–30% of the previous production. Table 4 indicates about a 2 t ha^{-1} increase in rice production in areas with applied organic fertilizer vis-à-vis the control areas.

In the villages of Astomulyo and Rukti Endah, farmers were shown how to improve the nutritive value of rice straw through the fermentation process. However, feeding rice straw solely for cattle requires supplementation with concentrated feed.

West Java. The crop-livestock system model in West Java was used in the village of Sukasenang, Banyuresmi, Garut District. At this location, 35 farmers were involved in the activity within an area of 50 ha. The integrated farming system included rice or maize cultivation, the raising of cattle, and the development of fish ponds. The farmers were grouped into two based on their application of technology in rice cultivation. Group I adopted such technologies as (1) the use of an outstanding rice variety, (2) planting with the *legowo* system, (3) urea fertilization based on the leaf color chart, (4) phosphorus and potassium fertilization based on recommendations, and (5) the integration of fisheries. Group II adopted similar technologies, except that the phosphorus and potassium fertilization was only half of the level in group I but organic fertilizer was applied at 1.5 t ha^{-1}. Results of the trial indicated that the use of the leaf color chart in urea fertilization proved to be more efficient when the fertilizer could be used only twice, at 14 and 42 days after planting, with 30 kg N ha^{-1} each time of application. This means that 30% of the urea fertilizer was saved. Rice straw was not used for feeding cattle. Most was burned or buried in the soil while preparing the land for the next cultivation. The fermentation process of rice straw can improve the nutritive value, which is indicated by an increase in protein content from 4% to 9%.

The integration of fisheries into rice cultivation under the legowo planting system resulted in 50% empty area available for fish, with which farmers' income can be increased, even though the fish growth rate was still under the optimal rate (0.99 g day^{-1} versus 1.5 g day^{-1}) because of the water shortage.

Organic fertilizer was applied to the horticulture plantation at 1.5 t ha^{-1} at the time of soil preparation. The phosphorus and potassium (KCl) fertilizers were given at half of the recommended rate, while urea was applied based on the leaf color chart. The results indicated that plant growth was better when organic fertilizer was applied and the grain produced was more filled.

Treated rice straw used as cattle feed resulted in a daily gain of 0.7 kg on average. The interesting thing was that all feedstuffs for cattle fattening were derived from agricultural residues such as rice straw, maize straw, rice bran, corn stover, and coconut waste. Manure from cattle was collected for organic fertilizer processes. The organic fertilizer was used in horticultural cultivation during the dry season.

Central Java. The location of the crop-livestock system trial in Central Java is in the district of Grobogan, which was actually the continuation of a previous activity of the crop-livestock system (CLS) since 1999, when this location was used as a milestone in the development of the crop-livestock model. The characteristics of the location were indicated by a flat area, 40 m above sea level, soil pH was 7.6 to 8.3, soil P_2O_5 and K_2O content was high at 141.3 and 51.0 mg 100 g^{-1} soil, respectively. Ambient temperature ranged from 26 to 36 ºC, with rainfall of 2,203 mm per year. Rice and maize are the predominant agricultural practices. Production was 5.8 to 7.1 t ha^{-1} for rice during the early wet season and 5.0 to 5.6 t ha^{-1} for the late wet season. Maize production was 6.8 t ha^{-1} of grain. The cattle used at this location were for breeding purposes; therefore, cows were primarily kept by farmers. Artificial insemination was used. Rice straw and maize straw are fed to cattle supplemented with rice bran and maize bran.

Trial results indicated an increase in rice production from 6.45 to 7.0 t ha^{-1} during the early wet season and from 6.0 to 6.3 t ha^{-1} during the late wet-season cultivation.

The cattle pregnancy rate was 46% because of a relatively low adoption of technology by farmers who have not been used to cattle management. Cattle manure was processed for organic fertilizer and used as fertilizer for rice cultivation. It was observed that the integration of cattle into agricultural practices can reduce production costs and increase family labor use because of additional activity in

cattle management. Unfortunately, the grouped cattle shelter system has not been fully accepted by farmers because of the distance from the farmers' home and security.

East Java. A crop-livestock system model was developed in three villages, Curahtulis, Besukagung, and Tanjungrejo. All locations are lowland, approximately 4–7 m above sea level, with average rainfall from 1,001 to 1,500 mm per year. The agricultural system is an irrigated rice-producing area. Most farmers involved in the crop-livestock model application have adequate experience in livestock management, in which more than 90% have been involved in livestock raising for more than 10 years. They are interested in breeding so that they can obtain better animal performance, with better cattle reproductive ability. About 40% of the farmers have an elementary education level, and 20% to 53% have not completed elementary education. Only 4% to 10% have attended high school. Most farmers owned 0.4 to 0.6 ha of land, with livestock ownership of 1.5 to 1.8 head per farm family. This is a general description of farmers in East Java. The agricultural commodities are rice, soybean, watermelon, and maize, except in Besukagung village, where tobacco is also planted. Rice production was 2 to 7 tons of harvest-dried grain per ha, which was lower than with the previous system (7.2 to 8.6 tons of harvest-dried grain per ha). The average service per conception of cattle was 1.8 to 2, with a calving interval of 17.1 to 21.2 months. Rice straw has been used to feed cattle for a long time in East Java; however, no treatment to obtain a higher nutritive value was used. Cattle manure has also been used as fertilizer without any additional treatment to improve its quality. The use of manure for the land did not follow a standard procedure. However, farmers in Besukagung did not use manure for fertilizing their land because they believed that manure would reduce the quality of tobacco. Most rice straw is used as cattle feed (68–70%) in Curahtulis and Tanjungrejo, but only 10% in Besukagung. On the other hand, 5–6% of the rice straw is burned, but 25% in Besukagung. Rice straw was fed at about 8–12 kg head^{-1} day^{-1}.

West Nusa Tenggara. Livestock in West Nusa Tenggara have generally been collectively confined in communal shelters outside the farmers' residence. Farmers usually apply manure for soil fertilization. The adoption of collective shelters as the model of animal shelters has been advantageous for health care and artificial insemination purposes. Rice straw has been processed to increase its nutritive value. Manure is also processed for organic fertilizer.

South Sulawesi. The crop-livestock system in South Sulawesi has not been fully developed. The effort to make collective cattle shelters has not been successful because farmers prefer to bring the cattle back home and tether them under the house. This is done because of the lack of security for the cattle if they are left in the collective shelter. Most farmers don't use manure for fertilizer in rice fields. A study on the use of manure as fertilizer showed that it did not have a significant effect on rice production. The use of rice straw for feeding cattle has not been practiced because harvesting is generally done by cutting the rice plant at the top and leaving behind most of the lower part of the straw in the field. Therefore, farmers should cut the remaining part eventually if the rice straw will be used as feed for cattle. This may be because natural grasses are sufficiently available and therefore farmers do not use rice straw to feed their cattle. Social matters therefore become the main factor determining a successful crop-livestock system.

Yogyakarta. The crop-livestock system in Yogyakarta has been practiced for a long time. The use of rice straw for feeding cattle and the development of communal cattle shelters have been practiced. Manure, however, was not processed for organic fertilizer, but was collected and left for several months to allow organic matter degradation to take place naturally. This manure was not used for rice fields in Yogyakarta but was taken to other areas, usually for horticultural cultivation in the upland areas of Wonosobo. The communal cattle shelters are generally located at a similar site, which is owned by the village government, and could be used by any farmers. The cattle are individually managed.

Bali. The crop-livestock system in Bali has not been assessed completely. However, farmers were enthusiastic about adopting the CLS that was introduced to them. The farmers themselves have been keeping cattle in the rice field, but rice straw is not used for feeding cattle since the farmers can still find native grasses easily for feeding their cattle.

Integrated fish-animal farming system

Integrating fish into the rice field during the first 4 weeks when the water is still deep enough in the rice field has been practiced by some farmers, especially those in the irrigated rice areas in West Java.

The integrated fish-animal farming system, such as that between fish and chickens, has been practiced. Chicken shelters are built above the fish pond so that the chicken manure and spilled feed could drop into the pond. The fish and duck system is also similar to the fish and chicken system. Duck shelters are built above the fish pond, with herbivorous fish being kept in the pond.

Empirical data indicated that the fish-chicken system could increase farmers' income up to 7-fold vis-à-vis fish farming only. The integration of fish and sheep/goats is also practiced in some areas. This fish-sheep system did not give a daily income to farmers because the sheep/goats will only be sold after being kept for 3 months. Therefore, the fish-sheep/goat system under small-scale management may not be promising for development in rural areas (Jangkaru et al 1981).

Possibility of developing off-farm small-scale industries

The development of the crop-livestock system model has encouraged emerging new small businesses in the village, such as the development of agricultural services (workshop of agricultural machinery), agricultural shops (production inputs, tools, information, etc.), and small-scale home in-

dustries (handicrafts, bakery, etc.), to take advantage of the free time of farmers. If this development is supported by small-scale banking facilities such as credit schemes, the economy of the village should improve.

Crop-animal production system: issues and constraints

Livestock management. Several factors affect the potential for developing large ruminants, such as social, economic, and government policy and the integration of institutions that are related to the livestock subsector. The social factors primarily are related to the increase in the human population, improved education, and health awareness, for which good food becomes an unavoidable daily requirement of individuals. Improvement in tourism services will also affect the availability of good food. The increase in meat demand will influence the supply, which could lead to an increase in slaughtering meat-producing livestock. Therefore, a higher demand for meat may reduce the livestock population if appropriate management is not undertaken.

Cattle and buffalo. The increasing ruminant population requires an increase in roughage availability. Agricultural residues such as rice straw, corn stover, soybean, peanut haulm, and others can be used as feed resources for ruminants. The potential of straw production throughout the country was large enough to support the roughage requirements of millions of cattle. The nutritive quality of straw was relatively low (Table 5) (Lebdosukojo 1983). The problems in using agricultural wastes as feedstuffs for ruminants is that the ruminants require supplemental feed (such as natural grasses, legumes, etc.). Other problems are difficulties in collecting the materials, cost of collection, new technology for needed nutritive improvement, etc.

The use of rice straw as feedstuff for buffaloes was not adequate to fulfill the animals' needs; therefore, the animals should be supplemented with concentrate diets. Feeding approximately 7.5 kg of rice straw (dry) and 2.5 kg of concentrate resulted in an increase in body weight gain of 6 to 210 g per day. The total feed dry matter intake (DMI) was approximately 5.9 kg head^{-1} day^{-1}, which equals 350 to 475 g of protein under the assumption that the protein content of rice straw was 4.04% (dry matter basis) (Zulbardi et al 1983).

Buffaloes are considered to be more appropriate for land preparation than cattle because they are more powerful and more resistant to low-quality feed. Farmers use buffaloes to help in land preparation. Buffaloes are used for 5 hours per day and can help in preparing 0.18 ha of land. Plowing the land using buffalo traction is common in Central Java. A pair of buffaloes needs 6.5 days to finish plowing 1 ha of land. Technically, irrigated land is easier to plow than nontechnically irrigated land, which is indicated by the difference in land area that can be prepared by a pair of buffaloes during 3 hours of work (0.099 versus 0.081 ha). Forking the land is easier than plowing (0.64 ha for technically irrigated land and 0.48 ha for nonirrigated land) vis-à-vis the capacity for plowing the land as indicated above, even though the duration of work is the same (3 h) (Sumadi and Kuncoro 1982).

Table 5. Protein and digestible dry matter content of agricultural residues.

Kind of straw	Characteristics	
	Protein content (%)	Digestible DM (%)
Rice straw	4.51	39.2
Maize straw, upper parts	7.44	49.2
Maize straw, lower parts	4.77	45.3
Sorghum straw	4.39	38.0
Sweet potato vines	11.30	60.0
Peanut haulm	11.08	52.9
Soybean straw	10.56	52.9
Sugarcane tops	5.63	42.7

Source: Lebdosukojo (1984).

Traditional management of buffaloes provides simple shelters, with the animals being herded in the grazing areas without supplemental feed, used for plowing agricultural land, and used in a natural breeding system. However, as with cattle, the population tends to decrease. Difficulties for improving the reproductive capacity of buffaloes may be related to the unseen menstrual cycle and the lack of male buffaloes. Frozen buffalo semen was not readily available for artificial insemination compared with frozen cattle semen.

Sheep and goats. Feed availability throughout the year is a limiting factor, especially among small ruminants in some areas. In rice-producing areas such as those in Cirebon (West Java), feed resources for farmers' livestock are primarily obtained from lands owned by other farmers. About 66% of the farmers use public land as the source of their livestock feed. Unlike in the highland areas in which horticulture is the main farming system, feed resources for their livestock are obtained from farmers' own land (Sabrani 1982).

Raising sheep on marginal land usually has promising results for farmers. Because these animals are generally confined in sheds, they contribute less to land erosion and other detrimental effects on the soil. In addition, they also help increase farmers' income. There is no significant relationship between keeping livestock (sheep) and land owning since keeping sheep in a confined system does not require a great deal of land. However, feed should be obtained from other areas, such as in the forest vicinity, where grasses are cut and then carried to where the sheep are kept. They are fed twice a day. Forage offered was generally variable between the rainy and dry seasons (Djadja et al 1982). In the higher plain of Wonosobo, Central Java, the sheep were kept in confined shelters, and were fed with cut-and-carry grasses and other leguminous leaves. Manure is not removed from the animal shelter, rather, the manure is left inside the shelter as bedding for the sheep. The manure is then taken out after 3–4 months and used for fertilizer on horticultural land, including that cultivated to tobacco. The sheep could

reach more than 100 kg liveweight with an economic value of more than 2 million rupiah (around $250).

All family members are involved in livestock management. Herding the sheep varies among locations. In Cirebon, farmers herded their sheep for 292 minutes day^{-1} within a distance of approximately 3.27 km. In Garut, the values were 166 min day^{-1} and 1.63 km; in Bogor, 147 min day^{-1} and 2.1 km. The farming pattern and management system of keeping the sheep may be factors affecting the difference in time taken by farmers to look after livestock (Mulyadi et al 1984).

The beneficial effect of keeping livestock is determined by the successful selling of the animals at the appropriate time. The bargaining power of farmers in general is low; therefore, they are very dependent on middlemen. In village conditions, the middlemen characteristically have a low educational background, but do have economic orientation. Middlemen have a strong bargaining position in determining the price of sheep or goats that will be sold because middlemen know the market situation better than do the farmers. Middlemen have a wider area of information because the livestock market is also spread over several different regions of subdistricts. There is also strong cooperation among middlemen, especially for determining the price and providing capital (Damanik et al 1984).

Poultry in rice production systems: issues and problems

In general, the traditional management system of poultry in the village is considered as a reason the productivity of local chicken is low, because of low-quality feed and the lack of disease prevention. Black Kedu, White Kedu, Nunukan, Pelung, and Kampong chickens are examples of local chickens.

Health care through New Castle disease (ND) vaccination at 1 day, 21 days, and 6 weeks of age is usually suggested. Results of laboratory observations indicated that hen-day production was 32.5% (Melung), 41.3% (Kampong chicken), 50.0% (Nunukan), 54.0% (White Kedu), and 58.8% (Black Kedu), with an egg weight average of 40.6 g (Melung), 43.6 g (Kampong chicken), 47.5 g (Nunukan), 39.2 g (White Kedu), and 44.7 g (Black Kedu) (Creswell and Gunawan 1982). Table 6 indicates the growth rate of several strains of native chicken mentioned above.

Kampong chickens developed slowly because of their low productivity, high mortality rate, low feed quality, and inadequacy of feed. The hatchability of Kampong chicken eggs was 66.7% $\pm$ 21.9%. This means that these were 6.67 day-old chicks per hen and this will drop to 3.37 per hen at weaning age and further decline to 2.67 per hen until a mature age. The mortality rate until weaning age was 49.2% and could increase to 58.9% until maturity. Weaning age was 107 days (99 to 107 days). Twenty-two days after weaning, the hen starts to lay eggs for the next laying period (Tri Yuwanta et al 1982).

Future directions of crop-animal systems

Research activities for crop-animal integration began in the 1970s, continued in the 1980s, and were followed by limited activities in the 1990s; therefore, research reports were also limited. Crop-animal integration was reconsidered with more expanded objectives, and with special reference to efforts to increase rice production, in early 2000.

Evolution of the crop-animal model indicated that this integrated model would be advantageous in sustaining natural resources, and maintaining soil productivity. The interdependencies between crops and animals in using locally available resources would increase farmers' income. Therefore, development of the crop-livestock system, with special emphasis on optimizing the use of available natural resources in rice production areas, should be enhanced. Agricultural development should not focus narrowly on specific commodities or areas but rather on several in an integrated system (Atmadilaga 1979, 1983). Crop-animal system development is the way to go if the government is to provide maximum benefit to the poorer segments of society.

Increasing the productivity of food crops under existing agricultural management practices is hampered by socioeconomic factors such as limited land ownership, lack of capital, and lack of labor, especially in the outer islands of Java. On the other hand, decreasing land productivity caused by declining land fertility is also becoming a serious problem. This should receive special attention for efforts to increase food production. Farmers' socioeconomic capacity should be supported through special government acceleration efforts.

Government support through extension activity as well as research work to solve any constraints are a necessity. Further studies to develop appropriate technologies to support rice production should include social, economic, and

Table 6. Changes in body weight (g) of several strains of native chicken.

Age (wk)	Melung	Black Kedu	Kampong chicken	White Kedu	Nunukan
4	151	165	148	140	161
8	423	313	370	404	370
12	665	575	708	739	669
16	1,165	765	932	950	1,010
20	1,618	1,480	1,408	1,320	1,203

Source: Creswell and Gunawan (1982).

ecological factors. This is important because the technologies that will be introduced to existing practices should be accepted socially, be economically feasible, and not deteriorate ecological resources.

Technologies to improve the nutritive value of agricultural residues as well as technologies that would help convert manure into organic fertilizer are strongly encouraged as their use has been found beneficial. The fact that the potential of agricultural residues has not been used optimally, in parallel with the increasing cost of inputs in agricultural practices, such as the cost of fertilizers, pesticides, and insecticides, and labor and transportation, provides an incentive to introduce an integrated crop-animal system that could use available local resources in a maximal way. However, capital availability at the farmers' level may become a major constraint to developing the integrated crop-animal system as a large amount of capital is required. The role of government becomes the key factor for the successful development of this integrated crop-animal system, especially in providing a source of capital. Moreover, government policy in terms of marketing of products should also be directed to helping farmers so they will not be hurt by the uncontrollable fluctuation of prices of products, whether it be rice or livestock.

Appropriate application of the Indonesia-ICM prescription (within a *"Rice-Check Methodology")* especially in irrigated rice should be encouraged as it promotes more sustainable rice farming while strengthening the closer integration of crops and animals. The components of this prescription are (1) adherence to a climate/crop-sequence-determined sowing date, (2) locally appropriate cultivars, (3) effective leveling and tillage management, (4) the use of good-quality seeds/seedlings, (5) the establishment of a sufficient plant population to ensure adequate grain-sink size for farmers' target yield, (6) balanced plant nutrient management, with demand-driven nitrogen topdressing, (7) P and K fertilizer application based on soil analysis, (8) animal manure to supply part of the rice N-supply, and (9) harvest and postharvest operations at appropriate grain-moisture.

The government policy to develop large ruminants has been directed to improving farmers' income and creating labor or job opportunities. Government, through its extension units, should continue to promote animal management based on five proper measures: good heritage, good feed and feeding, good management, appropriate disease control, and an appropriate marketing system.

References

Adnyana MO et al. 2000. Assessing the rural development impact of the crisis in Indonesia. CASER and the World Bank.

Arifin B, Munir A, Hartadi ES, Rachbini DJ. 2002. Food security and markets in Indonesia: state-private sector interaction in rice trade. In: Kebijakan Perberasan dan Inovasi Teknologi Padi. Pusat Penelitian dan Pengembangan Tanaman Pangan. Badan Penelitian dan Pengembangan Pertanian. Hal. p 31-39.

Atmadilaga D. 1979. Ternak sebagai komponen usaha tani terpadu pada lahan kering di daerah transmigrasi. Seminar Pola pengembangan usahatani terpadu pada lahan kering di daerah transmigrasi. Fakultas Pertanian. Unpad. Bandung.

Atmadilaga D. 1983. Ruminansia Besar dalam perspektif system pembangunan peternakan di Indonesia. Pros. Pertemuan Ilmiah Ruminansia Besar. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 122-132.

CBS (Central Bureau of Statistics). 2000. Statistical year book of Indonesia. BPS, Jakarta.

CBS (Central Bureau of Statistics). 2001. Statistical year book of Indonesia. BPS, Jakarta.

Creswell DC, Gunawan B. 1982. Pertumbuhan badan dan produksi telur dari 5 strain ayam sayur pada system peternakan intensif. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 236-240.

Damanik KI, Salangka MK, Ihalauw JOI, Sasongko G, Sulandjari dan S, Supardan EW. 1984. Peranan blantik dalam system produksi dan pemasaran kambing/domba di Jawa Tengah. Pros. Domba dan Kambing di Indonesia. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 220-225.

Directorate General of Livestock Services. 2003. Statistical book on livestock 2002. Directorate General of Livestock Services, Department of Agriculture, Jakarta.

Diwyanto K, Haryanto dan B. 2003. Akselerasi peningkatan produksi melalui Sistem Tanaman-Ternak. In: Kebijakan Perberasan dan Inovasi Teknologi Padi. Pusat Penelitian dan Pengembangan Tanaman Pangan. Badan Penelitian dan Pengembangan Pertanian. Hal. p 93-102.

Djadja SK, Rukmana MP, Sulaeman, Hartati dan Mardjiwo. 1982. Prospek pengembangan ternak domba pada lahan kritis di Jawa Barat. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 151-155.

Gaylord M. 1986. The role of rural sociology in farming systems research. Proceedings of the workshop on farming systems research and development. Levine J, Sabrani M, editors. CRIAS. p 62-76.

Gunawan B, Hetzel DJS. 1981. Performans itik-itik local dan silangannya pada sistim peternakan secara extensive dan intensif di Karawang. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 424-429.

Hetzel DJS. 1981. Egg production characteristics of Alabio, Bali, Tegal and Khaki Campbell ducks under intensive management conditions. Proceedings of the Second Conference. Australian Association of Animal Breeding and Genetics, Melbourne.

Ismail IG, Djauhari A, Bambang P, Sabe W, McIntosh JL. 1985. Methodology, plans and progress of the crop/livestock systems research in Batumarta, South Sumatra. Proceedings of the International Farming Systems Workshop, Sukarami. Agency for Agricultural Research and Rural Development. p 97-114.

Jangkaru Z, Djajadiredja R, Yunus M. 1981. Usaha pemeliharaan ikan bersama ternak. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 34-40.

Kariyasa K. 2003. Dampak tarif impor dan kinerja kebijakan harga dasar serta implikasinya terhadap daya saing beras Indonesia. Analisis Kebijakan Pertanian. Pusat Penelitian

dan Pengembangan Sosial Ekonomi Pertanian. 1(4):315-330.

Lebdosukojo S. 1983. Pemanfaatan limbah pertanian untuk menunjang kebutuhan pakan ruminansia. Pros. Pertemuan Ilmiah Ruminansia Besar. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 78-84.

Martojoedo SH, Dulatip N, Tawaf dan R, Amas U. 1982. Motif pemeliharaan ayam sayur pada petani peternak di Kecamatan Ciamis. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 249-257.

Mulyadi AN. 1986. Socio-economic constraints on livestock production within existing farming systems. Proceedings of the workshop on farming systems research and development. Levine J, Sabrani M, editors. Center for Research in Animal Science. p 51-61.

Mulyadi AN, Knipscheer dan HC, Mathius IW. 1984. Karakteristik system pemeliharaan domba dan kambing di Jawa Barat: Aspek tenaga kerja. Pros. Domba dan Kambing di Indonesia. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 197-201.

Nitis IM, Lana K, Suarna M. 1985. Three-strata system for cattle feeds and feeding in dryland farming area in Bali. Proceedings of the 2nd Monitoring Tour Crop-Livestock Systems Research. Nepal and Indonesia. p 245-271.

Nur M, Marwan dan HM, Basri AB. 2003. Pengelolaan Tanaman Terpadu Nangroe Aceh Darussalam. Pros. Lokakarya Pelaksanaan Program Peningkatan Produktivitas Padi Terpadu (P3T) Tahun 2002. Pusat Penelitian dan Pengembangan Tanaman Pangan. Badan Penelitian dan Pengembangan Pertanian.

Sabrani M. 1981. Prospek pengembangan kambing domba bagi petani kecil dan perlunya pendekatan keilmuan terpadu. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 27-33.

Sabrani M. 1982. Respons pengembangan ternak domba terhadap pola tanaman dan jumlah keluarga petani. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 145-150.

Sabrani M, Kusnadi U. 1986. Farming systems research (Indonesian experience). Proceedings of the workshop on farming systems research and development. Levine J, Sabrani M, editors. Center for Research in Animal Science. p 7-31.

Sabrani M, Sudaryanto B, Prabowo A, Tikupadang dan A, Suparyanto A. 1992. Dampak integrasi ternak dalam usahatani terhadap pendapatan. Pros. Agro-industri Peternakan di Pedesaan. Pusat Penelaitian dan Pengembangan Peternakan. Bogor. Hal. p 64-73.

Santoso dan B, Prawiradiputra R. 1981. Budidaya ternak di daerah transmigrasi Sitiung. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 86-95.

Sembiring H, Daniel M, Rinaldi, Siregar A., Akmal, Helmi, Sembiring T, Yusuf A, Thahir B, Ahyar, Sariman dan Maezuki. 2003. Peningkatan Produktivitas Padi Terpadu Sumatera Utara. Pros. Lokakarya Pelaksanaan Program Peningkatan Produktivitas Padi Terpadu (P3T) Tahun 2002. Pusat Penelitian dan Pengembangan Tanaman Pangan. Badan Penelitian dan Pengembangan Pertanian.

Siregar AP, Sabrani M. 1981. Prospek peternakan itik di daerah pantai. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 419-423.

Siregar AR, Soediman S, Manurung dan T, Siregar AP. 1981. Budidaya ternak dalam usaha tani terpadu di daerah transmigrasi. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 78-85.

Soeharto Pr, Nurtini dan Taryadi S. 1981. Masalah ternak kerbau dan mekanisasi pertanian. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 161-168.

Sudaryanto B, Djamal dan S, Siregar ME. 1982. Produksi limbah pertanian dengan pola tanam tertentu untuk makanan ternak. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 337-340.

Sudaryanto T, Simatupang P, Irawan B, Swastika DKS. 2002. Medium- and long-term prospects of rice supply and demand in Indonesia. In: Sombilla M, Hossain M, Hardy B, editors. Developments in the Asian rice economy. Proceedings of the International Workshop on Medium- and Long-Term Prospects of Rice Supply and Demand in the 21st Century. Los Baños (Philippines): International Rice Research Institute. p 97-125.

Sumadi, Kuncoro. 1982. Hubungan antara kedalaman bajak, panjang garu dan luas sawah yang dikerjakan dengan ternak kerbau di Kabupaten Klaten. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 69-77.

Suradisastra K. 1984. Sikap dan persepsi: Suatu karakteristik mental peternak dalam usaha pengembangan peternakan domba. Kasus desa Ciburuy, Cijeruk (Bogor). Pros. Domba dan Kambing di Indonesia. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 193-196.

Tri Yuwanta, Wihandoyo, Harimurti S. 1982. Hubungan prestasi ayam kampong saat DOC, lepas induk dan dewasa kelamin pada kondisi pemeliharaan tradisional di pedesaan. Pros. Seminar Penelitian Peternakan. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 241-248.

Zulbardi M, Siregar dan AR, Mathius W. 1983. Jerami padi dengan jagung dan dedak padi sebagai makanan kerbau. Pros. Pertemuan Ilmiah Ruminansia Besar. Pusat Penelitian dan Pengembangan Peternakan. Bogor. Hal. p 33-36.

Notes

Authors' addresses: Sri Nastiti Jarmani and Budi Haryanto, Research Institute for Animal Production; Arti Djatiharti, Research Institute for Rice, Agency for Agricultural Research and Development, Department of Agriculture, Indonesia.

Acknowledgments: The authors express their gratitude and appreciation for the support of funding by the SLP/ILRI and the opportunity to do this collaborative work with IRRI. Our deep gratitude also goes to other institutions whose inputs were valuable in the preparation of this review of the crop-livestock system in Indonesia.

Integrated crop-animal systems in the Philippines: current status and future prospects

Grace C. Cataquiz, Fermina T. Rivera, Guadalupe O. Redondo, Rowena G. Manalili, Mary Jane R. Nievera, and Mercedita A. Sombilla

There are around 1.2 million hectares of rainfed rice areas in the Philippines, where potential for increasing agricultural production is more difficult because of fragile and adverse conditions. Rice is grown only during the rainy season and yield growth is equally experiencing a declining trend. These reasons partly explain the high incidence of poverty on rainfed lowland and upland farms. Rice farmers are considered among the poorest people.

Farm diversification has provided smallholders in rainfed lands with potential for improving welfare and promoting income security. While rice continues to be grown, other commodities, especially high-value crops, are increasingly being cultivated on the same piece of land to increase productivity and help boost income. Fruit trees such as citrus, mango, papaya, banana, etc., are established on the periphery for food and for sale. A key and important component of farm diversification over the past years is animal raising. A carabao is almost always present for draft power. Smaller animals such as pigs and chickens are raised in small numbers for food, for sale, and for special occasions. In more recent years, the establishment of on-farm aquaculture has increasingly been promoted.

Diversification in these environments, however, has faced problems. The most critical of these pertain to the need for continued support, from both public and private institutions, to the establishment of a good and effective extension, financial, and market system that would facilitate their integration to the more progressive production areas as well as to the nonfarm economy (www.sdnbd.org).

Objectives

This country monograph focuses on the animal component of rice-based systems, primarily in rainfed areas. It aims to characterize the integrated development of rice and animal production by accomplishing the following more specific objectives:

1. Describe the current status and prospects of production and demand of the rice and animal sectors in the country.
2. Identify various rice-animal systems and describe their interactions.
3. Determine the factors that contribute to or impede the growth of integrated crop-animal systems (ICAS) in the country.
4. Review government interventions, especially those that promote ICAS.

Profile of the crop and animal sectors

The country's rice economy

Rice is the most dominant and important commodity in Philippine agriculture. It contributes 16% to gross value added in agriculture, 3.5% to gross domestic product, and 3.3% to gross national product. Its importance, however, relates more to its being the staple food of over 80% of the population. Per capita consumption of rice has remained almost constant at about 100 kg per year over the last decade. The agricultural sector also employs 70% of the total labor force that depends directly and indirectly on rice cultivation and marketing for its livelihood. About 44% of the income of a Filipino family is spent on food and a quarter of that is spent on rice.

Despite this importance, however, sustaining its production growth to match demand and helping boost income among rice farmers have increasingly become more difficult (Fig. 1). Population has increased steadily at a much

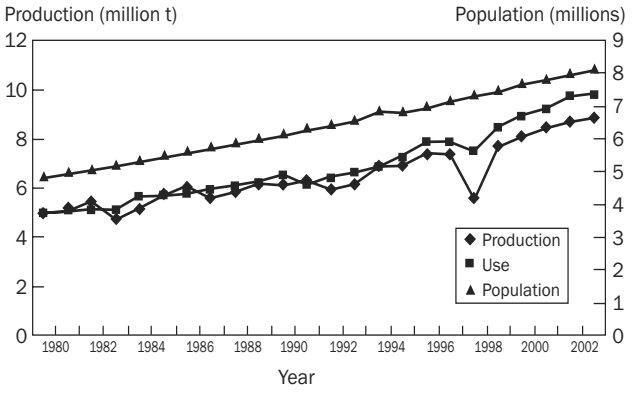


Fig. 1. Trend of population, rice production, and use, Philippines, 1980-2001. Source: BAS (2003).

Table 1. Growth rates in paddy production, area, and yield in the Philippines, 1955-2001.[a]

Item	1955-65	1965-75	1975-85	1985-2003
Production	2.4	4.6	4.5	2.3
	(100)	(100)	(100)	(100)
Area	1.3	1.2	–	1.2
	(54)	(24)	–	(52)
Yield	1.1	3.4	4.5	1.1
	(46)	(76)	(100)	(47)

[a]Numbers in parentheses are the share of growth in output.
Source: Francisco (2000).

faster rate than production, which created the supply gap, especially in more recent years. The country has thus been a net importer of rice since 1984.

Table 1 shows a decomposition of output growth. Before 1975, the growth in output was accounted for by expanding the area devoted to rice production. The decade after that witnessed area growth still averaging 1.2% while yield growth increased to 3.4% per annum. In 1975-85, yield growth accounted for most of the production increases as cultivated area remained unchanged with the closing of the land frontier. But, in 1985-2003, area growth once again exceeded yield growth. This time, such growth did not come from the addition of more land into rice cultivation but rather from the increase in cropping intensity as farmers became more able to plant two or more rice crops a year with the increasing availability of irrigation water. The decline in yield growth, on the other hand, ensued with the exhaustion of the productivity potential of the current technology.

Constraints to sustained growth in rice production

According to Francisco (2000), development of the rice sector is impeded by socioeconomic, policy, institutional, and technological constraints.

Socioeconomic, policy, and institutional constraints. These constraints are

- Limited management skills of farmers
  On average, there are more rice farmers in the Philippines who have limited skills in making rice farming an agribusiness venture. The relatively low fertilizer use and proper timing of application, accompanied by poor cultural management practices, are major sources of inefficiency. Socioeconomic studies showed that the typical Filipino farmer is only 40% as efficient as the best Filipino farmer.
- Deteriorating terms of trade
  Although nominal protection of domestic rice production has been positive over the years, net effective protection has been declining because of higher protection on tradable inputs and overvaluation of exchange rates. The deterioration of effective protection worked against the rice sector at the micro level and discouraged investment to further develop rice farms.
- Lack of appropriate and adequate infrastructure
  Because of limited access to credit, processing, and storage facilities, farmers are forced to sell their marketable surplus during harvest months when prices are low. Farmers cannot wait for a good price because they do not have a place to dry or store their rice. As a result, wholesalers dictate prices to retailers and consumers.

  Another problem is the lack of effective irrigation systems, primarily caused by (1) the substantial increase in costs for irrigation development and (2) problems in the management of large-scale irrigation systems.
- Frequent changes in leaders and programs
  According to Tolentino (2001), the average period in service of the Secretary of Agriculture since 1971 was 33 months. With each change in leadership came changes in sectoral and department goals, objectives, strategies, timetables, programs, projects, and activities. This resulted in intensified politicization of senior bureaucrats; weakened planning, policy, and analytical capability; and inappropriate institutional structure.

Technological constraints. These constraints are

- Technology plateau
  Rice scientists generally agree that the technology plateau in rice took place in the late 1980s. After the introduction of IR8 in the late 1960s, which triggered the Green Revolution in Asia, no genetic material has been developed with the same magnitude of technological impact.
- Emergence of biotypes
  Rice production declined after the mid-1980s because of the emergence of new biological problems. The development of new strains and biotypes of rice pests was compounded by the regular occurrences of natural calamities such as flood, and drought.
- Low technical efficiency
  PhilRice studies show that farmers have low technical efficiency relative to the best farmers' performance. Also, first-generation varieties are still used by nearly half of the farmers. These varieties produce relatively low yield and have poor grain quality, low milling recovery, and poor tolerance of biotic and abiotic stresses. Seeding rates are still high at 120 to 200 kg ha^{-1}.
- Problem soils and declining soil fertility
  As mentioned earlier, about 1.2 million ha are classified as problem soils in the Philippines. This area consists of about one-half of the national rice area. Of the total area of problem soils, 600,000 ha have adverse water and nutrient conditions, 100,000 ha are saline-prone, 10,000 ha are alkaline, 15,000 ha are peat soils, and 50,000 ha are acid sulfate soils.

Table 2. Animal inventory (in 000 head) by production system, Philippines, 1992-2003.

Year	Carabao		Cattle		Goats		Swine/hogs		Chickens		Ducks	
	Backyard	Commercial	Backyard	Commercial	Backyard	Commercial	Backyard	Commercial	Broiler	Layer	Backyard	Commercial
1992	2,573	4.0	1,577	153	2,294	12.8	6,717	1,305	27,356	7,406	7,661	679
1993	2,570	5.0	1,755	160	2,552	10.3	6,663	1,290	31,173	8,602	8,175	531
1994	2,555	4.0	1,769	167	2,662	10.6	6,766	1,460	34,771	8,342	7,585	602
1995	2,702	5.5	1,835	186	2,815	12.6	7,181	1,760	27,885	9,364	6,855	2,217
1996	2,835	5.9	1,929	199	2,969	12.3	7,239	1,787	39,312	10,796	7,335	2,135
1997	2,982	6.3	2,056	210	3,013	12.0	7,788	1,964	46,558	11,466	6,762	2,161
1998	3,007	6.4	2,168	209	3,072	14.0	8,031	2,180	46,386	13,170	6,957	1,870
1999	3,000	6.2	2,229	196	3,035	16.0	8,179	2,218	34,770	13,367	6,560	2,025
2000	3,018	6.0	2,307	187	3,112	13.0	8,327	2,383	29,024	14,913	7,097	2,168
2001	3,059	6.5	2,307	188	3,203	12.0	8,542	2,521	28,960	14,860	7,810	2,177
2002	3,115	6.5	2,364	184	3,280	14.0	8,935	2,717	33,160	16,280	7,650	2,261
2003	3,159	6.9	2,380	177	3,296	15.0	9,463	2,901	38,150	17,710	7,480	2,323

Sources: BAS (2003), Food and Agri Business Yearbook & Directory (1997, 2000).

The country's animal sector[1]

Hogs are the largest source of meat in the country. They constitute about 75% of total livestock production. Chicken is the most popular substitute for pork because it is one of the cheapest sources of protein since it requires less feed to produce 1 kg than hogs and cattle.

On the other hand, the Philippine ruminant (cattle, carabao, goat, and dairy) industry lags behind the poultry and swine industries. It remains basically a smallholder-based industry since 97% of the ruminant animals are in the hands of small-scale farmers.

Animal resources

An inventory of Philippine animal resources by type of production system from 1992 to 2003 is presented in Table 2.

Although the carabao is an important farm resource for draft power, meat, and milk in the country, its population decreased from 1990 to early 1994, with an average decline of 1.9% annually. This was attributed to low productivity, a high extraction rate, and high mortality rate. However, from 1995 to now, a positive growth of 3.6% per year has been observed. This growth was attributed to carabeef importation, which led to a lower extraction rate, and the establishment of the Philippine Carabao Center (PCC) in 1993 that promoted carabao production and development.

Most of the carabao raisers are found in Cagayan Valley, Southern Tagalog, Western Visayas, Bicol, Southern Mindanao, and Ilocos regions. About 55% (1.6 million head) of the country's total carabao population comes from these raisers. Top commercial carabao raisers are concentrated in Bicol, Cordillera Autonomous Region (CAR), Central Luzon, Eastern Visayas, Northern Mindanao, and Ilocos regions. These regions contribute about a 74% share of the carabao inventory on commercial farms.

Research has indicated that the cattle/beef sector has the biggest potential for growth. In 2003, the total cattle inventory was estimated at 2.6 million head, which is only 0.35% higher than that of 2002. The backyard sector, which accounted for 93% of the total cattle population, grew by about 0.7%, whereas the commercial sector indicated a negative growth of about 4% over that of 2002. This situation further shrank the country's cow-calf operations in both number and production performance.

The top cattle-producing regions are Ilocos, Southern Tagalog, Central Visayas, Northern Mindanao, and Western Visayas, which contribute 53.0% of the total cattle population. On the other hand, Bicol, Central Luzon, Southern Mindanao, Northern Mindanao, and Southern Tagalog led the commercial sector and contributed 83.4% of this sector's total inventory.

Goat's popularity as a "poor man's cow" boosted its total production from 70,869 t liveweight in 1990 to 75,190 t liveweight in 2000. Its inventory increased from 2.2 million head in 1990 to 3.3 million in 2000. The local sheep meat supply (mutton), on the other hand, is enhanced by imports.

Hogs are the largest source of meat in the country. In 2003, the hog population reached about 12.4 million head. Its population increased by 4% per annum from 1995 to 1999. Although the industry was struck by foot-and-mouth disease (FMD) in mid-1995, only the top-producing region, Central Luzon, was affected. Fortunately, other areas were hit only slightly and their production growth more than compensated for the losses in Central Luzon. The industry actually registered a positive growth during the period. Hog farms are mostly found in Southern Tagalog, Central Luzon, and Southern Mindanao.

[1]The ruminant part is largely adapted from PCARRD (2002).

Table 3. Backyard and commercial livestock farms in the Philippines. Adapted from Rivera (2002).

Animal species	Backyard		Commercial		Total	
	Inventory	Share (%)	Inventory	Share (%)	Inventory	Share (%)
Ruminants						
Carabao	3,115,444	99.8	6,582	0.2	3,122,026	100
Cattle	2,364,133	92.8	183,686	7.2	2,547,819	100
Goats	3,280,139	99.6	13,761	0.4	3,293,900	100
Nonruminants						
Hogs	8,935,400	76.7	2,717,300	23.3	11,652,700	100
Chickens	75,889,231	58.6	53,705,367	41.4	129,594,598	100
Ducks	7,650,162	77.2	2,261,107	22.8	9,911,269	100

The chicken inventory grew by an average of 6% per annum from 1995 to 1999. The broiler chicken inventory soared in 1996 because of the outbreak of FMD in the hog sector. Demand for pork slumped while buyers shifted to chicken and beef. Chicken production exhibited huge increases as integrators pursued stock expansions. Chicken production went up by almost 20% during the year. However, when the hog industry recovered from FMD, the demand for chicken decelerated, resulting in an oversupply and depressed prices for a long time.

The duck population also increased from 8.3 million birds in 1992 to 9.8 million in 2003. Duck production is predominantly backyard.

Animal production systems

There are two types of animal production systems: backyard or small-scale and commercial. The first one is predominant, in which about 79% of the nonruminant animal inventory is classified as belonging to the backyard type. The number is 99% among the ruminant animal inventory, especially for carabao and goats, which are integral parts of smallholder farming systems. In 2000, 99.8% of the total carabao population of about 3.0 million was raised in backyards, whereas the commercial sector contributed only 0.2% (Table 3). Commercial cattle production is bigger, covering about 7% of the total inventory. Among the nonruminants, chicken raising is the most commercialized, with 41% of the total inventory.

Demand and supply trends

Because of the increase in human population and improvement in income that enhanced consumers' buying capacity, the demand for meat has grown in more recent years. During 1980-95, total meat consumption increased by 41%. Consumption of beef and carabeef exhibited a much bigger increase (72%) during the same period.

Demand for milk and milk products equally increased such that the gap between local milk production and actual demand widened significantly. Local production amounted to less than 1% of the total requirements. Milk and dairy product imports increased to fill this increasing gap. The volume of milk imports increased by 26.3% from 1992 to 1998.

Beef cattle

Beef consumption is income-responsive but price-inelastic. From an average of 2 kg capita^{-1} year^{-1}, beef intake increased to 2.47 kg. However, this figure is still way below the 4.5 kg year^{-1} Recommended Dietary Allowance (RDA) established by the Food and Nutrition Research Institute (FNRI).

For the past ten years, demand for beef has gradually increased. To achieve such growth, at least 500,000 head of cattle must be slaughtered annually. In 1999, about 24% of the total supply of 3.3 million head was slaughtered for meat. This was an increase of about 3.7% over the number slaughtered in 1998.

Beef imports supplemented domestic production. Beef imports in 1995 to 1997 increased annually by 23%. The volume and value of beef imports increased by 38% and 24%, respectively, from 1998 to 1999. In 2000, total beef imports were 43,900 t, amounting to $51.2 million (f.o.b. price). Beef products were mostly imported by hotels and restaurants. From 1996 to 1998, the United States (55%), Australia (32%), India (5%), and New Zealand (3%) were the major sources of imported bone-in beef, while other countries shared 4%. For boneless imports, the major sources were Australia (51%), India (25%), New Zealand (7%), and the U.S. (4%). The other countries shared 13%.

