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

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

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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.

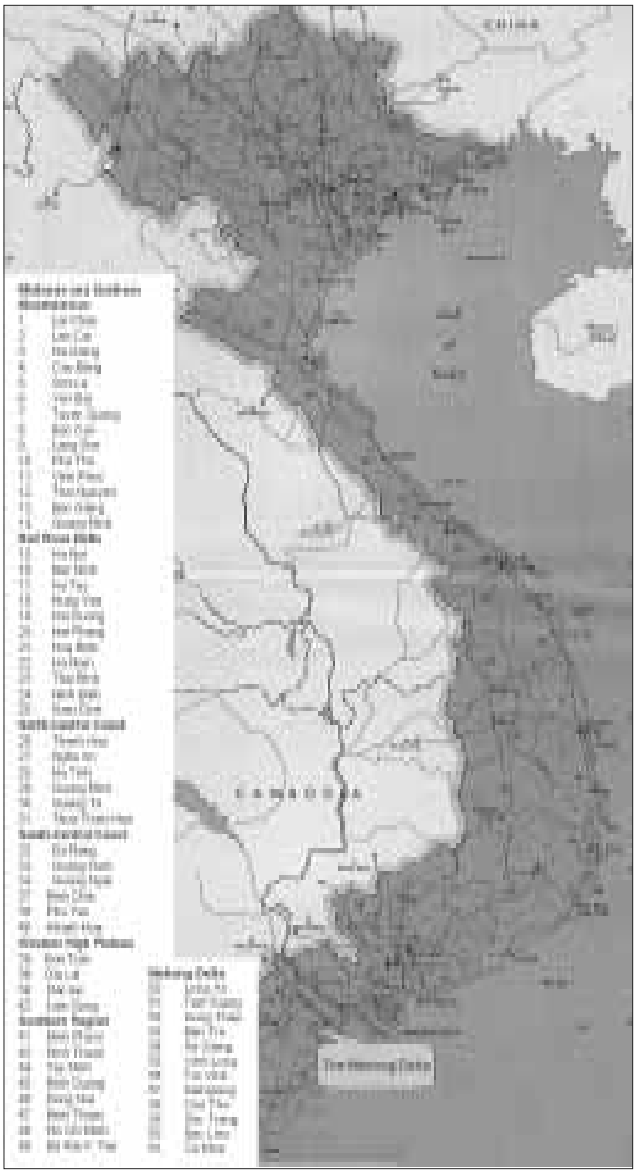

Fig. 1. Agroecological zones and provinces of Vietnam.

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

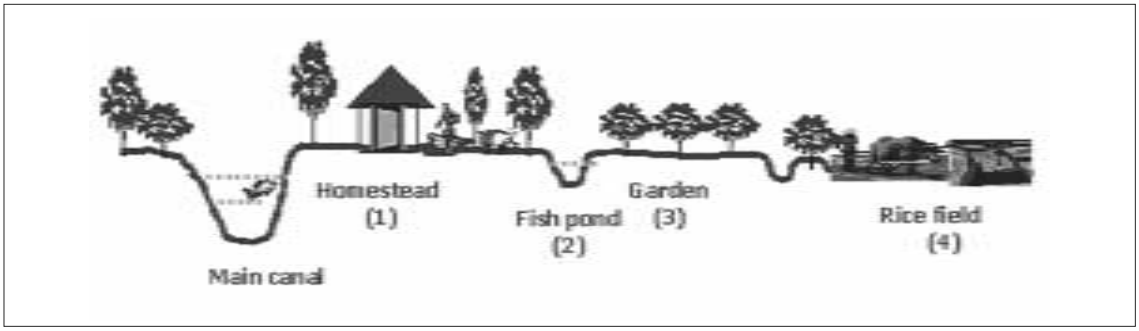

Fig. 1. Typical rice farm in the Mekong Delta.

- 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