Carabao

The average volume of local carabeef production from 1992 to 1999 was 108,400 t. Total carabeef production in 2000 reached 124,000 t, or an increase of 4.2% from the 1999 figures. On average, 220,423 head, or 8% of the population, are slaughtered annually.

Carabao is an indigenous livestock resource whose importance in farming activities cannot be denied. The Philippines has around only 3.2 million head. Local carabao raisers could not possibly meet the country's demand for

carabeef, so we need to import it. Importation of buffalo meat started in 1993 at 436 t; in 1999, imports were 34,430 t. Massive importation grew by 7,796.7% from 1993 to 1999. This increase was due to the increase in demand for carabeef brought about by the increase in human population and increasing buying capacity. In 2000, the government allowed importation of about 39,800 t of carabeef. This adds to our local supply of 71,600 t to meet our requirement of 111,400 t. The demand for carabeef was also due to the increase in the meat-processing sector, which consumes much of our locally produced and imported meat. Most of the carabeef produced by local raisers was sold to the wet markets, whereas that imported was taken directly to the processing plants for corned beef, sausages, burgers, and other processed meat products.

The increasing trend of replacing carabao with small tractors has brought about the use of this animal as food. The rate of animal substitution by machines is 15–35% on irrigated farms and 3–5% in rainfed areas.

Small ruminants

Domestic per capita consumption of goat carcass increased from 0.32 kg in 1995 to 0.33 kg in 1999. No increase has been reported for the last seven years.

Hogs/swine

In 1995, hog raisers had a good start. There was an inventory buildup on both backyard and commercial farms. Unfortunately, FMD struck in 1996. Consumers shied away from pork, which resulted in a decrease in sales, of both fresh meat and processed products. But when the disease was controlled, the demand for pork bounced back. However, the supply was low because of FMD mortality and the deliberate depopulation of farms to avoid losses from low prices. This situation pushed pork prices up to a record high.

The country exports minimal amounts of pork but has regularly imported the commodity. During the FMD scare, imports bloated by more than 800% in terms of value (US$7.6 million) as import restrictions were lifted.

Chickens

Chicken, which is the closest substitute for pork, enjoys a tremendous boost whenever pork faces problems like the FMD outbreak in 1996. As the meat market normalizes, the chicken industry suffers problems of oversupply and depressed prices. The situation worsened with the entry of imported chicken cuts in 1998. This entry of cheap chicken technically smuggled in from the duty-free zones of Clark reportedly hurt the industry in 1999.

The Philippines does not export chicken meat. Imports come mainly from the United States. The big integrators are the main players in the industry. These companies use a contract growing scheme and thus have a direct hand in the commercial sector. They are also the main sources of dressed chicken in urban areas, selling not only through upscale supermarkets but also through wet markets, which have been the traditional outlets of backyard raisers (Food and Agri Business Yearbook & Directory 2000).

The integrators include Swift Foods Inc., Vitarich Corporation, San Miguel Foods, Inc., Pure Foods Corp., and Tysons. These integrators produce approximately 90% of the chicken supply. The balance comes from other commercial farms and backyard raisers. These integrators are also engaged in other product lines such as feeds, flour, and consumer products, including beverages and packaging materials. Other product lines serve as support to poultry production.

Ducks

The production of duck meat and eggs is mostly done on backyard farms, as ducks are easier to care for than chickens. Furthermore, ducks generally use fiber more efficiently than chickens; thus, most agricultural wastes and by-products (e.g., palay and rice bran) make more suitable and cheaper feed alternatives. Recently, commercial feeds have also become available.

Commercial farms are concentrated in Central Luzon, where duck feed (rice bran) is abundant. On the other hand, duck raisers mainly for egg production are concentrated in Pateros and Laguna.

Constraints to development of the animal sector

Farmers are usually more concerned about activities related to crop production, particularly to rice, which is the staple food, and high-value crops that help increase income. Since animal production is primarily backyard, farmers have paid little attention to improved technologies that help increase feed efficiency and animal productivity. Support programs and projects on improving animal management from government as well as from private institutions are not as ample as with crops. Technology development likewise is not as up to date.

The following sections point out several constraints.

Beef cattle

- Low breeding base
- Absence of an organized beef cattle development and breeding program
- Poor-quality feed
- Nonadoption of improved husbandry practices and forage technologies
- Unavailability of ranching areas, including squatter encroachment and land tenure problems in grazing areas
- Inefficient marketing system and structure
- Inadequate farm-to-market roads and processing facilities
- Inadequate veterinary and extension services

Carabao

- Biological characteristics of carabao. Inherently longer gestation period than any domestic farm ruminants, average gestation of which is 310–315 days.

Given a postpartum service period of 60–90 days under optimum conditions, production of one calf per year is not likely achievable even under the best conditions.

- **Socioeconomic constraints**. Carabao in the Philippines are raised on smallholder farms. If the carabao is to be a vital economic unit for increasing family income, new approaches, strategies, and programs should be developed.
- **Import liberalization**. Immediate and long-term effects of carabeef importation should be analyzed. More efforts should be made to make local production more competitive. Likewise, the milk feeding program has to be institutionalized and support to milk producers should be available.
- **Credit policy**. The major constraint to production is capital. Hence, credit windows for smallholder farmers should be created with affordable interest rates and accessible repayment schemes. This is also true for other animals such as cattle, swine, and even chickens and for other crops such as rice, maize, and other vegetables for which starting capital is very high.

Small ruminants

- Attempts to raise goats commercially failed because of the lack of technology and understanding of goat production management.
- High mortality rates in goats because of pneumonia and other diseases such as hoof and mouth.

Swine/hogs

- Local producers are not competitive with imports because of the low feed conversion ratio and small average size of the litter of locally grown hogs.
- Costs of feed are relatively expensive because of the high price of maize, the principal cost component.
- Increased availability of pork substitutes due to trade liberalization.
- Lack of good-quality slaughterhouses and storage and transport facilities.

Chickens

- The entry of cheaper chicken and chicken meat substitutes due to import liberalization.
- High cost of production because of high price of maize.
- Locally grown chicken is not competitive with imported chicken because the production costs of foreign farms are far lower and their operations are more efficient.

Ducks

- Depressed prices of eggs in the local market and the presence of imported substitutes, i.e., powdered eggs. Powdered eggs are imported eggs mainly from the U.S., used by mayonnaise manufacturers and bakers, especially in making cakes. From 1990 to 2000, imports grew by 26%, amounting to 374 tons ($799,786 in 2001).

Socioeconomic factors that influence the development of the crop and animal sectors

Several factors affect the trends in supply and demand of both crops and animals. The key ones are changes in income and in the number and structure of the population. Preferences for certain food types because of taste and versatility in their cooking preparation have likewise influenced production growth. Food requirements vary depending on the rate at which income rises and various factors that influence the population structure such as declining mortality, high fertility, and migration to urban areas (Hossain and Sombilla 1999).

The Philippine annual population growth rate is one of the highest in Southeast Asia (2.3%). This rate has remained almost constant from 1990 to 2000, while that of Singapore (1.0%) and Thailand (1.4%) continued to slow down. At this rate of growth, the Philippine population of 84 million is bound to double by 2030. High population growth rate, continuing poverty and malnutrition, and unabated environmental degradation are making it difficult to balance crop supply and demand (Royandoyan, 2002). Because of the seeming growth of poverty incidence, per capita intake of rice has remained constant at about 100 kg per year. This trend is unlike those in other developing countries in Southeast Asia such as Thailand, where per capita intake of rice has been showing a declining trend. There is a need to find ways to grow enough rice for the expanding population in the coming decades, sustain higher rice production, and maintain the natural resource base and protect the environment. Since the most productive lands have been exhausted, the only way to progress is to achieve better resource use to increase production per unit of land, increase the creativity of human resources, and put marginal rainfed lands into high-tech but low-input conservation agriculture.

To meet these challenges, the government has supported programs like hybrid and biotech rice. This new order of production in rice gives hope to meeting the demands of the burgeoning population in the face of declining land devoted to rice farming.

Growth in meat demand, on the other hand, has been affected not only by population growth but also by improved income and changing lifestyles and eating habits, especially when people move to urban areas. The rate of urban migration has been increasing over time such that the urban population now makes up 48.05% of the total population. This growth in meat demand created incentives for the emergence and proliferation of commercial feedlot fattening. Such operations, however, heavily depend on the importation of feeder stocks. Those for cattle have come mostly from Australia (Fig. 2). From 1990 to 2000, feeder

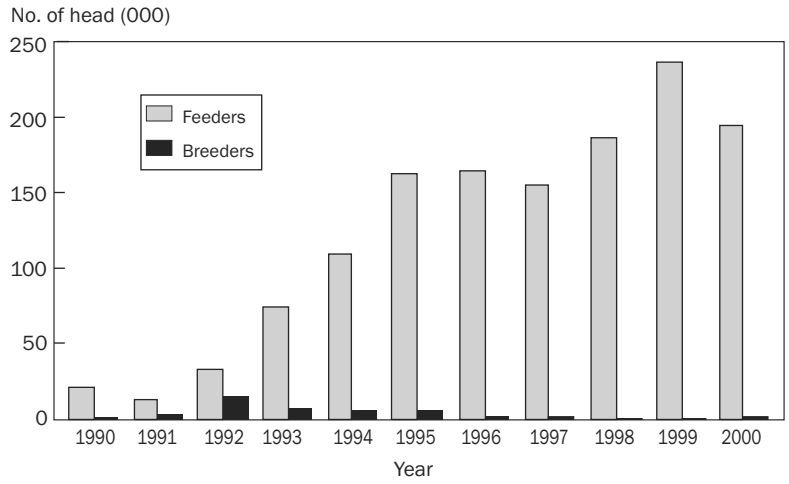


Fig. 2. Cattle importation, 1990-2000.

cattle importation totaled 1.3 million head versus breeder cattle importation of only 48,000 head. The 1999 importation of live cattle increased by 27%. The importation of live cattle instead of beef gave the cattle feedlot industry an opportunity to add about 40% to the value of feeder stocks. Fattening thus increased the cattle sector's contribution to the economy.

Because of the growing demand and a result of both greater market orientation and production efficiency, hog production increased from about 8 million head in 1990 to 10.7 million in 2000. Of the total inventory, 77% was produced by backyard raisers while 22.8% was produced by commercial raisers. The local hog industry generated 3.48% more output in 2000. There were 8,318,700 slaughtered pigs in the slaughterhouse, whereas 9,654,300 were slaughtered on farms. Filipino consumers favor pork the most among meat products available in the market. Domestic per capita consumption of pork has been increasing for the past five years, from 1.4 kg in 1995 to 1.91 kg in 1999. Consumers prefer pork because of its relatively lower price and greater versatility in preparation. In addition, hog raising is a part of the rural households, allowing rural folks to have access to pork. Even as the subsector contributes significantly to the gross national product, hog production still lags behind our rapidly growing population (see www.bai.da.gov.ph).

Government intervention and impact on growth of the crop and animal sector

The development of a sector depends on the programs and other interventions made by the government. The first part of this section discusses the existing programs of the government in support of rice and animal production and the latter part focuses on reviews of policies on crop and animal production, including the fishery sector.

GMA Rice Program

The *Ginintuang Masaganang Ani* (GMA) Rice Program is the rice production program of the current administration. Its major components are production support such as seed subsidy, fertilizer support, agricultural mechanization, and postharvest development; research and development; credit; marketing assistance; and policy formulation and analysis.

Aside from rice, planting of other crops after rice is also encouraged in this program to increase farmers' income and maximize the use of their land. Pilot testing of the rice-based cropping system is conducted in selected rainfed areas in coordination with the GMA High-Value Commercial Crops Program.

Agricultural and Fisheries Modernization Act (AFMA)

The Republic Act (RA) 8435, otherwise known as the Agricultural and Fisheries Modernization Act (AFMA), of 1997 became effective in 1998. This law stipulates that the state shall ensure the development of the agricultural and fishery sectors in accordance with seven principles: (1) poverty alleviation and social equity, (2) food security, (3) rational use of resources, (4) global competitiveness, (5) sustainable development, (6) people empowerment, and (7) protection from unfair competition (Reyes 2002).

Under the AFMA, research and development on integrated production systems is being emphasized to address the problems of low productivity, low farm income, instability of food supply, and inefficient use of resources in a particular strategic agricultural and fishery development zone. The ultimate goal is to raise the value added from farming, expand the menu of economically viable technologies for small- and medium-scale farmers and fisherfolk, and promote crop diversification.

Policy environment for rice, animal, and fish sectors[2]

In the Philippines, a wide variety of intervention policies had been introduced. Consequently, such measures had been known to alter directly and indirectly the price mechanism and incentive structure operating within the rice sector. Among these are sectoral and macroeconomic policies such as exchange rate, tariffs, subsidies, incentives, transport, infrastructure, and irrigation. Existing policies are summarized here.

Trade policies. Before the ratification of the General Agreement on Tariffs and Trade–World Trade Organization (GATT-WTO), restrictive import quotas historically protected rice production. As the mandated agency to handle importation, the National Food Authority (NFA) has historically determined the country's programmed rice requirement. Thus, any imported rice that will penetrate the local market will be subjected to an intense quota requirement. However, with the ratification of GATT-WTO in 1994, the Philippines agreed to transform its rice quota levels into its tariff equivalent rates.

As a commodity under the Green Box measure, the country was mandated to lower its tariff levels to 40% by 2004. At present, the tariff level for rice is 50% and the NFA is the only mandated institution to import the required amount of rice. This will put local producers at a disadvantage because of the large disparity in the price of locally produced and imported rice.

Rice production subsidies. A major feature of rice production in the Philippines during the 1970s up to the mid-1990s was the prevalence of subsidies on material inputs and credit. While this type of intervention had increased the use of modern rice varieties and techniques, recent farm production trends have been declining because of the constraints posed by deteriorating technological change.

The Grain Enhancement Program (GPEP), launched in 1993, provided for subsidized prices of seed and fertilizer. Although yield levels have increased substantially, the GPEP failed to satisfy the country's domestic rice needs, thus prompting program management to shift from subsidy- to credit-based intervention systems. As a result, the *Gintong Ani* for Rice program was launched. It is a culmination of the lessons learned from the various GPEPs. Its main feature includes accessibility to high-quality seed and fertilizer through credit.

At present, the new rice program of the government is the *Ginintuang Masaganang Ani (GMA)* program. Among its features is the availment of trade and fiscal incentives by the private sector to invest in seed production and postharvest equipment, which is intended to increase farmers' profits. It also aims to promote high-quality seeds and cost-effective technologies such as the leaf color chart, balanced fertilization strategy, integrated pest management, synchronous planting, mechanization, and others.

As a signatory to the GATT-WTO, the Philippines removed all forms of distortionary subsidies. Although the country has identified rice as part of the Green Box commodities, it has not yet availed of the Aggregate Measure of Support (AMS) for rice. The AMS is a form of assistance and is legitimate within the GATT-WTO accords.

The use of modern technologies such as high-quality seeds, proper fertilizer, and pest management helped the rice industry to perform well in increasing its productivity, and production has steadily increased. But still, the Philippines has remained a net importer of rice. This is primarily attributed to the rapid increase in the country's population.

Irrigation development. The trend of irrigation investments during the 1970s up to the early '80s substantially increased, peaking in 1975, when the program accounted for a 48% share of total public expenditures. Before the 1990s, yearly irrigation expenditures accounted for approximately 20% of total public expenditures and 40% of agriculture's expenditures. By the start of the 1990s, irrigation expenditures relative to agriculture fell to 10%. Consequently, the number of irrigated areas declined from 13% in 1975 to 1.42% in the 1990s.

Transportation infrastructure. The transportation system in the Philippines remains inadequate and inefficient. Research indicated that road densities in prime agricultural areas have been typically lower than those of roads in urban areas. The lower road expenditure levels in rural agricultural areas reflect the historical policy bias in favor of urban centers. This has caused farmers to be marginalized because of the inefficient transmission of prices from the farm to the market and vice versa. This has primarily kept farmers from being integrated to the market and nonfarm economy.

Marketing, price determination, and rice reserves. The rice market is one where prices behave asymmetrically: changes in the retail rice price do not immediately influence the price at the farm gate and vice versa. One reason for this behavior has been stated earlier: the state of the country's infrastructure, particularly transportation conditions. Another factor relates to the presence of middlemen who add cost to the marketing of palay (rough rice) and the inappropriate government policies that distort rather than strengthen the market environment.

One government policy that has been subject to critical scrutiny is NFA's rice procurement program, supposedly to maintain sufficient rice reserves to intervene in smoothing prices in times of market abnormalities. However, because of the inefficiencies in a public-sector institution, NFA procured only less than 6% annually of the total rice production in 1988-99. NFA's highest procurement level occurred in 1995, with a level equal to 5.74%, while the lowest occurred in 1995 (0.07%). With this level of procurement, it comes as no surprise that, for the past several years, NFA has been unsuccessful in influencing the prices of palay.

[2]Adapted from work of Rivera (2002).

Industrial protection system and macroeconomic policies and exchange rate. Another set of policies that have gained economic importance are those regulating macroeconomic variables such as the exchange rate, monetary and fiscal policies, as well as policies that influence the overall trade regime. Such policies have important theoretical implications. However, empirical evidence has revealed a significant and differential impact with regard to the incentive structure of most developing economies. Estimates showed that distortions emanating from the exchange rate policy had large taxing effects.

In the Philippines, the pursuit of an import-led strategy encouraged the growth of high and restrictive tariff and nontariff barriers. The imposition of these restrictive trade instruments appreciated the peso. Uncoordinated macroeconomic policies in the past due to balance of payments problems led to the further worsening of the peso appreciation, resulting in an exchange rate misalignment. The rate of deviation of the actual exchange rate from its long-run equilibrium levels is called the exchange rate overvaluation.

Time-series estimates reveal that, over the past 30 years before the currency devaluation of 1997, the exchange rate was overvalued from 24% in 1961 to 20% in 1996. This, however, exacerbated the disprotection received by the agricultural sector and likewise penalized its most important crop, rice.

However, with the occurrence of the 1997 devaluation, it is expected that the magnitude of penalty in rice will dissipate, giving the commodity some leeway of protection.

Agrarian reform. R.A 6657, known as the Comprehensive Agrarian Reform Program (CARP), which has been recently amended to include not only rice land but other agricultural land as well, is benefiting tenants and all landless workers to become small landowner-producers. This law covers (1) land tenure improvement, (2) program beneficiaries' development, and (3) agrarian justice. Support services being provided to farmers-beneficiaries and affected landowners intended to develop their agricultural enterprises are research and extension, irrigation and postharvest facilities, marketing assistance and farm-to-market roads, other infrastructure development and public works for barangay site improvement, technical assistance, education and training, financial assistance, and strengthening farmers' cooperatives.

Under this law, beneficiaries are being provided with potable water and power resources. In Nueva Ecija, where the land reform program was inaugurated, the project launch included the linking of livestock development with crop production, the promotion of the area as an Agro-Industrial Development Area (AIDA), and piloting of crop-animal integration among the low-income farmer-beneficiaries in depressed barangays under the Small Low Income Municipalities (SLIM) and the Agrarian Reform Communities (ARCs) Programs. Funding for animal integration came from the Asian Development Bank (ADB), World Bank (WB), and Japan Bank International Corporation (JBIC).

Livestock and poultry development programs

The important actions that made up the livestock and poultry program and policy environment from 1930 to the present are presented and discussed here by relevant period.

1930-70

Animal dispersion program. In the 1930s to 1960, the livestock dispersal program took place, which included importation of cattle and the purchase of local stocks for breeding purposes. Some 4,856 head of cattle were dispersed during the program cycle, which ended in 1973.

The "piggy bank in the backyard" was also introduced during this period. The Bureau of Animal Industry (BAI) provided piglets to recipients who enrolled in the program.

Philippine livestock promotion fund. This fund was used for the genetic improvement of livestock and distribution of improved breeds of animals; establishment, operation, and maintenance of stock farms, breeding stations, and slaughterhouses; manufacture of biological products; and research. Funds came from slaughter fees.

Tariff and customs law. The schedule of tariffs on livestock products was 70% for poultry meat, 100% for eggs, 15% for other meat, 60% for live poultry, and 0% for other live animals. Revenues generated were used to encourage local breeding of superior stocks and to conserve foreign exchange.

Genetic improvement. This involved the introduction of frozen semen and embryos of purebred animals, a much cheaper method of importing exotic genetic material.

1970-80

Livestock rehabilitation. The government initiated the "Operation Animal Rehabilitation Program," which included the distribution of carabao for draft; breeding of piglets, goats, and boars in hog-raising areas; breeding of chicks among poultry raisers; and the production of feeds and feedstuffs for animals.

Bureau of Animal Industry regulations. The government regulated livestock and livestock product trade through its licensing power along with the sole right to import live animals and meat products.

Bakahang barangay. A special credit program for backyard cattle raisers was launched in 1977. This is a supervised credit program designed to support small cattle raisers. It also aimed to transform every farm household into a backyard cattle feedlot and small cow-calf operator integrating crops, livestock, fish, and organic recycling into the farming system.

1980-90

The most dominant policies for livestock in the 1980s and '90s were the Comprehensive Agrarian Reform on Livestock (CARL), the General Agreement on Tariffs and Trade (GATT), and the Medium-Term Livestock Development Program (MTLDP). These programs targeted social equity, income enhancement and profitability of livestock farmers, global competitiveness, and sustainability.

Open market. Under GATT, the Philippines agreed to (1) convert all quantitative restrictions imposed on agriculture into tariffs, (2) reduce tariffs on agriculture, (3) reduce domestic subsidies, (4) reduce export subsidies, and (5) harmonize sanitary and phytosanitary measures.

Under this arrangement, small-farmer beneficiaries under CARP cannot compete with farm producers in other countries who are mostly engaged in large-scale operations, enjoy government subsidies, use modern technologies, and sell their products cheaply, including livestock products.

Agricultural tariffication. The agricultural tariffication act converted all quantitative restrictions on agricultural products into tariffs and created the Agricultural Competitiveness Enhancement Fund; it also repealed a sectional provision of the Magna Carta of small farmers (RA 7607).

The Philippines has a slim chance of survival under this arrangement as its crop, animal, and fish production systems use less advanced technologies and costly inputs. Raw materials for livestock feed are still imported. Lately, cheap meat products are being smuggled into the country under uncontrolled procedures; this can destroy the local animal industry.

Executive Order 288 (1995). This provided a two-time tariff structure of 3% and 10% for raw materials and finished products. Starting 1 January 2004, a uniform rate of 5% ad valorem on the same articles will be enforced. Executive Order No. 313 (1996) set the in-quota and out-quota tariff rate for agricultural commodities, including livestock, poultry, and other meat products.

Development plan. The Medium-Term Livestock Development Plan (MTLDP), also known as the *Gintong Ani* Livestock, lays the foundation for a productive, efficient, economic, and sustainable livestock and poultry industry. The gains in the livestock sector are ensured to be shared by small- and medium-scale livestock farmers.

National Dairy Administration (NDA). The NDA, created by R.A. 7884, became effective on 12 March 1995. It envisions a globally competitive dairy industry anchored on an expanded base of empowered producers and processors who operate sustainable cooperative dairy enterprises.

Fisheries policies. A total of 685 laws/policies, rules, and regulations on fisheries that emanated from the Office of the President, senate/congress, and national government agencies were formulated, an average of 11 per year. By source of policy initiatives, the record shows that 352 (52%) came from government agencies such as the Bureau of Fisheries and Aquatic Resources; 324 (47%) came from the Department of Environment and Natural Resources; 24 (3%) from the Central Bank, Philippine Coast Guard, and Philippines Ports Authority; and 14 (1.2%) from the Laguna Lake Development Authority. About 211 (31%) came from the Office of the President and 112 (17%) were enacted by the senate/congress.

A majority focused on interventions to avert illegal fishing activities: 198 (29%); amending/modifying fisheries laws, 154 (23%); converting/creating schools of fisheries, 81 (11%); reorganizing/creating fisheries agencies/committees, 54 (8%); support services, 51 (7%); trade, 33 (5%); agrarian reform and fisheries association, 3 (0.4%) and 2 (0.3%), respectively. Other areas of concern numbered 33 (5%).

Sixteen studies were conducted on the implementation of fishery laws/policies, rules, and regulations. It was found that 11 of these studies reported that efforts to implement existing policies/laws, rules, and regulations were rather weak. Among the reasons given for this were (1) bribery and lack of political will, (2) laxity in enforcing the laws/policies, rules, and regulations, (3) low compliance/poor enforcement of laws and policies, (4) strict implementation not achieved, (5) enforcement alone was not enough, and (6) there was no law/policy/ordinance to implement. Unfortunately, these deterring reasons are true for the fisheries sector and for all other sectors, in both agriculture and nonagriculture.

The potential of ICAS in rice-farming ecosystems, especially in rainfed rice lands, is greatly influenced by government policies affecting the rice, animal, and fish sector, and especially crop-animal/fish mixed livelihood ventures. Implementation of ICAS as a sustainable development strategy involves negotiations among the stakeholders involved in the three development processes: community and farm household development with the local government and stakeholders playing lead roles; lowland rice farmers, researchers, extension workers, entrepreneurs, government and nongovernment organizations, and consumers; and characterizing and understanding rainfed rice lands as a basis for technology design, improvement, innovation, and change.

ICAS typology in rice-based farming systems

Types of ICAS and extent of coverage

The dominant cropping pattern in the Philippines is shown in Table 4. Common crops grown are rice and maize, legumes, and vegetables. But only a few farmers grow fodder for animals although this is a key component, particularly in rainfed areas and hilly lands. Animals that are almost always raised are carabao, cattle, goats, pigs, chickens, and ducks. In some areas, sheep could be seen on farms. Fishponds that grow mainly tilapia are becoming increasingly adopted.

The major producers of animals such as cattle, carabao, goats, chickens, and ducks are in regions I, III, VI, and CAR. It is in the CAR where interactions between crops and animals are still strong.

It can be noted that, as with farms in other developing countries, diversification has been widely practiced in the Philippines. The extent of diversification among rice-based farms is further analyzed using data collected from two provinces, Nueva Ecija and Samar. Respondents were those who planted palay during the wet season and were raising animals such as carabao, cattle, pigs, chickens, goats, and/or ducks during the survey.

In Nueva Ecija, an equal percentage of rice-rice with animals and rice-nonrice crop with animals was reported by

Table 4. Dominant cropping patterns in the Philippines.

Region	Cropping pattern	Major animals produced
I/CAR	Rice-rice, rice-garlic, rice-tobacco, maize-white potato, rice-legume, white potato-vegetable	Cattle, carabao, goats, hogs, chickens
II	Rice-garlic, maize-maize, rice-rice, maize-legumes	Carabao
III	Rice-rice, rice-legumes, rice-fallow	Cattle, carabao, hogs, chickens
IV	Rice-rice, rice-fallow, coconut-coffee, pineapple, rice-tomato-coconut monocrop	Hogs, chickens
V	Rice-rice, rice-maize, coconut + rice, coconut + root crops, coconut + maize	Cattle
VI	Rice-rice, rice-maize, rice-fallow, maize-root crops	Carabao, goats, hogs, chickens
VII	Maize-maize, rice-rice, rice-fallow, maize-root crops	Cattle, goats, hogs, chickens
VIII	Rice-rice, rice-fallow, coconut monocrop, maize-fallow	Chickens, hogs, carabao
IX	Coconut monocrop, rice-rice, cassava-fallow, maize-fallow	Goats
X	Rice-rice, maize-maize	Cattle
XI	Rice-rice, maize-maize, coconut	Chickens, ducks, hogs
XII	Maize-maize-maize, coconut, rice-rice	Hogs

Source: Bureau of Agricultural Research and Extension Agenda.

29% of the sample respondents in the town of Lupao. This was followed by 18% of the respondents reporting rice-fallow with animals. In Talugtug, 44% reported that they practiced rice-rice with animals, followed by 42% with rice-fallow with animals.

In northern Samar, the most prevalent cropping pattern was rice-rice with animals. Only one respondent each practiced rice-fallow and had no animals and rice-fallow with animals. For San Roque, rice-rice with animals is practiced by 39% of the respondents, followed by 38% using rice-fallow with animals and 15% practicing rice-nonrice crop with animals.

Profitability analysis of ICAS showed that animal production plays a big role in augmenting the income of rice farmers. Sales from large animals could be a source of capital for rice and other crop production; can finance other household expenditures such as schooling of children; can provide basic needs such as clothing, electricity, and other emergency expenses that the farmer's family might face; and can be a source of food security for the family. Small animals such as chickens and ducks provide meat and eggs and goats provide milk. Animal by-products are also used in crop production as fertilizer and crop by-products serve as feed in animal production.

Aside from rice farming, household respondents' sources of additional income are from other agricultural activities: growing vegetables, root crops, fruits, or trees in homestead areas; growing fish in ponds; and collecting nipa leaves and bamboo.

Crop-animal interactions

Paris (1992), summarizing the results of a rice-based crop-livestock farming systems research activity in the Philippines and other Asian countries, enumerated crop-animal interactions as follows:

1. Use of animal power in crop production, transportation, and processing; and use of crop by-products (straw, bran, and residues) by livestock and poultry.
2. Use of animal manure to improve land productivity and cut input costs.
3. Minimizing production risks by combining crop and livestock enterprises.
4. Small-farm household consumption of milk, meat, and eggs, thus substantially improving human nutrition and health.
5. Sale of livestock and poultry and their products to improve and stabilize farm income for the purchase of cash inputs and to offset household expenditures such as school fees, social obligations, and health care.

The main issue in crop-animal interactions is the lack of methodology for measuring the benefits derived from them. It has been mentioned that there is a paucity of information on the socioeconomic benefits of crop-animal interactions. The major reasons given were lack of skilled social scientists within national agricultural research and extension systems; inadequate understanding of methodologies for crop-animal research; limited knowledge of the application of economic analysis for crop-animal interactions; overemphasis on component technologies; lack of concern for gender and other socio-cultural implications for technology development and dissemination; poor linkage among farmers, researchers, extension workers, and rural development planners; and lack of village support mechanisms to sustain the adoption of new technologies.

Trends in the development of ICAS

Despite its growing importance, rainfed lowland rice has only recently received the attention it deserves. These lands are generally characterized as heterogeneous in any single location, diverse across locations, and unpredictable everywhere. In fact, the very ambiguity of the definition of rainfed lowland rice may account for the historic lack of attention given to it (Mackill et al 1996). The first comprehensive

book on characterizing and understanding rainfed environments came out only in 2000 (Tuong et al 2000).

FSRD programs were implemented in rainfed rice lands by the national government, in tandem with the International Rice Research Institute and state universities and colleges engaged in agricultural and resource research and extension. Potentials of ICAS in any ecosystem need micro biophysical and socioeconomic characterization using participatory approaches to secure data.

Probably because of poor documentation and inadequate reports on existing ICAS practices, related intensive practices of small farmers in rainfed rice lands that include crop-animal mixes were not reflected in local and national studies.

Potentials for further development of ICAS

Total rice lands in the Philippines cover more than 3 million ha. Of this area, about 1.4 million ha are rainfed. One-half million ha of rainfed rice lands are drought-prone. Around 53% of the rainfed area is devoted to rice-based cropping systems, with rice as the main crop, sometimes followed by another rice crop using shallow pumps. Most small-scale animal production is found in this area.

Landholding per farm family is becoming smaller. From 1971 to 1980, the average farm size decreased from 3.6 to 2.8 ha and about 97% of all farms were below 5 ha. With the current aggressive implementation of the Agrarian Reform Program of the government, the number of smallholder farmers will continue to increase, while the average farm size will become even smaller. This trend will encourage maximum use of farm resources through more diversified farming systems.

The Philippines has attained self-sufficiency in poultry, eggs, and pork. The phenomenal growth in the swine and poultry industries in the country could be attributed to the rapid adoption of improved swine and poultry production technologies by farmers, accompanied by a consistently high demand for these animal products. The cattle, buffalo, and other ruminant production enterprises in the Philippines have remained mainly as small backyard operations and are managed basically according to the traditional system (see www.fao.org).

Potential for strengthening ICAS is already indicated in several entry points, which are identifiable in government thrusts, programs, and policies as follows:

1. Elimination of poverty, including its dimensions of hunger, malnutrition/undernourishment, and disease, as a top agenda of the national government.
2. Department of Agriculture priority on modernization of agriculture and fisheries for global competitiveness and increasing exports, and evolution of total food/feed system agency-based research and development to farm family-centered participation.
3. DAR Program Beneficiaries Development and the support services provision in R.A. 6657, to which livestock development is being linked in individual and cooperative enterprises, such as the Tulong Dairy Cooperative in Pangasinan.
4. Partnership of local government units and the United Nations, with other foreign and local organizations being involved, on a priority agenda that includes poverty elimination, reduction of infant mortality, reproductive health, gender equity, and environmental care.

The Philippines has a well-developed livestock sector, yet, in spite of the profitability of integrated farming systems demonstrated by local researchers, very few Filipinos have adopted new technology. Perhaps more data and information should be obtained through research coupled with an effective extension program.

References

Bureau of Agricultural Statistics. 2003. Carabao industry performance report: January–December 2002. Livestock and Poultry Statistics Division, BAS-Department of Science and Technology.

Bureau of Agricultural Statistics. 2003. Cattle industry performance report: January–December 2002. Livestock and Poultry Statistics Division, BAS-Department of Science and Technology.

Bureau of Agricultural Statistics. 2003. Chicken industry performance report: January–December 2002. Livestock and Poultry Statistics Division, BAS-Department of Science and Technology.

Bureau of Agricultural Statistics. 2003. Duck industry performance report: January–December 2002. Livestock and Poultry Statistics Division, BAS-Department of Science and Technology.

Bureau of Agricultural Statistics. 2003. Goat industry performance report: January–December 2002. Livestock and Poultry Statistics Division, BAS-Department of Science and Technology.

Bureau of Agricultural Statistics. 2003. Swine industry performance report: January–December 2002. Livestock and Poultry Statistics Division, BAS-Department of Science and Technology.

Food and Agri Business Yearbook. 1997. Pasig City (Philippines): University of Asia and the Pacific and Belgosa Publishing.

Food and Agri Business Yearbook & Directory. 2000. University of Asia and the Pacific, Millennium Edition.

Francisco S. 2000. Exploring the yield gap to attain self-sufficiency: some R, D and E imperatives. In: Opportunities and initiatives in Philippine rice RD&E. Proceedings of the Philippine Rice RD & E Scholars' Forum. PhilRice-BAR.

Hossain M, Sombilla M. 1999. World grains market: implications for a food security strategy. In: Cabanilla L, Paunlagui L, editors. Food security in the Philippines. Philippines: ISPPS/UP-CIDS.

Mackill J, Coffman WR, Garrity DD. 1996. Rainfed lowland rice improvement. Los Baños (Philippines): International Rice Research Institute.

PCARRD-DOST. 2002. National Ruminant Commodity R & D Team 2001. R & D status and directions (2000 and beyond): ruminants. Los Baños (Philippines): Philippine Council for Agriculture, Forestry, and Natural Resource Research and Development. 39 p.

Paris T. 1992. Socio-economic issues concerning women in animal production. Paper presented at the Sixth Annual Science Congress, 22-28 November 1992. Bangkok, Thailand.

Reyes S. 2002. AFMA, food security and biotechnology. Food and Agri Business Monitor. 18(7).

Rivera F. 2002. Integrated crop-animal systems in rainfed ricelands: a Philippine study. Part of IRRI-ILRI-PhilRice Project.

Royandoyan O. 2002. Food security: the role of rice research. FarmNews and Views 2nd and 3rd quarter 2002.

Tolentino B. 2002. Governance constraints to sustainable rice productivity in the Philippines. In: Sombilla M, Hossain M, Hardy B, editors. Developments in the Asian rice economy. Proceedings of the International Workshop on Medium- and Long-Term Prospects of Rice Supply and Demand in the 21st Century, 3-5 December 2001. Los Baños (Philippines): International Rice Research Institute. p 153-172.

Tuong TP, Kam SP, Wade L, Pandey S,. Bouman BAM, Hardy B, editors. 2000. Characterizing and understanding rainfed environments. Proceedings of the International Workshop on Characterizing and Understanding Rainfed Environments, 5-9 December 1999, Bali, Indonesia. Los Baños (Philippines): International Rice Research Institute. 488 p.

Notes

Authors' addresses: G. Cataquiz, G. Redondo, R. Manalili, and M.J.R. Nievera, Philippine Rice Research Institute, Maligaya, Muñoz, Nueva Ecija; F.T. Rivera, Central Luzon State University, Maligaya, Nueva Ecija; and M.A. Sombilla, International Rice Research Institute, Los Baños, Laguna, Philippines.

Integrated crop-animal systems in Thailand

S. Simarak, B. Loapaiboon, K. Sommart, M. Duangjinda,
V. Pattarajinda, P. Lowilai, T. Vongpralab, P. Sanchaisuriya,
S. Kanharieng, and Y. Phasuk

Thailand's diverse topographical and ecological characteristics account for the country's diverse farming systems and farming practices. In the central region, where farms are relatively bigger than in the other regions, the dominant farming system is still rice-based, but specialized production activities are common sights. Production of horticultural crops for commercial and export purposes is increasing, especially in areas where irrigation is abundant. Also common sights are the commercial poultry and swine farms, including the more specialized dairy farms. Integrated farms in the region are declining. This is very much in contrast to the farming systems in the northern region, where wet rice in lowland or upland rice cultivation on mountain slopes is still very much integrated with other crops and/or livestock. The majority of the households in this region are poor smallholders who are engaged in forest-related activities with the huge forest that covers most of the landscape. High-value temperate horticultural crops have been introduced and grown in the highlands. The northeastern region is the poorest because of its meager natural resource endowment. It is nonetheless a major livestock production area, especially for cattle and buffaloes, which are raised under smallholder systems. Wet rice is a main production activity in the lowland, whereas, in the upland, commercial cash crops such as cassava and sugarcane are prevalent. Most of the farmers are smallholders practicing rice-based integrated farming systems in both lowland and upland. Recently, sugarcane has been gradually replacing cassava because of market demand. The southern region is more prosperous than the northern and northeastern regions. Besides shrimp culture and marine fishery, this region is covered by para-rubber, oil palm plantations, and orchards.

During the past few decades, policy reforms were instituted in Thailand that gave emphasis to strengthening exports, in particular agricultural exports. These policies facilitated changes in farming systems, transforming the almost subsistence smallholdings in the northern, northeastern, and southern regions into more commercialized and specialized systems. This subsequently diminished the role of integrated systems and in their place came about the greater practice of monoculture that required more inputs obtained from outside the farms. Monocropping, for example, expanded to forest areas in the northern region. This had a great impact on livestock raising because of the sector's dependence on grazing areas, which gradually dwindled because of the shift in land use.

The importance of crop-animal integration remains intense, however, among the small and poorer farming households in rural areas, especially in the northeastern region. Animal sales continue to supplement income from crops, with higher prices of animals, especially cattle and buffaloes. In this regard, the integrated crop-animal system (ICAS) needs to be sustained and the Thai government recognizes this. Hence, more recent government projects such as the one-million-baht village fund are partially meant to encourage farmers to continue practicing ICAS. The increasing regard for organic farming is another avenue being pursued to further strengthen ICAS. In the past few years, it has been observed that ICAS is indeed coming back in certain areas of Thailand.

Pressure to increase the supply of meat and other meat products will continue to take place in the mixed crop-animal system as demand for these products continues to rise with economic growth. This has been the predominant system of animal production in the developing world (FAO 1995). More intensified development of this system is very appealing as the major actors and beneficiaries remain the small and landless farmers. The integrated crop-animal system has thus been often regarded as a potential strategy for reducing rural poverty, promoting food security, increasing land productivity, improving livelihood, and caring for the environment and natural resources. However, it has con-

tinuously become more and more difficult to sustain the complementarities between crop and animal activities in the rice areas of Southeast Asia. This is especially the case in Thailand, where development trends have been geared toward more specialized production systems to cater to the growing export market. The rate of mechanization of farm production activities has increased, particularly in the irrigated rice areas of the central region. The availability of soft credit terms fueled the demand for small tractors and this has significantly decreased the demand for buffaloes for draft power. Likewise, rural-urban migration, particularly of the younger members of rural households, also diminished the labor force, which is a key input in rice and other farm activities.

But despite this increasing effort toward specialization, smallholders still make up the bulk of the Thai agricultural economy. These farmers are still primarily involved in the production of not only rice and other crops, but also of buffaloes, beef cattle, and nonruminants in essentially mixed subsystems. Goats and sheep are mainly found in the south of Thailand, where they are raised as a secondary enterprise after crop production and primarily for subsistence. In northern Thailand, both buffaloes and cattle graze under tree crops (tea, coffee, fruit trees) and in forests. Questions loom with regard to the future direction of the integrated crop-animal system in this country.

In this monograph, the potential for strengthening ICAS is explored, especially along the direction of promoting more sustainable agricultural development. It aims to present the direction of agricultural development as influenced by government policies and programs and how such direction has affected and will affect the promotion of integrated farming systems, including the rice-animal system. More specifically, the monograph intends to do the following:

- Describe the different variations of integrated crop-animal models in Thailand and identify where these systems have been commonly practiced based on the agro-physical properties of the different regions.
- Describe the extent of the linkages between crops, in particular rice, and animals and determine how these linkages have changed over time.
- Determine the influence of socioeconomic and policy changes on the production trends of major traditional crops as well as the promotion of high-value crops. How have these policies changed production systems and crop-animal mixes?
- Discuss the potential of the integrated crop-animal system and identify its role as a strategy for poverty alleviation, food security, and livelihood improvement among smallholders. In this connection, the document also tries to identify specific problems needing to be solved to further develop ICAS so that it becomes an effective tool to sustain production and increase farm income.

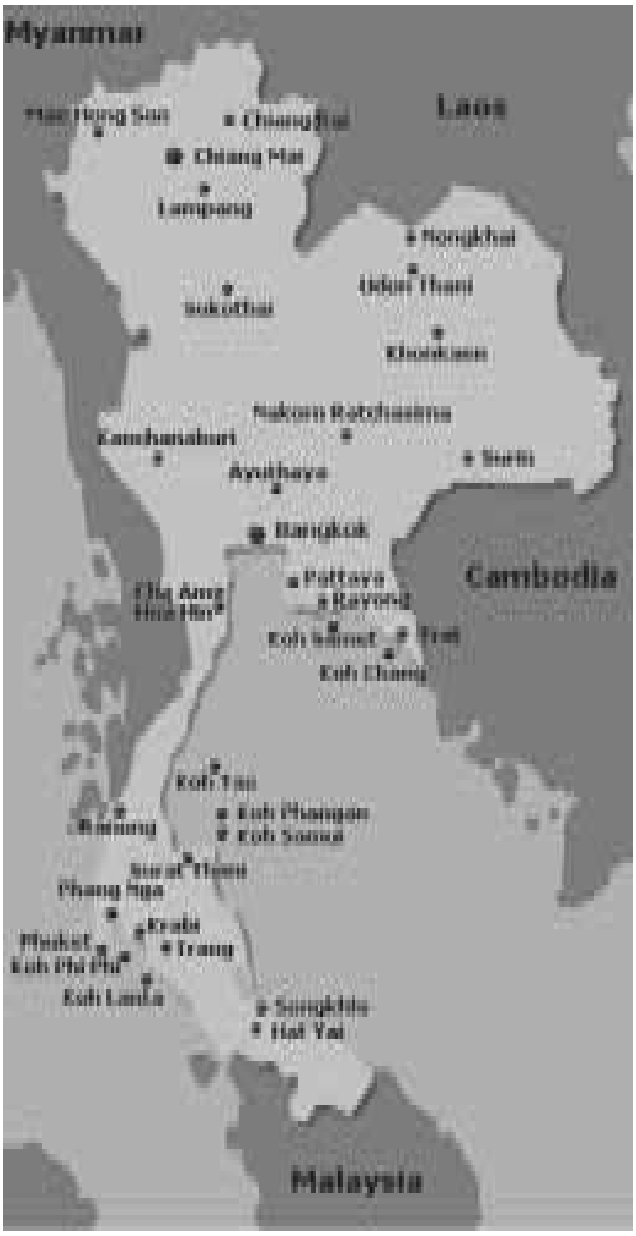


Fig. 1. Map of Thailand. Source: www.go-thailand.com.

An introduction to Thailand

Thailand is in Southeast Asia. It covers an area of nearly 513,115 km^2, extending about 1,620 km from north to south and 750 km at its widest point from east to west. It is approximately the same size as France, with a coastline of approximately 2,700 km along the Gulf of Thailand and 865 km along the Indian Ocean. It shares land borders with Myanmar (Burma) in the north and west, the Andaman Sea in the west, Laos in the north and northeast, Cambodia and the Gulf of Thailand in the east, and Malaysia in the south (Fig. 1).

Facts about thailand

Area: Thailand covers a land area of 513,115 km^2.
Lowest point: Gulf of Thailand at 0 m.
Highest point: Doi Inthanon in the north at 2,576 m.
Natural resources: Tin, rubber, natural gas, tungsten, tantalum, timber, lead, fish, gypsum, lignite, fluorite.
Agricultural exports: At present, Thailand is the number-one exporter of rice, para-rubber, shrimp, chicken, and canned tuna.
Climate: The climate is subtropical, with long hours of sunshine and high humidity. There are three seasons: the hot season from March to June, the rainy season from July to October, and the cool season from November to February. The average low temperature is 20 ºC and the average high temperature is 37 ºC. The geographic and climatic conditions make the country suitable for the cultivation of a wide range of tropical and semitropical agricultural crops.
Rainfall: The average rainfall pattern and average amount of rain in the country from 1961 to 1990 are shown in Figure 2. The rainy season usually begins in May but can sometimes start as early as the middle of April. The amount of rainfall is still small during the early part of the season but peaks in September. The season ends by mid- or late October. The amount of rainfall varies significantly each year. Frequent drought and short dry spells during the season cause fluctuations in crop productivity, especially in rice. The central and southern regions receive more rain than the northern and northeastern regions. The rainy season in the south comes later than in the other regions.

Geographical regions

Thailand is divided into four distinct geographical regions.

Northern region. This region is bordered by Myanmar and Laos. It is primarily characterized by forested mountains at the lower extremities of the Himalayan foothills, and fertile river valleys. It features diversity of low and upland ecology, including hill tribes and forests as well as an invigorating cool season. A majority of the people are subsistence smallholders with integrated farming systems. Even in the highland on mountain slopes, rice-based farming with other crops or livestock is practiced. However, monocropping and high-value horticultural crops have been on the rise.

Northeastern region. The northeast plateau is bordered in the north and east by the Mekong River and Laos, and in the south largely by Kampuchea (Cambodia). The region is primarily characterized by semiarid plateau with rolling topography. Land is used mainly for crop growing (mainly rice, sugarcane, and cassava) and livestock raising (such as cattle and buffaloes). It is a main livestock production area, especially of cattle and buffaloes. This is the most populous but poorest region mainly because of its limited natural resource endowment. Most of the farmers are subsistence smallholders that practice integrated crop-animal production systems. In the last decade, however, a decline has been observed in the animal population and production because of the increased use of machinery to facilitate land preparation as monocropping of upland crops such as kenaf, cassava, and sugarcane intensified. The role of animals in farming households has once again gained importance in recent years as their prices rise, especially for cattle and buffaloes, because of increasing demand for meat and dairy products. Some government projects have therefore been launched to encourage an increase in the production of cattle and buffaloes within mixed-farming schemes.

Central region. This region is mainly flat and fertile because of its large rivers. This is the main rice-growing area of Thailand. Geographically, the central region extends from the rugged western mountains that border Myanmar to a plateau in the east and northeast; northward to Nakhon Sawan Province, where the Ping, Wang, Nan, and Yom rivers unite to form the Chao Phraya; and southward to Prachuap Khirikhan Province, where Thailand is compressed to its narrowest point, some 60 km wide between the western mountains and the Thai Gulf. The Chao Phraya River flows southward to dissect Bangkok before entering the Gulf

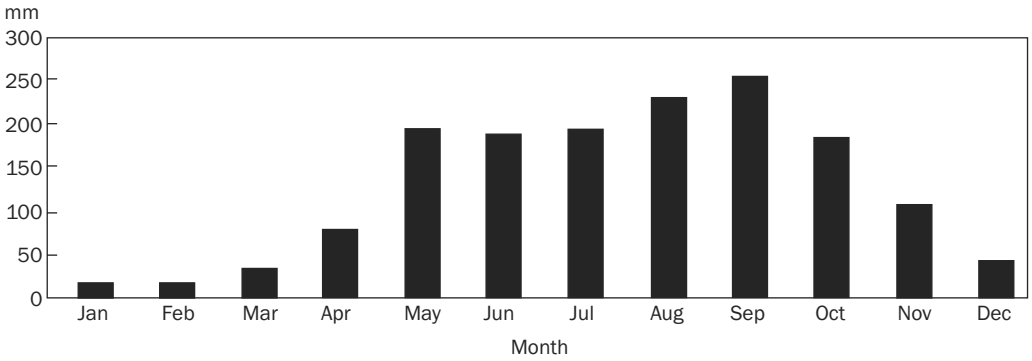


Fig. 2. Average amount and pattern of rainfall in Thailand, 1961-90. Source: The Meteorological Department, Ministry of Information and Communications Technology (2003).

of Thailand. It largely irrigates the Central Plain, one of the world's major rice- and fruit-growing areas, and sustains an intricate network of canals that irrigate bountiful orchards. There are fewer subsistence smallholders in the central region than in the other regions. Agricultural production during the past few decades has been primarily oriented to cater to the export market, hence, the proliferation of commercialized and specialized farms.

Southern region. Geographically, southern Thailand extends through the Kra Isthmus from Chumphon, 460 km south of Bangkok, to the Thai-Malaysian border. In the east, it is bordered by the Gulf of Thailand and in the west by the Indian Ocean. The region is hilly and mountainous and is mainly covered with rainforests, para-rubber, and oil palm plantations. The land is rich in mineral deposits. Lining the coastal area from east to west are commercial shrimp and rice farms. Shrimp are channeled for domestic and export markets. Compared with the people in northern and northeastern Thailand, those in the south are economically better off. This area also receives the most annual rainfall.

Thailand's economic structure

From the 4th 5-year National Economic Plan to the 8th (1977-81 to 1997-2002), the contribution of the agricultural sector to the gross domestic product (GDP) at 1988 prices declined from 26.1% to 10.1% while the contribution of the nonagricultural sector increased from 73.9% to 89.9% (Table 1). In the 8th National Socioeconomic Plan, the gross value added from agriculture was baht 297,855 million, while that from nonagriculture was baht 265,732 million (Fig. 3). Percentage-wise, there has been a great change in both sectors, possibly as a result of the export-oriented and industrial policies that encouraged labor migration from rural to urban areas, which facilitated changes in cropping practices (toward monocropping and the greater use of external inputs), promoted deforestation, altered the livestock population and production systems (toward more commercialized and less small and integrated systems), and produced other social changes.

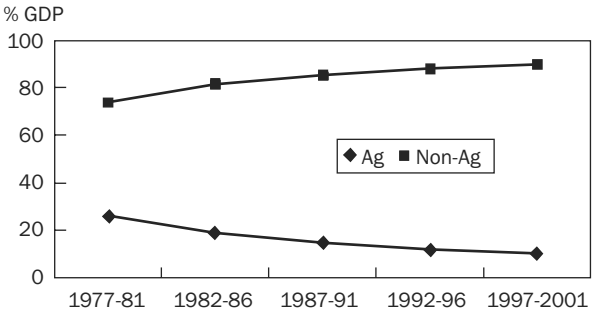


Fig. 3. Contribution of the agricultural and nonagricultural sectors to gross domestic product, 4th to 8th National Socioeconomic Plan.

Land ecosystems

Arable land in Thailand covers about 34% of the total land area or 5.4 million hectares. Out of this, about 44,000 km^2 are irrigated. Permanent crops cover about 6% of the total land area, permanent pastures 2%, and forests and woodland 26%. The remaining approximately 5.12 million ha or 32% of the total land area are unclassified.

The land ecosystem can be regarded as a major criterion for land-use planning. It is also among the key factors for the development of appropriate models of mixed farming systems. According to satellite image interpretations, soil maps, topographic maps, and other forms of information search, the land ecosystem can be divided into seven units (Fig. 4).

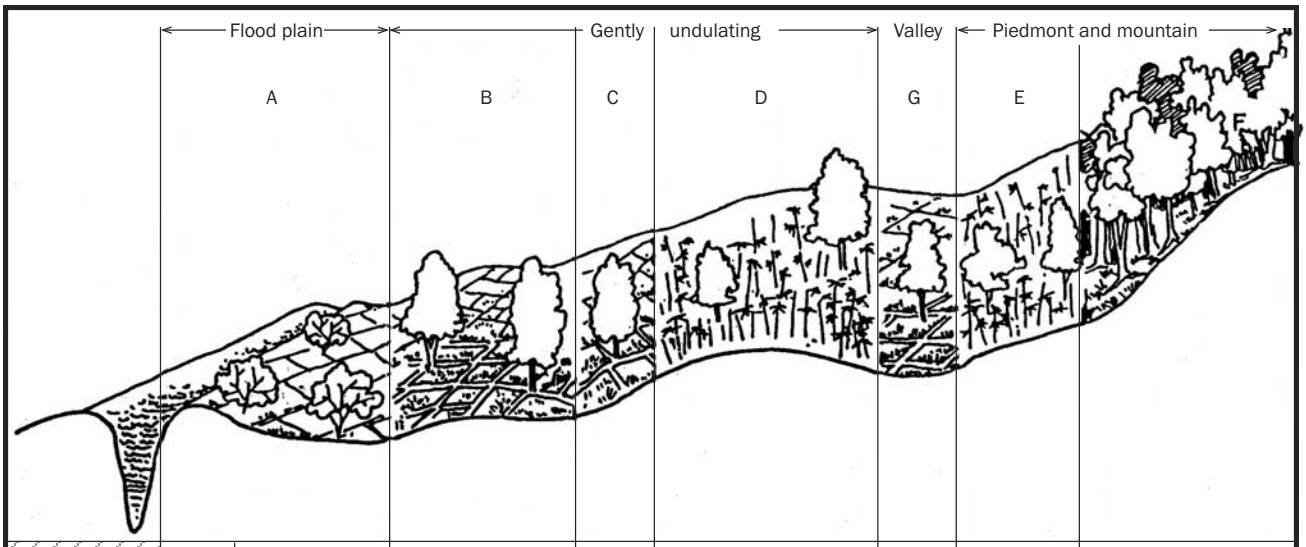
Unit F: Mountain and hill with dense forest

This unit can be divided into two subunits:

F1: Consists of deep slopes on mountainsides, with healthy evergreen forest and dipterocarp forest at lower elevation. Soils are often shallow and not fully developed, with sporadic rock outcrops. The area is best maintained as forest reserve and is not recommended for any form of agriculture.

Table 1. Average quarterly contribution and percentage of agricultural and nonagricultural sectors in gross domestic product (GDP), 4th–8th National Socioeconomic Plan.

GDP	National Socioeconomic Plan (million baht)				
	4th (1977-81)	5th (1982-86)	6th (1987-91)	7th (1992-96)	8th (1997-2001)
Agriculture	150,496	187,740	280,325	334,434	297,855
Nonagriculture	426,116	800,364	1,601,053	2,475,939	2,657,318
			(%)		
Agriculture	26.1	19.0	14.9	11.9	10.1
Nonagriculture	73.6	81.0	85.1	88.1	89.9



Land use	-Shrub -Herba-ceous	Paddy field with shrub	Paddy field with sparse trees	Upper paddy field	Upland crop with sparse trees	Paddy field	Upland crop	-Forest -Degraded forest
Land type	Levee	Flood plain	Low terrace	Middle terrace	Middle and high terrace	Valley	Piedmont	Mountain and hill
Land type	Loamy	Clayey	-Sandy loam -Saline soil -Sandy -Lateritic	Sandy loam	-Sandy loam -Lateritic -Sandy	Sandy loam	-Sandy loam -Loam -Clayey	-Shallow soil -Skeletal soil
Drainage	Mode-rate	Poor	Poor	Well	Well	Poor	Very well	Very well

Fig. 4. Land ecosystems of Thailand (Mongkolsawat et al 1988).

F2: Similar to F1 except that parts of the forest have been cleared. This is the area for efficient reforestation programs. No form of agriculture is recommended.

Unit E: Piedmont

This unit can also be divided into two subunits:

E1: Soils in this unit are derived from a combination of colluvium and residuum of sandstone. The soil is coarse-textured, well drained, and suitable for upland crops, particularly cassava. Approximately 25% of the area is still covered with forest. With the institution of proper soil conservation methods, the site can be opened up for agroforestry or mixed farming with plant and livestock production as major components. Fish culture is not suitable in this land unit.

E 2: This unit includes a dissected erosion surface with heavy-textured soils. The area is very fertile and suitable for field crops such as maize, sorghum, and fruit trees.

Unit G: Valley

Alternately presented with unit E, it functions as waterways and is often connected to watershed areas on mountaintops. The unit is characterized by sandy loam texture and is used for paddy cultivation.

Unit D: Consists of three units

D1: High and middle terrace with sandy loam soils
This is the main unit of upland crops in the northeastern region. The soils are sandy loam in texture and well drained, with an accumulation of clay at 20–25-cm depth. The soils are moderately fertile and often used for main upland crops such as cassava, sugarcane, kenaf, and leguminous crops. The soils may not be suitable for maize or sorghum. Fish culture is not recommended.

D2: Middle terrace with sandy-textured soils
The soil in this unit has a very sandy texture to at least 80-cm depth and is well drained. It has low potential for field crop production. However, the soil can be easily managed, as the subsoil often remains moist even in the dry season. The unit is generally used for growing upland crops, especially cassava or sugarcane. Dipterocarp trees are sporadically observed.

D3: Middle terrace with laterites
This unit occupies shallow soil underlain close to the surface with a laterite layer. Part of this is still covered with dwarf dipterocarp trees. Outcrops of laterites may be present in certain areas. It has low potential for agriculture. However, it could be developed into pasture for livestock. Deep-rooted plants or fish culture could be suitable in this land ecosystem.

Unit C: Upper paddy areas

The forest in this unit has long been encroached upon and opened up for upland crop cultivation. Most of this unit is also used for rice cultivation, as it is the staple food of the local people. However, rice areas are often left fallow, particularly in drought years. Soils in this unit are similar to those in unit D, but they have greater physical problems that are more difficult to manage.

Unit B: Low terrace

Four subunits are under this ecosystem.

B1: Low terrace with sandy loam soils
This unit is mostly used for paddy cultivation. Accumulation of alluviated clay is often present at a depth of 15 cm. This unit is suitable only for paddy growing during the rainy season. Rice-fish culture could be introduced in the area. Crop production in the dry season is possible if there is irrigation.

B2: Low terrace with very sandy soils
The soils in this unit are very sandy. Physical and chemical properties of the soils are unfavorable for agriculture. But the unit is still used for paddy cultivation by farmers.

B3: Low terrace with saline soils
The soils in this unit have been affected by salt. Surface encrustation of salt occurs during the dry season. These soils are underlain by rock salt. Paddy cultivation is possible when the soils are waterlogged. They can be regarded as unsuitable for any form of agriculture.

B4: Low terrace with laterite soils
This unit is used for paddy cultivation. Agricultural potential at this site is directly related to the depth of the underlying lateritic layer. Fish culture is suitable in this unit but pond construction could be a problem.

Unit A: Flood plain and river levee

This unit occupies flood plains with heavy-textured soils. The soils are fertile, with high paddy yield in most areas. The unit is suitable for fish culture if overflow water can be controlled. The best farming system for this unit is wet-season paddy followed by vegetables and ICAS has a high potential. The river levee is covered by trees and shrubs and is partly used for vegetable growing. This is mainly in the central region.

Other units: Coastal and mangroves

In addition to the above units, Thailand also has coastal and mangrove land ecosystems that are mainly in the southern region. However, the mangroves have been overused and are now relatively degraded by the increased undertaking of shrimp-farming activities that polluted the ecosystem.

Regional distribution of different units

The northern region is covered mostly by units F, E, and G and some of unit D. The central region is covered mostly by units A, B, and C and some of unit D. The northeastern region is covered mostly by units B, C, and D and some of A, G, and E. The southern region is covered mostly by units E and G and some of unit D. The coastal and mangrove areas are also mostly in this region. This distribution has influenced the development of various models of crop and animal integration.

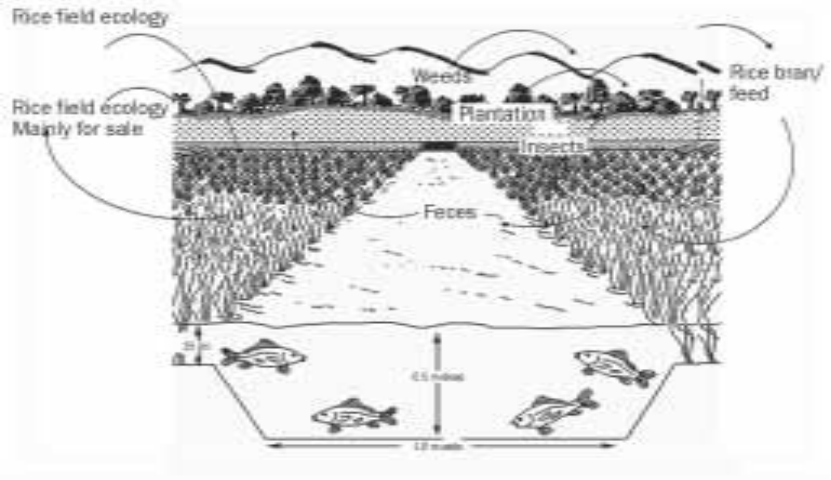
Integrated farming system models

Rice-based mixed and integrated farming systems have been traditionally practiced in Thailand. Despite the move toward more commercialized and specialized farms and agricultural activities, the systems have been maintained but barely improved because of limited research and development activities conducted in the area. The systems can be classified into different models based on their suitability in the various land ecosystems described above.

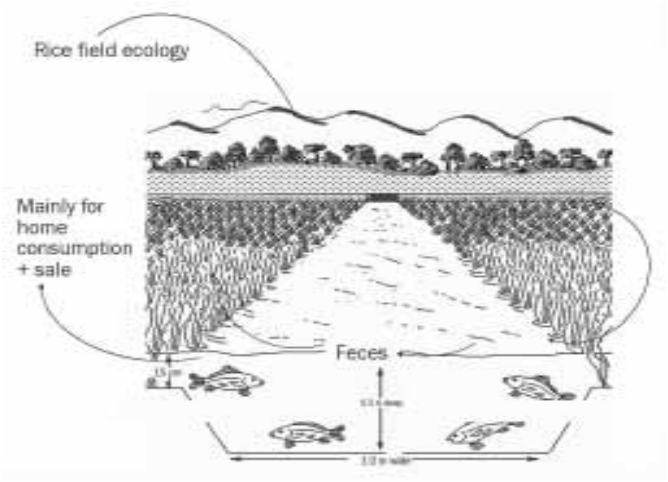
Model 1. This model consists of native fish stocked in rice paddies, and that are mainly used for home consumption when harvested. No additional feed input is needed to grow the fish. Nutrients such as weeds, insects, and planktons from rice fields serve as their feed. When the water recedes, fish are captured in a small pond at the lower corner of the rice field. Their feces are left at the bottom of the fields, and then fertilize the soil.

Model 2. Model 2 is a modification of the first model but, instead of stocking native fish varieties, the new high-yielding varieties are kept. Cultured fish need additional feed, such as rice bran and other crop residues, termite mounds, and/or commercial feed obtained from outside the system. Fish harvested are primarily for sale. A small portion is left for home consumption.

Rice-fish systems are found mainly in lowland areas in the central region as well as in lower terraces of upland areas in other parts of the country, particularly in the northeastern and northern regions. The simple and traditional fish ponds (Model 1) remain the central focus of rice-based integration because they are low-input systems. Productivity depends to a large extent on the type of native fish stocked, the level and duration of water, and the fertility of the paddy fields. With the decline in native fish stocks because of overharvesting, environmental degradation, and chemical pollution from pesticide use, cultured fish were introduced, which greatly improved fish productivity. This enabled farm households both a sufficient source of protein for their family needs and surpluses for sale in the market. The number of improved fish ponds (Model 2) is increasing tremendously everywhere because of the information drive conducted by NGOs and subsidy provided by the government to promote



Model 1. Rice-fish capture.



Model 2. Rice-fish culture.

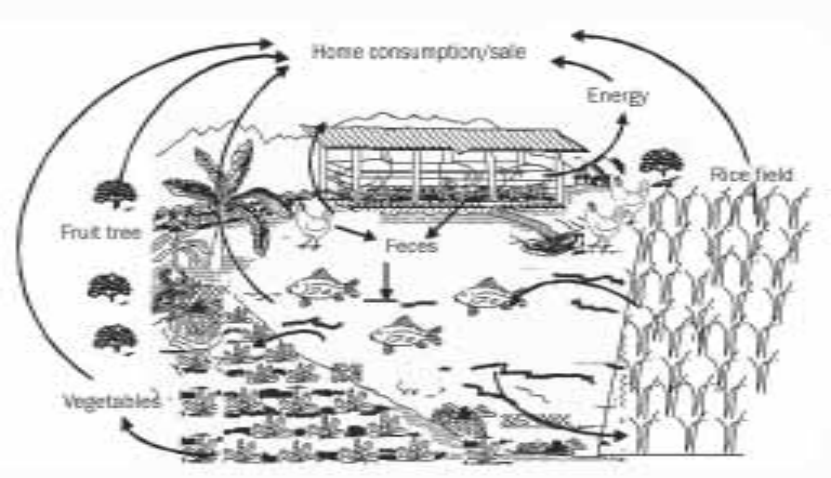
the system as a sustainable means to achieve the King's sufficiency economy concept through effective and efficient management of small water resources.

Some problems have been hindering more rapid development of these systems, however. One is the labor scarcity, which has become more serious with the slower growth in population as initiatives in family planning intensify, and with increased migration, particularly of rural young people, to urban areas. Farmers have also indicated that theft is a problem because fish ponds are situated away from the village settlements.

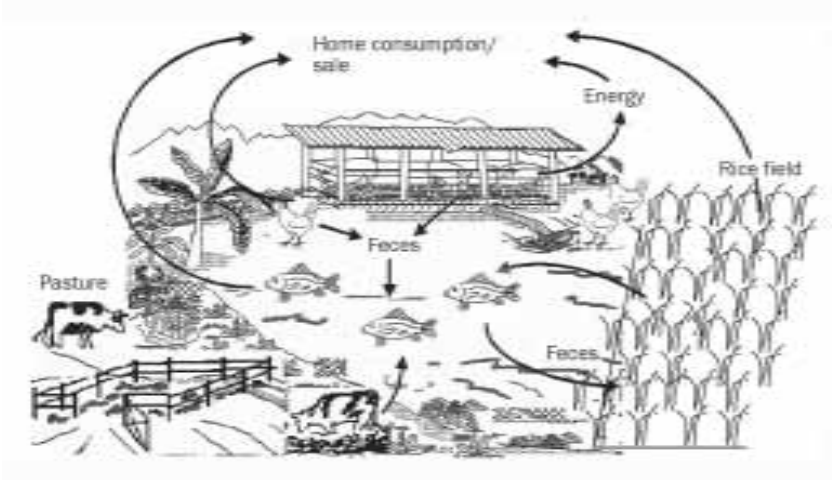
Recent modifications of the system have been its establishment among rice fields. Crops are grown on the embankments that surround the pond for home consumption, for sale in the market, or for fish feed.

Model 3. Model 3 introduces intensive livestock raising (mainly poultry and swine) into the rice-fish system. Fish-pond layout is better planned in this model because of the addition of small livestock pens that are often constructed on top of the pond. Animal wastes become feed for fish, but this could vary in different locations depending on their effect on water quality. The balance between the number of animals and quality of water in the pond is critical and must be carefully managed. Too much animal waste deteriorates water quality and may affect the fish cultured in the pond. Animal manure also serves as fertilizer since mud that settles at the bottom of the pond is scooped out and added to the surrounding fields, which are cultivated with rice, vegetables, fruit trees, and other crops. Crops or crop residues may additionally be given to the fish or animals as feed as well as commercial feed that is obtained from outside the system. Fish and animals produced are mainly channeled to the market for sale.

The diversity and integration involved in the system increase its production sustainability. The development direction, however, has been geared toward greater com-



Model 3. Rice/horticulture crop-animals.



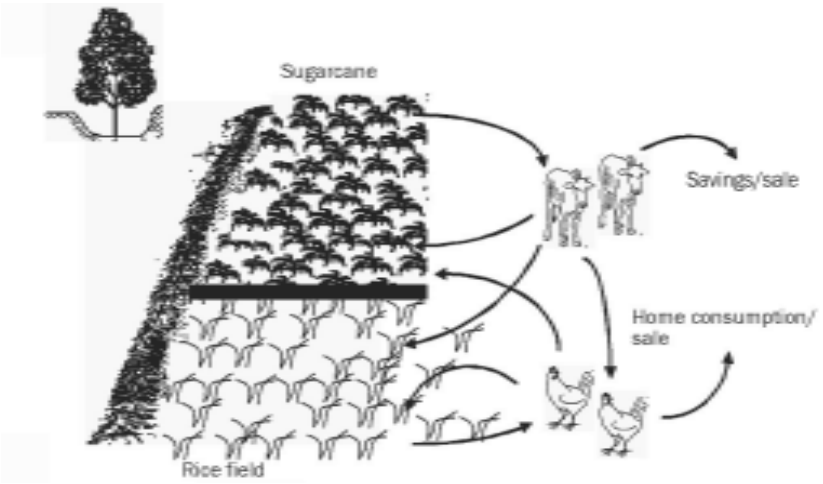
Model 4. Rice-animals-fish.

mercialization. Adequate water resources are a prerequisite for the much wider adoption of the system. In addition, the animal-raising component necessitates the increased dependence on capital resources for the purchase of improved animal breeds, commercial feed, and veterinary care. The need for skilled labor also increases as the system becomes more complex and more commercialized.

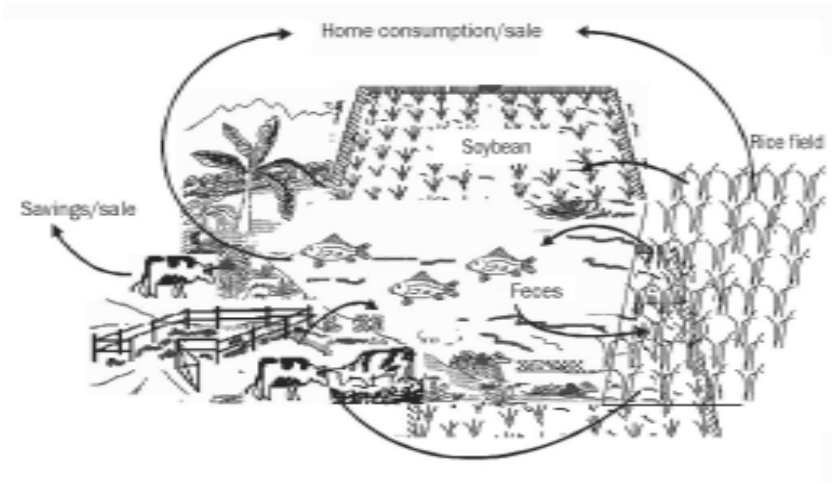
Model 4. This model is similar to the third model, but with the addition of larger animals such as cattle or buffaloes. Cattle contribute manure to the pond as well as crops. Again, care should be practiced to maintain the appropriate balance between the number of livestock kept in cages on top of the pond and water quality to prevent water degradation that can later be detrimental. Large animals as part of the component are very limited.

Model 5. The fifth model is not a water-based system but has a major field crop such as sugarcane along with rice. Livestock are native chickens and/or cattle. Rice straw is fed to the cattle and unhusked rice to the chickens. Other crop residues are seldom used. Chickens are mainly for home consumption although a small portion are sometimes sold. Cattle, on the other hand, are usually kept as a form of savings and sold in times of emergency. Adding large livestock to the system is now seldomly done because of the limited grazing area and higher investment cost. The nutrient cycle is not complex in this system. Chicken and cattle manure are directly deposited in fields since chickens are left uncaged and go to the fields to find food while the cattle are usually tied in the middle of the paddies after rice is harvested to graze and eat the stubbles.

Model 6. Since most of the soybean is grown in lowland, the ICAS with soybean is usually associated with a fish pond (water-based system). Native chickens and cattle may be part of the system. The nutrient cycle concept is similar to that of the other systems. Wastes from animals go to the fish, rice fields, or other crop fields and wastes from fish go to the bottom of the pond and are then returned to the rice fields. The use of cattle is similar to that in the previous model.



Model 5. Rice/sugarcane-animals.



Model 6. Rice/soybean-fish-cattle.

Model 7. The seventh model is without the fish-pond component. Chickens may be raised along with cattle. Wastes from cattle are used as fertilizer for rice or vegetables. The purpose for having livestock uncaged is similar to that in the other systems.

In some areas in the southern region, goats are a traditional part of the system. More recently, sheep have also been introduced in the northern region under the King's project.

Table 2 summarizes the general distribution of the different models of integrated farming systems in different regions of the country. This does not strictly mean that each model is confined only to the regions indicated in the table. It can appear in other regions to a certain extent.

Crop-animal integration in rainfed rice areas

Most upland paddy areas are rainfed and located in the northeast region. Most of the farm systems in this area are rice-based but rice insufficiency remains a common problem. Seasonal rainfall variations and soil infertility limit rice productivity. One important strategy for overcoming this problem is to increase household income to enable households to purchase their rice needs from the market. Animal raising has provided the needed income supplement to these households in the region. Traditional cattle and buffalo raising is still a common sight on a number of rice farms in the north-

Table 2. Distribution of rice-based integrated farming systems.[a]

Model	Land ecosystem unit	Main regional distribution
1	A	NE,C
2	B_1, B_2, B_3, G	NE,C
3	B_1, B_2, B_3, G	NE,C
4	B_1, B_2, B_3, G	N,NE,C
5	B_1, B_2, B_3, G, and C	NE
6	B_1, B_2, B_3, G	NE
7	A, B_1, B_2, B_3, and G	NE

[a]N = northern, NE = northeastern, and C = central region.

Model 7. Rice/vegetables-animals.

ern and northeastern regions. This practice has gradually diminished in the central and southern regions. Animals are still employed to prepare land, primarily during the wet season when the fields are cultivated for rice. During the dry season, paddy areas are used for grazing, where animals primarily feed on the rice stubbles. Rice straw as feed is important during the dry season as well as during the rainy season when paddy land is occupied by rice and other grazing areas are not easily accessible. The importance of cattle and buffalo manure as fertilizer is also gaining popularity because of the increasing demand for organic crops and other farm produce. Manure trading is now showing great potential for growing into a big business enterprise. All of this plus the fact that cattle and buffaloes command relatively high market prices have influenced the gradual return of these animals to fields.

The introduction of small rice-milling machines in villages also encouraged pig raising in the region. But this opportunity has been confined more to a few families and their relatives who are affiliated with rice mill owners who could obtain rice bran for animal feed. The relatively well-off households raise modern breeds of pigs that need more feed input in the form of rice bran and other feed concentrates. They also practice more intensive care and management with the help of people with veterinary expertise.

Raising of native chickens is another traditional practice attached to rice farming in all regions of the country and more so in rainfed areas. Unhusked rice is used as feed for the chickens. The system is low-input in nature. Chickens are used for home consumption, for sale, for rituals/ceremonies, or in exchange for labor employed.

Raising of fighting cocks is most common among smallholder rice farmers. It is rapidly expanding now not only in rainfed areas but throughout the country because of its export potential, which gives the animals their more premium price. Cockfighting as a hobby, especially among richer households, is now becoming popular, with prizes at stake making it more and more enticing.

Expanding crop-animal endeavors in the rainfed environment has always been hindered by the limited availability of communal land and landholding size.

Demographic characteristics

The population estimate of Thailand in mid-2002 was 62,354,402. The growth rate was computed at 0.88% in 2001: a drastic drop from the 1.2% average growth rate estimated for 1990-2001. The recent growth rate estimate took into account the severe effect of AIDS infection, which lowers life expectancy and increases infant mortality and death rates. Changes in the distribution of population by age and sex also took directions that are beyond those that were originally expected (CIA 2002). The pyramid shape of the population structure in 2000 is expected to become a jar shape in 2025 as projected by the U.S. Census Bureau (Table 3 and Fig. 5).

This indicates a more rapid expansion of population in the age bracket 15–65. This is the economically active segment of the population that would require sufficient food and energy to do work; hence, the expected continued increase in demand for food.

There will also be continued pressure on the agricultural sector to produce more food surpluses for the increasing labor force that is projected to move out of agriculture into industrial activities, especially with the current focus on the modernization of the industrial sector. Data from the 1990 census reveal that, while the agricultural sector is still

Table 3. Projected age structure of the Thai population in 2025.

Age	%	Males	Females
0–14	23.3	7,404,227	7,121,083
15–64	69.9	21,469,186	22,090,520
>65	6.8	1,868,632	2,400,754

Source: CIA (2002).

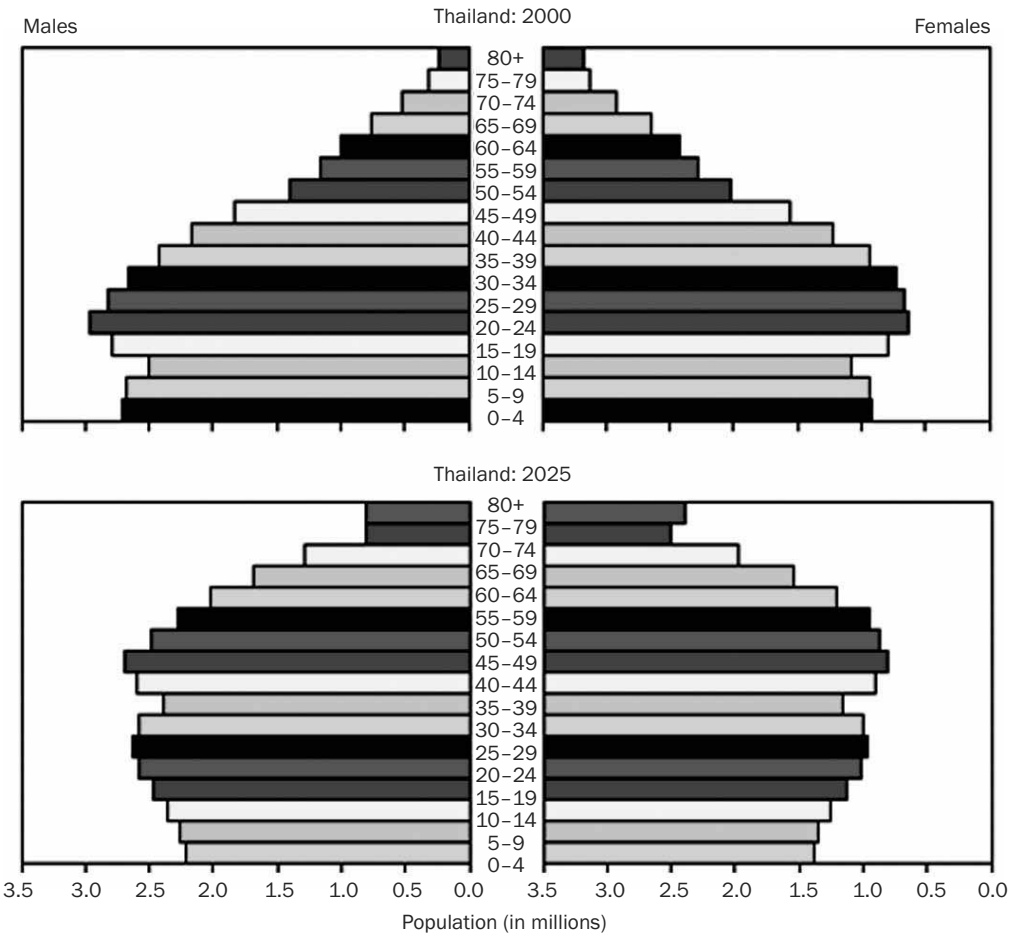


Fig. 5. Pyramid of Thai population in 2000 and 2025. Source: U.S. Census Bureau, International Data Base.

dominant in Thailand, the proportion of the labor force engaged in agriculture has declined from 79.3% to 66.0% during 1970-90. Labor force participation in the industry and service sectors, on the other hand, increased from 8.3% to 13.5% and 12.4% to 20.5%, respectively (NSO 2003). Table 4 shows that, at the beginning of 2004, only 34% of the labor force was engaged in agriculture and agriculture-related activities.

Regional distribution of Thailand's population and incidence of poverty

Table 5 shows the regional distribution of Thailand's population. It can be noted that about a tenth of the population lives in Bangkok, the capital city. The northeastern region accounts for the highest number of people, with about 20 million, followed by the northern region. The combined total population of these regions accounts for almost 50% of the whole Kingdom. Table 6 also shows that poverty incidence among households is highest in the north and northeast regions, with percentages of households under the poverty line at 48% and 43%, respectively, of total households. The poverty line for Thai people is less than baht 20,000. Note that about 36.2% of Thai households have income less than the poverty line, about 6% higher than the government target of about 30%.

Migration trends in Thailand

Table 7 shows the movement of people within the country and in and out of Bangkok and the other growth centers. Migrants to Bangkok and its vicinity have particularly been those in the 15–24 years' age bracket, unmarried and only finished a primary education. Recent migrants to Bangkok, however, especially those from the eastern seaboard and within the vicinity of regional growth centers, are mainly of the 25–34 age group. They are mostly males with secondary and higher level of schooling and married persons. Migrants into the different regions also vary in terms of their occupational skills. In Bangkok, these people were mostly engaged in service, crafts, and hired labor. In the Bangkok vicinity and eastern seaboard, the proportion engaged in white-collar occupations is equal to that engaged in blue-collar work, but, in regional growth centers, a majority of

Table 4. Number and percentage of employed persons by industry (in thousands) by region, 2004.

Industry	Region					
	Total	Bangkok	Central	Northern	Northeastern	Southern
Total	33,745.7	4,607.9	8,186.5	6,255.5	10,335.9	4,359.9
Agriculture	11,612.4	44.2	2,198.4	2,856.5	4,574.1	1,939.2
1. Agriculture, hunting, and forestry	11,174.6	32.7	2,068.2	2,831.5	4,492.7	1,749.5
2. Fishing	437.8	11.5	130.2	25.0	81.4	189.7
Nonagriculture	22,133.3	4,563.7	5,988.1	3,399.0	5,761.8	2,420.7
1. Mining and quarrying	64.9	5.6	25.8	4.5	27.2	1.8
2. Manufacturing	6,035.1	1,154.6	2,316.7	781.9	1,422.2	359.7
3. Electricity, gas, and water supply	89.8	3.0	35.4	24.0	20.5	7.0
4. Construction	2,221.2	187.9	384.0	459.9	978.0	211.4
5. Wholesale and retail trade, repair of motor vehicles, motorcycles, and personal and household goods	5,677.6	1,065.4	1,374.3	902.0	1,532.3	803.7
6. Hotels and restaurants	2,338.7	568.1	573.9	343.7	460.4	392.6
7. Transport, storage, and communication	1,187.8	356.5	306.7	107.2	273.9	143.6
8. Financial intermediation	289.6	119.0	75.4	40.4	35.6	19.3
9. Real estate, renting, and business activity	638.9	266.8	143.4	77.6	79.2	71.9
10. Public administration and defense, compulsory social security	968.8	179.4	217.0	152.8	304.7	114.9
11. Education	1,081.6	200.0	219.1	299.1	298.5	134.9
12. Health and social work	521.7	129.3	97.6	106.6	132.9	55.3
13. Other community, social, and personal service activity	733.8	205.4	158.5	129.2	165.7	75.0
14. Private households with employed persons	269.7	112.2	57.2	40.3	30.3	29.8
15. Extraterritorial organizations and bodies	6.4	5.5	0.3	–	0.6	–
16. Unknown	7.8	5.0	2.8	–	–	–
			Percentage (%)			
Total	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture	34.4	1.0	26.9	45.7	44.3	44.5
1. Agriculture, hunting, and forestry	33.1	0.7	25.3	45.3	43.5	40.1
2. Fishing	1.3	0.2	1.6	0.4	0.8	4.4
Nonagriculture	65.5	99.0	73.1	54.3	55.7	55.5
1. Mining and quarrying	0.2	0.1	0.3	0.1	0.3	0.0
2. Manufacturing	17.9	25.1	28.3	12.5	13.8	8.2
3. Electricity, gas, and water supply	0.3	0.1	0.4	0.4	0.2	0.2
4. Construction	6.6	4.1	4.7	7.4	9.5	4.8
5. Wholesale and retail trade, repair of motor vehicles, motorcycles, and personal and household goods	16.8	23.1	16.8	14.4	14.8	18.4
6. Hotels and restaurants	6.9	12.3	7.0	5.5	4.5	9.0
7. Transport, storage, and communication	3.5	7.7	3.7	1.7	2.6	3.3
8. Financial intermediation	0.9	2.6	0.9	0.6	0.3	0.4
9. Real estate, renting, and business activity	1.9	5.8	1.8	1.2	0.8	1.6
10. Public administration and defense, compulsory social security	2.9	3.9	2.7	2.4	2.9	2.6
11. Education	3.2	4.3	2.7	3.7	2.9	3.1
12. Health and social work	1.5	2.8	1.2	1.7	1.3	1.3
13. Other community, social, and personal service activity	2.2	4.5	1.9	2.1	1.6	1.7
14. Private households with employed persons	0.8	2.4	0.7	0.6	0.3	0.7
15. Extraterritorial organizations and bodies	0.0	0.1	0.0	–	0.0	–
16. Unknown	0.0	0.1	0.0	–	–	–

Source: NSO (2004).

Table 5. Total midyear population.

Year	Total population	Bangkok	Central	South	North	Northeast
			(× million)			
1996	59.46	8.90	10.30	7.71	11.90	20.65
1997	60.12	9.00	10.42	7.81	11.99	20.90
1998	60.82	9.11	10.56	7.94	12.09	21.12
1999	61.40	9.24	10.68	8.07	12.10	21.31
2000	61.66	9.31	10.96	8.15	12.10	21.36
2001	61.90	9.40	10.76	8.22	12.12	21.40
2002	62.31	9.53	10.85	8.31	12.13	21.45

Source: Department of Provincial Administration (2003).

Table 6. Distribution of households by poverty incidence, Thailand.

Region	Total households surveyed	Income greater than poverty line[a]		Income less than poverty line	
		N	%	N	%
Central	1,604,752	1,329,319	82.8	275,433	17.2
Northeast	3,008,542	1,711,741	56.9	1,296,801	43.1
North	1,775,488	927,308	52.2	848,182	47.8
South	1,063,652	784,076	73.7	279,578	26.3
Total	7,452,434	4,752,442	63.8	2,699,992	36.2

[a]Poverty line is set at less than baht 20,000 year^{-1} household^{-1}.
Source: Department of Provincial Administration (2003).

Table 7. Number of in- and outmigration from registration record, 1999.

Region	Inmigration		Outmigration	
	Males	Females	Males	Females
Whole Kingdom	1,663,698	1,554,655	1,493,884	1,411,286
Bangkok and vicinity	319,089	329,527	336,073	328,504
Bangkok	197,332	204,019	235,066	228,162
Subcentral region	84,170	74,066	62,306	57,954
Eastern region	133,027	127,872	118,487	113,092
Western region	93,757	85,504	75,100	72,122
Northern region	293,722	268,846	254,540	239,631
Northeastern region	492,720	428,348	432,429	389,578
Southern region	247,213	240,492	214,949	210,405

Source: NSO (2003).

the migrants were working in agriculture. Also evident is the greater number of migrants employed in manufacturing and construction during the nonagricultural season.

Household income and expenditures

Income and expenditures of Thai families increased while family size decreased. Family size decreased from 5.5 in 1975 to 3.6 in 2001. Income, on the other hand, increased from baht 3,375 to 12,185 in the same period and expenditures increased from baht 3,374 to 10,025 (Table 8). Continued growth of household income, occupation, and residence influence the expenditure pattern (Table 9). Per household expenditures on grains and cereal products are lowest in Bangkok and highest in the northeast. But, per household expenditures on other foods are about the same in all regions, and have increased with income growth.

Summary on demographic characteristics

The Thai population has been increasing, but at a much lower rate than in the past. Demographic change will take

Table 8. Average monthly income and expenditures of households.

Year	Average household size	Average monthly income of household (baht)[a]	Percent of change per year	Average monthly expenditures of household (baht)	Percent of change per year
1975-76	5.5	1,928	–	2,004	–
1981	4.5	3,378	11.87	3,374	10.98
1986	4.3	3,631	1.45	3,783	2.31
1988	4.0	4,106	6.34	4,161	4.88
1990	4.1	5,625	17.04	5,437	14.31
1992	3.9	7,062	12.05	6,529	9.58
1994	3.8	8,262	8.16	7,567	7.66
1996	3.7	10,779	14.22	9,190	10.20
1998	3.7	12,492	7.65	10,389	6.32
1999	3.7	12,729	1.90	10,238	–1.45
2000	3.6	12,150	–4.55	9,848	–3.81
2001	3.6	12,185	0.29	10,025	1.80

[a]Currency rate: baht 40 = US$1.
Source: NSO (2003).

Table 9. Average household expenditures (baht) in a 7-day period for food, beverages, and tobacco by region and area, 2004.

Food and beverages	Whole Kingdom	Region						
		Greater Bangkok	Central	North	Northeast	South	Municipal area	Non-municipal area
Percent of households	100.00	17.40	19.10	19.40	31.60	12.50	19.20	63.40
Average household size (persons)	3.50	3.30	3.40	3.20	3.70	3.80	3.20	3.60
Food prepared at home	547.64	585.70	565.89	465.30	529.62	640.96	548.64	538.07
Grains and cereal	101.76	73.49	87.04	93.95	127.82	105.45	92.42	111.24
Products								
Rice	51.96	44.58	64.23	40.49	44.78	78.05	50.53	54.17
Glutinous rice	31.53	2.55	2.63	41.45	69.23	1.56	21.67	41.31
Rice and wheat flour and oats, cassava flour, and corn flour	0.44	0.35	0.46	0.31	0.37	0.88	0.38	0.48
Noodles, macaroni, and spaghetti	4.43	3.50	4.63	3.59	5.40	4.18	4.07	4.76
Bread and cake	6.28	11.73	6.92	4.11	3.21	9.37	7.11	4.71
Pastries	4.53	7.23	4.46	2.24	3.03	8.41	4.76	3.81
Bean curd	1.53	2.43	2.64	0.93	0.92	1.19	2.52	1.03
Other cereal products such as malt, sago, malt flour, etc.	1.06	1.12	1.07	0.83	0.88	1.81	1.38	0.97
Meat and poultry	99.72	90.45	96.23	90.06	111.17	102.41	96.37	102.91
Lean pork	40.16	32.91	44.07	43.00	38.23	44.01	38.00	42.53
Spareribs and other pork	7.50	9.16	8.84	8.24	5.11	8.29	8.18	6.91

Source: NSO (2004).

place so that the Thai population will increase the proportion of its economically active population. Migration from rural areas to the city and urban growth centers will also increase, thus the expected expansion of urban areas. People working in urban areas will definitely have different work and food consumption habits. A rise in income and attainment of higher levels of education are also expected to take place. All these factors will affect demand for food, and thus should be considered in plans for agricultural development. Observations and recent trends seem to indicate that the inclination is toward more consumption of animal protein, as shown in Table 10.

Rice production

Rice is a dominant subsector of the country's crop income and it continues to be the dominant economic activity of farmers in rural Thailand. The commodity has likewise continued to be a major export crop. But, despite this, rice farmers are regarded to be among the poor. The Thai government has continued to support the industry not only to maintain the competitive strength of Thai rice in the international market but also to help prevent the seemingly worsening welfare of rice farmers. Government attention has thus been more and more focused on restructuring cropping sys-

Table 10. Number of livestock slaughtered by region, 1997-2000.

Year	Total	Bangkok and vicinity	Subcentral	Eastern	Western	Northern	Northeastern	Southern
Cattle								
1997	440,756	27,531	18,764	9,778	29,744	70,636	223,709	60,594
1998	389,303	24,380	14,430	8,478	26,106	66,662	188,737	60,510
1999	372,987	35,485	14,801	8,231	24,660	62,135	177,918	49,757
2000	335,923	34,460	9,860	9,040	19,641	64,797	167,352	30,773
Buffalo								
1997	124,875	10,487	9,409	15,465	364	18,708	66,791	3,651
1998	98,993	5,926	6,040	14,351	51	18,715	50,763	3,147
1999	103,464	3,112	15,953	14,300	246	22,472	44,787	2,594
2000	110,199	2,220	10,964	14,973	296	25,211	55,189	1,526
Swine								
1997	3,834,566	347,389	242,948	436,037	426,724	905,478	750,759	725,231
1998	3,741,348	392,663	216,655	421,678	379,796	895,584	737,267	697,705
1999	3,634,412	445,855	254,343	413,297	340,458	871,580	721,210	587,669
2000	3,665,243	450,402	236,110	362,125	346,434	940,590	761,301	568,281

Source: Department of Livestock Development, Ministry of Agriculture and Cooperatives (2004).

Table 11. Wet- and dry-season rice: area, production, yield, and farm price and value, crop year 1992-93–2001-02.

Year	Planted area (000 rai)[a]	Harvested area (000 rai)	Production (000 t)	Yield (kg rai^{-1})	Farm price (baht[b] per ton)	Value (million baht)
1992-93	60,453	57,248	19,917	348	3,286	65,447
1993-94	59,251	53,015	18,447	348	3,727	68,752
1994-95	60,677	56,095	21,111	376	3,857	81,425
1995-96	63,353	56,870	22,016	387	4,764	104,884
1996-97	63,728	57,920	22,332	386	5,522	123,317
1997-98	64,189	61,955	23,580	381	6,962	164,164
1998-99	62,698	59,447	22,999	387	5,756	132,382
1999-2000	64,443	62,312	24,172	388	4,679	113,101
2000-01	66,492	61,820	25,844	420	4,621	119,425
2001-02	66,272	63,283	26,514	419	4,714	124,987

[a]Land unit: 6.25 rai = 1 ha. [b]Currency rate: baht 40 = US$1.
Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives (2003).

tems toward greater diversification and integration of production activities.

Trends in rice production

Cultivated area of rice (both dry and wet season) in the country has steadily increased from 60 million rai[1] in 1992-93 to 66 million rai in 2001-02 (Table 11). Harvested area shows the same trend but is slightly lower in coverage. Production increased from 19 million t in 1992-93 to 26 million t in 2001-02 while yield per rai increased from 348 to 419 kg during the same period. The farm-gate price, however, fluctuated. From 1992-93 to 1995-96, the price remained slightly below baht 4,000. From 1996-97 to 1998-99, farm-gate prices gradually rose to reach close to baht 7,000 in 1997-98. From 1999-2000 to 2001-02, the farm-gate price averaged around baht 4,700. The value of rice production followed the same trend as the farm-gate price, peaking in 1997-98 at baht 164 billion.

From 1999-2000 to 2001-02, the total and regional wet-season rice cultivated and harvested areas were more or less stable (Table 12). The total cultivated area of the country averaged around 57 million rai, of which 12 million rai are found in the north, 32 million rai in the northeast, 9.7 million rai in the central region, and only 2.5 million rai in the south. The trends in harvested area and its distribution across regions are similar to that in cultivated area. Total production, on the other hand, shows some variation across years, in which the highest recorded was about 21 million t in 2001-02 and the lowest at about 19 million t in 1999-2000. For each region, total production showed an increasing trend until 2001-02, except in the south. The northeast achieved the highest production (8–9 million t), followed by the north (4–5 million t), the central region (a little less than 5 million t), and the south (0.7–0.8 million t). Yield per rai also reflects the same pattern: 348 kg in 1999 and 380 kg in 2002. Yield per rai is highest in the central region and lowest in the northeast (about 500 vs 300 kg, respectively).

[1] 1 hectare = 6.25 rai.

Table 12. Wet-season rice: planted area, harvested area, production, and yield by region.

Region	Planted area (rai[a])			Harvested area (rai)		
	1999-2000	2000-01	2001-02	1999-2000	2000-01	2001-02
North	12,374,656	12,515,977	12,754,163	11,733,479	11,691,558	12,289,342
Northeast	31,858,692	33,090,626	32,997,722	30,911,916	29,906,947	30,910,752
Central	9,817,805	9,697,033	9,857,928	9,587,663	9,180,998	9,595,376
South	2,531,342	2,471,017	2,228,192	2,488,271	2,346,355	2,135,330
Total	56,582,495	57,774,653	57,838,005	54,721,329	53,125,858	54,930,800

Region	Production (t)			Yield (kg rai^{-1})		
	1999-2000	2000-01	2001-02	1999-2000	2000-01	2001-02
North	4,959,508	5,413,972	5,760,935	423	463	469
Northeast	8,537,114	9,138,697	9,465,818	276	306	306
Central	4,669,353	4,469,952	4,924,125	487	487	513
South	849,694	765,748	747,680	341	326	350
Total	19,015,669	19,788,369	20,898,558	348	372	380

[a]Land unit: 6.25 rai = 1 ha.
Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives (2003).

Table 13. Dry-season rice: planted area, harvested area, production, and yield by region.

Region	Planted area (rai[a])			Harvested area (rai)		
	1999-2000	2000-01	2001-02	1999-2000	2000-01	2001-02
North	2,869,908	2,985,859	2,593,866	2,831,496	2,980,490	2,558,934
Northeast	639,739	871,875	628,516	599,643	863,166	616,510
Central	4,110,685	4,632,115	5,093,134	3,924,453	4,627,127	5,060,089
South	240,724	227,628	118,551	235,220	222,783	116,308
Total	7,861,056	8,717,477	8,434,067	7,590,812	8,693,566	8,351,841

Region	Production (t)			Yield (kg rai^{-1})		
	1999-2000	2000-01	2001-02	1999-2000	2000-01	2001-02
North	1,852,948	2,201,129	1,732,304	654	739	677
Northeast	301,010	451,066	287,238	502	523	466
Central	2,889,187	3,301,594	3,543,164	736	714	700
South	112,598	101,720	52,568	479	457	452
Total	5,155,743	6,055,509	5,615,274	679	697	672

[a]Land unit: 6.25 rai = 1 ha.
Source: Office of Agricultural Economics, Ministry of Agriculture and Coperatives (2003).

Dry-season rice cultivation is much less than wet-season cultivation because of the scarcity of water for irrigation. Cultivated area fluctuated in all regions from 1999 to 2001 (Table 13). The Central Plain has the largest cultivated area, which ranged from 4.1 to 5.1 million rai in 1999-2000 and 2001-02. The extent of dry-season rice cultivated area in the north comes next, but this decreased from about 2.9 million rai in 2000-01 to 2.5 million rai in 2001-02. The northeast cultivated area returned to about 0.63 million rai after expanding to 0.89 million rai in 2000-01. The least cultivated land is in the south (0.11–0.24 million rai). Again, harvested area is closely related to cultivation area. Total dry-season rice production ranged from 5.1 to 6 million t from 1999-2000 to 2000-01 and fell to 5.6 million t in 2001-02. The regional production trend closely reflects the trend shown by cultivated area. Yield per rai averaged 679, 697, and 672 kg in 1999-2000, 2000-01, and 2001-02, respectively. The southern region has the lowest yield per rai (452 to 479 kg) while the central has the highest (700 to 736 kg). Compared with the yield gain in the wet season, yield in the dry season is relatively higher. However, over the three-year period, a general decline in yield has been more no-

ticeable in the dry season than in the wet season. This is probably due to the frequent droughts and insufficient irrigation water that the country has recently experienced. To help alleviate this problem, the Thai government has been trying to get farmers to reduce dry-season rice cultivation by replacing it with crops that require less water, but this program has not been very effective.

Regional variation in rice production

Great variation occurs in rice cultivation by region, particularly in the varieties grown and in production management and processes.

Rice varieties

Farmers in Thailand grow several rice varieties. The more popular varieties are RD1, 2, 3, 4, and 9, which are nonphotosensitive varieties grown widely in all seasons. These varieties are promoted by the government. Photosensitive varieties include San Pathong, Kumpai, Rueng Pratue 123, Nangpaya 132, Jasmine 105, and RD 6. These are usually grown only in the wet season. Other varieties also exist but their cultivation is very much attached to certain areas or ethnic groups because of their more distinct characteristics. In the north and northeast regions, glutinous rice is grown mostly for consumption, whereas nonglutinous varieties are mostly for sale. Farmers in the central and southern regions, on the other hand, grow mostly nonglutinous rice.

Cultivation and other management practices

Rice cultivation and management practices also vary by region, primarily because of the differences in land elevation, climatic conditions, and water availability. For plant establishment, for example, three major systems are practiced.

Upland rice system. This is practiced on high-elevation land such as upland and mountain slopes with relatively little water available. Land preparation is minimal. Several seeds are buried in a shallow and small pit made by a sharp stick or similar tool. Seeds germinate by moisture from soil during the rainy season. Weeding is needed. This practice covers a small area in the northern and southern part of the country.

Transplanted rice. This system is widely practiced and it can be divided into two phases. The first phase is germination of rice seeds in a rice seedling bed. It takes about 30 days for the seedlings to grow. When the seeds are ready, they are transplanted, which is the second phase of cultivation. This is also known as direct-seeded rice cultivation.

Broadcast rice. This type of cultivation needs land preparation. Rice seeds are broadcast into a prepared rice field. This is also a type of direct-seeded rice cultivation and can be further classified according to different techniques in land preparation and seed preparation. This practice is less extensive but suitable when drought is frequent or a labor shortage exists.

Most farmers practice the transplanting system on lowland farms between mountain ranges and the direct-seeded rice system on upland farms located on the mountain slopes in the northern region, where most paddy land is rainfed, but a few areas are irrigated and, hence, are also cultivated with dry-season rice.

Paddy lands in the northeast region are mostly undulating and rainfed lowlands. They are frequently affected by drought. In the northern part of the region, a majority of the farmers grow transplanted early-maturing varieties of glutinous rice. In the southern part and in the area along the Mekong River, a majority of the farmers grow late-maturing varieties of both glutinous and nonglutinous rice. Even though the transplanting system predominates, the broadcast system is spreading very fast. This region has the largest rice cultivated area but landholdings are small.

Most of the central region is alluvial and has the largest irrigated rice area. Nonglutinous rice is predominant. Where the water depth is 1–3 m during the flooding season, floating or deepwater rice varieties are used. Where there is an irrigation system, the rice paddy is cultivated in both the dry and wet seasons. Wet-season rice extends from May to January, whereas dry-season rice extends from January to April. Productivity is higher in this region than in the other regions. The total cultivated area is smaller than that of the north and northeast regions but is much larger than that of the south. Farm size per household is bigger, however, and production is more commercially oriented.

Rice-growing areas in the southern region are rainfed lowland along the coast and lowland between mountain ranges. This region has the smallest rice cultivated area. The onset of the rainy season comes earlier on the eastern coast but later than in the other regions. Most of the farmers grow wet-season rice except in small irrigated areas where dry-season rice can be grown. Direct-seeded rice on para-rubber plantations is practiced in some areas. Wet-season rice is harvested during November and February.

Hand tractors have mostly replaced animal power in land preparation in the central region. Likewise, harvesting machines combined with threshing machines are also becoming more popular in the region. Animal draft power is still used in the northern and northeastern regions, whereas harvesting and threshing are still done by hand.

Fertilizer application. Recommended rates of fertilizer application also vary and are highly dependent on soil types.

In clayey, loamy, and clayey-loamy soils that are predominantly found in the central, northern, and southern regions of the country, the recommended fertilizer use is as follows:

1. Before transplanting: application of NPK (nitrogen, phosphorus, potassium), which could be 16-20-0, 18-22-0, or 20-20-0 at 20 kg rai^{-1}).
2. Before flowering: application of ammonium sulfate (20% N) at 12–22 kg rai^{-1} or urea (45% N) at 6–10 kg rai^{-1}.

Table 14. Sugarcane production: cultivated area, production, and yield by region, 1998-99–2000-01.

Region	Cultivated area (rai)[a]			Production (t)			Yield (kg rai^{-1})		
	1998-99	1999-2000	2000-01	1998-99	1999-2000	2000-01	1998-99	1999-2000	2000-01
North	1,322,019	1,287,954	1,181,312	11,391,153	12,097,791	10,391,682	8,616	9,393	8,797
Northeast	2,068,315	2,064,494	1,994,493	18,859,249	20,341,991	18,153,103	9,118	9,853	9,102
Central	2,344,240	2,292,099	2,245,382	20,081,165	21,054,496	20,525,497	8,566	9,186	9,141
Total	5,734,574	5,644,547	5,421,187	50,331,567	53,494,278	49,070,282	8,777	9,477	9,052

[a]Land unit: 6.25 rai ha^{-1}.
Source: Office of Cane and Sugar Board and Office of Agricultural Economics (2003).

Table 15. Country sugarcane production: cultivated area, production, yield rai^{-1}, price, and value, 1991-92–2000-01.

Year	Cultivated area (000 rai)[a]	Harvested area (000 rai)	Production (000 t)	Yield (kg rai^{-1})	Price t^{-1} (baht)	Value (baht million)
1991-92	5,791	5,729	47,480	8,288	336	15,953
1992-93	6,267	6,198	39,827	6,426	359	14,298
1993-94	5,355	4,997	37,823	7,569	468	17,701
1994-95	5,887	5,767	50,597	8,774	435	22,010
1995-96	6,279	6,156	57,974	9,417	386	22,378
1996-97	6,314	6,127	56,394	9,204	410	23,122
1997-98	5,897	–	46,873	7,949	507	23,765
1998-99	5,735	–	50,332	8,776	470	23,656
1999-2000	5,906	–	53,494	9,058	446	23,858
2000-01	5,421	–	49,070	9,052	491	24,093

[a]Land unit: 6.25 rai = 1 ha.
Source: Office of Cane and Sugar Board and Office of Agricultural Economics (2003).

In sandy, sandy loam, loamy sand, and sandy loamy-clayey soils that are predominant in the northeastern and some parts of the southern region, the recommended fertilizer use is

1. Before transplanting: application of NPK, which could be either 16-20-0 or 20-20-0 at 20 kg rai^{-1} in combination with potassium oxide (60% K_2O) at 4 kg rai^{-1} or 16-16-8 at 25 kg rai^{-1}.
2. Before flowering: application of ammonium sulfate (20% N) at 4–12 kg rai^{-1} or ammonium chloride (25% N) at 4–10 kg rai^{-1} or urea (45% N) at 2–6 kg rai^{-1}.

For most farmers, especially smallholders, the recommended fertilizer use has not always been followed because of economic problems in terms of investments.

Other important crops

Besides rice, other important crops directly or indirectly interact with livestock such as sugarcane, cassava, and para-rubber. Brief information on these crops is given below.

Sugarcane

Sugarcane is mostly grown in the uplands of the northern, northeastern, and central regions. The cultivated area for sugarcane in the north is about half of that in the northeast or central regions, respectively (Table 14). Over the past decade, a surge in sugarcane area and production took place in the northeast as sugar mills increasingly relocated to the region.

The sugar industry was once dubbed one of the country's promising industries until 1996-97. The years that followed witnessed a downturn in both cane and sugar production because of a relatively weaker export market. Area cultivated to sugarcane contracted after that and so did production, with yield rai^{-1} having remained almost constant (Table 15). Whether such a trend continues will greatly depend on various reforms to improve production efficiency, deregulate domestic markets, and explore new avenues and partners in the export market. Further development of the industry is still among the top priorities of the Thai government as the industry is also dominated by small farmers and their families.

Sugarcane-livestock interactions are few. In fact, sugarcane cultivation has often been in conflict with livestock grazing area, especially in upland areas. Sugarcane by-products such as molasses are widely used, however, as feed ingredients, especially for dairy cattle. Potential use of other sugarcane by-products as feed is limited.

Para-rubber

Para-rubber has been grown commercially in Thailand for over a century. Its by-products, from both sap and wood, are valuable as they help promote economic growth in the region. A plantation of these trees is mainly a smallholding

Table 16. Para-rubber production: cultivated area, yield, price, and value, 1992-2001.

Year	Cultivated area (000 rai)[a]	Harvested area (000 rai)	Yield (000 t)	Yield (kg rai^{-1})	Price (baht kg^{-1})	Value (baht 1 million)
1992	11,124	8,872	1,712	192.96	16.80	28,761.6
1993	11,213	9,067	1,811	199.73	16.00	28,976.0
1994	11,308	9,213	1,988	215.78	22.64	45,008.3
1995	11,376	9,348	2,061	220.47	31.13	64,158.9
1996	11,444	9,495	2,121	223.38	27.53	58,391.1
1997	11,454	9,548	2,169	227.16	23.29	50,516.0
1998	11,494	9,595	2,162	225.32	23.06	49,855.7
1999	11,526	9,676	2,199	227.26	18.05	39,691.9
2000	11,558	9,768	2,378	243.00	21.52	51,175.0
2001	11,590	9,857	2,424	245.91	20.76	50,322.2

[a]Land unit: 6.25 rai = 1 ha.
Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives (2003).

Table 17. Regional distribution of cassava production.

Region	Cultivated area (rai)[a]			Harvested area (rai)		
	2000	2001	2002	2000	2001	2002
North	1,035,380	971,637	885,721	994,247	927,290	876,753
Northeast	4,219,849	3,861,890	3,339,746	4,037,690	3,617,323	3,314,294
Central	2,150,742	2,084,242	1,998,397	2,036,451	2,013,188	1,985,329
Total	7,405,971	6,917,769	6,223,864	7,068,388	6,557,801	6,176,376

Region	Production (t)			Yield (kg rai^{-1})		
	2000	2001	2002	2000	2001	2002
North	2,669,761	2,549,433	2,298,346	2,685	2,749	2,621
Northeast	10,472,343	9,829,443	8,791,606	2,594	2,717	2,653
Central	5,922,180	6,016,925	5,778,356	2,908	2,989	2,911
Total	19,064,284	18,395,801	16,868,308	2,697	2,805	2,731

[a]Land unit: 6.25 rai = 1 ha.
Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives (2003).

and was believed to be most suitable only in the southern part of Thailand. However, para-rubber plantations are now expanding into the northeast.

From 1992 to 2001, cultivated area increased slightly and has averaged about 11 million rai (Table 16). There were slight increases in production and yield per rai during the same period. The price per kg fluctuated around baht 20 except in 1995, when it rose to baht 31.

Interactions with livestock raising are also nil, except for the use of plantation areas for grazing underneath trees.

Cassava

Like sugarcane, cassava used to be one of Thailand's important export crops, especially for the European market, but that market declined markedly. This affected cassava production, primarily the cultivated areas, which declined over time after years of preferential trade with the EU. However, it is still an important crop for farmers in the eastern part of the central region and the northeast region because it is tolerant of drought and pests and easy to cultivate and look after. It can grow well in upland areas with poor soil fertility. Expansion of cassava cultivation area causes a reduction in livestock grazing land. The use of cassava as animal feed has been employed but not fully exploited.

Total cultivated and harvested area for cassava declined from 7.4 to 6.2 million rai and from 7.3 to 6.0 million rai from 2000 to 2002, respectively. The northeast region accounts for the largest contribution to cassava production, in both area and production (Table 17). However, yield per rai is not much different across the regions (2.6 to 2.9 t).

Livestock, fish, and shrimp

Livestock are the second most important subsector within the agricultural economy in terms of value added. Livestock production is closely related to the crop production

Table 18. The cattle population in Thailand (head).

Year	Region				
	Central	Northeastern	Northern	Southern	Total
1986	1,211,084	1,501,736	979,739	595,297	4,287,856
1987	1,193,136	1,490,967	1,051,569	595,751	4,331,423
1988	1,237,185	1,553,524	1,120,073	589,958	4,500,740
1989	1,363,614	1,762,387	1,239,528	621,412	4,986,941
1990	1,479,527	1,959,185	1,417,016	655,265	5,510,993
1991	1,704,775	2,286,484	1,731,145	713,373	6,435,777
1992	1,846,544	2,418,377	1,866,620	767,439	6,898,980
1993	1,711,923	2,713,393	2,047,417	762,651	7,235,384
1994	1,659,101	2,874,947	1,986,639	885,045	7,405,732
1995	1,627,590	2,811,216	1,955,937	927,078	7,321,821
1996	1,242,521	2,477,834	1,272,189	861,985	5,854,529
1997	1,060,221	2,302,091	1,046,774	882,850	5,291,936
1998	904,957	2,027,597	887,236	748,160	4,567,950
1999	855,232	2,219,437	875,403	685,669	4,635,741
2000	849,237	2,522,961	943,251	585,165	4,900,614

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

system and is characterized by joint products and services. And, as with fish, livestock have long been the main staple food–providing dietary protein for the Thai people. This chapter discusses Thailand's development efforts in relation to livestock, including dairy, beef fattening, cattle, buffalo, swine, poultry (broiler and native chicken), as well as freshwater fish and shrimp production.

Cattle production

Cattle raising in Thailand is mainly practiced by smallholders and is integrated with other activities, mainly rice cultivation. The purpose of cattle raising is to provide financial security as cattle can be sold when an immediate need for cash arises or slaughtered for special occasions. The cattle population in Thailand was 4,900,614 head in 2000; more than half of the total number are in the northeastern region (2,522,961) and 943,251, 849,237, and 585,165 head are raised in the northern, central, and southern regions, respectively (Table 18). The cattle population started to drop in 1996 for various reasons. One major reason was the extensive practice of monocropping for commercial purposes that replaced subsistence systems. Farm mechanization by hand tractors that made land preparation more efficient reduced grazing land. Low cattle prices also contributed to the population decline. In more recent years, the cattle population has been once again on the rise. The reversal of the cattle price trend provides incentives to farmers to go back to cattle raising. Government policies and programs have also been contributing to the gradual reestablishment of cattle farms among smallholders. This includes the intensified campaign for integrated or organic farming as well as the development of the program that involves the promotion of one product per village (e.g., one million–one village) that will be discussed in more detail later.

Two major subcomponents of cattle production in Thailand involve dairy production and cattle fattening for beef.

Dairy production

Prior to 1942, dairy raising was in the hands of Indians or Pakistanis who were then working with Kasetsart University and the Department of Livestock Development (DLD) that started dairy production trials. In 1967, some farmers and the private sector began to realize that dairy farming might be a good addition to their agricultural activities. The highlight of dairy-farming history was when his Majesty the King of Thailand and King Frederic IX of Denmark inaugurated the Thai-Danish dairy farm in January 1972. A demonstration dairy farm and milk-processing center were also established in the King's palace in Bangkok, complete with a marketing arm and scheme. An intensive campaign to increase milk consumption, especially among school children, started in 1985 with the setup of a National Committee for Milk Drinking Campaign. Milk consumption per capita was targeted to be increased from 2 L per person per year in 1984 to 7, 18, and 25 L per person per year in 1989, 1997, and 2001, respectively. However, because of the 1997 economic crisis, the production of ready-to-drink milk was affected despite the expanded dairy production activities, in which the dairy cattle population increased from 209,880 in 1992 to 365,209 in 2001 (Table 19). Market expansion slowed down at 5–10% per year. Milk consumption targets were not attained but efforts in dairy development continued.

With the industry's well-established institutional setup, dairy farming now appears to be more stable and have greater promise of providing farmers with a good opportunity to

Table 19. Number of dairy cattle and milk production in Thailand during 1992-2001.

Year	Dairy cow (head)	Milk production (t)
1992	209,880	217,994
1993	224,007	255,048
1994	241,500	205,407
1995	265,254	307,229
1996	286,932	343,387
1997	307,964	385,728
1998	323,254	437,116
1999	339,265	464,514
2000	352,010	520,115
2001	365,209	564,313

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

increase income. Almost all dairy farmers are members of dairy cooperatives, which are spread all over the country where dairy production and related activities are present. Each cooperative becomes a member of the national dairy cooperative. The Dairy Promotion Organization Northeast, Thailand (2000), reported that an average dairy farm-holding size is 33.8 rai, with 13.4 head of dairy cattle, 4 or 5 head of which are milking cows. The average milk yield is 9.5 kg per cow per day, hence providing each average farm with a total daily milk production of at least 38 kg. This is roughly equivalent to a monthly gross income of about baht 15,490 per month per farm.

Regional dairy production activities are shown in Table 20. In 2001, there were 365,209 dairy cattle, most of which were concentrated in the central region, with a total number at 242,034. The respective populations in the northeastern region, northern region, and southern region are 87,038, 29,243, and 6,894 head. Further expansion of the dairy industry among the small farm holders, however, has been affected by the comparatively high initial investment to establish a dairy farm. The other problem relates to fresh-milk marketing, which has occurred from time to time not because of a slack in demand but because of inefficient local market mechanisms.

Basically, dairy production in Thailand depends on both roughage and crop by-products for feed. In areas where there are pineapple-processing factories, palm oil mills, sugarcane plantations, or any other major crop by-products available, supplementary feeding of feed formulated by using by-products combined with concentrate is used to maintain full milk production throughout the year. In the central region, where corn, including baby corn, is produced and pasture is limited, corn stalks, baby corn residues, and rice straw are commonly used in the feeding system. Dairy cattle feeding the northern region is mainly the cut-and-carry system with little pasture area for grazing; thus, supplemental concentrate feeding is important. Crop by-products such as soybean, rice straw, corn stalks, and by-products from brewery as part of the feeding system are also used. In the northeastern region, a small pasture area of each farm is used for grazing with concentrate supplement. Main-crop by-products, cassava, and rice straw are used, unlike in the area of the lower northeast and northeast of the central region, where each farm has a larger area of pasture grazing and the cut-and-carry system is practiced. Here, farm mechanization with heavy equipment, such as a tractor and accessories, is often used. Unlike in the systems in the southern region where the main crops are para-rubber, oil palm, fruit trees, and coconuts and pasture area is limited, crop residues are used as a part of concentrate feeding and roughage sources.

Beef fattening

Besides general cattle and buffalo raising, Thailand has also developed beef-fattening farms, but still in a limited quantity and intensity compared with dairy operations. Exotic breeds are used for crossbreeding with native Brahman. Yearlings are sold for fattening while slaughtered cattle and beef are sold in specific markets. To some extent, beef production has replaced frozen beef imports. Farmers in beef-fattening endeavors are also formed into cooperatives or groups, especially in the central and northeastern regions.

Buffalo production

Buffaloes have been mostly raised by small farmers, primarily for animal power and secondarily for meat production. The buffalo population in Thailand was 1,702,223 head in 2000, with the northeastern region accounting for the largest population (1,406,422 head). The buffalo population in

Table 20. Dairy cattle and milk production by region.

Region	Dairy cows (head)			Fresh milk (t)		
	1999	2000	2001	1999	2000	2001
Northern	25,344	27,561	29,243	35,166	39,781	46,773
Northeastern	84,714	84,790	87,038	99,997	113,648	129,557
Central Plain	222,699	232,954	242,034	321,844	358,226	378,919
Southern	6,508	6,705	6,894	7,507	8,460	9,064
Total	339,265	352,010	365,209	464,514	520,115	564,313

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

Table 21. The buffalo population in Thailand (head).

Year	Region				
	Central	Northeastern	Northern	Southern	Total
1984	412,849	3,699,938	844,844	161,282	5,118,913
1985	374,845	3,936,178	792,261	148,949	5,252,233
1986	334,798	3,764,385	742,750	138,861	4,980,794
1987	316,045	3,602,539	646,085	118,930	4,683,599
1988	300,364	3,564,860	650,696	103,906	4,619,826
1989	286,439	3,646,048	583,184	96,021	4,611,692
1990	303,329	3,735,930	564,669	90,362	4,694,290
1991	324,752	3,817,452	566,360	96,507	4,805,071
1992	310,090	3,792,678	532,975	92,528	4,728,271
1993	287,048	3,908,575	524,790	83,733	4,804,146
1994	255,971	3,460,440	431,025	77,355	4,224,791
1995	228,023	3,009,063	398,562	74,413	3,710,061
1996	153,892	2,258,494	236,686	70,602	2,719,674
1997	135,618	1,911,639	187,095	59,586	2,293,938
1998	109,806	1,614,867	171,371	55,024	1,951,068
1999	97,879	1,503,175	151,134	47,417	1,799,605
2000	98,968	1,406,442	151,829	44,984	1,702,223

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

other regions was 151,829, 98,968, and 44,984 head in the northern, central, and southern areas, respectively (Table 21). The population trend of buffalo has been downward because of factors similar to those in the case of cattle but with greater emphasis on the replacement of animal power by hand tractors. The buffalo population is not expected to increase to the same number as in previous years in the near future since buffalo raising is comparatively more difficult than cattle raising. More labor is needed to look after the animals during watering and wallowing. In addition to this is their great dependence on water, unlike cattle. Labor looking after cattle could attend to other activities at the same time.

Pig production

Pig production in Thailand has changed from traditional or backyard production based on forest and other agricultural by-products and household wastes or leftovers as feed to industrial production systems that are more dependent on commercial feed and that involve more specialized equipment. It has also changed from raising low-yielding indigenous breeds to the high-yielding exotic breeds. Thai swine producers use three popular breeds of pig: Large white, Landrace, and Duroc. All these changes took place in the last decade, especially in the provinces around Bangkok, and catered to more discerning markets such as Hong Kong and Japan. Traditional systems have continued to be observed in very limited areas, however, especially in rural areas far from the cities. But the proportion of these systems has dwindled significantly over time.

Swine production and consumption have remained stable during the past decade (Table 22). Unless the export market for pigs and pig meat expands further, the growth rates in pig production and consumption will be more or less maintained. Table 23 shows the regional distribution of pig-raising households in Thailand. The central region accounted for 3.9 million head in 2002. In the northeastern, northern, and southern regions, the populations were 1.4 million, 1.1 million, and 0.7 million head, respectively.

More recent efforts to strengthen the pig industry were the revival of the traditional system of pig raising in line with the growing campaign toward the promotion of sustainable agricultural practices. This revival, however, involved more modern technology, especially that related to breed selection, feed management, housing, and animal

Table 22. Pig production and consumption in Thailand (million head).

Year	Pig production	Consumption
1992	8.67	8.34
1993	9.18	8.73
1994	9.79	9.85
1995	9.78	9.02
1996	10.23	9.46
1997	10.66	10.47
1998	9.38	10.09
1999	9.08	8.89
2000	9.48	9.36
2001	9.67	9.58
2001	9.80	9.70
Growth rate (%)	0.46	1.02

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

Table 23. Number of pigs by region in Thailand.

Year	Region				
	Central	Northeastern	Northern	Southern	Total
1984	2,387,485	1,229,449	1,272,945	453,157	5,343,036
1985	2,986,523	1,181,150	1,288,093	463,076	5,918,842
1986	3,189,965	1,153,302	1,141,806	387,447	5,872,520
1987	3,409,527	1,072,110	1,029,344	355,906	5,866,887
1988	3,033,011	1,221,207	1,130,287	355,894	5,740,399
1989	3,093,289	1,393,815	1,043,283	485,011	6,015,398
1990	4,059,541	1,448,421	1,284,897	556,851	7,349,710
1991	4,642,614	1,616,615	1,362,850	580,393	8,202,472
1992	4,466,067	1,594,233	1,515,526	756,842	8,332,668
1993	4,307,256	1,860,633	1,650,352	780,885	8,599,126
1994	4,636,895	1,523,744	1,545,303	773,458	8,479,400
1995	4,656,843	1,414,974	1,717,817	772,287	8,561,921
1996	5,332,550	1,360,637	1,194,921	819,779	8,707,887
1997	5,763,198	1,890,084	1,455,986	1,029,772	10,139,040
1998	4,846,228	1,688,647	1,257,636	979,764	8,772,275
1999	4,145,954	1,463,789	1,040,555	772,803	7,423,101
2000	4,393,218	1,391,184	1,195,630	781,024	7,761,056
2001	4,720,146	1,382,109	1,274,065	826,950	8,203,270
2002	3,978,677	1,142,126	1,105,955	762,394	6,989,152

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

health care. In 1992, 0.56 million households were raising pigs but about 99.3% were just secondary pig raisers in the sense that they had other activities as their primary occupation. These households took care of a few head in their backyard or close by their homestead, primarily to supplement household income. Included here are the traditional growers, some of them still using indigenous breeds. Most of these farmers are owners of small rice mills or are related to the owners of rice mills. They use the rice bran from rice milling as supplemental feed for their animals. The primary raisers, which account for only 0.7% of the pig-raising households, devote full time to pig raising. These were further classified into three groups according to the number of animals they hold per farm: small farms (with less than 100 head), 39.1%; medium farms (with 101–500 head), 40.0%; and big farms (with more than 500 head), 20.9%. The proportion of primary versus secondary pig raisers has not changed. Current observations indicate that the primary pig raisers have grown to about a million and the proliferation of the medium to big farms has been more rapid, whereas the small farms have been decreasing. Some existing primary pig raisers have more than 5,000 sows per farm.

Primary pig raisers are further classified according to whether they are independent, on contract, or of a commercial type as follows:

Independent farms. Independent farms range from small to large farmers, with animal numbers ranging from 1,984 to 2,002. The owners are responsible for all investments on inputs. The feed supply for production on big farms is usually their own formulation, which is a mixture of several raw feed ingredients. In the small to medium farms, feed used is usually a mixture of raw feed materials that are available in the local area (such as rice bran, broken rice, cassava, etc.) and commercial feed concentrates that are bought from the market. These farmers are responsible for slaughtering and marketing the animals.

Contractual pig raisers. Owners of contracted farms are responsible for some inputs such as housing and equipment, labor, water, electricity, and land. The companies they are in contract with are responsible for the animals, feed (which is mostly commercial feed), vaccine and medicines, technical advisers, and marketing. The farmer-contractor shares in pig sale proceeds, usually about baht 300 per fattening pig per crop or about baht 25,000 per 100 sows raised per month.

Commercial or industrial farms. Commercial or industrial farms are companies that operate their business in a vertically integrated fashion. They control every step from selection of breeding stock to marketing pork in the market. The feed resources are mostly produced by the feed industry section of their own company. Feed concentrates produced consist of raw materials from local and imported sources, especially protein sources (such as soybean meal and fish meal) from South America and China. Big industrial farms produce a large number of fattening pigs for domestic consumption (90% of production) and export to neighboring countries in Asia as processed products.

Poultry production

Among the subsectors within the livestock sector, the broiler industry has become the most important in terms of export earnings. Chicken production has been on the increase, too. Exports have been mostly to neighboring countries in the

Table 24. Production of broilers, 1998-2000, and native chickens, 1997-99, by region (unit = no. of birds).

Region	Broilers			Native chickens		
	1998	1999	2000	1997	1998	1999
Northern	61,676,927	63,555,931	64,090,285	30,691,302	30,859,312	33,733,067
Northeastern	76,743,327	80,534,944	83,115,970	39,887,242	40,736,911	43,172,041
Central Plain	614,456,148	640,157,348	674,289,629	12,050,452	12,090,309	12,720,223
Southern	66,898,521	69,316,043	69,469,091	8,862,858	8,972,959	9,713,673
Whole Kingdom	819,774,923	853,564,266	890,964,975	91,491,854	92,659,491	99,339,003

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

region, primarily to Japan. New finished or semifinished chicken products such as chicken balls and sausages are also helping to boost Thai exports. Native chicken production remains in the hands of smallholders.

Broiler production

Production of broilers in Thailand expanded dramatically over the period 1998-2000 (Table 24). The highest concentration of production is in the central region, with more than 600 million birds. There were only 83 million, 169 million, and 64.1 million birds in the northeastern, southern, and northern regions, respectively.

Broiler production is mainly operated by big agro-industry enterprises, for both domestic consumption and export. In 1999, Thailand produced 848.0 million broilers, of which 491.8 million are for domestic consumption and 356.5 million for export. Besides broilers, native chickens also contributed 13% to the total chicken meat produced. In the central part of Thailand in 1993, 6,029 commercial broiler producers could be classified according to their size (Table 25).

Broiler production is vertically integrated. Figure 6 shows the industrial broiler production system. The industry supplies inputs, chicks, feed, medicine and vaccine, housing and equipment, and marketing to producers in a form of credit and manages the slaughterhouse and packing system. The industry also operates the feed industry, parent stock, veterinary products, hatchery, and slaughterhouse down to meat products and products for export. Producers under contract simply operate the raising part. A small amount of backyard chicken production goes through this operation.

Types of broiler producers

Independent broiler producers make their own investments in inputs just like those in pig production. The price of broilers very much depends on demand and supply. These producers are limited in number.

Contracted producers, on the other hand, invest in housing, equipment, and labor while the contractor industry supplies credit in kind in the form of chicks, feed, and vaccinations. The price of output as well as its market are guaranteed although sometimes these do not work well. Credit is deducted from income derived from broilers sold.

Table 25. Classification of broiler producers according to farm size.

Farm size (head)	%
500–2,000	16.72
2,001–5,000	36.63
5,001–10,000	24.43
Over 10,000	20.22

Source: Modified from Office of Agricultural Economics, and Department of Livestock Development of Thailand (2001).

Agribusiness-type farms usually cater to both local and export markets. In 2002, 20 million chicks per week were produced from this type for domestic consumption and export. In 2003, chicken meat exports to the European market increased because of concerns about food safety with the outbreak of mad cow disease and bird flu. As a result, production expanded to 21.5–24.0 million chicks per week. Most of the big producers improved their production system and even tried to establish disease-free and high-quality controlled-colony farms primarily to cater to the import demand of the European market.

Native chicken production

Native chicken raising (13% of national chicken meat production) has been with smallholder farmers in Thai rural society for a long time. It is part of their traditional livelihood. The native chickens are raised primarily for animal protein, for entertainment (cock fighting), and minimally for sale in the domestic market as well as for the export market. With the greater emphasis on genetic conservation, the production of native chickens has become more and more popular.

Native chicken production is highest in the northeastern region, with 43.2 million birds. The numbers were 33.7 million, 12.7 million, and 9.7 million in the northern, central, and southern regions in 2000, respectively (Table 24). Most native chicken production is for domestic consumption in both rural and urban areas, with a value of about baht 5,960 million (baht 60 each) in 1999.

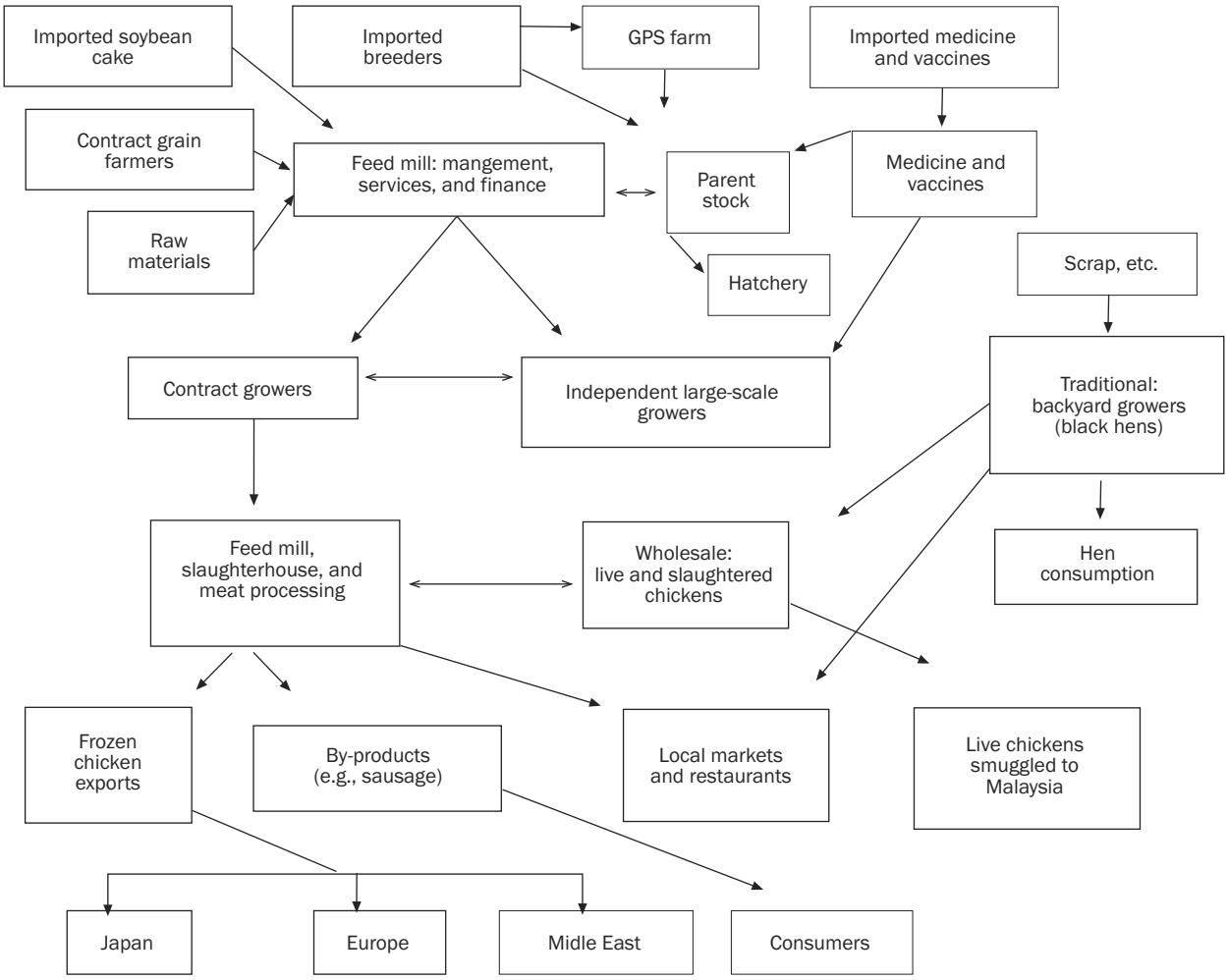


Fig. 6. Inputs and outputs in the commercial Thai chicken industry. Source: cited from Falvey (2000).

Because of the higher price of fighting cocks, more farmers have gone into raising them to take advantage of the value added in profits, especially when these are exported. Many of the raisers have become very particular regarding quality improvement through better breeding and selection procedures. To ensure this, Conservation and Development of Cock Fighting Assemblies (CDCFA) have been established in almost every province. The fighting-cock production system is shown in Figure 7.

Fighting cocks are exported to many countries, with the biggest import demand from Indonesia (Table 26). Fighting-cock orders from this country alone are for 500 good-quality cocks per month at a price of baht 5,000 per head (Pradthana Ngarmwongwarn 2001). Unfortunately, farmers could not meet that country's requirement. Other country importers of fighting cocks are Malaysia, Brunei, the United States, and more recently some countries in the Middle East.

Other animals with good economic potential

Besides livestock production, two kinds of exotic animals were introduced into Thailand as alternative species to help increase income of farmers.

1. *Deer production.* Thailand started to use exotic breeds of deer about 10 years ago for velvet and meat production. Initially, 970 Rusa deer were introduced in 1997 by the Cooperative Deer Raisers of Thailand. The other deer breed is Sika, from Vietnam. The big farms are in the northeastern region (Nongkai and Nakorn Ratchasrima provinces). The wild native deer, Samba (*Cervus unicolor*), is prohibited by law for both raising and production, although it yields good-quality velvet. The price of Rusa and Sika deer is about baht 35,000 each and baht 50,000–70,000 each, respectively.

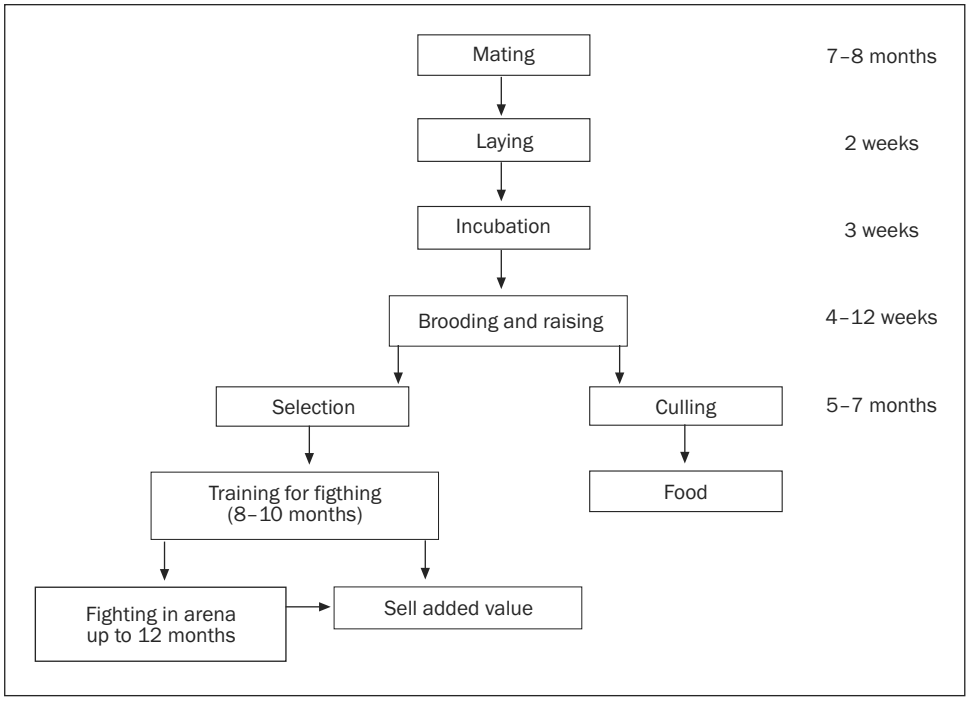


Fig. 7. The fighting-cock raising system.

Table 26. Fighting cocks exported from Thailand.

Export country	1998		1999		2000		2001		2002	
	Birds	Baht[a]	Birds	Baht	Birds	Baht	Birds	Baht	Birds	Baht
Total	1,937	953,900	3,628	4,702,260	5,437	6,446,000	5516	8,138,000	5666	3,089,900
Indonesia	1,737	863,500	3,513	4,572,000	5,204	6,212,500	5272	7,801,000	4459	2,219,900
Malaysia	25	12,500	0	0	75	37,500	112	194,000	266	359,000
U.S.	6	3,000	7	6,500	17	31,000	18	14,000	30	15,000
Philippines	11	3,000	0	0	0	0	0	0	0	0
Myanmar	0	0	0	0	0	0	20	30,000	45	51,500
Vietnam	0	0	0	0	2	2,000	0	0	2	1,000
Brunei	10	5,000	26	31,220	14	7,000	14	7,000	31	15,500
Laos	2	400	0	0	0	0	0	0	0	0
Cambodia	0	0	20	4,000	0	0	0	0	1	500
Hong Kong	0	0	0	0	55	65,000	0	0	0	0
China	0	0	0	0	14	10,000	0	0	0	0
France	0	0	0	0	17	20,000	10	20,000	11	5,500
United Arab Emirates	0	0	0	0	15	23,000	12	6,000	23	11,500
Kuwait	0	0	0	0	2	4,000	0	0	505	252,500
Bahrain	0	0	0	0	5	0	42	58,000	286	154,500
Switzerland	0	0	0	0	13	26,000	0	0	0	0
Other	146	66,500	62	88,540	4	8,000	16	8,000	7	3,500

[a]Currency rate: baht 40 = US$1.
Source: International Animal Quarantine Station, Bureau of Disease Control and Veterinary Service, Department of Livestock Development (2001).

Table. 27. Marine fishery shrimp production (including aquaculture) in Thailand, 1996-2000.

Item	Year				
	1996	1997	1998	1999	2000
Production (000 t)	3,112.1	2,979.2	3,076.6	3,166.4	3,240.7
Value (million baht[a])	88,844.8	97,533.2	109,907.1	118,947.1	142,004.3

Source: Division of fishery economics, Department of Fishery (2003).
[a]Currency rate: baht 40 = US$1.

Table 28. Inland fishery production (captured and cultured) by regions, 1996-2000 (unit: 000 t).

Region	Year				
	1966	1997	1998	1999	2000
Total	437,091	405,211	429,196	459,457	472,511
Northern	112,979	102,346	104,124	99,632	102,568
Northeastern	133,937	114,627	119,723	135,626	134,752
Central Plain	164,076	169,084	183,778	199,205	206,934
Southern	26,099	19,154	21,571	24,994	28,257
Total value (million baht)[a]	11,781	11,109	14,639	15,175	15,458

Source: Division of Fishery Economics, Department of Fishery (2003).
[a]Currency rate: baht 40 = US$1.

2. *Ostrich production.* In the Ninth National Economic and Social Development Plan (2002-06), ostrich (*Struthio* spp.) production was introduced. This is a ratite bird, which is raised for its skin, meat, and feathers. Presently, the major constraint to production is marketing because the channels are still not well established. A day-old ostrich chick costs about baht 2,500–3,000 each, and a one-year-old bird costs about baht 15,000–20,000 each.

Fish production

Fisheries in Thailand can be classified into marine, coastal (shrimp farming), and inland. Marine fishery by capture can be divided into commercial and small-scale enterprises based on the device/equipment used and the technology. Almost 80% of the total fish production comes from marine-capture fishery. The tonnage of marine capture and shrimp production did not change much but the value increased greatly from 1996 to 2000 from baht 88,844 million to baht 124,004 million (Table 27). Shrimp farming is located primarily in the coastal areas of Thailand and the country gained the position of being the largest exporter of shrimp in 2001. However, the establishment of about 25,000 shrimp farms has been causing great environmental damage to the mangroves and other natural habitats of marine species.

Inland fishery can be classified into five production systems: traditional rice-fish capture, pond culture, paddy field culture, ditch culture, and cage culture systems. Traditional rice-fish capture is practiced in the lowland and is most popular in the Tong Kula Longhai area in the northeast region. However, in terms of productivity, cage-culture fish is the most effective system. In addition, livestock-fish farming systems have also become very popular recently. Nile Tilapia, catfish, and Thai silver carp are the most popular freshwater species in Thailand.

From 1996 to 2000, inland fish production increased from 437 to 472 million tons (Table 28). The central region has the highest production at 206 million tons, while the southern region contributed only 28 million tons. The northeastern and northern regions produced 134 and 102 million tons, respectively. The total value of inland fish production in the country in 2000 was baht 15,458 million.

Policies, programs, and agricultural development

Thailand has indeed successfully developed its agriculture to become a vibrant and dynamic sector catering to not only domestic consumers but also to the export market. Through various government policies and programs, the agricultural sector was gradually restructured. This has been indicated in the production trends of various agricultural commodities as discussed briefly in the last two chapters. The shifts in production focus were brought about by significant changes in production systems and agricultural practices as the move toward greater industrialization heightened. Monoculture and production in a more specialized

and commercial manner took over the traditional systems practiced prior to the adoption of the country's 1st National Economic and Social Development Plan; thus, the significant alteration of crop and animal mixes. The following section briefly discusses the various policies and programs that influenced agricultural development and how these have been biased against the promotion and strengthening of integrated crop-animal systems.

Price intervention to promote import substitution

The 1st National Economic and Social Development Plan in the early 1960s clearly indicated the dual role of the agricultural sector as a provider of foreign currencies needed to finance the move toward industrialization as well as a provider of cheap food sources for the rapidly growing urban and industrial population. As a provider of cheap food, agricultural policy emphasized further improvement of yield and production intensification to increase productivity. The Central Plain of Thailand took advantage of the policy where a full-scale Green Revolution took place. In this area, double and triple rice cropping became widespread with massive applications of fertilizer and pesticides. Farm mechanization, especially plowing tractors and combine-harvesters, was introduced and has predominated in the region since the mid-1980s. The monoculture of rice, in particular, left little time for farm households to do anything else, not even raise animals or cultivate other crops. This started the move away from integrated farming systems.

As Thailand is a major export earner, price intervention was imposed in the form of export taxes on agricultural raw materials, including rice, primarily to increase the foreign exchange revenue of the government. At the same time, domestic price subsidies were provided to help raise farmers' as well as millers' income while passing on to consumers lower-priced food (Siamwalla 1991). This was in line with the government's cheap food policy that later on proved to be very expensive. In fact, government intervention did not yield good results as farmers started to shift away from producing export goods such as rice. It also harbored inefficiency among farmers even in the major production areas, which hurt the agricultural sector as a whole.

Market liberalization for export promotion and industrialization

The 1980s saw another change in Thailand's trade policy that shifted explicitly in the direction of export promotion, thus reducing export taxes and devaluing the baht. At the same time, protection of local industries and local tariffs decreased. The liberalization of Thai trade and the financial systems presumably promoted the expansion and commercialization of agriculture in formerly remote areas (Coxhead and Phagpraphan 1998). Farm production began to be vertically integrated with factory processing and agribusiness management. These trends, along with infrastructure development, facilitated specialization in agricultural economies even in those areas where subsistence concerns formerly dominated land-use decision-making. The restructuring of the agricultural system came about to curb the simultaneous occurrence of the end of the land frontier, the fall in agricultural prices (particularly for staple crops), and the industrial boom that confronted Thai farmers with a cost-price squeeze. Government efforts gradually shifted production away from upland rice and maize cultivation geared primarily for domestic consumption to the more intensive cultivation of high-value crops such as sugarcane and cassava (because of their good export prospects until the late 1990s), and more recently vegetables, flowers, fruit trees, bamboo, cattle, and milk cows that were primarily absorbed by the manufacturing sector (TDRI 1995).

Various programs have been launched to promote and facilitate agricultural restructuring. One such program is the One Tambon One Product (OTOP) program that stimulates each village to get involved in the local processing of food, including meat, fish, fruits, and/or vegetables rather than selling them raw in the market. A similar program is the One ฿ Million One Village that provides capital investment for villages to venture into expanding agricultural opportunities and projects. As overall support for these development programs, credit systems were expanded and strengthened and farmers' existing debts were restructured, extending their debt payment for an additional three years.

The transformation of highland agriculture in northern Thailand provides a vivid example of how the restructuring policy has made an impact so far. Just about two decades ago, food cultivation in the highlands of this region consisted almost exclusively of rice, maize, and minor vegetable crops, all grown primarily for susbsistence. A majority of the rural population derived its income primarily from agriculture. Animal-drwn carts were the only means of transportation over roads that became effectively impassable during the rainy season. Poverty was endemic, and average levels of educational attainment extremely low. Today, however, most agriculture is commercially oriented, and remote households that once produced subsistence staples almost exclusively are now able to produce a much wider range of crops—notably fruits and vegetables—for distant urban markets, taking advantage of paved roads, pickup trucks, and cellular phones. Farm households, especially their children, have increasingly participated in off-farm and urban labor markets. For the typical farm family, all these changes have raised real income and reduced vulnerability across seasons and years.

The overall success of the agricultural restructuring policy will still have to be evaluated, however, not only on the basis of its economic impact but also its long-term effect on the environment, as this has primarily taken place in the more fragile upland areas. Much of this success is contingent upon the ability of the government to provide adequate technology to sustain and further improve productivity in

these crops as the private sector's contribution may be much smaller than expected. It is also contingent upon the development of markets for these "new" high-value products that would encourage farmers to invest in infrastructure and equipment to sustain the systems. Except for rice, the domestic prices of all major agricultural products are determined by prices in the world market, which Thailand has too small a part of to influence in any significant way.

Promotion of more sustainable agriculture

Past agricultural policies have harbored specialization and commercialization, even in the remote rural areas, and drifted away from what was once the traditional production system based on integrated farming, including crop-animal integration. Concerns about sustainability are now increasing from all sectors, including the government; hence, the King's new theory of encouraging and reinvigorating agricultural production based on the sustainable use of natural resources with minimal impact on ecosystems and the environment. The 8th and 9th National Economic and Social Development Plans embody more strongly, although vaguely, the concept of "sustainable agriculture" based on natural farming, organic farming, integrated farming, and agroforestry. With this new policy development, crop-animal integration can again be at the forefront, especially in the countryside of the north and northeast regions where farmers are poorest and income from crop cultivation, particularly rice, is most meager because of the small landholdings.

Policies specific to the development of the rice sector

Thailand aims not only to maintain its position as a top exporter of rice but also to dominate the market for high-quality rice. In line with this objective, greater efforts have been channeled into improving production efficiency and maintaining high grain quality standards, thus the continued focus on technology development through research, improvement of postharvest and infrastructure, more strategic market expansion, and promotion. Rice research stations have long been established all over the country and all these are fully functioning. Research is geared primarily toward higher-quality grain from breeding to marketing, but the achievement is still fragmented. Research on rice by-product development for value added is very much a part of the rice research agenda, but until now has been limited.

Rice exporting is mostly in the hands of the private sector. However, government support is primarily for improving the mechanism to facilitate and expedite export procedures. It has also helped in advertising Thai rice by setting up "road shows" in different countries to promote Thai products, such as rice, especially jasmine rice, and promote new rice varieties such as organic rice. With its more liberal market policy, the government no longer intervenes in commodity prices as it did before but tries to establish different mechanisms to help keep the price from going down and to see to it that rice farmers receive a fair proportion of benefits from selling rice.

Specific policies to further develop the livestock sector

Numerous policies and initiatives directly or indirectly influence livestock production, processing, and marketing. The more relevant ones that have implications for strengthening integrated crop-animal systems are presented below. Note that some of these policies/initiatives have already been mentioned earlier.

Farmer debt restructuring. The program allowed a number of indebted farm households, some of them involved in integrated farming, a three-year grace period to repay their loans. It also provided seed capital for raising cattle and/or buffalo. This program supports the agricultural restructuring effort of the government.

One ฿ million one village. One ฿ million one village appears to play an important role in reviving the livestock population, especially cattle. Because of the high present value of cattle, many farmers use their share of this available budget to buy livestock and incorporate them onto their farms.

Sustainable agriculture. Organic farming, alternative agriculture, or integrated farming systems are included. These practices are similar and they generate more demand for livestock manure; thus, livestock can be integrated into the systems and this in turn stimulates livestock raising and manure trading. In certain provinces, organic farming has become a provincial policy. Government and nongovernment agencies are involved in extending these practices. Local farmer organizations and their networks are creating social movement in this direction. Organic livestock farms have started to emerge now.

Sufficiency economy. This is proposed by the King and has become a strong trend and more or less a development policy by emphasizing self-reliance. The system also created a similar demand for livestock raising and manure as with the above group of practices.

Contract farming. Contract farming, though it has not been spelled out clearly as a policy, is increasing. The most obvious activities are broilers, layers, swine, and fish.

Livestock bank. A livestock bank, especially cattle and/or buffalo banks, has long been promoted and established by the King, government, and nongovernment sectors. Failure and success are reported.

Charity fund raising or donations. Charity fund raising or donations as cash or as animals to save livestock, especially cattle or buffaloes, from being slaughtered have been with the Thais for a long time. This practice is based on Buddhist beliefs and it is also linked to the livestock bank. Both the livestock bank and livestock fund have helped in the redistribution of livestock back into rural areas.

Slaughtering license. Issuing a license to slaughter pigs, cattle, and buffalo has recently been passed down to the tambon level. This resulted in more widespread meat selling stalls in rural areas (issuing of the license is under the Local Administration Department, Ministry of Interior).

Dairy promotion (1997-2001). This program is to increase the quality and quantity of milk production; the production target is 3.6 t per year per animal. Within five years, 40,000 dairy cows would be extended to farmers. Before this program, there were policies related to dairy such as Dairy Products Manufacturing (Ministry of Commerce 1985), by which recombined-milk producers must use fresh milk to recombined milk or skimmed powder milk to fresh milk at a ratio of 1:1 or 1:20, respectively. This enlarged the market for locally produced fresh milk and the dairy population. There has also been a program known as school-milk since 1994 for school children in rural areas. At present, local fresh-milk processors must buy fresh milk from farmers and supply school-milk to schools in the area. A milk-drinking campaign has also been promoted to increase milk consumption.

Livestock development policy (2003). The Department of Livestock Development (DLD) has recently undergone some restructuring to improve its delivery of services to efficiently and effectively meet public-sector needs. The commitments are embodied in the new livestock development policy and include

1. Research and development that aim to increase the potential of livestock and livestock products in the country and abroad.
2. Technology transfer and service. There are two target groups for this service, subsistence farmers and commercial producers. The recently established center for technology transfer at the tambon level all over the country would be used as the coordinating body for subsistence farmers.
3. Provision of basic infrastructure. Vaccine production, the central cattle and buffalo market, milk laboratory facility, and slaughterhouse would be improved and/or established.
4. Information technology. A national network of information by using information technology would be established to provide public accessibility.
5. Laws and regulations related to several isues involving livestock would be revised or promulgated to provide justice to both producers and consumers. These issues include food safety, standardization of livestock farms, etc.
6. Cattle and buffalo market. A one-day-a-week cattle and buffalo market has long been promoted and has become a normal activity in many areas. This market stimulates a lot of movement of live livestock. However, it produces both positive and negative effects on the livestock population. It is part of a livestock outlet for farmers, but a group of traders could make an unfair profit. This facilitates the movement of livestock to the slaughterhouse, thus helping to reduce the livestock population.

Trends and potential of ICAS

ICAS development in the past

After industrial development, Green Revolution development, and several socioeconomic development plans, which emphasize only economic gain and markets without concern about human resource development, equity, autonomy, and environmental value, Thailand realizes that changes are needed. Therefore, the 8th and 9th socioeconomic development plans emphasized human resource development, empowerment, good governance, a self-sufficient economy, environmental protection, and conservation and sustainable development. Lessons learned from the past, particularly those that have a bearing on the growth of the agricultural sector and have affected its immediate beneficiaries, are summarized below:

1. Wider gap between rich and poor.
2. Natural resource degradation and environmental pollution.
3. Extensive monocropping and less biodiversity.
4. Unplanned urban development and growth that increased dependence on the rural sector.
5. Rural-urban labor migration within the country and inmigration from neighboring countries.

Extensive monocropping and changes in cropping patterns imply many complications. These practices affected the animal sector. They reduced animal grazing area, promoted farm mechanization, decreased demand for cattle and buffalo for draft, which affected their prices, and reduced the animal population, especially cattle and buffaloes. It should be noted that the need for mechanization also resulted from the increased outmigration of farm labor to urban areas. These practices also necessitated an increased use of chemical inputs to support the intensity of rice production. As farmers do not have sufficient capital to cover production expenditures needed, they start to depend on financial institutions or private lenders that charge very high interest rates. Lastly, the practice of monocropping also increased deforestation and environmental degradation, which greatly affected the natural food resources on which rural people depended. ICAS was weakened.

At the same time, the animal sector also witnessed the growth of commercial pig, broiler, and layer farms that have to depend on feed sources that are external to the farm. Similar to the rice farmers, the big animal growers also have to depend on financial establishments for their capital needs to purchase commercially produced animal protein and fish meal. As both endeavors were meant to be market-oriented, they benefited some farmers but not all. A majority of the smaller farmholders fell into a vicious circle of debt. This scenario is in contrast to the integrated (ICAS) and subsistence systems of the past when farmers were free of debt and were more autonomous.

At present, only ducks and/or native chickens are generally observed as an integrated component of rice farming. However, returns to the cattle and buffalo population, to a lesser extent, are observed in certain areas where the cropping pattern is less competitive to livestock raising (grazing). This is probably also due to a more favorable price.

Potential for further ICAS development

The above scenario is a great challenge to the development of ICAS. Key questions are: How can ICAS be put back into the present farming systems, which are different from the past systems? What will be the system models? What should be the strategies?

As indicated in the policy section, the last two national socioeconomic development plans have adhered more strongly to the principles of integrated farming, a favorable sign for ICAS to return as an important component in production systems. It is inevitable that the Thai population will increase in spite of successful family planning and people in the cities will advance further with higher education and more health consciousness. Demand for healthy animal protein will certainly increase.

The strategy is to build up enough information to locate the area and type of households that have potential for the purpose. People in these areas must be helped to be ready for ICAS. But this has to come with a concept of sustainable development, a self-sufficient economy, and self-reliance at the initial phase. At the same time, favorable policy must be reinforced with the horizontal integration of all implementing agencies.

Research and development must be directed and integrated toward the purpose with budgetary support. It has to be clear that results must be usable by the small farmholders. Therefore, participation of the concerned parties is a key to success. Research organizations, policy, programs, planning, and goals have to be structurally reorganized. Research to gain lessons learned from the ICAS-practicing farmers and their network will be useful for expansion. Research has to also generate or improve existing techniques to increase the population of appropriate breeds, improve feeding systems, prevent disease, and do management with sustainability in mind. Sustainability must also be holistically covered and clearly defined by all concerned parties and linked with ICAS. In fact, ICAS is technically a part of sustainable farming systems. Native breeds and indigenous technical knowledge have to be exploited and carefully integrated with modern knowledge.

On the other hand, commercial farms, where and when appropriate, should be further developed. More research is also needed, but with technical management these farms can look after themselves. Strategically disease-free farms and areas must be developed for export purposes. Animal processing and product quality standardization are needed for the same purpose and for domestic consumption. Policy adoption and implementation for both small farmholders and commercial farms must be carefully managed so that they are complementary instead of competitive.

Future ICAS (prospectus)

It is clear from the view of population growth, migration, and expansion of urban areas that demand for animal protein, including fish and shrimp, will increase in the future. On the other hand, the number of smallholders and household size are declining, but a majority of them will continue to grow rice. At the same time, big enterprises related to livestock production will expand because of both domestic and export demand. Key questions are, Who will practice rice-based ICAS? Where will it be practiced? What will be the production systems? Answers to these questions are not easy because Thailand is going through very dynamic socioeconomic changes. However, projection trends can be discussed.

In the previous chapters, statistics indicated that broiler production will be operated by big commercial farms themselves and through subcontract farms in a vertical fashion. These big operators will cover the complete cycle of production systems, from providing major inputs to marketing and export. The systems used are not smallholder ICAS. The industry is growing fast. A similar pattern follows for swine production but there is a larger proportion of independent commercial farms. Smallholder swine producers are limited and sometimes integrated with rice-based fish raising. Layer chickens are also in the hand of big enterprises and independent commercial farms mostly concentrated in the central region. However, limited rice-based layer integration can be observed. Shrimp production is concentrated in the coastal area and mostly on big farms. It is expanding because of export demand. Therefore, the remaining livestock production that can be integrated into rice-based farming is native chickens, and other comparatively minor poultry such as ducks or geese, buffalo, cattle, dairy cows, goats, and fish. However, the future practice of ICAS needs to be discussed in terms of limitations and opportunities.

Buffalo

The declining buffalo population, labor outmigration, and loans from financial institutions for agricultural inputs had contributed to more and more farm mechanization and less animal (buffalo) power use. Even though small farm machinery is relatively expensive and its function depends on mostly imported fossil fuel that is also expensive and not renewable, livestock can be bred and raised by farmers with low inputs and without pollution. But buffalo raising is comparatively more difficult than cattle in terms of labor and water requirements. The buffalo population is concentrated in the northeast region.

However, under labor-shortage circumstances, farm machinery can help farmers finish their work faster and on time and no labor is needed to look after the livestock. Many years of chemical fertilizer use resulted in a hardened soil surface; therefore, ploughing by hand tractor is easier than using a buffalo. Therefore, the opportunity to include buffaloes in the rice-based system by smallholders for animal power is limited. But, the higher price and need for manure, especially in organic farming, and the availability of a suit-

able grazing area and village loan could provide some opportunities.

Cattle

The cattle population pattern is similar to that of buffaloes, but presently their population is increasing. The opportunity for low-input cattle raising under the rice-based system is greater than for buffaloes because of the current higher price and government village loan policy. Cattle are easier to raise because of less labor demand and available free feed resources. However, the continuing changes in cropping patterns have limited grazing area and feed resources and the higher initial investment may exclude smallholders. Integrated rice-based cattle raising is concentrated in the northeast region.

Dairy

Dairy production is mostly in the hand of smallholders, with a majority in the central region. Growth of dairy production is very slow now because of the high investment cost, intensive management, and competition with the lower price of imported powdered milk. Some farmers still hold on to the rice-based system.

Native chickens

Low-input native chicken raising will continue to be a part of rice-based farming systems among smallholders all over Thailand. But growth of this system is very slow or constant because of frequent disease outbreaks. However, fighting cocks, which are also native, have raising systems that could expand among smallholders and beyond because of the high price, export demand, and current trend of indigenous and cock-fighting sport value.

Other poultry

Other poultry such as ducks will be raised by smallholders under low-input systems as with native chickens but very limited in number compared with native chickens. But, some relatively large farms using rice grain left over in the field from harvesting also exist in certain areas such as in the Central Plain or other lowland areas.

Goats

Goats are raised by some smallholders in the southern part of the country, mostly in Muslim communities. They may or may not be integrated with rice farming.

Freshwater fishing

Low-input fish raising will be dominant in rice-based integrated farming for smallholders in all regions of the country, especially in lowland areas where water resources can be managed.

The practice of developing small ponds within landholdings of households is growing very fast and will continue to grow. Small fish ponds plus livestock such as cattle, native chickens, or other poultry, and minor crops in the form of home gardens fit the King's concept of a self-sufficient economy and his idea of small-scale sustainable water management, which is now promoted by the King himself and various government and nongovernment organizations. This practice goes well with the increasing trend of organic farming and demand for healthy food. In the long term, investment is very low. However, there are some limitations such as topography and water-holding capacity of the soil, especially in the southern, northeastern, and northern regions.

In conclusion, major animal protein production will be in the hand of big and specialized enterprises. Smallholders will practice ICAS, but their number may decrease over time. At present, natural resources that have been used as bases of livelihood by rural smallholders are declining fast. Therefore, the productive agricultural labor force continues to move out of rural areas. In the long term, a new generation of people with higher education preferred to live in urban areas. This will have a strong impact on ICAS development, unless the concept and values of self-reliance, local community, and sustainable development are reintroduced effectively.

The survival of ICAS depends on how the policies and measures discussed above are properly implemented. It also depends on the direction of the country's development objectives. If agricultural specialization and commercialization, especially for export, are emphasized, integrated farming systems, including ICAS, would decline. However, integrated systems are still vital to poor smallholders' survival. Because they do not have access to high investment capital and large land resources, most of them practice integrated systems. Most of these farmers are in the northeast region and to some extent in other regions. Particularly, in the northeast region, cattle, buffaloes, and native chickens have been part of their livelihood. Even though the cattle and buffalo populations have been declining, they are coming back to the scene. Moreover, land unit classifications with different models of integration, presented earlier, are important in this region.

References

CIA. 2002. World's fact book: Thailand. Central Intelligence Agency. Available at www.odci.gov/cia/publications/factbook/index.html.

Coxhaed I, Phangpraphan J. 1998. Thailand's economic boom and agricultural bust: some economic questions and puzzles. Staff paper series No. 419. Department of Agriculture and Applied Economics, University of Wisconsin-Madison.

Department of Livestock Development, Ministry of Agriculture and Cooperatives. 2004. Available at www.nso.go.th/syb2001/agricult2001.pdf.

Department of Provincial Administration. 2003. Population status in Thailand during 2536-2544. Ministry of Interior, Bangkok.

Division of Fishery Economics, Department of Fishery. 2003. Available at www.fisheries.go.th/stat/t-612.htm.

Falvey L. 2000. Thai agriculture. Kasetsart University Press.
International Animal Quarantine Station, Bureau of Disease Control and Veterinary Service, Department of Livestock Development. 2001. Available at www.dld.go.th.
Mongkolsawat C, Laopaiboon B, Jaruratjamon P, Pakdee P, Ngarm-Sak S. 1988. Studies on models of mixed-farming as related to administration and management of natural resources and ecosystems: a case study of Ubon Ratchathani, Thailand. Faculty of Agriculture, Khon Kaen University.
NSO. 2003. National Statistical Office Thailand. Available at www.nso.go.th/eng/stat/stat.htm.
NSO. 2004. National Statistical Office Thailand. Available at www.nso.go.th/eng/stat/stat.htm.
Office of Agricultural Economics, and Department of Livestock Development of Thailand. 2001. Available at www.oae.go.th/satatistic/yearbook/.
Office of Agricultural Economics, Ministry of Agriculture and Cooperatives. 2003. Available at www.oae.go.th/statistic/index.html.
Office of Cane and Sugar Board and Office of Agricultural Economics. 2003. Available at www.oae.go.th/.
Siam Fighting Cock Magazine. 4(1):80.
TDRI (Thailand Development Research Institute). 1995. Agricultural diversification/restructuring of agricultural production systems in Thailand. Paper prepared for the Food and Agriculture Organization, United Nations.
The Metrological Department, Ministry of Information and Communications Technology. 2003. Available at www.tmd.go.th/index.php.
U.S. Bureau of the Census. 1998. International brief of world population at a glance: 1998 and beyond. U.S. Department of Commerce. Economics and Statistics Administration: IB/98-4. Available at www.census.gov/ipc/ prod/wp98/ib98-4.pdf.

Notes

Authors' address: Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.

Section 3

Integrated crop-animal systems in rainfed rice lands: a Philippine study

F. Talens Rivera, P.A. Alviola, M.A. Sombilla, and G.C. Cataquiz

Preface

This publication uses the Preface differently. For the first time perhaps, instead of using this space to examine highlights and discuss their importance to the advancement of integrated crop-animal systems (ICAS) research and extension (R&E), especially in the light of the changing rural community and agricultural, technological, and ecological development and policy decisions in the rainfed rice ecosystem, we take this opportunity to explain the philosophy, vision, mission, goals, objectives, and core values for supporting the activities undertaken under it.

This Preface is a statement of principles, a precondition to give direction to ICAS R&E as a strategy for easing the pain of living and improving welfare within a three-pronged sustainable development challenge at the barangay level—the local community and farm household; complex, diverse, and risk-prone (CDR) agriculture; and an Earth care systems view.

Philosophy

Social justice is for all—less for the self, more for others, enough for all, and all for God.

Prioritizing and promoting ICAS on small rainfed lowland rice farms as an area of urgent concern will reduce poverty and inequality, and somewhat eliminate bias toward more well-endowed irrigated lowland rice farmer households.

Vision

Productive small farmer entrepreneurs and their families live happily and peacefully in safe, secure green communities on 1.4 million ha of rainfed rice land providing the sustenance required for all.

The Philippine vision of agriculture and fishery modernization is clear—enough food (rice, fish, meat, milk, and eggs) on a poor family's table, assured higher education, labor productivity, better nutrition and health, using and promoting environment-friendly technologies, with our children's children living happily in a safe, secure nation governed by professional leaders.

Mission

The sustainable productivity of small rainfed rice farms will reach about 40% from behavioral and social reform, ICAS R&E methodological and technological reinventing, small farmer entrepreneurs' ownership of competitive home-grown ICAS enterprises, and the active participation and solidarity of farm families in their own sustainable development.

Goals

The goals are productivity, social acceptability, ecological soundness, equity, economic viability, and efficiency (Agenda 21).

Objectives

The objectives are

- To improve smallholders' livelihood systems.
- To reduce poverty and inequality and at the same time improve human welfare.
- To use environment-friendly technologies such as ICAS intensively without compromising the welfare of future generations.
- To manage available local resources and enjoy government-NGO support services for appropriate ICAS technology adoption while maintaining environmental quality and conserving natural resources.

Suggested core values as a covenant of stakeholders in ICAS improvement, innovation, and change

The following values are essential: simplicity, integrity, and commitment; accountability, responsibility, and transparency; conservationism and volunteerism; a work ethic; and servant leadership and citizen modeling.

All this underscores the value of human and societal conditions as a prerequisite for supporting a farm household total food/feed systems approach to sustainable agroindustrialization, of which ICAS R&E on rainfed rice farms for sustainable rural development is a major strategy.

Introduction

Small rice farmers, especially those on rainfed rice lands, are beset with multifarious problems. Among others are the high cost of living, costly farm inputs, including the La Niña and El Niño phenomena, declining rice productivity, flooding of the market with cheaper imported products, transportation costs, the low price of paddy, and dwindling income. Hence, there is a common perception among these farmers that monocrop rice production is becoming a poor livelihood option. On rainfed rice lands where one cropping season followed by fallow is common, the socioeconomic situation of small rice farmers may be even worse.

In contrast, some small rice farmers have traditionally practiced mixed crop-animal farming. They use farm residues, by-products and wastes, surplus grains, and leftover food scraps for raising animals. Casual observation shows that cattle, carabao, goats, chickens, ducks, and sometimes sheep and fish are the main species raised as primary or secondary components with rice, maize, and vegetables. This type of farming is said to be better as it increases farm income by 20% or more. For many small farmers, animal raising is a form of status symbol and security that anchors the family for the children's education, expenditures for special family occasions, social obligations, and changing lifestyles, which in the Filipino culture are large expense items.

A new scenario looms ahead. Livestock and poultry are the most important economic subsector over all agriculture. As population and urbanization increase, and economic reform leads to higher gross domestic product (GDP), the demand for animal products will grow stronger. In the Philippines, the combined consumption of beef, mutton, chevon, pork, poultry, eggs, and milk rose by 50% from 1973 to 1996 (Gonzales 1998). Domestic consumption alone will spur the growth of this sector. In the short term, this augurs well for animal producers and agribusiness entrepreneurs.

Fish, another potential ICAS component for increasing the protein supply for Filipinos who eat rice and fish, will also become important, especially if the chief waterways, both saline and fresh, continue to deteriorate in quality so that Philippine fishery productivity, although growing now, may still decline if environmental care is not sustained.

At the same time, trends in rice production indicate that becoming self-sufficient in this primary staple may still take a few years to attain, and rice exports for augmenting needed foreign exchange an even longer time. The opportunity to attain self-sufficiency and to export premium-quality organic rice still forms part of making rainfed rice lands become more productive with livestock and poultry playing a triple role: community and farm household livelihood systems; complex, diverse, risk-prone (CDR) agriculture; and a rainfed rice ecosystem improvement strategy.

Today, other benefits claimed from ICAS are better resource use, increased production per unit of land and cost of production, and improved nutrition and health because of a larger supply of protein.

Crop-animal interactions demonstrated that the use of crop residues and farm wastes as animal feed and the use of animal power and manure on crops are considered a good strategy for efficient resource allocation and environmental conservation. Livestock and poultry can improve soil quality as their manure is a natural ingredient for soil fertility. Partial or full organic fertilizer replacements can significantly reduce inorganic inputs and enhance soil conditions.

To find out more about the socioeconomics of ICAS, this study was undertaken, reviewing studies conducted for the last two decades. The results will be used as background resource material for a proposed project on sustainable food-feed systems and improved livelihoods of the poor on rainfed rice lands, with the Philippines, together with four other countries in Southeast Asia, playing a catalytic role.

Rationale

Why is there a need to look at ICAS in the Philippines today? The following reasons are given:

1. As a strategy for increasing the productivity of rainfed rice lands and resource-use efficiency, alleviating poverty and inequality, practicing conservation agriculture, and intensifying the role of women and youths in total food/feed farming systems.
2. Livestock are becoming the most important subsector in agriculture, as stated earlier, because of declining income from rice alone, runaway population growth, increased demand for meat, milk, eggs, and other products because of more education, awareness of family nutrition and health, food substitutions such as rice for maize, and changing lifestyles.

Results of the study are important inputs into identifying ICAS R&E issues and gaps and improving existing rice, animal, and fish policies that will also benefit the development and promotion of ICAS.

Objectives

The results of the study aim to provide useful knowledge for rationalizing action on total food/feed ICAS technology development and promotion in the rainfed lowland rice ecosystem.

More specifically, it aims to

- Review the ICAS R&E paradigms used.
- Characterize smallholder rice, animal, and fish production farms.
- Describe the socioeconomic context of ICAS in terms of the regional profile of rice ecosystems; macro supply and demand trends in the rice, animal, and fish sector; regional poverty and causes; human welfare;

population growth and demographic change; and implications for ICAS R&E.
- Describe the existing ICAS practices undertaken in various rice ecosystems, and support research, extension, and training structures and services.
- Describe the policy environment for the rice, animal, and fish sectors, including ICAS.
- Identify problems of ICAS small rice farmers and R&E stakeholders from the perspectives of the small rice farmers as direct beneficiaries, and other stakeholders providing enabling conditions, from which to establish recommendation domains.

Methodology

Methodology as used here refers to the procedures used for conducting a review of ICAS R&E studies. Briefly, these procedures are as follows:

1. Developing and using a framework for inventorying the ICAS R&E paradigms used.
2. Using secondary data to describe regional rice ecosystems, analyzing rice, animal, and fish macro supply and demand trends, population growth and demographic change, regional poverty and causes, and human development achievement.
3. Characterizing ICAS in rice-farming communities and in R&E support structures and services.
4. Documenting ICAS practices to augment written reports about them.
5. Describing the policy environment for rice and animal sectors.
6. Identifying ICAS problems and solutions.
7. Writing a monograph.

Toward the use of a common ICAS R&E paradigm

The ICAS R&E general framework

In reviewing the status of ICAS R&E in the Philippines, an ICAS paradigm is introduced (Chart 2), based on a general framework (Chart 1), showing ICAS R&E as a three-pronged

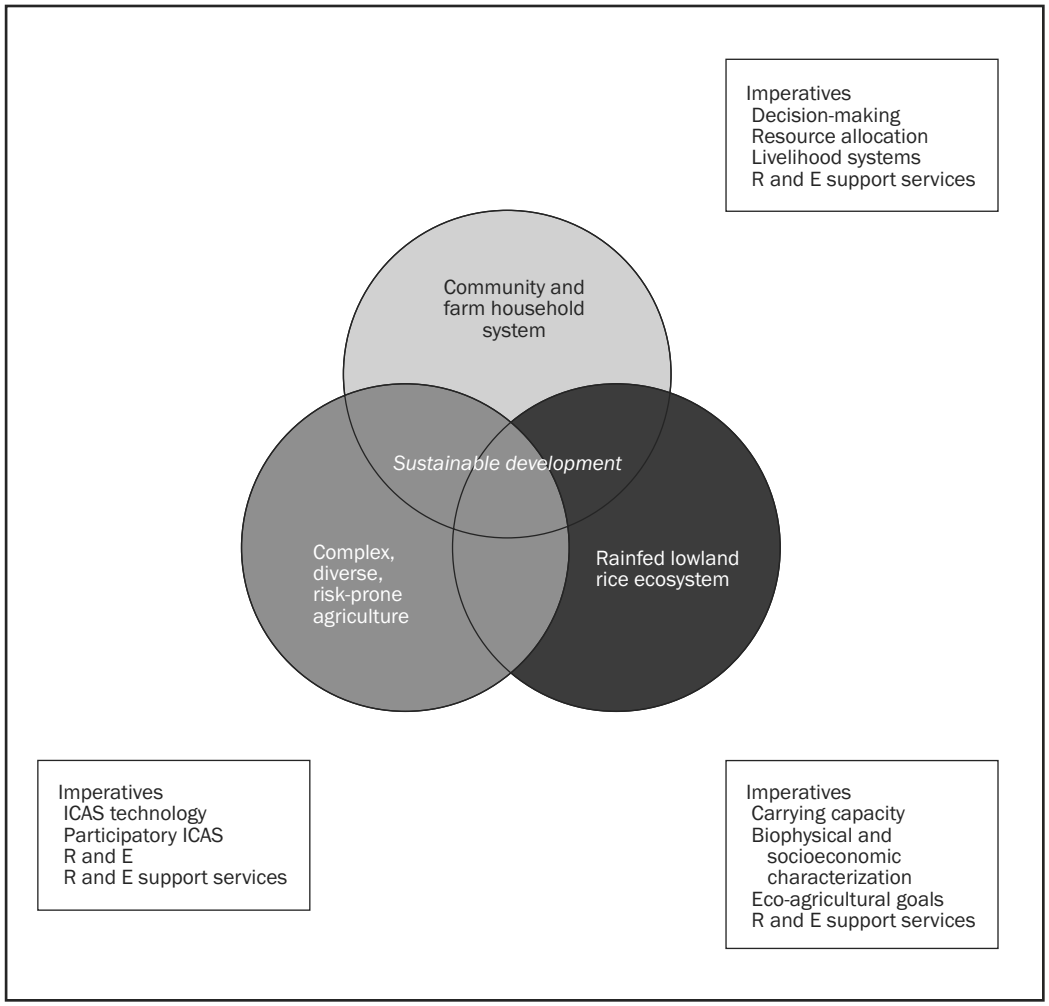


Chart 1. A general framework for ICAS R&E as a three-pronged sustainable development challenge in balancing the imperatives of community and farm household, CDR agriculture, and the rainfed lowland rice ecosystem.

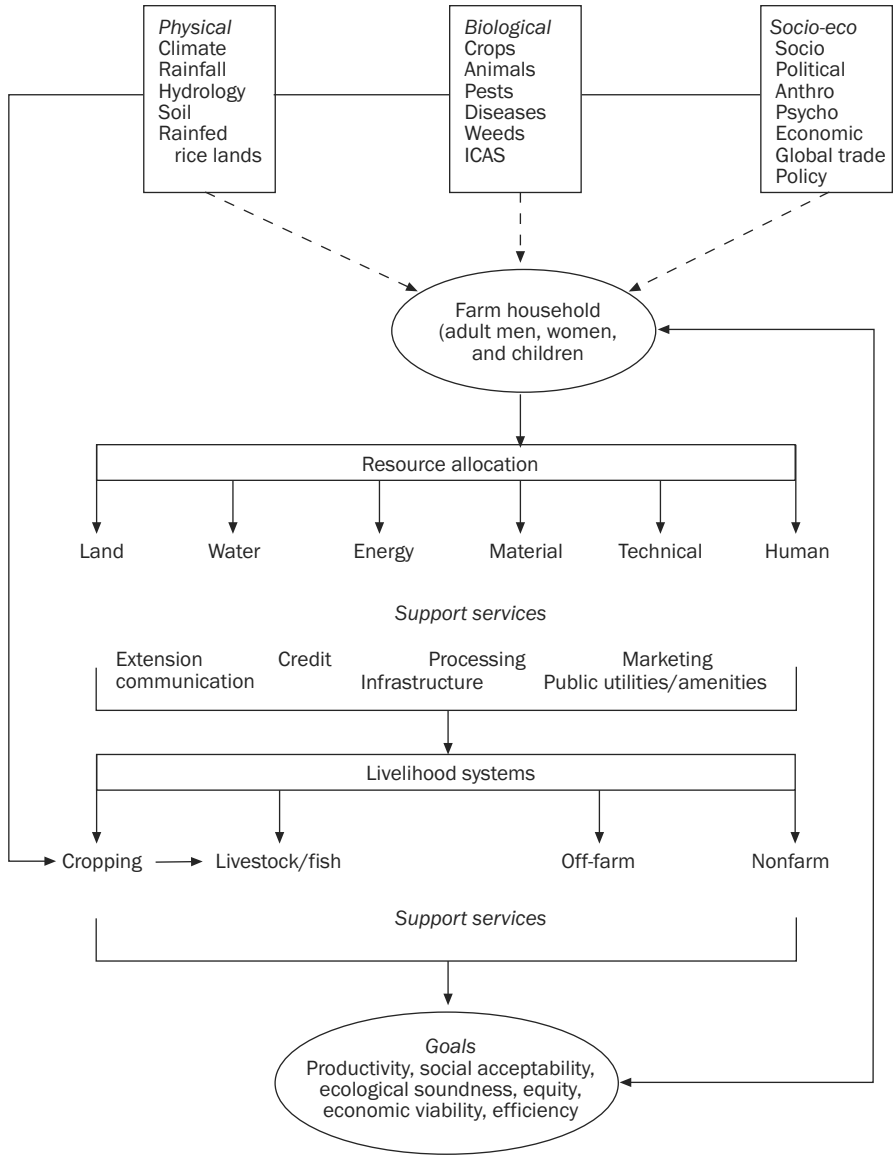


Chart 2. Suggested ICAS R&E paradigm.

sustainable development challenge with its imperatives from the community and farm household; complex, diverse, and risk-prone (CDR) agriculture; and rainfed lowland rice ecosystem perspectives. ICAS R&E is so vast a territory that there is a need to zero in on some common imperatives for all stakeholders to agree upon and work on.

Sustainable community development for improving rainfed communities. Sustainable community development is needed for improving lowland rice-farming areas, which means developing communities, families, educated and responsible citizens, ecosystems, and civilization itself. The imperatives of community and farm household development are to be identified and defined by stakeholders and grouped into active local learning circles of ICAS R&E.

Sustainable agriculture through integrated crop-animal systems. Agricultural development through ICAS as a form of simultaneous conservation and economic activity is essential also for human life and civilization. It is meant to build the viability of rainfed lowland rice farming, which later, if viable, can be promoted in other ecosystems. ICAS is an important strategy for developing the rainfed lowland rice-farming market economy. In the past, agricultural production increased largely by expanding the area under cultivation.

The possibilities of continuing this trend are nearly exhausted and present increases in production will have to come almost entirely from the intensification of land use per unit area accompanied by appropriate agricultural technology development and promotion. However, technology developers and promoters have to initially face a nontechnology problem in that small farm holders by and large do not easily shift to new, although promising, prac-

tices. In the development of resource-limited rainfed areas, the ICAS, a veritable farming systems approach, assumes strategic significance. A holistic farm perspective in the whole technology improvement and human change process fits well into CDR ICAS technology use.

Ecological development. Ecological development reproduces the biological wealth and climatic conditions necessary for life and Earth. The imperatives of ecological development are to respect carrying capacity, conserve and recycle resources, reduce farm and household waste, and manage household and farm solid waste. Crop-animal interactions provide the key to ecological development at the household and community level.

Sustainable development. Sustainable development is a process of bringing these three development processes into balance with each other. The implementation of ICAS as a sustainable development strategy therefore involves negotiations among the stakeholders involved in the three development processes—community and farm household development with the local government and stakeholders playing lead roles; lowland rice farmers, researchers, extension workers, entrepreneurs, government and nongovernment organizations, and consumers; and characterizing and understanding rainfed rice lands as a basis for technology design, improvement, innovation, and change.

In this study, one observation is that the use of a common ICAS R&E paradigm among researchers and extension workers is not explicit. For the component ICAS R&E workers, though, the simple diagram below seems to depict the framework used:

ICAS technology<<<<<<<>>>>>>> socially acceptable,
component testing, technically and
single discipline-based economically viable

- recipe-type R&E
- researcher-led on-station experimentation

- participatory R&E
- farmer-led on-farm experimentation

The farmer-led and researcher-led experimentation are interactive in that the first identifies actual field problems and the second helps solve them. The participatory R&E element, in which farmers play active learners' roles, is a new development. Only the ARFSN and the CASREN researchers and extension workers use a holistic view similar to what is being recommended in this study.

The modal ICAS R&E paradigm

Based on Chart 1, and full-blown farming systems paradigms developed by other researchers (Norman being one of the pioneers), the modal ICAS R&E paradigm shown in Chart 2 was designed. As shown in this chart, an ICAS is viewed as an intensive diversified small agribusiness enterprise. The major factors influencing it are biophysical and socioeconomic, represented by boxed parameters. Consumption and production sustainability require a livelihood system like ICAS that preserves the ecological base for this development strategy, although socioeconomic benefits derived involve dynamic changes in the biophysical ecosystem. In the operation of ICAS in rainfed rice lands, the survival, well-being, and integrity of life support systems at the local and national levels are simultaneously considered. Although different ICAS R&E spheres and elements are boxed to delineate specific parts, they should not be seen in isolation from each other. Instead, they should be examined with the woof and warp of a well-woven tapestry, simultaneously observing the intricate matrices of community and farm households, agriculture, and ecological sustainability imperatives and using these to advantage.

Sustainability is also defined as an improvement in the productive performance of a system without depleting the natural resource base upon which future performance depends (Lucas et al 2000).

We assume that the biophysical and socioeconomic circumstances, when favorable, are the sets of conditions for operating on-farm, off-farm, and nonfarm livelihood activities in which ICAS plays a central role. Being convinced of its viability for attaining productivity, social acceptability, ecological soundness, equity, economic viability, and efficiency, a farm family opts to adopt market-oriented crop-animal mixed enterprises along a total food/feed system. To operationalize demand-driven multiple agribusiness enterprises, however, requires an input-output market system in which around 200 small farmers, members of the Farm Business Resources Cooperative (FBRC), benefit in both ways. This idea has been operationalized in Aliaga, Nueva Ecija, where one of the authors is a volunteer consultant.

The socioeconomic sphere. As depicted in Chart 2, the farm household, composed of adult men, women, and children, is at the heart of ICAS, indicating more socio-cultural and economic variables. At the same time, it is the central production, processing, and marketing unit that feeds or acts upon natural resources of land, water, and energy as well as material, technical, and human capital. Land, water, and energy are natural life-support systems, often adversely affected by the vagaries of nature. Material capital, which is always scarce, refers to wealth or accumulated assets (land, money, animal/machine power, transportation, small-farm infrastructure, etc.) at the farm household's disposal. Technical capital refers to knowledge, both indigenous and borrowed, or results of on-farm and on-station R&E activities. Human capital refers to labor and capabilities for operating ICAS. Amplified by prompt and timely delivery of support services—extension/training, credit, processing and packaging, marketing, crop/animal husbandry, management that considers a health information and care system vital to its success, public utilities, and social amenities— ICAS adop-

tion can take place. All support services are enabling conditions and motivational forces that, if lacking, can stall ICAS development and expansion.

Depending on the world view, aspirations, goals, and attitudes of a farm household, as well as local government political will and resolve to provide a safe and secure community, ICAS development can only succeed. The result of thorough farm household and farm community appraisal, as part of the socioeconomic circumstance, is thus important to the understanding of dynamic human behavior, both individually and as a group.

The socioeconomic sphere contains overlapping sociological, political, anthropological, psychological, and economic elements inherent in social, cultural, political, educational, and economic institutions and organizations. Institutions are patterned ways of human group behavior, whereas organizations are frameworks by which the work of institutions is performed, providing the required channels, point of origin, flow of management direction, and control to carry out a determined course of action (Iñigo 2000). This takes place even in the smallest organization such as the farm family household.

This time, what are being inventoried are human and institutional resources, including processes, to understand a dynamic CDR agricultural system, such as ICAS, interacting with community rainfed rice lands while following off-farm and nonfarm livelihood systems. An appropriate global trade and policy environment can help push competitive ICAS enterprises right onto smallholder farms or into backyards. There is still time for the Philippines to strive to enhance small farmers' dream to become enterprising ICAS operators.

The biophysical sphere. The biophysical appraisal of a community where target farm households are situated and promising ICAS technologies are proposed to be intensified is also an important inventory and subject matter for analysis. As shown in Chart 2, the major physical elements are climate, rainfall, hydrology, soil, and the rainfed rice farm itself within a fast-changing rural community and deteriorating environment, especially a metamorphosing landscape resulting from changing land use.

The biological resources are crops, animals and fish, and farming systems, as well as their residues and wastes. Pests, diseases, and weeds and the means of controlling them fall under this particular sphere.

Other uses of the suggested ICAS paradigm. The ICAS paradigm has other uses that could be maximized as the proposed project progresses, as follows:

1. As a tool for developing a common understanding among stakeholders of ICAS as a three-pronged challenge of sustainable development at the local level—community and farm household, CDR agriculture, and rainfed rice ecosystem, including their imperatives (Chart 1) upon which the ICAS R&E paradigm (Chart 2) is based.
2. As a common reference when developing a participatory ICAS R&E methodology that a CDR ICAS requires.
3. As a starting point for developing content of training modules and ICAS information kits and establishing local learning circles of mixed groups (farmers, researchers, etc.).
4. As an outline for an ICAS project management plan, from database development and benchmarking to local information and communication technology (ICT) service delivery.
5. As an input into the ecoregional ICAS R&E for long-term economic growth and improved human well-being.

Characterization of smallholder food production farms and macro supply and demand trends of rice and animals

The review of ICAS R&E in the Philippines was carried out against the backdrop of regional profiles of rice ecosystems and small-scale rice, animal, and fish farming that characterizes most staple food production farms of the country, and the macro rice, animal, and fish supply and demand trends in the Philippines.

Smallholder food production farms

In this study, existing smallholder rice, animal, and fish farms were described in terms of structure and productivity.

Smallholder rice production system. Following agrarian reform laws and policies, land distribution started in 1978, the year when the "Land to the Tiller Program" was first carried out and resulted in small-scale rice production. Rice production used to take place on big *haciendas* (large tracts of land) run by *katiwala* (farm managers) but owned by *encomenderos* (large owners), a kind of rent capitalism.

Today, rice farms where most paddy palay is produced for more than 80 million rice-eating Filipinos average only around 2.0 ha or even less per family. In Region 1, it is reported that because of the parcellation of rice farms, mostly because of marriage of a jobless family member, the average farm size in some areas is around 0.5 ha. This may be smaller in some places. The Philippines' per capita agricultural land availability is 0.144 ha, whereas the farm household dependency ratio ranges from 0.17 to 0.33.

Average production on 1.7 million ha of irrigated rice lands is around 3.5 t ha^{-1} and on 1.4 million ha of rainfed rice much lower at around 2.3 t ha^{-1}. These are the same farms where animals, fish, vegetables, and other food/feed grains are grown. Thus, when speaking of ICAS, except for a few commercial farms, these are the same small farms.

As a result of widespread implementation of the Comprehensive Agrarian Reform Program (CARP), the bipolar landowner-tenant tandem resulted in social structures of smallholder owner, amortizing owner, lessee, and newer

owner-tenant relationships. These were clear-cut distinctions of farmer classes. Today, because of dynamic land transactions and markets, access to land with corresponding management styles rather than ownership per se continues to become an important variable of small-scale rice farming. "Cultivatorship" is not necessarily ownership. It may be just the right or access given to till the small farm, usually on landowner-*kasugpong* (landless worker), *sangla* (mortgaged), rent or lease/contractual arrangements. These are newer social classes in the rice-farming business.

The landowner-kasugpong tandem is called *porsyentuhan* (percent). This is a kind of owner-tenant tiller-sharing system in which the kasugpong who performs all the farm work except planting and harvesting, which uses hired farm labor, derives 10–15% of net income from all enterprises every cropping season. The legal landowner has in principle become an absentee landlord in much the same way as before the CARP era.

The sangla system is an arrangement between the owner and the mortgagor whereby the owner gets a substantial loan (sometimes called *sanglang bili* or arrangement to sell) and the latter continues to farm the land until the loan is paid, or loses the land altogether after deciding to sell. A rent or lease arrangement is the usual way of seasonal or yearly payment of a sum representing a right to cultivate the land.

These prevailing land markets connote varied land arrangements and management styles in Nueva Ecija (Rivera and Mangalindan 1989). Upon verification, they still exist today. Because of changing land uses, some small farmers whose landholdings are situated near urban centers have become instant millionaires by selling their farms.

Small rice farmers and food security. Food security is defined by the Agriculture and Fishery Modernization Act (AFMA) as having safe and nutritious food available and affordable to every Filipino at all times. The average Filipino spends 80% of income for food. Every family, however, pays two or three times more than the Thai or Vietnamese households for their rice. Food security at the farm household level depends on income level and the efficiency of the marketing system to quickly correct supply and demand imbalances in local markets. More than 50% of rural families are living on incomes below the poverty threshold as the average rural family earns about one-half of what the urban family earns.

Farm labor. As of 2001, agricultural labor totaled 11.3 million, an increase of 8.2% from 10.4 million in 2000, but its share of the total employed remained constant at 37%. The 368,000 employed in agriculture are unpaid family workers, 250,000 are workers, and 234,000 are wage and salary workers. Smallholders' problems related to labor are scarcity at the peak of farming operations and higher wage rates.

The smallholder livestock and poultry production system. There are two animal production systems: (1) backyard or small-scale and (2) commercial. The first one prevails, with 79–99% for ruminants and nonruminants as a whole. For ruminants, the commercial scale is negligible, as carabao and goats are almost all small-scale. Cattle commercialization is somewhat intensive (10%). As shown in Table 1, among the nonruminants, only chickens had a higher percentage of commercialization (25%). For small-scale animal farms, there are also two kinds of operation, independent or integrated two-level strata or three-level strata business enterprises, which are rare. In the independent animal production system, there could be just one animal species, or there might be other farming enterprises, crops, and fish or animal species, each operated independently of the other or jointly in an integrated way.

In the latter case, the interactions would depend on the degree of crop-animal integration from which the small farmers expect greater benefits.

Livestock and poultry in the Philippines are raised on a small scale as pure, one species, or several species, or as intensive crop-animal mixed enterprises. The production of carabao (99.67%), goats (99%), cattle (88%), ducks (88%), hogs (83%), and chickens (72%) are through the "backyard" system, in which field crops are invariably common enterprises (Paris 1992). Commercial farms produce only about 28% and 17% of chickens and hogs, respectively (Adriano 1989).

Table 1. Backyard and commercial livestock farms in the Philippines.

Animal species	Inventory (000)	Backyard commercial		Total		Share (%)
		Share (%)	Inventory (000)	Share (%)	Inventory (000)	
Ruminants						
Cattle	1,498	90	160	10	1,658	100
Carabao	2,475	99	4	1	2,479	100
Goats	2,227	99	12	1	2,239	100
Nonruminants						
Hogs	6,717	83	1,305	17	8,022	100
Chicken	47,370	75	15,757	25	63,127	100
Ducks	7,661	91	687	9	8,348	100

Source: BAS data.

Animals provide an important source of cash and food for farm families. Benefits from the animal component in an integrated farming system are approximately 17–20% of the total gross cash income of these families. The bulk of this income is from cattle and swine raising.

Any improvement in the productivity of livestock and poultry would therefore be beneficial to small backyard raisers, or rice or ICAS farmers, especially in terms of higher intake of eggs and meat and higher farm household income.

The smallholder fish production system. As in animal production, there are two fish production systems, small-scale and commercial, consisting of capture fishing and aquaculture production. The capture fishing system is composed of two subsectors: commercial and municipal capture fishing. While most capture fishing is shared by the two subsectors, inland capture fisheries are the smallest in the level of catch production. Cagauan (personal communication, 2003) observed that inland aquaculture (mostly tilapia culture) is passing from intensification to commercialization, with big players coming in as a result of the success of all-male Y-Y tilapia and the genetically improved farmed tilapia for efficient fingerling and breeder production, respectively.

Catches in capture fishing have dwindled over the years primarily because of overfishing, resource-use conflicts, pollution, siltation, and, most importantly, the growing poverty rate within the coastal areas.

It is well documented that, where the population growth rate is high, there poverty resides and, where poverty reigns, widespread overfishing and pollution occur.

The weak enforcement of property rights coupled with widespread pollution from human settlements results in both resource-use conflicts and the severe depletion of marine resources. At the same time, the intrusion of saline water and heavy chemicals in inland fisheries potentially threatens the productivity of these farm resources.

Macro supply and demand trends of rice and animals

The simultaneous fuller development of the rice, animal, and fish sectors, as chief ICAS components in rainfed rice-farming communities, with the local government as jointly responsible, is the millennium challenge and opportunity to reduce poverty and inequality and protect the environment through efficient but limited resource management.

Rice supply and demand trends. The Philippines has made notable progress in rice production in the last three decades. Production increased from 4.1 million t in 1965 to 10.5 million t in 1994, an annual increase of 3.3%, which was much faster than the growth of population.

Growth was achieved almost entirely through an increase in yield brought about by the gradual replacement of traditional low-yielding cultivars with the modern high-yielding ones, supported by an expansion of irrigation and intensive use of chemical fertilizers. Rice yield increased from 1.3 to 2.9 t ha^{-1} in 1965-94.

Growth has slowed down since the mid-1980s, with a drastic decline in public investment for the expansion and maintenance of irrigation infrastructure and limited scope for further expansion of areas under modern varieties as more than 90% of the land is already covered. Since 1982, rice yield has increased by only 1.7% per year compared with the 2.4% per year increase in population, largely eroding the higher grain yields obtained earlier.

The demand for rice, however, continued to increase because of the high population growth rate. This may be due to a poorly implemented family planning program up to now. Recent projections show that the population will still grow at 1.3% per year by 2020, and it will take much longer to achieve a more stable population growth rate. Population is projected to increase by another 24% over the next decade and by 56% over the next 25 years. Rice supplies must grow at this rate to maintain per capita consumption at the present level.

But per capita consumption itself may increase with the alleviation of poverty as the economy moves out of the stagnancy experienced in the 1980s. The current consumption of cereal grains is about 30% lower than the norm set by the FAO (300 kg per person per year, including provisions for seeds and wastage) required to meet the energy needs of individuals.

While the low cereal consumption is due to high levels of consumption of fish and meat compared to countries at similar levels of income, it is also due to the large proportion of poor people who cannot afford to meet their grain needs.

The conservative estimate of the income elasticity of demand for rice at present is 0.1. It is expected to become negative when poverty disappears and per capita income reaches US$1,500. But this income level will not be reached before 2010 even if the Philippines succeeds in sustaining a rate of growth in gross national product (GNP) of 6% per year. Thus, as per capita income grows, per capita rice consumption will increase only marginally.

The other factor that may put upward pressure on per capita rice consumption is the substitution of rice for maize as human food. The present per capita consumption of maize in the Philippines is about 20 kg per person, one of the highest in Asia. The income elasticity of demand for maize, however, is –0.25. If per capita income increases at a more modest rate of 4% per year, consumption of maize as human food could decline by about 20% by 2010. Maize is likely to be substituted by rice.

Livestock and poultry supply and demand trends. Domestic livestock population trends indicate that, from 1929 to 2001, with the exception of the 1940s (war years), stocks of ducks, hogs, and chickens steadily increased (Fig. 1). Poultry's steady rise was almost entirely due to the introduction of new breeds of chicks coming from the U.S. after the war years (Fig. 2). It continued to rise because of the increasing demand for eggs and chicken meat, which

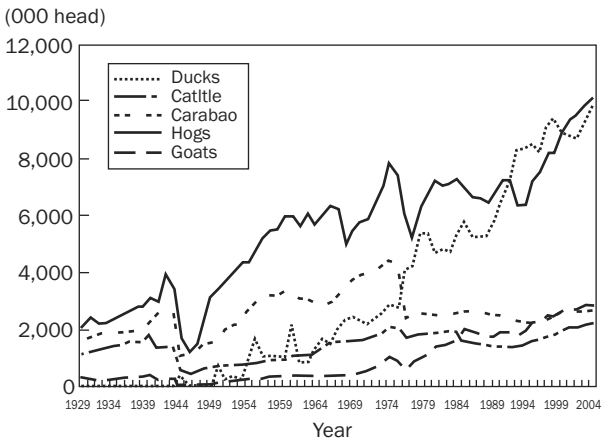


Fig. 1. Livestock and poultry supply from 1929 to 2004.

Table 2. Demand projections of beef, pork, and poultry (t), 1996-2004.

Year	Beef	Pork	Poultry
1994-95 average consumption	147,576	776,286	319,759
1996	157,463	828,297	341,183
1997	168,014	883,793	364,042
1998	179,270	943,007	388,433
1999	191,281	1,006,188	414,458
2000	204,098	1,073,603	442,227
2001	217,772	1,145,535	471,856
2002	232,362	1,222,285	503,470
2003	247,931	1,304,179	537,203
2004	264,542	1,391,559	573,195

Source: Gonzales (1997).

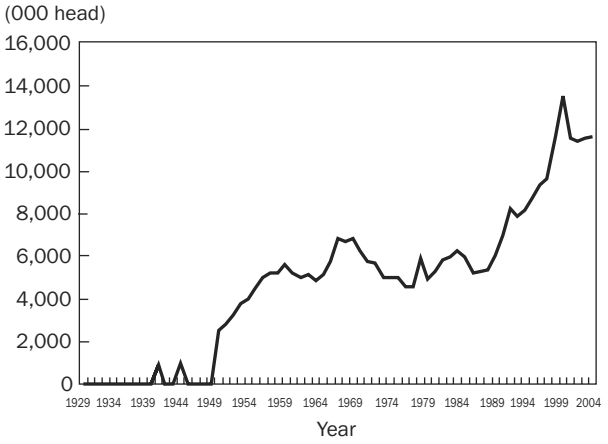


Fig. 2. Trend in poultry population.

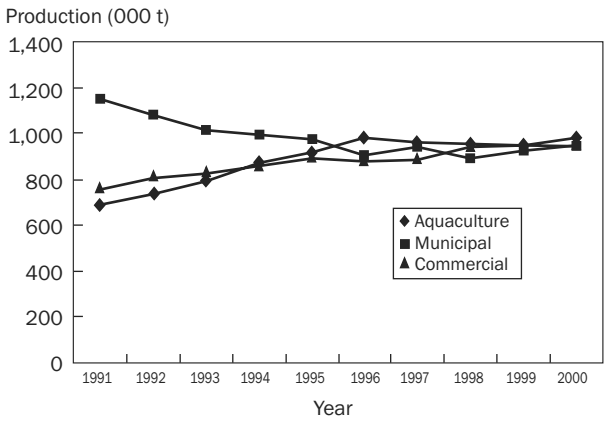


Fig. 3. Trends in fish production, 1991-2000.

prompted a steady supply of superior breeders, which produce more eggs.

The hog population has also sustained its growth because of the importation of superior swine. With various cross combinations of local and imported breeds, the industry provided consumers with superior growth coupled with local adaptation to the Philippine climate. Also, improvements in feeding and general management have dramatically improved the hog industry's performance (Gonzales 1998).

However, for ruminants such as carabao, cattle, and goats, the population performance has been slow relative to other livestock. During the late '30s, carabao and to a major extent cattle were the main sources of farm draft power. The native breeds during the 1940s were almost decimated, with half of their prewar population wiped out.

With the introduction of farm machines and equipment (4- and 2-wheel tractors) in the '60s and their refinement in the '70s, the carabao population slowed considerably owing to the substitution of animals by machines, especially during land preparation. For cattle and goats, the population's lackluster performance was mainly due to the slow commercialization process. Statistics show that almost 90% of carabao, cattle, and goat production has emanated from backyard raising, while the remaining 10% has been shared by the commercial sector (Gonzales 1998).

The main market for the country's livestock sector is still the domestic market (Table 2). Given that the major domestic poultry and livestock products have little competitive edge over their imported counterparts, the sector has no choice but to concentrate its efforts on the domestic market. Aside from the tariffs that are imposed on imported livestock products, prospects from the domestic market would come from a high population growth rate and consequently high demand for livestock products.

Fish supply and demand trends. Figure 3 shows the country's fish production trends by type of system from 1991 to 2000. It is clear that, under capture fishing, the municipal sector has been declining, whereas the commercial sector has been steadily increasing. The major reason for this trend is that the major fish resources from coastal and inland waters have been declining, probably because of the increase in production of commercial fishing companies. Also, because of the overall decline in capture fishing,

commercial fishing has encroached on the fishing grounds of the municipal fishing sector. In contrast, the aquaculture sector has increased at a stable and steady rate. This is due to the introduction of new and tested technologies such as sex reversal and others, which have greatly enhanced the sector's production level. It is projected that, in the near future, most of the protein derived from fish will come from this sector.

According to Aguilar and Saclauso (2002), the average per capita consumption from fish is approximately 36 kg capita^{-1} year^{-1}. Using this parameter to estimate the projected demand for fish, it was found that the current level of production cannot keep up with the country's growing population. Without corresponding measures to increase production, the projected deficit would amount to 0.6 million t within the next 2 years.

Population growth and economic situation of small rainfed rice farmers in the Philippines

The economic situation of small rice farmers is also viewed from the standpoint of population, poverty, and human development. Macro data were used in the analyses embracing the entire populace but, nevertheless, by interpolation, the results of the analyses are applicable to rainfed farmers, as they are among the poorest of the poor.

Population growth and demographic change

Population growth itself influences food demand and requirements. A rapid increase in population means greater food requirements. The ability to feed an increasing population depends on efforts to increase productivity. At the same time, it should be emphasized that food requirements will vary depending on structural changes in the population such as declining mortality, high fertility, and migration to urban areas. Food demand, especially for meat, is greatly affected by improved income, better education, and changing lifestyles. The Philippine population can be characterized by increasing childbirth, declining mortality, and rural-urban migration.

The Philippine annual population growth rate, although it has continuously declined since 1970, is still one of the highest in Southeast Asia (2.3%). This rate remained steady from 1980 to 1995, while that of Singapore (1.0%) and Thailand (1.4%) continued to slow down.

On the other hand, many people moved to the cities in 1980-90, with the urban population growing by leaps and bounds (30%), to almost equal to the rural population. Another historic fact is that the Philippine population of 80 million today will probably double by 2030, and that of the world's 6 billion will probably double by 2050. Food security and affordability will have to be worked out today in preparation for a future with so many mouths to feed here and abroad.

The demographic composition of more young people and a growing population of women suggests newer technologies, product development, human capital improvement, and improved strategies of agricultural development, with women playing even more active roles. Since most productive lands have been exhausted, the only way to progress is to achieve better resource use to increase production per unit of land, increase the creativity of human resources, and put marginal rainfed lands into high-tech but low-input conservation agriculture. With overseas employment and armed conflicts drawing more men away from farms, women and children will have greater roles in food production. It can be mentioned in passing that women have traditionally worked in the food/feed realm. Men are becoming prominent in the food business scene outside the home, however.

Poverty and inequality, and the place of ICAS

Regional profile of poverty and inequality. Table 3 shows the official estimates of regional head-count poverty incidence of families in 1994, which ranges from a low of 8% in the National Capital Region (NCR) or Metro Manila to a high of 60% in the Autonomous Region of Muslim Mindanao (ARMM). Poverty incidence by province shows a much starker contrast. By interpolation, small rainfed farmers, who are among the poorest of the poor with their marginal unproductive lands, were in the direst economic straits.

Inequality in human development (Table 4) shows that Metro Manila (0.819 and above) has the highest human development index (HDI), composite score for life expectancy (in years), functional literacy (rate in percent), and real per capita income (in pesos). Eastern Visayas is shown to have the lowest HDI (below 0.500).

Causes of poverty and inequality. According to Balisacan and Fujisaki (1999), the causes of poverty are functional illiteracy, land inequality, small farm size and lack of tenancy, poor agricultural terms of trade, lack of irrigation, lack of roads, lack of electricity, and an unfavorable political and economic environment.

Table 5 shows the relative importance of each causal factor. Most of the identified causes are rural community- and agriculture-related, areas that for many years have been neglected by the government.

In a way, agriculture, on which more than 70% of Filipinos depend for their livelihood, is both the root and the solution of the interrelated problems of food security, poverty, inequality, and environmental protection for sustainability.

Functional literacy is defined as the proportion of the adult population that can read, write, and compose simple messages. Land inequality is expressed by the farmers' landholding ratio, which has extreme values of one (perfect inequality) and zero (perfect equality). Farm size is average farm size. Tenancy is defined as the ratio of area of farms under share tenancy to the total area of farms.

Irrigation is expressed as the ratio of irrigated to total farm area. Agricultural terms of trade are defined as the ratio of the price of agriculture to the price of nonagriculture.

Table 3. Regional poverty incidence (%).

Region	Population share	Poverty incidence		Contribution to national poverty	Annual poverty threshold (pesos per person)	
		Family	Population		Family (%)	Population (no.)
Philippines	100.0	35.5	40.6	100.0	100.0	8,885
Metro Manila (NCR)	13.8	8.0	10.5	3.1	3.6	11,230
Ilocos (I)	5.5	47.9	53.6	7.5	7.3	10,022
Cagayan Valley (II)	3.9	35.5	42.1	4.1	4.0	8,316
Central Luzon (III)	10.4	25.2	9.2	7.1	7.5	9,757
Southern Tagalog (IV)	13.0	29.7	34.9	11.3	11.2	9,537
Bicol (V)	7.0	55.1	60.8	10.7	10.5	8,319
Western Visayas (VI)	9.0	43.0	49.9	10.8	11.0	8,197
Central Visayas (VII)	7.2	32.7	37.5	6.9	6.6	6,425
Eastern Visayas (VIII)	5.2	37.9	44.8	5.8	5.7	6,444
Western Mindanao (IX)	4.0	44.7	50.6	5.0	5.0	7,074
Northern Mindanao (X)	5.9	49.2	54.1	8.0	7.8	7,938
Southern Mindanao (XI)	7.2	40.3	45.6	7.9	8.1	8,201
Central Mindanao (XII)	3.2	54.7	58.7	4.8	4.7	8,971
Cordillera Administrative Region	1.9	51.0	56.4	2.7	2.7	10,853
Autonomous Region of Muslim Mindanao	2.7	60.0	65.3	4.4	4.3	8,889

Source: National Statistics Office, Family Income and Expenditure Survey, in Balisacan and Fujisaki (1999).

Table 4. Human development index (HDI) by region.

Region	HDI over time		
	1985	1990	1994
National Capital Region	0.865	0.832	0.819
I. Ilocos	0.518	0.543	0.543
II. Cagayan Valley	0.483	0.511	0.514
III. Central Luzon	0.576	0.611	0.618
IV. Southern Tagalog	0.599	0.631	0.641
V. Bicol	0.462	0.515	0.528
VI. Western Visayas	0.532	0.560	0.575
VII. Central Visayas	0.528	0.577	0.591
VIII. Eastern Visayas	0.425	0.480	0.493
IX. Western Mindanao	0.436	0.478	0.500
X. Northern Mindanao	0.569	0.566	0.569
XI. Southern Mindanao	0.572	0.580	0.583
XII. Central Mindanao	0.470	0.516	0.533

Source: Philippine Human Development Report (1997), in Balisacan and Fujisaki (1999).

Road wealth is the quality of adjusted road length per square kilometer of land. Electricity is defined as the proportion of households with access to electricity.

The functional literacy variable reflects the predetermined quality of human capital in the region. The irrigation variable is a proxy for land quality. The terms of trade variable reflects relative price incentives for agriculture. Road wealth is a proxy for access to markets and off-farm employment.

Three-year dummy variables are also included to capture significant differences in the political and economic environment during the period of interest—1985 was the peak of the short-lived economic recovery in the 1980s (Aquino regime), 1991 was the lowest ebb of the relatively long recession beginning in 1989 (severely weakened Aquino regime), and 1994 was the early period of the economic recovery and of renewed policy and institutional reforms (Ramos regime). All the regression equations take a double-log specification. Hence, the coefficients, except for dummy variables, can be interpreted as poverty elasticities.

Functional literacy is highly significant in all regressions. Its coefficient suggests a very elastic response of poverty to improvement in human capital. This result confirms the popular contention that substantial improvements in human capital form part of the building blocks for sustained economic growth and poverty reduction (World Bank 1993, as cited by Balisacan and Fujisaki 1999).

Land inequality is consistently significant in all regressions, thereby affirming the negative association between landholding inequality and rural poverty. Elasticities in this variable reflect the responsiveness of national poverty to the consumption index.

Human development

Table 4 shows the level of achievement in human welfare among Filipinos. As shown in this table, as of 1994, the National Capital Region (NCR) seemed to enjoy the highest human development index (0.819, with Eastern Visayas, 0.493, having the lowest). Other regions that belonged to the bottom five were Western Mindanao (0.500), Cagayan Valley (0.514), Bicol (0.528), and Central Mindanao (0.533). They were all within just 40 points of each other.

The HDI is a composite of three basic outcome measures: health as proxied by life expectancy, knowledge as proxied by functional literacy, and standard of living as proxied by real per capita income. Within the 10-year period, except for the NCR, these HDI scores improved somewhat for the rest of the regions.

Table 5. Poverty determination functions.

Explanatory variable	Incidence	Depth	Severity
Functional literacy	–3.120	–4.070	–4.637
	(–5.07)	(–5.38)	(–5.25)
Land inequality	2.579	3.406	3.946
	(6.92)	(7.42)	(7.36)
Farm size	–0.358	–0.468	–0.499
	(–2.82)	(–2.99)	(–2.73)
Tenancy	0.045	0.057	0.080
	(0.43)	(0.44)	(0.53)
Agricultural terms of trade	–0.255	0.115	0.609
	(–0.50)	(0.18)	(0.82)
Irrigation	–0.175	–0.307	–0.404
	(–3.51)	(–5.00)	(–5.63)
Road wealth	–0.427	–0.613	–0.727
	(–3.17)	(–3.70)	(–3.77)
Electricity	–0.148	–0.317	–0.394
	(–1.64)	(–2.11)	(–2.18)
Year 1988 dummy	–0.066	–0.140	–0.184
	(–0.87)	(–1.48)	(–2.68)
Year 1991 dummy	–0.190	–0.209	–0.203
	(–2.05)	(–1.84)	(–1.53)
Year 1994 dummy	–0.230	–0.328	–0.376
	(–2.70)	(–3.13)	(–3.08)
Constant	–0.076	–1.060	–1.858
	(–0.27)	(–3.01)	(–4.52)
Adjusted R^2	0.867	0.887	0.890
F-value	28.97	34.65	35.63

Source: Balisacan and Fujisaki (1999).

Farm size and irrigation are also important determinants of poverty in all regions except Metro Manila. The irrigation variable suggests that improvements in land quality offer an important avenue for reducing poverty, in both agricultural and nonfarm areas.

Road wealth is highly significant in all equations. Electricity is significant for the depth and severity regressions but not for incidence regression. At the very least, both variables suggest that access to markets and off-farm employment opportunities influence poverty.

The term of trade variable is insignificant, as is tenancy, which by itself is not as important and compelling a correlate as expected. Variation in income within tenure classes (reflecting the effect of farm size, yield, cropping intensity, land quality, etc.) has been found to be much greater than variation between classes.

The year dummy variables (political and economic environment during the Marcos, Aquino, and Ramos regimes) influence the incidence, depth, and severity of poverty as expected. These findings imply the importance of agriculture in general and perhaps ICAS enterprises in particular can help improve the poverty and inequality situation of small-scale farm families in disadvantaged rainfed rice lands.

Institutional research and extension structures and services

The national agricultural research and extension system (NARES) comprises a network of research and development (R&D) institutions and organizations, private and public, local and international, with the Bureau of Agricultural Research (BAR) and the Philippine Council for Agriculture and Resources R&D (PCARRD) providing lead roles. Besides their leadership and coordinating roles, they help obtain funds for conducting priority agricultural and fisheries R&D programs. Foremost among the collaborating R&D organizations and service agencies are the Department of Agriculture, with its national and regional R&D centers, the Philippine Rice Research Institute (PhilRice), state universities and colleges (SUCs), with their single-commodity R&D centers, nongovernment organizations, and the International Rice Research Institute (IRRI).

Department of Agriculture (DA)

The DA provides enabling conditions for ICAS development and promotion. Its beginnings are tied up with the multiple cropping systems research (MCSR) program initiated by the National Food and Agricultural Council (NFAC)

in tandem with the University of the Philippines College of Agriculture (UPCA) at Los Baños in the 1970s and '80s. This grew out of the need to increase the income and improve the diet of small farmers and their families by maximizing the use of land resources.

Table 6 chronicles the MCSR program and other related farming systems approach (FSA) national and regional agricultural development programs implemented by the DA and collaborating institutions. Those implemented after 1987 were part of an existing policy and general strategy to promote agricultural development, which mandated greater farmer participation in agricultural development and the use of a bottom-up self-reliant FSA for justice and equity (Executive Order No. 116, dated 30 January 1987).

Table 6 can be viewed as a much-traveled road map that traces the concerted effort made by the government and partner organizations to pave the way to a vigorous farming systems research and development (FSRD), which includes ICAS. The details of each step taken through relentless pursuit of FSA in farmers' fields, including biophysical and socioeconomic characterization of sites, could not be shown as the information on hand was not adequate. Therefore, determining the potentials of ICAS in rice ecosystems could also not be reported.

Not until 1985 were animals and women food-processing enterprise development and participatory approaches duly incorporated in the rice-cattle farming system in rainfed and irrigated areas in Pangasinan, Luzon (Paris 2002). Subsequently, ICAS R&E expanded to other ARFSN/IRRI sites in the Philippines.

Today, the DA, through the initiative of BAR, is intensifying and accelerating technology transfer in agriculture and fisheries through a farmer-centered agricultural resource management program. Community-based participatory action research (CPAR) has been put in place. This involves on-farm research (OFR) conducted in farmers' fields and managed by farmers, coordinated and supervised by the regional integrated agricultural research centers (RIARCs). The objectives of CPAR are

1. To accelerate technology transfer from the technology-generating system to the farming and fishing communities and increase total farm productivity and income.
2. To make research more meaningful and responsive to the needs of farmers/fisher folks.
3. To develop systematic feedback (regarding the farm situation) to the research system.
4. To provide a mechanism for effective research-extension interface at the provincial level, jointly by the DA and provincial local government unit (LGU), at the municipal level, jointly by provincial and municipal LGUs, and at the barangay level, or in farming communities, jointly by the municipal and barangay LGUs.

The various dimensions of CPAR are a (1) total farm approach, (2) total technology approach, (3) total family approach, (4) total community approach, and (5) market and credit.

Asian Rice Farming Systems Network (ARFSN) and the International Rice Research Institute (IRRI)

IRRI started its rice-based cropping systems research (CSR) work at the very beginning of its operation in 1960. This was broadened into farming systems research in 1972. In 1974, the scope of farming systems work was further expanded with the establishment of the Asian Cropping Systems Network (ACSN), a collaborative effort among five countries in Southeast Asia: Philippines, Thailand, Vietnam, Bangladesh, and India. It soon became the Asian Farming Systems Network (AFSN) in 1983, and the Asian Rice Farming Systems Network (ARFSN) in 1985. By this time, it had expanded to include the animal component of smallholder farms in Asia. The basic procedures of the CSR R&E methodology involving site selection and description, diagnosis, extrapolation and design, testing, and evaluation were used in ICAS R&E.

The ARFSN ICAS R&E sites in the Philippines were Pangasinan (Region 1), representing both the rainfed and irrigated lowland rice ecosystem; Cavite (Region IV), upland; and Tarlac (Region III), another rainfed site. The Pangasinan crop-livestock system, with the establishment of legumes and grasses for fodder, Cavite rice-pig with cowpea-cassava feed and feeding system interventions, and Tarlac crop-livestock project, with setaria, napier, and desmanthua on hedgerows as feed to improve the existing feeding system, were viewed as successful ICAS R&E in that the objectives of productivity, profitability, social acceptability, ecological soundness, and sustainability were attained. Both the Cavite and Tarlac projects were undertaken in collaboration with the DA Regional Integrated Agricultural Research System (RIARS), now the Regional Integrated Agricultural Research Center (RIARC), as part of an institution-building commitment of the ARFSN. In all cases, the MCSR methodology used in ICAS R&E was improved.

Both on-farm and on-station research experiments were used. The farmer-led on-farm research defined the problem, while the researcher-led on-station research helped solve the problem identified. Interdisciplinary research teams involving crop, animal, and social scientists worked together at a few sites.

Workshops and monitoring and evaluation tours were organized by the ARFSN, bringing together scientists from Asia, Africa, and Latin America to discuss and exchange notes on ICAS R&E. The objectives of these workshops and evaluation tours were to (1) identify and document methodologies for the application and measurement of interactions for the development of sustainable crop-animal farming systems, (2) describe the different types of crop-animal interactions in different rice ecosystems, and (3) formulate research priorities and strategies appropriate to the development of crop-animal systems in different rice ecosystems.

Table 6. Chronology of projects and activities related to farming systems research and development in the Philippines (1972-2002).

Years	Program/project	Agencies involved	Funding source
1972-79	Multiple Cropping Extension Pilot Production Program (MCEPP) in Laguna, Nueva Ecija, Camarines Sur, and Iloilo	UPLB, MAF, CSSAC, CLSU	IDRC
1974-85	National Multiple Cropping Program (NMCP)	MAF/UPLB	NFAC
1975-85	National Coconut Intercropping Program (NCIP)	MAF, BPI	NFAC
1975-80	Cropping Systems Research Outreach Project at Tanauan, Batangas; Sta. Barbara, Pangasinan; and Oton, Iloilo	IRRI/DA	IRRI/IDRC
1976-83	Antique Upland Development Project Foundation	UPLB, DA, LGUs	GOP & Ford
1977-81	Two Rice Crop Systems Projects in Pangasinan (MANBILAYAKA), Iloilo (KABSAKA), South Cotabato (KASATINLU), Zamboanga (ZAMDUGANI), and North Cotabato (MATISAYON)	IRRI/PCARRD	IRRI/PCARRD
1978-84	Cropping Systems Program at the Agusan, Bukidnon, and Capiz Settlement Areas (ABC project under the Second Rural Development-Land Settlement Project)	NFAC, IRRI	NFAC/World Bank
1978-present	Sloping Agricultural Land Technology (SALT) at Bansalan, Davao del Sur	MBLRC	MBLRC
1980-92	Cropping/Farming Systems Research Outreach Sites at Tuguegarao, Cagayan; Guimba, Nueva Ecija; and Claveria, Misamis Oriental	IRRI/DA	IRRI/IDRC
1980-85	Rainfed Agricultural Development (Iloilo) Project (RADIP), an expansion of KABSAKA	NFAC, DA	World Bank
1980-85	Rainfed Agricultural Development Outreach Sites (RADOS) in Ilocos Sur, Pangasinan, Oriental Mindoro, Leyte, Iloilo, Bohol, Davao del Sur, South Cotabato, and North Cotabato	NFAC/DA, IRRI/UPLB	World Bank
1981-85	Multiple Cropping Project under Philippine-Australian Development Assistance Program (PADAP)	DA	AIDAB
1981-90	Farming Systems Development Project in Eastern Visayas (FSDP-EV)	DA, ViSCA	USAID
1982-present	Palawan Integrated Area Development (PIADP) Phase I (1982-90) and Phase II (1991-97)	DA, NIA, DPWH, DENR, DOH, DSWD	ADB/EEC
1982-present	Farming Systems and Soil Resources Institute (FSSRI) in Los Baños	UPLB, DA	UPLB/WB
1983-88	Regional Integrated Agricultural Research Systems (RIARS) under the Agricultural Support Services Program (ASSP)	DA-ARO, IRRI, SCUs, World Bank	
1983-93	Northern Samar Integrated Rural Development Project (NSIRDP)	DA, LGUs	AIDAB
1984-88	Philippine Farming Systems R&D Program	PCARRD, DA, SCUs, PCARRD/DA	
1984-91	Farming Systems Development Project at Bicol (FSDP-Bicol)	DA, LGUs	USAID
1984-87	Philippine-Australian Rainfed Lowland Antique Project (PHARLAP)	DA-ARO	ACIAR/ANU
1985-90	Rainfed Resources Development Program (RRDP)	DA, PCARRD, SUCs	USAID

continued on next page...

Table 6 continued.

Years	Program/project	Agencies involved	Funding source
1985-present	Central Visayas Regional Project I and II (CVRP)	DA, DENR	USAID
1985-present	Farm and Resources Management Institute (FARMI at ViSCA)	ViSCA, DA	ViSCA/USAID
1986-91	Accelerated Agricultural Production Program-Research and Outreach Subproject (AAPP-ROS)	SUCs, DA-BAR	USAID
1987-present	Highland Agricultural Development Project (HADP)	DA, LGUs, BSU	ADB
1988-93	Sorsogon Integrated Area Development Project	DA, LGUs, NGO	EEC
1988-present	Central Cordillera Agricultural Program (CECAP) Phase I and II	DA, LGUs	WB/EEC
1989-present	Farming Systems R&D Network of DA-BAR/ATI, FSSRI	DA, SUCs	DA/USAID
1989-present	Southern Mindanao Agricultural Project (SMAP)	DA-SCO, LGUs	EEC
1990-present	Integrated Social Forestry Project (ISF)	DENR, DAR, DA, LGU	USAID/WB DENR
1991-present	Aurora Integrated Area Development Program (AIADIP)	DA, LGUs, NGO	EEC
1991-present	Sustainable Agriculture and Natural Resources Management (SANREM) – Collaborative Research Support Program (CRSP) SUCs	DA, PCARRD, LGUs	University of Georgia, DA, DENR, South Carolina Univ., DOST
1991-present	Fishery Sector Program: Research and Extension Outreach Component	DA-BAR, BFAR, PCAMRD	ADB,
1993-present	Community Sustainable Development Program: Farmer-Scientist Approach	UPLB, DA, DOST, LGUs, NGOs	DA, DOST
1994-present	Small Island Development Project (SMIDE)	DA, LGUs, NGOs	EEC
1995-present	Commodity-Integrated Research and Development Project (CIRDP)	Regional Consortium	PCARRD
1995-present	Farming Systems Development Program under the Agrarian Reform Areas	DAR, DA, PCARRD	World Bank
1995-present	Gintong Ani Program: Key Production Areas for Rice, Corn, High-Value Crops, Livestock, Fishery, and Marginal Areas	DA, LGUs, NGOs	DA
1995-present	Sustainable Agriculture Support Project (SASP)	DA, BAR, SUCs, NGOs	DA/NFAC
1996-present	Farmer-Centered Agricultural Resource Management Program (FARM)	NGO, LGUs, DA	FAO-UNDP
1997-present	Community-based Participatory Action Research Project	DA, LGUs, NGOs	DA-BAR

Source: Labios (1997).

During the series of workshops, papers on the progress and results of ICAS R&E and research methodology used in rice-based crop-animal systems and other crop-animal–based farming systems (wheat, root crop, etc.) were presented. The ARFSN was phased out, however, in 1996.

Philippine Rice Research Institute (PhilRice)

PhilRice, with its Rice-Based Farming Systems (RBFS), works closely with discipline-oriented divisions of the institute (Plant Breeding and Biotechnology; Agronomy, Soils, and Plant Physiology; Crop Protection; Rice Engineering and Farm Mechanization; Socioeconomics; and Rice Chemistry and Food Science). Support service areas of Seed Production and Health, Development Communication and Training, and Technology Management and Services actively support the various RBFS activities. PhilRice has established strong linkages with state universities and colleges (SUCs) and other service agencies and NGOs for a vigorous rice production program.

Among the common activities undertaken under interdepartment arrangements are multilocation testing of promising component technologies of various aspects of rice production and processing, pilot rice production programs, and national production programs. PhilRice works so that its promising component technologies are adopted by farmer-users to improve rice productivity.

PhilRice has a Socioeconomics Division that has developed a methodology for measuring the net profitability, net efficiency, and competitive advantage of different RBFS crop components. These aspects can be introduced to improve the current and future ICAS R&E methodology for measuring the benefits of the livestock component when added to a purely crop-based farming system with rice as the main crop.

The Institute also has a strong Food Science Division, which has developed potential rice-processing technologies, among which is rice wine based on the local wine (*tapuy*) popular in Ifugao Province, and it is now becoming an export rice-based product.

Furthermore, PhilRice has a well-knit network of GOs and NGOs, at the national and regional levels, that can help promote improved rice-based ICAS technologies for on-farm testing and piloting. Its farmer-clientele who have been involved in on-farm rice experiments are quite willing to try out improved integrated crop-animal technologies along a total food/feed systems approach.

Philippine Council on Agriculture and Resources Research and Development (PCARRD)

The NARES in the Philippines consists of a network of national and regional commodity R&E centers and regional R&D consortia being coordinated by PCARRD, with its 15 consortia in 15 regions of the country. A consortium is a quasi organization with research and service agencies in a region as members, with either a DA or an SUC as the base and secretariat. Its organization in the late 1970s and ’80s was based on the decentralized management of agricultural and resource R&D under the principles of cooperation, relevance, effectiveness, and efficiency. Its technology transfer and service delivery are much improved through user-oriented approaches—Farmer Scientists Bureau (FSB), Farmer Information Technology Systems (FITS), symposia and business fora, and rewarding the outstanding performance of R&D centers and institutions by giving Pantas (expert), Tanglaw (light), and Ugnayan (coordination) Awards for excellence in agricultural and resource R&E.

Today, its Livestock Division (LD) spearheads the implementation of an ICAS R&E program in the Philippines under the Crop-Animal Systems Research and Extension Network (CASREN). Its LD and team of experts from SUCs are carrying out a multidisciplinary, multiagency rice-rice + cattle farming system at two rainfed sites, Umingan and Don Montano, now being expanded to include three more rainfed sites, Sta. Barbara, Calasiao, and Balungao, in Pangasinan (Region I).

The International Livestock Research Institute (ILRI)

ILRI is a newcomer in Philippine ICAS R&E. It has spearheaded CASREN, involving the Philippines, China, Indonesia, Thailand, and Vietnam, signaling the start of ecoregional research. CASREN gives due recognition to livestock in improving the sustainability of ICAS livelihood systems of farm households. The network embodies continuing activities on various aspects of ICAS R&E—improved understanding of the new ecoregional perspectives, policy options for promoting rural income, diversification in the livestock sector, GIS applications, improved feed production and use, design and ex ante analysis for technical interventions, methodologies for analyzing household survey data, country characterization of rainfed sites, and ICAS technology development, promotion, and use.

Problems so far identified that could constrain the practice of ICAS were restrictions to capital and inputs, to access to markets, and to diversity of household activities—crops, animals, household, off-farm interactions, cultural preferences, and practices. Lessons learned were understanding complexities, developing improved component technologies, and improved feeding, management, and animal health. CASREN is improving ICAS R&E perspectives and methodology. Felt needs are the ex ante assessment as a tool for identifying technical constraints, technology adoption (e.g., the fodder bank, a technology developed by ILRI in West Africa), complementarity of systems, component research, and capacity development.

University of the Philippines at Los Baños (UPLB)

Multiple cropping systems research (MCSR) in the Philippines formally started in 1971 as a joint UPLB College of Agriculture (CA)-National Food and Agricultural Council (NFAC) national production program. The general objec-

tives were to increase the income of small farmers and improve their diet by maximizing the use of available land resources.

As a leading agricultural institution, UPLB was one of the SUCs with which ARFSN established a strong linkage for pursuing an ICAS R&E program nation-wide. This institution has strong crop, animal, and farming systems R&D projects. It has the right mix of capable agricultural scientists and relevant curricular programs, such as Livestock and Poultry, strongly supported by research, extension, and publications. While the ARFSN has the rice technologies and experts, UPLB has the crop and animal component technologies and experts. R&E funds, however, being always in short supply, have somewhat hampered ICAS R&E. UPLB continues to support ICAS R&E by including it among its priorities in graduate and undergraduate research.

Central Luzon State University (CLSU)

The major contribution of CLSU to ICAS R&E initiated by ARFSN was its rice-fish farming system, which has not progressed in the Philippines beyond the artisan type. Pingali (1998) gave several reasons why this may be so, but we are not aware whether the reasons have been verified. Other modified patterns that were tried, however, were rice-fish + duck + pig, rice-azolla + duck, and rice-fish + fingerling production, the latter being a combination of grow-out and fingerling production.

Earlier, CLSU was an active partner in the CSR/MCSR zonification projects of UPLB, from which its FSA/FSRD tradition evolved. Later, together with this institution, the DA, and Kansas State University (KSU), a land-grant institution in the U.S., they became major participants in the Integrated Agricultural Production and Marketing Project (IAPMP), a national project of the FSRD genre under which ICAS R&R grew for a while. This was funded by the USAID under Title XII of the U.S. Congress (1978-83), after which it did not prosper because of a lack of funds.

It had three components: policy, curriculum, and technological packaging ("tech pack" for short). The DA was the lead agency in policy, UPLB in curriculum, and CLSU in tech pack, along a total food system of production, processing, and marketing. The identified tech packs were farmer-proven technologies under small farmers' conditions across rice ecosystems around a 15-km radius from CLSU, involving communities with zero to partial to full water regimes. Among the major crop-animal packages tried on-farm were rice-rice + pig, rice-rice + poultry, rice-rice + fish, rice-rice + duck, and rice-rice + goat. The design and use of livestock housing units, feed, and a feeding system were among the technology components. Support facilities of the total food/feed system approach were two commercial processing centers with provision for small- to medium-scale feed and food product development and enterprise-building ventures, and a farmers' market.

Today, CLSU has strong carabao, goat, quail, and tilapia on-station and on-farm R&E. Among its major contributions to the component crop/livestock/fish industry, which can find their way to ICAS technology improvement, are artificial insemination and frozen semen commercialization for upgrading carabao. Upgrading native goat stocks through various imported breeds (Anglo-Nubian, etc.), sex-reversed/genetically improved farmed tilapia strains, and a variety of integrated crop-animal-fish systems are among the potential components for a vigorous revival of ICAS R&E.

The 25-cow dairy cooperative enterprise model in Pangasinan, now being promoted in other regions all over the country, and several goat cooperatives using upgraded Anglo-Nubian stocks, mostly in Nueva Ecija and Bulacan, can be added inputs in the proposed ICAS enterprises in a total food/feed system.

For the participatory R&E methodology to help improve current ICAS R&E, lessons can be drawn from the farmer-led organic fertilizer project under the Low External Input for Sustainable Agriculture (LEISA) periurban vegetable production and marketing project under the CLSU-AVRDC project, and the Central Cordillera Agricultural Project (CECAP), all using participatory agricultural development perspectives, with university faculty as R&E leaders.

The Local Government Unit (LGU)-based participatory extension of the Barangay Integrated Development for Agriculture and Nutrition Improvement (BIDANI) of CLSU can also give cues on participatory ICAS R&E with a political dimension. The LGU is used as the owner and carrier of rural development projects.

Other agencies/institutions

The Don Mariano Marcos Memorial State University (DMMMSU), Visayas College of Agriculture (ViSCA), now Leyte State University, and the Camarines Sur State Agriculture College (CSSAC) were mentioned in a DA report to have participated in the national ICAS R&E effort. Other institutions might have ICAS R&E activities that we may have failed to retrieve because of certain limitations. For example, resource materials on hand are not complete.

Characterization of ICAS in rainfed lowland, upland, and hilly rice ecosystems

ICAS classificatory system

ICAS can actually be classified according to varied agroecosystem and other classificatory descriptions as suggested below:

1. Agroecosystem, as fully or partially irrigated and unirrigated or rainfed lowland, hilly, or upland; shallow drought-prone, shallow drought- and submergence-prone, shallow submergence-prone, and medium-deep and waterlogged; rice-based or other crop-based.
2. Geography as a locale descriptive of varied landscapes useful in developing agro-tourism, which suggests social acceptability, technical feasibility, and equity;

includes regional (Regions I to XII, CAR, ARMM, and CARAGA) and zonal (Luzon, Visayas, and Mindanao) as a dummy for ethnicity.

3. Other classificatory descriptions may refer to farm size as small (<1 ha) and big (>1 ha); government or non-government organization (GO-NGO) initiated or operated; extension provision by state universities and colleges or service agencies; Department of Agriculture, Department of Agrarian Reform, etc., indicative of management inputs for enabling conditions.

The Food and Agriculture Organization (FAO) of the United Nations has classified types of agricultural lands into three, where ICAS technology may have been adopted differentially:

1. Low-potential lands—referring to rainfed with low and uncertain rainfall.
2. High-potential lands—irrigated or naturally flooded, or rainfed with good rainfall.
3. Problem lands—with excessive rainfall, steep slopes, or poor soils.

This latter typology also signifies a form of suitability and sustainability measure that can be easily understood by farmers. Forming a matrix of relationships using these typologies interacting with socioeconomic circumstances, for example, may yield newer information. This information was not used, however, when sorting on-farm ICAS.

As shown in Tables 7 and 8, on-farm and on-station ICAS technology development and promotion studies, mostly on component technology, were used as the main source for presenting ICAS: typology and geography, crop-animal interactions, socioeconomic benefits of livestock, and gender participation in ICAS. Table 7, which is for the rainfed lowland and irrigated rice ecosystem, and Table 8, for the upland and hilly ecosystem, provide a summary of component studies upon which a part of this section is based. In Table 8, only the rice-based upland and hilly-land ICAS were included.

The ICAS could not, however, be classified completely using the above classificatory systems because of a lack of information. Only the title of the ICAS projects, regional or provincial/city locale, organizations or agencies concerned, and authors'/study leaders' identity and components studied could be mentioned.

ICAS typology and geography

The common livestock and poultry components common to rainfed lowland and irrigated, upland, and hilly lands are carabao, cattle, goats, pigs, chickens, and ducks, and, to some extent, sheep and fish, mainly tilapia. Common crops grown are rice and maize, legumes, and vegetables. Only a few farmers mentioned growing fodder for animals.

Not all regions have reported, so we could not surmise that some of them did not consider ICAS technology adoption for the regions that reported, although the reports mentioned ICAS being studied even when only component technologies were reported. The economic benefits of component technologies tested or verified were measured using cost and return analysis.

There were more regions (5) that reported rice-based ICAS technology development and promotion activities in upland and hilly land than those in rainfed lowland and irrigated rice lands (9). The DA RIARCS were the most active ICAS R&E workers.

Socioeconomic benefits from ICAS

Adriano (1989) and Paris (1992) reported that crop-animal mixed farming provided the following socioeconomic benefits: a source of additional food supply, cash income, draft power, security, and prestige.

Another socioeconomic benefit not mentioned here, but true at least for Nueva Ecija and Bulacan, is the contribution of carabao to annual festivities, recreation (carabao races), and animal beauty contests. Annually, CLSU has a Miss Carabao contest, each year declaring the best-looking carabao depicting both physical and nutritional care. The university participates in national and regional rodeo contests, and a national rodeo hall of famer is a perennial winner.

Crop-animal interactions

Crop-animal interactions involving plant residues and by-products can directly benefit animals, which, in turn benefit farm families. The use of available weeds and tree leaves as fodder while crops use animal manure for faster growth reduces waste and results in waste recycling and extra income. Thus, ICAS helps conserve the environment while providing food security and helping alleviate poverty. However, other forms of interactions can have agronomic-socioeconomic, farmer-researcher participatory, research-extension, and GO-NGO links.

Paris (1992), summarizing the results of rice-based crop-livestock farming systems research in the Philippines and other Asian countries, enumerated crop-animal interactions as follows:

1. Use of animal power in crop production, transportation, and processing; and use of crop by-products (straw, bran, and residues) by livestock and poultry.
2. Use of animal manure to improve land productivity and cut input costs.
3. Minimizing production risks by combining crop and livestock enterprises.
4. Small-farm household consumption of milk, meat, and eggs, thus substantially improving human nutrition and health.
5. Sale of livestock and poultry and their products to improve and stabilize farm income for the purchase of cash inputs and to offset household expenditures, such as school fees, social obligations, and health care.

The main issue in crop-animal interactions is the lack of methodology for measuring the benefits derived from them. Paris (2002) mentioned that there is a paucity of in-

Table 7. Crop-animal/fish systems studies by region in rainfed lowland and irrigated rice lands in the Philippines, 1974-2001.

Title of project components	Region/province	Implementing agencies	Year
Crop-livestock farming systems crop component	Region I Pangasinan	ARFSN, MAF, UPLB	1984
Crop-livestock research	Region I Ilocos Sur Ilocos Norte (2 sites) Benguet Mt. Province Pangasinan (2 sites)	DA	1987
Crop-animal systems research: the Philippine site	Region I Pangasinan	CASREN	2001
Integrated rice-fish and livestock-based farming systems	Region II	ISU	1981
Rice-fish culture trials at the Banaue Agricultural Development Center	Region II Ifugao	CLSU	1988
The productivity of mono-mixed grazed goats and sheep	Region II	ISU	1994
Influence of shelter on the performance of grazing behavior of mono and mixed grazed goats and sheep	Region II Isabela	ISU	1996
Performance of carabao in the sulapi-based ration with UMMB supplementation	Region II Isabela	ISU	1997
Rice-rice cropping patterns using a combination of inorganic fertilizer and azolla + ducks	Region II Isabela	ISU	
ISU New Hampshire chickens for security and alleviation of poverty	Region II Isabela	ISU	
Varying levels of cassava meal in the performance of growing pigs	Region II Isabela	ISU	
Effect of mulberry leaf meal on the growth performance of pigs at finishing state	Region II Isabela	ISU	
Effects of kakawate leaf meal on the growth performance of fattening pigs	Region II Isabela	ISU	
Herbage production and persistence of selected lesser-known Philippine indigenous fodder trees and shrubs under Isabela conditions	Region II Isabela	PCARRD, DA, CVIARC	2000-01
On-farm verification trials of rice + ducks integrated farming systems	Region III Nueva Ecija	DA	–
Exploratory trial on rice-fish culture	Region III Nueva Ecija	FAC, CLSU	1974
Improved rice-fish culture in the Philippines	Region III Nueva Ecija	FAC, CLSU	1978
Preliminary trial on integrated rice-fish-pig farming systems	Region III Nueva Ecija	FAC, CLSU	1985
Tilapia integrated rice-fish culture with azolla	Region III Nueva Ecija	FAC, CLSU	1986
Rainfed rice-based crop-livestock farming systems research	Region III Tarlac	DA	1987

continued on next page...

Table 7 continued.

Title of project components	Region/province	Implementing agencies	Year
Transplanted rice + duck + transplanted rice + duck	Region IV Aurora	DA	1989-92
Technology verification trial on transplanted rice + cattle fed with urea-treated rice straw	Region IV Batangas	DA-STIARC	–
Transplanted rice + transplanted rice + duck	Region IV Romblon	DA	–
Improving the performance of native chickens by feeding rice by-products, cowpea, cassava, and other farm products	Region IV Cavite	PhilRice	–
Technology verification on crop-livestock integration with improved pasture	Region IV Oriental Mindoro	DA	–
Farmer's training on modern rice and rice-based production practices—use of organic farm residue as compost and animal management	Region IV Cavite	PhilRice	–
Livestock integration in rice-based farming systems 1. Different treatment methods to increase the feeding value of rice straw 2. Liveweight performance of junior bulls fed with different types of treated straw	Region VII	DA	1993-95
Crop-livestock research in Leyte	Region VIII	ViSCA	1983
Crop-livestock technology verification trials on rice-based cropping patterns	Region IX	DA	1990-92
Integration of ducks with swine fattening in rice-based cropping patterns	Region XI Surigao del Norte	DA	1989-94
Adaptability and preference trial of improved grasses and legume species	Region XI Davao City	DA	1992-95
On-farm verification on the integration of ducks and integrated pest management in rice-based cropping systems	Region XI	DA-SMIARC	1992-95
On-farm verification of Bureau of Animal Industry urea mineral molasses block supplement for growing/fattening cattle			1994-95
Piloting of urea mineral molasses block for growing/breeding cattle	Region XI	DA-SMIARC	1996-98
Growth performance of goats fed with some fodder species	Region XI	DA-SMIARC	1996-98
Dried broiler waste-based concentrate for backyard pigs	Region XI	DA-SMIARC	1999
Dried broiler manure-based concentrate for backyard poultry	Region XI	DA-SMIARC	1999

Table 8. Description of crop-animal systems research in each region under Department of Agriculture (DA), 1990-94.

Region/province	Land type	System	Component testing/intervention
CAR Banaue	Upland terrace	Rice + ducks, swine, chickens	Use of snails for ducks
CAR Banaue			
Region I Mt. Province		Fruit trees + forage + cattle, goats	Adaptability of different forages, stocking rate of cattle
Region I La Union	Hilly land	Fruit trees + cattle, goats	Collection and evaluation of forages and pasture grasses
Region II Cagayan	Hilly land	Fruit trees + goats, cattle	Assessment of seasonal diseases of ruminants
Region II Isabela	Upland plain	Carabao + upland cropping systems	Feeding of snails to swine
		Goats + pasture-based carabao reproduction	Survey, diagnosis, and treatment
Region IV Cavite	Upland	(Banana + upland rice + peanut + green corn) + cattle	Feeding schemes using indigenous feedstuff
		Upland rice-cowpea + ipil-ipil with goats	Forage evaluation, animal health, and sanitation improvement
		Upland rice + green corn + Tapilan with goats	Documentation of cattle and goat fattening scheme
		Upland rice + cowpea, cassava + native chickens, cattle	Gender analysis by product use
Region IV Laguna	Upland	Coconut + (corn + mung) + ducks	Feeding schemes trial
		Coconut + (corn + mung) + swine	
Region IV Quezon	Upland	Coconut + (corn + peanut) + cattle	
Region IV Rizal	Upland/hilly land	Santol + kakawate + napier + upland rice + cowpea + chickens	Improve breed and management of poultry
Region V Catanduanes	Upland plain	(Sweet potato + green corn + pasture) + goats, carabao	Upgrading carabao with Murrah buffalo through artificial insemination
			Milk performance of graded carabao
Region V Albay		(Corn + cowpea + sweet potato + corn + cassava) + swine	Introduction of pasture legumes into native pasture
Region V Albay	Upland plain	(Corn + sweet potato + corn) + swine	
		(Corn + peanut + corn) + cattle	
		(Corn + green bean + corn) + cattle	
		(Banana + pastures) + cattle	
Region V Camarines Sur	Upland	(Coconut + root crops) + swine	
	Upland	(Upland rice + upland rice + corn) + chickens	
Region V Camarines Norte	Upland	(Coconut + gabi + cassava) + swine	Use of farm by-products
		(Upland rice + peanut + green corn + sweet potato) + swine	
Region V Masbate	Upland	(Corn + corn + mung + pasture) + cattle	
		(Corn/sweet potato + squash) + swine	
		Mango + (upland rice + peanut) + goats	
Region V Sorsogon	Hilly land	Sloping agricultural land technology + goat	Integration of fodder trees on smallholder farms
	Upland	(Cassava + mung) + ducks	
	Upland plain	(Cassava + green corn) + pastures + goat	
Regio VI Capiz	Upland/hilly	Crop integration with livestock and poultry	Evaluation of forage grasses and legumes
Region VI Aklan	Upland/Hilly	(Upland rice + green corn + peanut/ pigeon pea + kakawate) + carabao	Night corraling for breeding system of carabao
			Evaluation of different forages
La Carlota Stock Farm	Upland	Pasture-based + carabao	Hormone study on estrus
			Synchronization in carabao

continued on next page...

Table 8 continued.

Region/province	Land type	System	Component testing/intervention
Region VII Bohol, Cebu, Negros, Siquijor	Upland/hilly	Verification trial on corn-based + goat/cattle integration systems	Cattle grazing on native/centro pasture with mineral supplementation Evaluation of forage trees, grasses, and legumes in strips Improved management schemes for crops and animals in hilly areas
Region VIII AES, Biliran, Leyte, Western Samar	Upland	Coconut + improved grasses + goats, sheep	Tethering study on sheep Weaning age performance of sheep Feed supplementation at different stages of pregnancy of sheep
Region VIII AES, Biliran, Leyte, Western Samar	Upland	Coconut + improved grasses + goats, sheep	Tethering study on sheep Weaning age performance of sheep Feed supplementation at different stages of pregnancy of sheep
Region IX Zamboanga City	Upland	(Upland rice + peanut) + goats	Pasture/forage and animal shed development
		(Fodder trees + pastures) + cattle	Breeding of Philippine sheep with Barbado sheep
Region IX Zamboanga del Sur	Upland	(Coconut + coffee + forage) + cattle	Dairy goat production Crop-fish livestock system on freshwater
Region IX Zamboanga del Norte	Upland	Coconut + pasture + goats	Stocking rate
	Upland	(Coconut + upland rice + mung) + goats	
		(Upland rice + corn) + goats	Feeding study on goats
Region X Bukidnon	Upland	(Corn + corn + peanut) + swine, goats	Profitability of backyard swine production
CARAGA Surigao	Upland	(Coconut + pastures) + goat	Chicken-freshwater fish trial
Region X Camiguin	Upland	(Coconut + grass/stylo) + cattle	
Region X Misamis Oriental	Upland	Leguminous fodder + goats	Adaptability of different forages
		(Upland rice + corn + peanut/ipil, kakawate, forages) + goats	Integration of fodder trees as strip in sloping areas
Region XI Davao Oriental	Hilly	Integration of goats in hilly-land system	Feeding practices/sources under different farming system scheme
Davao City	Upland	Coconut + corn + corn + pasture + goats	
Region XI Davao Sur	Upland	Coconut + (corn + corn-mung) + pasture + goats, cattle	Evaluation of upgraded goats
Region XI South Cotabato	Upland	(Coconut + corn) + cattle	
Region XII North Cotabato	Upland	(Corn + corn + peanut) + cattle	Improved feeding and management
Region XII Sultan Kudarat	Upland	(Corn + corn + peanut) + cattle	Upgrading of stock
Region XII Lanao del Norte	Upland	(Corn + corn + mung) + goats	Health improvement, mineral supplementation
		(Coconut + fodder trees) + cattle	Screening of fodder trees as feed

formation on the socioeconomic benefits of crop-animal interactions. Major reasons given were

1. Lack of skilled social scientists within NARES.
2. Inadequate understanding of methodologies for crop-animal research.
3. Limited knowledge of the application of economic analysis for crop-animal interactions.
4. Overemphasis on component technologies.
5. Lack of concern for gender and other socio-cultural implications for technology development and dissemination.
6. Poor linkage among farmers, researchers, extension workers, and rural development planners.
7. Lack of village support mechanisms to sustain the adoption of new technologies.

Livestock management

Among the studies conducted, only a few were on livestock management, mostly on the technical and economic viability of feeds, especially their combination or supplementation. Tables 9 and 10, used to depict the gender division of labor in Pangasinan, contain information on the kinds of feed used for cattle, such as rice straw, rice bran, indigenous grasses, and leucaena leaves.

Gender participation in ICAS

Gender participation in rice production shows more specialization of labor. Land preparation, transplanting, the application of fertilizers and insecticides, harvesting, and hauling are men's domain. Women work more on pulling of seedlings, threshing, and winnowing. Tables 9 and 10 show gender participation in livestock production on rainfed and irrigated lowland rice farms.

As shown in Tables 9 and 10, although carabao and cattle production is men's responsibility, more women participated in livestock care by gathering rice straw, weeds leucaena leaves, and mungbean fodder. Other activities in which more women were found were giving rice bran to animals, feeding, grazing, cleaning, and bathing.

The activities in which more men were found were stacking rice straw, gathering maize and acacia leaves, giving water, putting up animal shelters, and inspecting and selling animals.

Male children were more active than female children in the care of large animals on the rainfed lowland rice farms. There is more flexibility in the gender allocation of labor in livestock production.

In irrigated areas, women performed fewer activities in livestock production. There were more of them in only three activities—gathering leucaena leaves, giving rice bran to animals, and feeding and giving water. Men, young and old, dominated livestock production. Female children did not participate at all.

Men and women scientists urgently need good training on gender issues and gender-sensitive R&E methodology. Women lag behind in education, basic assets, and human rights.

Table 9. Percentage of households using different labor sources for carabao and cattle care, by type of activity and labor source, Carosucan, Sta. Barbara, Pangasinan, 1986.

Activity	Adults		Children[b]	
	Males	Females[a]	Males	Females
Gathering rice straw	83	94	44	0
Stacking rice straw	83	28	44	0
Gathering weeds	83	89	39	0
Gathering leucaena leaves	33	56	17	0
Gathering mungbean fodder	28	33	17	0
Gathering acacia leaves	17	11	0	0
Gathering maize stover	11	6	0	0
Giving rice bran	56	72	11	6
Feeding	78	89	50	6
Providing water	83	78	39	6
Grazing	72	89	56	0
Putting up animal shelter	61	6	6	0
Cleaning pen	56	72	33	0
Bathing animals	83	94	33	11
Collecting dung	0	28	0	0
Detecting estrus	39	6	0	0
Taking animal for breeding	8	6	0	0
Buying/selling animals	78	17	0	0

[a]Two of the households are headed by women (widows).
[b]Age 7–15. n = 18.

Table 10. Percentage of households using different labor sources for carabao and cattle care, by type of activity and labor source, Malanay, Sta. Barbara, Pangasinan, 1986.

Activity	Adults		Children[b]	
	Males	Females[a]	Males	Females
Gathering rice straw	74	63	26	0
Stacking rice straw	89	37	32	0
Gathering weeds	79	53	37	0
Gathering leucaena leaves	11	53	11	0
Gathering sugarcane tops	47	11	16	0
Providing rice bran	37	47	11	0
Feeding	79	74	37	0
Providing water	68	74	37	0
Grazing	79	68	32	0
Putting up animal shelter	84	26	16	0
Cleaning pen	79	74	32	0
Bathing animals	79	42	37	0
Detecting estrus	74	44	0	0
Taking animal for breeding	58	0	0	0
Buying/selling animals	47	21	0	0

[a]Two of the households are headed by women (widows)
[b]Age 7–15. n = 19.

Village women should have access to training on all kinds of skills and possibilities, to organize themselves and to participate in research. Gender sensitivity in farming systems research is of recent date and its focus has been on crop production more than on animal production.

Available micro studies show that women's participation in animal production may vary by farm size, ecosystem, socioeconomic status, and type of household and because of sociocultural and religious influence.

In the Philippines, season of participation and types of household (landless and family farmers with land) were compared. Men and women in farming families participate almost equally in livestock production during the wet season (May to August). The contribution of women in the dry season is lower than that of men. However, women in batch groups are engaged more in swine production than in cattle production activities. The results indicate that, despite traditional animals being men's business, women participate substantially in their care. There is greater flexibility for labor substitution in animal-care activities. Unlike in rice production, the extent of the involvement of household members in decision-making and in doing actual work in raising carabao shows male dominance. The wife participates significantly in decision-making regarding practices that require cash outlays (Adriano 1989). Swine production and marketing are her sole responsibility.

Women also make policy decisions such as obtaining rice bran for feeding swine. Similar and other related observations were made by Chua (in Adriano 1989), who mentioned that women contributed 66% to preparing feed rations, 60% to feeding, 57% to animals, and 66% to health care.

In chicken production, women make the nests, feed, gather the fowl, gather eggs, attend to newly hatched chicks, clean and fill drinking-water trays, provide health care, dress chickens, and sell chickens and eggs in the market.

Tools for collecting gender-based information. Tools used to collect gender-based information (Paris 2000) applicable to ICAS studies were (1) selection of target sites/areas; (2) initial site characterization and problem diagnosis of farming system; (3) identification of constraints to productivity; (4) identification of technology options/planning and designing experiments; (5) planning, designing, and testing of technology; (6) dissemination of technologies; (7) sensitization of LGU people, researchers, policy makers, and development planners; (8) evaluation of impact; and (9) establishment of support mechanisms to sustain project activities (Paris 1992).

Gender analysis. Data for gender analysis included collecting information on activities of men and women farmers and children; access and control of resources; decision-making processes; equal participation of men and women in all phases of R&E; benefits/incentives; and external factors that may influence the productive activities of men and women of different religion, culture, history, economic status, and other relevant matters (Paris 1992).

Reasons given why analysis is important to ICAS technology development and promotion are that no one's interpretation is gender-neutral; each intervention generates changes in gender relations, and continuous FSR analysis creates the possibility to adjust changes so that they no longer work against women's position. Women, like men, want to be treated as experts and that is why separate interviews of men and women are carried out (Paris 1992).

Socioeconomic issues concerning women's participation in livestock raising. The socioeconomic issues concerning women's participation in ICAS as studied by Paris (1992) are the inadequate supply of locally available ani-

mal feed; lack of capital and access to institutional credit; high cost of commercial feed; lack of access to low-cost technology, training, and extension services; competing use of resources; risk in production with small animals; and unstable market prices.

The recommended strategies for examining these socioeconomic issues concerning women in animal production were quantification of gender roles in livestock and poultry production in the FSR; identification of women's constraints in crop and animal production; inclusion of small animals and poultry in research activities; identification, testing, evaluation, and dissemination of technology in animal husbandry; inclusion of women as cooperators in the technology development process, particularly in relation to resource use; inclusion of women in extension services and training programs related to animal production/development of schemes that would provide women with access to capital and credit; and increasing the production of local animal feed.

Potentials of ICAS technology development and promotion in the rainfed lowland rice ecosystem

Despite its growing importance, rainfed lowland rice has only recently received the attention it deserves. These lands are generally characterized as heterogeneous at any single location, diverse across locations, and unpredictable everywhere. In fact, that very ambiguity of the definition of rainfed lowland rice may account for the historic lack of attention given to it (Mackill et al 1996). The first comprehensive book on characterizing and understanding rainfed environments just came out in 2000 (Tuong et al 2000).

Rainfed lowland rice can be classified into four types (Singh 2000): (1) shallow, drought-prone; (2) shallow, drought- and submergence-prone; (3) shallow, submergence-prone; and (4) medium-deep waterlogged.

Total rice lands in the Philippines cover more than 3 million ha. Of this area, about 1.4 million ha are rainfed. One-half million ha of rainfed rice lands are drought-prone. Around 53% of the rainfed area is devoted to rice-based cropping systems with rice as the main crop, sometimes followed by another rice crop using shallow pumps. Most small-scale animal production is found in this area.

As a result of the national government's implementing FSRD programs in rainfed lands in tandem with IRRI, SUCs engaged in agriculture and resources R&E partially characterized rainfed lowland rice ecosystems in Ilocos Norte (Region I), Claveria (Region IV), Tarlac (Region III), and Iloilo (Region VI). Table 8 gives the physical and biological characterization of the sites, as well as the main issues, characterization needs, methodologies, impact assessment, and identified gaps. There are still many unknowns for extrapolating recommendation domains. The potentials of ICAS in any ecosystem need micro-biophysical and socioeconomic characterization using participatory approaches in obtaining data identified in Chart 2.

Table 11. Dominant cropping patterns in the Philippines.

Region	Cropping patterns
I/CAR	Rice-rice, rice-garlic, rice-tobacco, maize-white potato, rice-legume, white potato-vegetable
II	Rice-garlic, corn-corn, rice-rice, corn-legumes
III	Rice-rice, rice-legumes, rice-fallow
IV	Rice-rice, rice-fallow, coconut-coffee, pineapple, rice-tomato-coconut monocrop
V	Rice-rice, rice-corn, coconut + rice, coconut + root crops, coco + corn
VI	Rice-rice, rice-corn, rice-fallow, corn-root crops
VII	Corn-corn, rice-rice, rice-fallow, corn-root crops
VIII	Rice-rice, rice-fallow, coconut monocrop, corn-fallow
IX	Coconut monocrop, rice-rice, cassava-fallow, corn-fallow
X	Rice-rice, corn-corn
XI	Rice-rice, corn-corn, coconut
XII	Corn-corn-corn, coconut, rice-rice

Source: Bureau of Agricultural Research and Extension Agenda in Adriano (1989).

Table 11 gives a profile of the dominant cropping systems in various regions of the Philippines (Adriano 1989). Although the profile is descriptive of major cropping patterns in all rice areas of the country, this can help provide cues to the existing cropping patterns in the rainfed rice ecosystem. Some degree of homogeneity can be observed with regard to these patterns. Could these be the same today?

Probably because of poor documentation and inadequate reports on existing ICAS practices, related intensive practices of small farmers on rainfed rice lands that include crop-animal mixes had not been reflected in local and national studies. Cursory observations of small farms as one travels around the countryside show that such practices do exist on small rice farms.

Policy environment for the rice and animal sectors

The potential of ICAS in rice-farming ecosystems, especially on rainfed rice lands, is greatly influenced by government policies affecting the rice and animal sectors, and especially crop-animal/fish mixed livelihood ventures. Existing policies are summarized here.

Past and present policies affecting the rice sector

In the Philippines, a wide variety of intervention policies were introduced. Consequently, such measures had been known to alter directly and indirectly price mechanisms and the incentive structure operating within the rice sector. Among these are sectoral and macroeconomic policies such as the exchange rate, tariffs, subsidies, incentives, transportation, infrastructure, and irrigation.

Trade policies. Before the ratification of the General Agreement on Tariffs and Trade-World Trade Organization (GATT-WTO), restrictive import quotas had historically protected rice production. As the mandated agency to handle importation, the NFA has historically determined the country's rice requirement. Thus, any imported rice that will penetrate the local market will face intense quota requirements. However, with the ratification of GATT-WTO in 1994, the Philippines agreed to transform its rice quota levels into tariff equivalent rates.

As a commodity under the Green Box measure, the country was mandated to lower its tariff levels to 40% by 2004. The tariff level for rice was 50% and the NFA is the only institution mandated to import the required amount of rice.

Rice production subsidies. A major feature of rice production in the Philippines during the 1970s up to the mid-'90s was the prevalence of subsidies on material inputs and credit. While this type of intervention had increased the use of modern rice varieties and techniques, recent farm production has been declining because of the constraints posed by deteriorating technological change.

The *Masagana 99* and then the Grain Enhancement Program (GPEP), which was launched in 1993, provided for subsidized prices of seeds and fertilizer. Although yield levels have increased substantially, the GPEP failed to satisfy the country's domestic rice needs, thus prompting program management to shift from subsidy- to credit-based intervention systems. As a result, the *Gintong Ani* for Rice program was launched. This program is a culmination of the lessons learned from the various GPEPs. Its main feature is accessibility to high-quality seeds and fertilizer through credit.

At present, the new rice program of the government is the *Ginintuang Masaganang Ani (GMA)*. It avails of trade and fiscal incentives for the private sector to invest in seed production and postharvest equipment, which is intended to increase farmers' profits. This program also aims to promote high-quality seeds and cost-effective technologies such as the leaf color chart, balanced fertilization strategy, integrated pest management, synchronous planting, mechanization, and others.

Being a signatory to the GATT-WTO, the Philippines removed all forms of distortionary subsidies. Although the Philippines has identified rice as part of the Green Box commodities, it has not yet availed of the Aggregate Measure of Support (AMS) for rice. The AMS is a form of assistance and is legitimate within the GATT-WTO accords.

Irrigation. Irrigation investments during the 1970s up to the early '80s substantially increased, with 1975 as the highest period, with approximately a 48% share of irrigation in total public expenditures.

During 1979-80, irrigation expenditures totaled approximately 20% of the total public expenditure and 40% of agriculture's expenditure. By the start of the '90s, irrigation expenditure relative to agriculture fell to 10%. Consequently, the percentage of irrigated area declined from 13% in 1975 to about 1.42% by 1993 (David 1994).

Transportation infrastructure. The state of the transportation system in the country remains inadequate and inefficient. It can be concluded that the road densities in prime agricultural areas have been typically lower relative to roads in urban areas. The lower road expenditure levels in rural agricultural areas reflect the historical policy bias in favor of urban centers. Because of this inherent bias against the agricultural sector, farmers have become marginalized because of the inefficient price transmission from the farm to the market. This has effectively kept farmers from becoming integrated in the farm-to-market rice continuum.

Marketing, prices, and rice reserves. Asymmetric price behavior is characteristic of the industry's rice prices primarily because there is no market integration within the industry. A market is said to be integrated if increases in prices at the farm gate are reflected in the retail price and decreases/increases in the retail price are reflected in the farm-gate price. In the industry, asymmetry exists because changes in retail rice prices are not reflected in the price at the farm gate. Another factor that causes nonmarket integration is the prevalence of bad roads, which inflate transportation costs from the farm to the wholesale market. Another is the presence of middlemen and inappropriate government policy intervention (such as the NFA procurement scheme), which serves to add additional cost to marketing rough rice and milled rice.

The Philippines has historically maintained rice buffer stocks in an effort to stabilize prices when they become unfavorable to the welfare of rice stakeholders. The government, through the NFA, has historically intervened in the procurement of rice buffer stocks to preserve a politically affordable price level. However, because of the inefficiencies involved in a public-sector institution, the NFA procured only less than 6% in 1988-99.

The NFA's highest procurement level occurred in 1995, equal to 5.74%, while the lowest was observed in 1995 (0.07%). With this level of procurement, it comes as no surprise that, for the past several years, the NFA has been unsuccessful in influencing farm-gate prices of rough rice.

Industrial protection system and macro policies. Another set of policies that have gained economic importance are those regulating macroeconomic variables such as the exchange rate, monetary and fiscal policies, and the overall trade policy regime. Such policies have important theoretical implications. However, empirical evidence as shown by Gonzales (1997) and Bautista (in Adriano 1989) revealed a significant and differential impact with regard to the incentive structure of most developing economies. Estimates showed that distortions emanating from the exchange rate had large taxation effects.

Exchange rate and macroeconomic policies. In the Philippines, the pursuit of an import-led strategy encouraged the growth of high and restrictive tariff and nontariff barriers. The imposition of these restrictive trade instruments appreciated the peso. Uncoordinated macroeconomic policies in the past due to balance of payments problems led to the further worsening of the peso appreciation, resulting in

an exchange rate misalignment. The rate of deviation of the actual exchange rate from its long-run equilibrium levels is called exchange rate overvaluation.

Time-series estimates reveal that, over the past 30 years before the currency devaluation of 1997, the exchange rate was overvalued from 24% in 1961 to 20% in 1996. This, however, exacerbated the lack of protection received by the agricultural sector and likewise penalized its most important crop, rice.

However, with the occurrence of the 1997 devaluation, it is expected that the magnitude of the penalty in rice will dissipate, giving the commodity some protection leeway.

Livestock and poultry policy

1930-70

In the policy climate for livestock and poultry from 1930 to the present, the following important actions were taken. From the 1930s to 1960, the livestock dispersal program included the importation of cattle and the purchase of local stocks for breeding purposes. Some 4,856 head of cattle were dispersed during the program cycle, which ended in 1973.

The "Piggy Bank in the Backyard" program was also introduced in this period. This Bureau of Animal Industry (BAI) program provided piglets to recipients enrolled in it.

Philippine livestock promotion fund. This fund was used for the genetic improvement of livestock and distribution of improved breeds of animals; establishment, operation, and maintenance of stock farms, breeding stations, and slaughterhouses; manufacture of biological products; and research. Funds came from slaughter fees.

Tariff and customs' law. The schedule of tariffs on livestock products was 70% for poultry meat, 100% for eggs, 15% for other meat, 60% for live poultry, and 0% for other live animals. Revenues generated were used to encourage local breeding of superior stocks and to conserve foreign exchange.

Genetic improvement. Frozen semen and embryos of purebred animals were imported, which represented a much cheaper supply of exotic genetic material.

1970s-'80s

Livestock rehabilitation. The government initiated the "Operation Animal Rehabilitation Program," which included distribution of carabao for draft; breeding of piglets, goats, and boars in hog-raising areas; breeding of chicks among poultry raisers; and the production of feed and feedstuffs for animals.

Bureau of Animal Industry regulations. The government regulated livestock and livestock product trade through its licensing power along with the sole right to import live animals and meat products.

Bakahang Barangay. This special credit program for backyard cattle raisers was launched in 1977.

1980s-'90s

The most dominant policies for livestock in the 1980s and '90s were the Comprehensive Agrarian Reform on Livestock (CARL), the GATT, and the Medium-Term Livestock Development Program (MTLDP).

Agrarian Reform. R.A. No. 6657 defined the structural arrangements of the agricultural sector.

Open market. Under GATT, the Philippines agreed to (1) convert all quantitative restrictions imposed on agriculture into tariffs, (2) reduce tariffs on agriculture, (3) reduce domestic subsidies, (4) reduce export subsidies, and (5) harmonize sanitary and phytosanitary measures.

Agricultural tariffication. The agricultural tariffication act converted all quantitative restrictions on agricultural products into tariffs and created the Agricultural Competitiveness Enhancement Fund; it also repealed a sectional provision of the Magna Carta of small farmers (RA 7607).

Executive Order No. 288 (1995). This provided a two-time tariff structure of 3% and 10% for raw materials and finished products. Starting 1 January 2004, a uniform rate of 5% ad valorem on the same articles was enforced. Executive Order No. 313 (1996) set the in-quota and out-quota tariff rate for agricultural commodities with minimum access volumes.

Development plan. The Medium-Term Livestock Development Plan, also known as the Gintong Ani Livestock, lays the foundation for a productive, efficient, economic, and sustainable livestock and poultry industry. Gains in the livestock sector are ensured to be shared by small- and medium-scale livestock farmers.

National Dairy Administration (NDA). The NDA, which was created by RA 7884, became effective on 12 March 1995. It envisions a globally competitive dairy industry anchored on an expanded base of empowered producers and processors who operate sustainable cooperative dairy enterprises.

Problems and recommendations

Problems as used here refer to difficulties, constraints, questions, issues, and gaps in promoting ICAS, from which recommendations were drawn. The problems were defined from two perspectives: from the small farmers and from the researchers and extensionists. From the small farmers' view, these problems were socioeconomic and biophysical. From the researchers' view, these were use of a common ICAS R&E paradigm and participatory R&E methodology, measuring the economic benefits and sustainability of ICAS, agricultural research and extension and other support services, institutional and electronic networking, and the policy environment for attaining goals of ICAS enterprises.

Rainfed farmers' problems

The identified problems of small farmers in rainfed areas can be grouped into just two categories, socioeconomic and biophysical spheres.

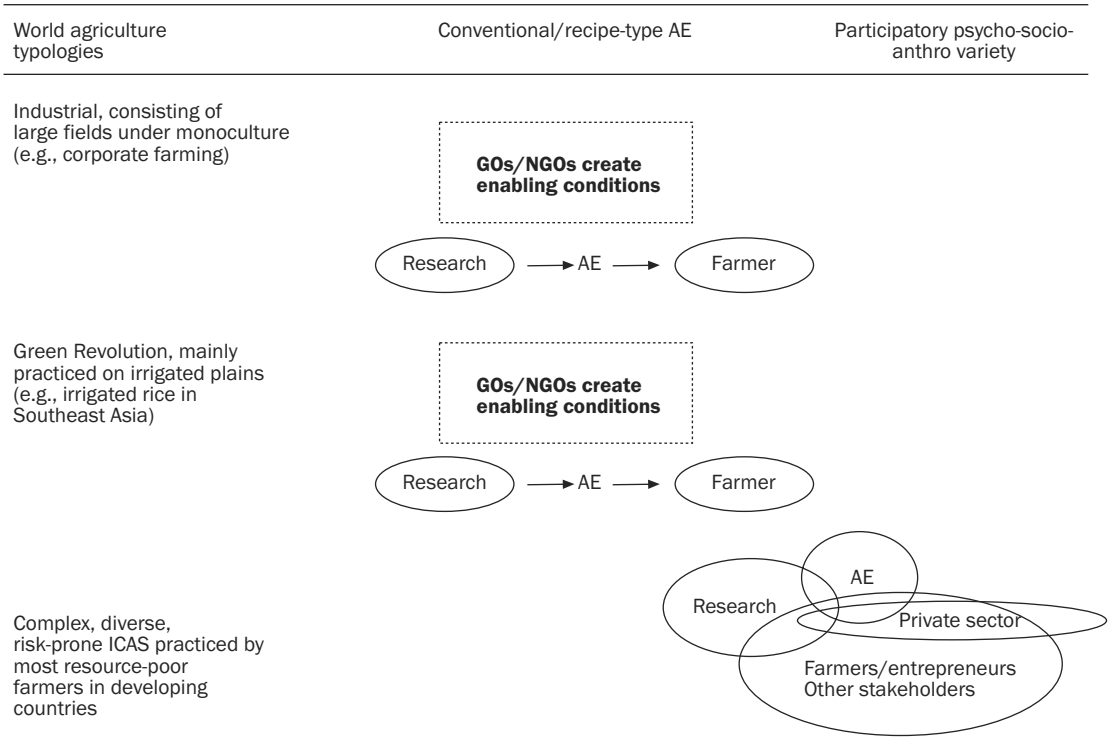
Socioeconomic sphere. The socioeconomic problems are lack of capital to improve operations, low income from agriculture, high cost of production inputs, low market price for farm products, lack of appropriate credit facilities, insufficient institutional linkages (limited to feed and veterinary drug companies, LGU, and DA), noninclination of family members toward farming, and inability to increase animal holdings because farmers need to sell them for varied emergency reasons. Fronda (personal communication 2003) attributes the failure of small farmers in cattle raising and other agricultural ventures to their inability to translate skills and knowledge acquired in training because of their individualism.

Biophysical sphere. Biophysical problems were identified as follows: pronounced wet and dry seasons, decreasing soil fertility, erosion and siltation, denudation of forest, and land conversion. Problems with regard to the raising of animals were poor growth and long growing-fattening period due to present production practice of *wayway* (no supplementation), use of the tethering method, low reproductive performance, low genetic quality of stocks, poor nutrition, lack of knowledge on proper feeding, supplementation and use of alternative indigenous feed, animal health problems, and lack of vaccines and dewormers. Another group of biophysical problems related to farming systems consists of the following: limited cropping options because of climatic conditions in the area, inadequate irrigation facilities, low yield of rice varieties, underuse of fodder tree legumes as feed, and low awareness of proper use of crop residues as feed.

Researchers', extensionists', and other stakeholders' problems

Use of a common ICAS R&E paradigm by stakeholders. The suggested ICAS R&E paradigm is the product of a review of existing systems frameworks used in FSRD in the Philippines. The use of a common systems framework and evolving a participatory ICAS R&E methodology required of complex, diverse, and risk-prone farming systems are not explicit in many component studies.

Researchers and extension workers using commodity component studies and recipe-type extension seem to prefer crop-animal/fish component testing and promotion, maybe because of the difficulty of undertaking a farming systems project. R&E funds are limited and most institutions, for practical reasons, prefer to engage in activities that can be completed within a short term. Not only is funding a constraint, but required multidisciplinary teamwork is easier said than done. In addition, the small farmers' view from the farm gate may not be so clear as top-down R&E approaches make these small farmers passive observers of newer technologies channeled to their farms. Chart 3 is sug-



Source: Adapted from Bruin and Meerman (2002)

Chart 3. Micro variants of support for agricultural research and extension services based on world agriculture typologies. AE = agricultural extension.

gested as a starting point for developing participatory ICAS R&E. The shift from active to facilitative R&E is delineated.

Suggested detailed ICAS R&E paradigm. Chart 2 can now be used to operationalize the imperatives shown in Chart 1. This is the starting point for detailing or consensus building among ICAS R&E stakeholders on the elements that form part of the biophysical and socioeconomic spheres, and how they are to be defined, gathered, analyzed, measured, and used for enterprise building.

By combining lessons from using the suggested ICAS R&E paradigm and changing roles in a user-oriented technology development and promotion, a participatory ICAS R&E can be evolved.

Measuring the economic benefits and sustainability of ICAS

Small farmers always want to know why ICAS technology would be a better livelihood source. The question they usually ask first is, Can it contribute significantly to existing livelihood systems? They have to be convinced that it can make their life better.

One of the weaknesses of the ICAS R&E methodology at present is the inadequacy of socioeconomic measures for determining the benefits derived from it. The usual tool used is a cost and return analysis. Alviola et al (2002) used several approaches that are recommended for determining benefits from the practice of ICAS.

With the membership of the Philippines in the GATT-WTO, the country with its agricultural sector is poised to embrace the inevitability of market globalization, especially in its array of agricultural products. This translates into the gradual opening of the agricultural sector as opposed to heavy protection and government intervention. And, as a vital component of the agricultural sector, the ICAS modality has no choice but to become globally competitive in its respective commodities/products.

However, for this system to succeed, compliance with the new world economic order is not enough as these rules serve only as transition points for the sector to be globally competitive. To be globally competitive is to possess the ability to compete with other countries by being able to convert resources in the most efficient manner, whether they are land, labor, or raw materials from all sources.

Another dimension of crucial significance is the potential of ICAS to provide security in food and other important nonfood requirements. This revolves around the question, Can ICAS provide and sustain increasing welfare in terms of providing adequate financial resources to access better opportunities and services? Another important point is the potential capacity of ICAS to reduce poverty in areas where many marginal farmers reside. This assertion indicates that, with higher income through increased savings, farmers can access production technologies, which can yield an array of investment choices to maximize income.

With these assertions, the use of economic tools such as profitability and competitive methodologies becomes an imperative for understanding the socioeconomic parameters behind ICAS and its crucial role in achieving competitiveness and reducing poverty.

Net profitability analysis

The profitability analysis assesses the financial viability of different commodities from the farm to the major wholesale markets. At the farm level, derived cost estimates were made to reflect the various input and output (I/O) coefficients.

Given the input and output coefficients from the farm to wholesale markets, the profitability equation can be denoted as

$$\pi = TR - TC$$

where π = net financial profit, TR = total revenue, and TC = total cost.

From the equation, a positive net profitability ($\pi > 0$) denotes efficiency in production, hence an incentive to expand production, while a negative net profitability ($\pi < 0$) indicates loss. A net profit equal to 0 ($\pi = 0$) denotes neutrality and indifference in pursuing or disengaging from a production activity.

Measures of comparative advantage of an ICAS component

The theory of comparative advantage can help small farmers decide what crop or animal components they should raise and to what extent they should engage in the activity, improve their ICAS using a particular animal species component, and improve their household total food/feed livelihood systems. In the past, the domestic resource cost (DRC) framework was used in determining the comparative advantage of grains and vegetables such as maize, onion, and garlic. To measure the comparative advantage of maize according to Gloria (2002), its border price is compared with the social or economic opportunity cost of producing and marketing maize if the Philippines produced it domestically instead. If the opportunity cost is less than the border price of maize, the country is said to have a comparative advantage in producing it (Gloria 2002).

The DRC is defined as

$$DRC = \frac{\sum b_k P^s_k}{P^b_f - \sum a_j P^b_{jf}}$$

where P^s_k = shadow price of nontradable input k, P^b_f = border price equivalent of 1 t of cattle in foreign currency, P^b_{jf} = border price equivalent of tradable input j in foreign currency, b_k = quantity of the k nontradable input needed to produce 1 t of crop, and a_j = quantity of j tradable input needed to produce 1 t of crop.

The DRC can be thought of as the "own exchange rate" of a particular production activity (in this case maize production), since the enumerator is expressed in local cur-

rency and the denominator in foreign currency. To be a measure of comparative advantage, the DRC should be compared with the SER of the economy. If the DRC is less than the SER, this means that the opportunity cost of producing maize is lower than the opportunity cost of importing the commodity. The smaller the DRC relative to the SER, the greater the comparative advantage of maize production.

Measuring the comparative advantage of incorporating maize production into ICAS for rainfed rice lands could help to improve total food/feed systems. Its comparative advantage should be measured in terms of its economic benefit and for potential of crop-animal interactions, which has implications for food security, poverty reduction, and agriculture.

The domestic resource cost approach

It is always in the interest of trade economists to determine the "relative position of competitiveness" of a country in the production and trade of rice and rice-based commodities. In this respect, the notion of relative position of competitiveness of a country has two dimensions. The first is comparative advantage, which indicates whether it is economical to expand the production and trade of a commodity. The other is competitive advantage, which indicates whether a country can successfully penetrate the world market for the trading of a single commodity or basket of commodities.

Both of these measures use the DRC approach to estimate each respective comparative and competitive advantage indicator. The fundamental difference lies in the use of prices. Whereas the comparative advantage parameter employs shadow/economic prices (prices that should be reflected in the absence of interventions), the competitive advantage uses market-based or financial prices (observed price indices). Since the interest of this paper is to compare the Philippines with the rest of the world, the competitive advantage indicator is used.

In this respect, the DRC is the ratio of the domestic cost of production and the difference between the border price of output and foreign cost.

In equation form, this is

$$DRC = \frac{\textit{Domestic cost in market price per unit of output}}{\textit{Border price of output – foreign cost per unit of output in border prices}}$$

By dividing the DRC by the official exchange rate (OER), the competitive advantage measure can now be estimated. This ratio, known as the resource cost ratio (RCR), compares the cost of domestic production of a certain product with the corresponding opportunity cost in the world market.

The parameter values range from less than to greater than unity. And it is in these range values where the competitive advantage or disadvantage of rice and other commodities is determined.

The measure can be denoted as

RCR = DRC/ OER if

RCR < 1 (competitive advantage)
RCR = 1 (neutral)
RCR > 1 (competitive disadvantage)

From the criteria, it is clear that, if the cost of domestically producing rice and other crops is greater than the opportunity cost in the world market (RCR >1), the commodity has no competitive advantage. This means that the producer has to spend more than $1.00 of domestic resources to earn revenue equal to $1.00. Likewise, if RCR is less than OER, the production activity has a competitive advantage. This implies that it takes less than $1.00 of domestic resources to earn revenue equivalent to $1.00.

Measuring the sustainability of ICAS as a proxy for measuring benefits from crop-animal interactions

Another central issue in the ICAS R&E methodology is measuring its sustainability benefits, which can be a proxy for crop-animal interactions. In this regard, the measurement of the intensive rice-based multiple cropping systems in Ilocos Norte in the northwestern part of Luzon, Philippines, can serve as a model for measuring the sustainability benefits of ICAS. In the Ilocos Norte case, five crops—maize, garlic, mungbean, sweet pepper, and tomato—were integrated with rainfed lowland rice. Once an animal species (or several species) is integrated in a cropping pattern, it can be treated as one of the crops in measuring the sustainability benefits of ICAS. Total factor productivity (TFP) is considered for northwestern Luzon by Lucas et al (in Tuong et al 2000).

TFP is considered to be a more meaningful concept than partial factor productivity for assessing sustainability (Harrington 1993). As all inputs and outputs are accounted for, a declining trend in TFP is an indicator of possible degradation of the resource base, or unsustainability.

Although the definition requires the inclusion of all inputs and outputs, data limitations and valuation problems mean that some inputs and outputs that can be easily measured and valued are generally included.

Externalities, such as environmental pollution, which are difficult to value, are often excluded from TFP calculations. Similarly, changes in prices of inputs and outputs can affect TFP values over time despite the use of methods that attempt to correct for many price effects (Rayner and Welham 1995). Despite some of these practical limitations to calculating TFP, the trend in TFP is considered to be a useful indicator of sustainability and has been widely used (Capalbo and Antle, in Tuong et al 2000).

Following the method suggested by Rayner and Welham (1995), we used the Tornqvist-Thiel method to calculate the TFP index. The Tornqvist-Thiel method is considered to be theoretically superior to other methods since it is consistent with a flexible production function

that does not arbitrarily constrain the substitution possibilities between inputs.

The input index $I(X)_t$ is computed as

$$I(X)_t = I(X)_{t-1} \exp[1/2" (s_{it} + s_{i,\,t-1})1\text{n}\, x_{it} - 1\text{n}\, x_{i,\,t-1})] \qquad (1)$$

where x_{it} = quantity of input I in period t, s_{it} = share of input I in total cost in period t;

$$s_{it} = \frac{w_{it}x_{it}}{\Sigma w_{kt}x_{kt}},\ i,k = 1, \ldots n, \text{ and} \qquad (2)$$

$w_{it}w_{kt}$ = actual prices of inputs in period t. Similarly, the output index is computed as

$$I(Q)_t = I(Q)_{t-1} \exp[1/2\Sigma(r_{jt} + r_{j,\,t-1})\ 1\text{n}\, q_{jt} - 1\text{n}\, q_{j,\,t-1})] \qquad (3)$$

where q_{jt} = quantity of output j in period t, r_{jt} = share of output j in total revenue in period t,

$$r_{jt} = \frac{p_{jt}q_{jt}}{\Sigma p_{it}q_{it}},\ i,j = 1, \ldots m, \text{ and} \qquad (4)$$

$p_{jt}p_{it}$ = actual prices of outputs in period t. Finally, the TFP index is obtained as the ratio of $I(Q)_t / I(X)_t$.

The computation of these indices follows the following procedure. For each year, all crop outputs produced and all inputs used were included in the calculation. Analysis was limited to the period 1992-97 as the data for 1991 and 1998 were incomplete. A combination of province-level data was used in the analysis as farm-level data for 1992-94 did not include all outputs for all farmers. On the output side, provincial-level data on yield and farm-gate prices for 1992-97 were used.

For the cost of production, data for individual crops for each year were not available at the provincial level. Hence, farm-level data were used for this purpose. Indices of the value of outputs and inputs were subsequently obtained using equations 1 and 3.

Agricultural extension and other support services

Support services needed for intensifying and sustaining ICAS are appropriate crop/animal/fish production, processing, product development and packaging, efficient market channels and marketing systems, farmer-proven technologies, crop-animal health information and care schedules, training and communication, electronic networking, and participatory R&E approaches as newer ways of developing and promoting technologies.

Evolution of a participatory agricultural R&E appropriate for CDR ICAS

The evolution of a participatory ICAS R&E has three interrelated steps as follows:
(1) the use of suggested ICAS R&E systems framework, (2) evolution of participatory ICAS R&E as an agricultural development project using crop-animal/fish mixes, and (3) preparation of a manual.

Changing roles of ICAS R&E stakeholders

As a result of the shift from top-down to bottom-up user-oriented project management, the creation of conditions conducive to participatory ICAS R&E necessitates changing the main role of stakeholders, from one of being directive to one of being facilitative, an enabling role. Table 12 represents newer roles of stakeholders. There has been a brief mention of the need for a participatory perspective in ICAS R&E in many groups. Castillo (1983) asked the question, How participatory is participatory R&E?, as early as 1978. According to her, this query has yet to be answered and to be developed as a full-blown proceeding from the current ICAS R&E methodology in use, which can be refined in actual practice.

A participatory ICAS R&E can be evolved starting with the top-down methodology already in use. This can be done by considering the following:

1. Incorporating bottom-up approaches—shifting roles from active to facilitative (see Chart 3), using experiential hands-on learning instead of recipe-type extension.
2. Incorporating participatory tools and techniques as follows: participatory rural appraisal, focus interview, farmer field school, participatory technology development, farmers' case studies, participatory process documentation, and others.
3. Developing technological packages to consist of farmer-proven technologies, derived from pilot-tested on-farm farmer research, to be translated into easy-to-understand information kits.

Preparation of a participatory ICAS R&E manual is part of a continuing commitment to improve the ICAS R&E methodology. Results of participatory process documentation research or retrospective process analysis can help the team compile this.

Training and communication materials

One of the constraints to our study is that there were only limited resource materials on ICAS R&E activities carried out in a systems way in the rainfed lowland rice ecosystem in the Philippines. The reporting system may have caused the seeming scarcity of such materials.

The recent research work of Paris (1992, 2001, 2002), Devendra (1995), and Devendra and Frio (2000) was exten-

Table 12. Changing roles of ICAS stakeholders as facilitators of rural development.

Partners	Role changes	Unique contributions
Farmers	From passive recipients of messages to active participants in their own development process; self-learners	Offering relevant physical, social, economic, and ecological context; farmer-proven ICAS; participatory facilitation
Extensionists	From provider of recipe-type messages to skills facilitator of learning processes	
Researchers	From detached scientists to facilitators and participants in on-farm research	Experimental design know-how
Private sector	From chemical "pusher" to partner in a process moving toward more ecological agriculture	Participatory ICAS R&E know-how
GOs, NGOs, LGUs	From organizing production, especially means to facilitating conditions conducive to participatory development; from projects defined in time and space supporting long-term, open-ended development processes	Process management, resources
Donors	From financing limited projects to supporting open-ended development processes	Create conditions conducive to knowledge-intensive process; guide these processes; provide technical back-up and resources

Source: Adapted from Bruin and Meerman (2002).

sive but it relates to Asia, South Asia, and Southeast Asia. It was difficult to draw out the Philippine experience from this. Furthermore, the ICAS studies conducted were not always on rice-based farming systems, nor in the rainfed lowland rice ecosystem. Retrieval of ICAS studies was difficult.

In reviewing the literature on rice-fish/animal farming systems, one of the facets that the authors considered useful was the production of information kits on farmer-proven integrated agriculture-aquaculture technologies.

In 1992, the International Center for Living Aquatic Resources Management (ICLARM) spearheaded a two-week workshop in collaboration with the International Institute of Rural Reconstruction to produce an Integrated Agriculture-Aquaculture Technology Information Kit for small farmers' livelihood systems. Featured here were farmer-proven technologies of the Philippines, Thailand, and Indonesia.

They were written simply so that any layperson could translate the information into practices. These were widely shared among target users in the Philippines and throughout Asia. Procedures on how to prepare this type of kit can be learned for preparing farmer-proven ICAS technologies.

Feldstein and Poats (1990) have suggested the use of case studies on participatory gender and development methodology for training the ICAS R&E team. Paris (2001) presented the highly successful Sta. Barbara rice-cattle study as one of the case studies in her book.

How to prepare and use case studies for training is found in Feldstein and Poats' book. Bruin and Meerman (2002) presented 16 years of participatory IPM R&E in Zanzibar in a book titled *New Ways of Developing a Technology* and many lessons can be derived from their book to develop a participatory perspective in ICAS R&E projects. Participatory technology development and promotion can also be learned from the rich experiences of the National Irrigation Administration (NIA) participatory approach program now being further improved and used in the Southern Philippines Irrigation Sector (SOPI) water management program and the Low External Input for Sustainable Agriculture (LEISA) organic fertilizer technology transfer in the Philippines.

Institutional and electronic networking

One of the major difficulties we face is weak institutional and electronic networking. ICAS R&E data and information could not be easily retrieved.

The NARES are already in place, but linkage among member institutions is still weak. Each member of the established R&E system is fully aware of its functions, but electronic connectivity is still deficient. Selected activities that could be undertaken are

1. Through the leadership of DA and PCARRD, further strengthen the institutional network and electronic connectivity.

2. For those who have not done so, each member institution of the network could put up its own Web site and link with each other on the Web site.
3. NARES and members of the network could improve and update their database and include ICAS R&E for those willing to participate in it.
4. Only a few SUCs out of a total of 176 (Table 13) offer agriculture and fishery curricular programs with instructional, research, extension, and agribusiness entrepreneurship thrusts and are active in ICAS R&E, even just with on-farm or on-station crop-animal/fish mixed component testing. One of their projects should be a student/faculty study of farmer-led ICAS experiments, including evolution of the participatory R&E methodology. Selected SUCs that will be involved in ICAS R&E for each region, especially in the poverty pockets of rainfed areas in Luzon, Visayas, and Mindanao, should be strengthened. Undergraduate and graduate faculty and students conducting research, extension, and agribusiness entrepreneurship as part of their academic requirements are human resources that can make a difference in their respective areas of responsibility. Most of their scholarly work can be rechanneled to more vital household and rural community food security enhancement in the regions where they are located.
5. Different institutions and organizations in the NARES and among SUCs contacted had fax and e-mail services. The DA RIARS and the regional offices of the Commission on Higher Education (CHED) are easier to contact. Interconnectivity needs to be improved.

Table 13. Number of schools offering programs in agriculture and fisheries by region.

Region	Higher education institutions		Total
	Agriculture	Fisheries	
I	4	4	4
II	9	1	9
III	15	2	15
IV	12	9	19
V	14	9	17
VI	16	9	22
VII	14	2	14
VIII	15	6	18
IX	9	1	9
X	9	1	10
XI	13	3	14
XII	9	2	9
CARAGA	5	3	5
ARMM	5	1	5
CARAGA	6	0	6
NCR	3	0	3
Total	158	53	179

Source: Sanggalang and Papa (2000).

Policy for sustainable ICAS enterprises in rainfed lowland communities

Although policies for fuller development of the rice and animal sectors are now in place, a fresher policy environment needs to be established for the operation of competitive household enterprises within a total food/feed system perspective where livestock play a distinct role. According to an Asian Development Bank study, liberalization did not curb poverty. Data on the country's regions over the period 1988-2000, during which significant liberalization took place, indicated benefits to regional development. However, no direct impact on poverty reduction was observed.

Some data show this. It is therefore recommended that policies be more explicit in targeting poor household food security, equity, and poverty reduction, and ICAS enterprises as proposed seem to be a promising intervention. Another reason given for the resiliency of poverty in the country is the poor performance of foreign-funded projects.

The Philippine economy posted a 4.6% GDP and a 5.2% GNP in 2003. This surprising but pleasant economic performance exceeded the projected NEDA predictions for both. The important issue is, Does this redound to farm household growth and development? Policies to improve the livelihood systems of farm households and communities are therefore needed. Can ICAS achieve this?

References

Adriano MS. 1989. Role of women in livestock production in the Philippines. Report prepared for FAO Regional Office for Asia and Pacific (RAPA), September 1987.

Alviola IV PA, Cataquiz GC, Francisco SR. 2002. The socioeconomic dimensions of rice-based farming systems. Maligaya, Science City of Muñoz (Philippines): PhilRice.

Balisacan AM, Fujisaki S, editors. 1999. Causes of poverty myths, facts, and policies: a Philippine study. Diliman, Quezon City (Philippines): University of the Philippines Press.

Bruin CA, Meerman F. 2002. New ways of developing agricultural technologies: Zanzibar experience in participatory integrated pest management.

Castillo GT. 1983. How participatory is participatory?: a review of the Philippine experience. Manila (Philippines): Philippine Institute for Development Studies.

Devendra C. 1995. Environmental characterization of crop-animal systems in rainfed areas: crop-animal interactions. In: Proceedings of an International Workshop, Khon Kaen, Thailand, 27 September-1 October 1993.

Devendra C, Frio AS, editors. 2000. Improving the contribution of livestock to crop-animal systems. In: Rainfed areas in Southeast Asia. Proceedings of the Second Workshop of the Crop-Animal Systems Research Network. Nairobi (Kenya): International Livestock Research Institute.

Feldstein H, Poats S. 1990. Women in rice farming systems: review report. Manila (Philippines): International Rice Research Institute. 40 p.

Gloria RAB. 2002. Changing comparative advantage of corn production in the Philippines: the years 1994 and 2000. An undergraduate paper in partial fulfillment of the requirements for the degree of Bachelor of Science in economics, Diliman, Philippines.

Gonzales LA. 1998. The growth leaders. Food and Agriculture Industries. Food and Agribusiness Centennial Book.

Gonzales LA. 1997. The yellow corn livestock agribusiness: some agenda for action. Commissioned paper for Agribusiness Systems Action Plan (ASAP) of the Department of Agriculture. Manila (Philippines): STRIVE Foundation.

Iñigo CE. 2000. Management for Filipinos: principles and applications. Revised edition. Quezon City (Philippines): Design Plus.

Labios RV. 1997. Evaluation of intensive farming systems in the Philippines. Paper presented at the 14th session on Farm Management in Asia and the Far East, held on 2-5 December 1997, Ho Chi Minh City, Vietnam.

Mackill D, Coffman WR, Garrity DD. 1996. Rainfed lowland rice improvement. Los Baños (Philippines): International Rice Research Institute.

Lucas MP, Pandey S, Villano RA, Culanay DR, Marcos TF. 2000. Economics of intensive rainfed lowland rice-based cropping systems in northwest Luzon, Philippines. In: Tuong TP, Kam SP, Wade L, Pandey S, Bouman BAM, Hardy B, editors. Characterizing and understanding rainfed environments. Proceedings of the International Workshop on Characterizing and Understanding Rainfed Environments, 5-9 Dec 1999, Bali, Indonesia. Los Baños (Philippines): International Rice Research Institute. p 391-403.

Paris TR. 2002. Crop-animal systems in Asia: socio-economic benefits and impacts on rural livelihood. Agric. Syst. 71:147-168.

Paris TR. 2001. Bringing women from the margin to the mainstream of rice research and technology development: strategies and lessons learned. Unpublished thesis. University of Western Sydney, Hawkesbury, NSW, Australia.

Paris TR, Diaz CP, Morales AC, Luis JS. 1992. Integrating concerns for gender roles in farming systems research: a case in partially irrigated and rainfed farms in Central Luzon, Philippines. Los Baños (Philippines): Social Sciences Division, International Rice Research Institute. (Unpublished mimeo.)

Paris TR. 1992. Socio-economic issues concerning women in animal production. Paper presented at the Sixth Annual Science Congress, Bangkok, Thailand, 22-28 November 1992.

Pingali PL. 1995. Crop-livestock systems for tomorrow's Asia: from integration to specialization. In: Davendra C, Sevilla C, editors. Crop-animal interactions. Proceedings. Los Baños (Philippines): International Rice Research Institute.

Rayner AI, Welham SJ. 1995. Economics and statistical considerations in the measurement of total factor productivity (TFP). In: Barnett V, Payne R, Steiner R, editors. Agricultural sustainability: economic, environmental, and statistical considerations. New York (USA): John Wiley. p 23-28.

Rivera FT, Mangalindan MB. 1989. The structure of land transactions in Nueva Ecija. Central Luzon State University, Science City of Muñoz, Philippines.

Sanggalang RS, Papa AG. 2000. The status of agricultural education in the Philippines. National Agricultural and Fishery Education System, Department of Education, Culture, and Sports, Manila, Philippines.

Tuong TP, Kam SP, Wade L, Pandey S, Bouman BAM, Hardy B, editors. 2000. Characterizing and understanding rainfed environments. Proceedings of the International Workshop on Characterizing and Understanding Rainfed Environments, 5-9 Dec 1999, Bali, Indonesia. Los Baños (Philippines): International Rice Research Institute.

Acknowledgments

The authors wish to acknowledge the following persons for helping make this monograph possible within a stipulated six-month period:

Dr. Tereso Abeella, dean, College of Fisheries, CLSU
Dr. Miladis M. Afidchao, Secretariat, CVARRD, Isabela State University
Dr. Teotimo M. Aganon, director of research, CLSU
Engr. Feliciano Bolisay, NEUST, graduate student, CLSU
Dr. Rebecca Cagmat, consortium director, NOMCARRD
Professor Sonia S. Carbonell, CSSAC, graduate student, CLSU
Engr. Elmer Castillo, Department of Agriculture, Region IV, graduate student, CLSU
Mr. Rufo C. Chan, Jr., regional executive director, Region 10, DA
Dr. Roger C. Chio, CESO III, regional executive director, SMIARC, Region XI
Dr. Catalino R. dela Cruz, consultant, SOPIS, NIA
Dr. Emilio M. Cruz, director, Small Ruminant Center, CLSU
Dr. Patricio Faylon, executive director, PCARRD
Dr. Josue A. Irabagon, dean, Institute of Graduate Studies, CLSU
Dr. Leonardo Gonzales, STRIVE Foundation, Los Baños, Laguna
Mr. Rolando V. Labios, Institution-Building, Bureau of Agricultural Research, DA
Dr. Maruja V. Lorica, Gender and Development Program director, PCARRD
Dr. Filomeno Mamuad, director, Philippine Carabao Center, CLSU
Engr. Honorato Panahon, NEUST, graduate student, CLSU
Dr. Thelma R. Paris, Social Sciences Division, IRRI
Dr. Federico O. Perez, dean, College of Agriculture, CLSU; consultant, CECAP
Mr. Rustico Pinili, farmer leader, Sto. Domingo, Nueva Ecija
Dr. Fe L. Porciuncula, associate director, CLSU
Dr. Eliseo L. Ponce, executive director, Bureau of Agricultural Research, DA
Dr. Arthur Razon, Isabela State University
Dr. Beatriz P. del Rosario, deputy director, PCARRD
Dr. Leocadio Sebastian, executive director, PhilRice
Dr. Ruben C. Sevilleja, vice president for academic affairs/director, Freshwater Aquaculture Center, CLSU
Mr. Roger D. Silvia, research aide, CLSU-PhilRice-IRRI Monograph Writing Subproject
Dr. Luciano T. Talens, volunteer consultant, California, USA
Dr. Rodolfo C. Undan, president, CLSU
Ms. Magdalena T. Wanawan, ATI, DA, graduate student, CLSU

List of acronyms and abbreviations

AAPP-ROS	Accelerated Agricultural Production Project-Research Outreach Project
ABC	Agusan Bukidnon Capiz Settlement Project
ACIAR	Australian Center for International Agricultural Research
ADB	Asian Development Bank
AIADP	Aurora Integrated Area Development Project
AMS	aggregate measures support
ARFSN	Asian Rice Farming Systems Network
ARMM	Autonomous Region of Muslim Mindanao
ASSP	Agricultural Support Services Program
ATI	Agricultural Training Institute
BAEX	Bureau of Agricultural Extension
BAS	Bureau of Agricultural Research
BFAR	Bureau of Fisheries and Aquatic Resources
BPF	Budhing Pilipinas Foundation
BPI	Bureau of Plant Industry
BRBDP	Bicol River Basin Development Project
BSWM	Bureau of Soil and Water Management
CAR	Cordillera Autonomous Region
CASREN	Crop-Animal Systems Research Network
CECAP	Central Cordillera Agricultural Program
CHED	Commission on Higher Education
CIRDP	Community Integrated Research and Development Project
CLSU	Central Luzon State University
CPAR	community participatory action research
CDR	complex, diverse, risk-prone
CSR	cropping systems research
CTM	cassava tuber meal
CVRP	Central Visayas Regional Project
DA	Department of Agriculture
DANR	Department of Agriculture and Natural Resources
DBM	dairy buffalo module
DCR	domestic cost ratio
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DTI	Department of Trade and Industry
EF	experimental farmers
FAC	Freshwater Aquaculture Center
FAO	Food and Agriculture Organization of the United Nations
FARM	farmer-centered agricultural resource management
FARMI	Farm and Resource Management Institute
FFS	farmer field school
FGD	focus group discussion
FP	farmer practice
FRK	farmer record keeping
FSA	farming systems approach
FSDP-B	Farming Systems Development Project-Bicol
FSDP-EV	Farming Systems Development Project-Eastern Visayas
FSRD	farming systems research and development
FSSRI	Farming Systems and Soil Resources Institute
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GOs	government organizations

GPEP	Grain Production Enhancement Program
HADP	Highland Agricultural Development Project
HDI	human development index
HEIs	higher education institutions
ICAS R&E	integrated crop-animal systems research and extension
ICAS	integrated crop-animal systems
IDRC	International Development Research Centre
IEC	information, education, and communication
IIRR	International Institute for Rural Reconstruction
ILEIA	Information Center for Low External Input and Sustainable Agriculture
ILRI	International Livestock Research Institute
IPM	integrated pest management
IRRI	International Rice Research Institute
ISF	integrated small forestry
JICA	Japan International Cooperation Agency
KABSAKA	Kabusugan sa Kaumahan ("Progress in Farming")
LEISA	Low External Input and Sustainable Agriculture
LGC	local government code
LGU	local government unit
MAF	Ministry of Agriculture and Food
MBCR	marginal benefit-cost ratio
NAFES	National Agriculture and Fishery Education System
NARES	national agricultural research and extension system
NCIP	National Coconut Intercropping Program
NCR	National Capital Region
NEDA	National Economic and Development Authority
NFA	National Food Authority
NGO	nongovernment organization
NIA	National Irrigation Administration
NMCP	National Multiple Cropping Program
NMCPP	National Multi-Cropping Production Program
NSCB	National Statistical Coordination Board
NSIRDP	Northern Samar Integrated Research and Development Project
NSO	National Statistics Office
OER	official exchange rate
PADAP	Philippine-Australian Development Assistance Program
PCC	Philippine Carabao Center
PCSD	Philippine Council for Sustainable Development
PCAMRRD	Philippine Council on Aquaculture and Marine Resources Research and Development
PHDI	Philippine human development index
PIADPI	Palawan Integrated Area Development Project
PIDS	Philippine Institute for Development Studies
PLDT	Philippine Long Distance Telephone Company
R&E	research and extension
RADIP	Rainfed Agriculture Development (Iloilo) Project
RADOS	Rainfed Agriculture Development Outreach Sites
RD&E	research, development, and extension
REECS	Research, Environment, Economic Center for Studies, Inc.
RIARCs	regional integrated agricultural research centers
RRA	rapid rural appraisal
SALT	sloping agriculture land technology
SANREM	sustainable agriculture and natural resources management
SASP	Sustainable Agriculture Support Project
SMAP	Southern Mindanao Agricultural Project
SMIARC	Southern Mindanao Integrated Agricultural Research Center

SMIDE	Small Island Development Project
SOPIS	Southern Philippines Irrigation Sector
SUCs	state universities and colleges
TC	total cost
TFP	total factor productivity
TMPCI	Tulong Multi-Purpose Cooperative, Inc.
TR	total revenue
UPCA	University of the Philippines College of Agriculture
UPLB	University of the Philippines Los Baños
USAID	United States Agency for International Development
WIRFS	women in rice farming systems
WTO	World Trade Organization

Essential information on the Philippines

Location: Southeast Asia, archipelago between the Philippine Sea and the South China Sea, east of Vietnam.

Coordinates: 13ºN, 122ºE.

Area: total of 300,000 km^2; land = 298,170 km^2; water = 1,830 km^2, with 7,107 islands, of which some 80% are uninhabited.

Coastline: 36,289 km.

Terrain: mostly mountains with narrow to extensive coastal lowlands.

Land use: arable land: 19%; permanent crops: 12%; permanent pastures: 4%; forests and woodland: 46%; other: 19% (1993 est.), irrigated land: 15,800 km^2 (1993 est.).

Rice production ($t \times 10^3$): Irrigated rice, 7,117; rainfed lowland rice, 2,396; upland rice, 68; flood-prone rice, 89; total rough rice, 9,670.

Yield ($t\ ha^{-1}$): irrigated rice, 3.4; rainfed lowland rice, 2.0; upland rice, 1.0; flood-prone rice, 1.0; average yield, 2.8.

Per capita rice consumption: milled, 99 kg; rough rice equivalent, 152 kg.

Per capita calorie supply (no.): daily total supply, 2,452; calories supplied by rice, 995.

Population: 84,000,000 (2004 est.).

Age structure: 0–14 years, 37%; 15–24 years, 20%; 60 years and over, 4%.

Religions: Roman Catholic, 83%; Protestant, 9%; Muslim, 5%; Buddhist and other, 3%.

Languages: Filipino (official, based on Tagalog) and English (official), plus around 55 different ethnographic groups with 171 languages and dialects.

Government: republic.

Capital: Manila.

Administration: 72 provinces and 61 chartered cities, 15 administrative regions.

Executive branch: chief of state: President Gloria Macapagal-Arroyo (since 2001). Note—the president is both the chief of state and head of government. Cabinet: appointed by the president with the consent of the Commission on Appointments.

Legislative branch: Bicameral National Assembly consists of a Bicameral Congress consisting of the Senate (24 seats—one-half elected every three years; members elected by popular vote to serve six-year terms) and the House of Representatives (221 seats; members elected by popular vote to serve three-year terms; note—an additional 50 members may be appointed by the president).

Judicial branch: Supreme Court justices are appointed for four-year terms by the president on the recommendation of the Judicial and Bar Council.

Monetary unit/conversion rate: Filipino peso (P), US$1 = P55 (United Nations official conversion rate as of December 2003).

Gross domestic product: (US$ $\times 10^6$) 43,860; agricultural share in GDP, 22%.

Regional divisions:

National Capital Region (NCR)

1. Manila
2. Quezon City
3. Caloocan City
4. Pasay City
5. Makati City
6. Las Piñas City
7. Mandaluyong City
8. Marikina City
9. Pasig City
10. Parañaque
11. Malabon
12. Navotas
13. San Juan
14. Muntinlupa
15. Pateros
16. Taguig
17. Valenzuela, Bulacan
18. Rizal Province

Cordillera Administrative Region (CAR)
1. Abra
2. Benguet (Baguio City)
3. Ifugao
4. Kalinga
5. Apayao
6. Mountain Province

Region I
1. Ilocos Norte (Laoag City)
2. Ilocos Sur
3. La Union
4. Pangasinan (Dagupan City and San Carlos City)

Region II
1. Batanes
2. Cagayan
3. Isabela
4. Nueva Vizcaya
5. Quirino

Region III
1. Bataan
2. Bulacan
3. Nueva Ecija
4. Pampanga (Angeles City)
5. Tarlac
6. Zambales (Olongapo City)

Region IV
1. Aurora
2. Batangas (Batangas City and Lipa City)
3. Cavite (Tagaytay City, Cavite City, and Trece Martires City)
4. Laguna (San Pablo City)
5. Marinduque
6. Occidental Mindoro
7. Oriental Mindoro
8. Palawan (Puerto Princesa City)
9. Quezon (Lucena City)
10. Rizal
11. Romblon

Region V
1. Albay (Legaspi City)
2. Camarines Norte
3. Camarines Sur (Naga City and Iriga City)
4. Catanduanes
5. Masbate
6. Sorsogon

Region VI
1. Aklan
2. Antique
3. Capiz (Roxas City)
4. Guimaras
5. Iloilo (Iloilo City)
6. Negros Occidental (Bacolod City, San Carlos City, Cadiz City, Bago City, La Carlota City, Silay City)

Region VII
1. Bohol (Tagbilaran City)
2. Cebu (Cebu City, Danao City, Lapu-Lapu City, Mandaue City, and Toledo City)
3. Negros Oriental (Bais City, Canlaon City, and Dumaguete City)
4. Siquijor

Region VIII
1. Biliran
2. Leyte (Tacloban City and Ormoc City)
3. Southern Leyte
4. Eastern Samar
5. Northern Samar
6. Samar (Calbayog City)

Region IX
1. Basilan
2. Zamboanga del Norte
3. Zamboanga del Sur

Region X
1. Bukidnon (Malaybalay City)
2. Camiguin
3. Misamis Oriental (Cagayan de Oro City and Gingoog City)
4. Misamis Occidental

Region XI
1. Davao
2. Davao del Sur
3. Davao Oriental
4. South Cotabato
5. Sarangani

Region XII
1. Lanao del Norte
2. Cotabato
3. Sultan Kudarat
4. Cotabato City
5. Marawi City

Autonomous Region in Muslim Mindanao (ARMM)
1. Lanao del Sur
2. Maguindanao
3. Sulu
4. Tawi-tawi

Caraga
1. Agusan del Norte (Butuan City)
2. Agusan del Sur
3. Surigao del Norte (Surigao City)
4. Surigao del Sur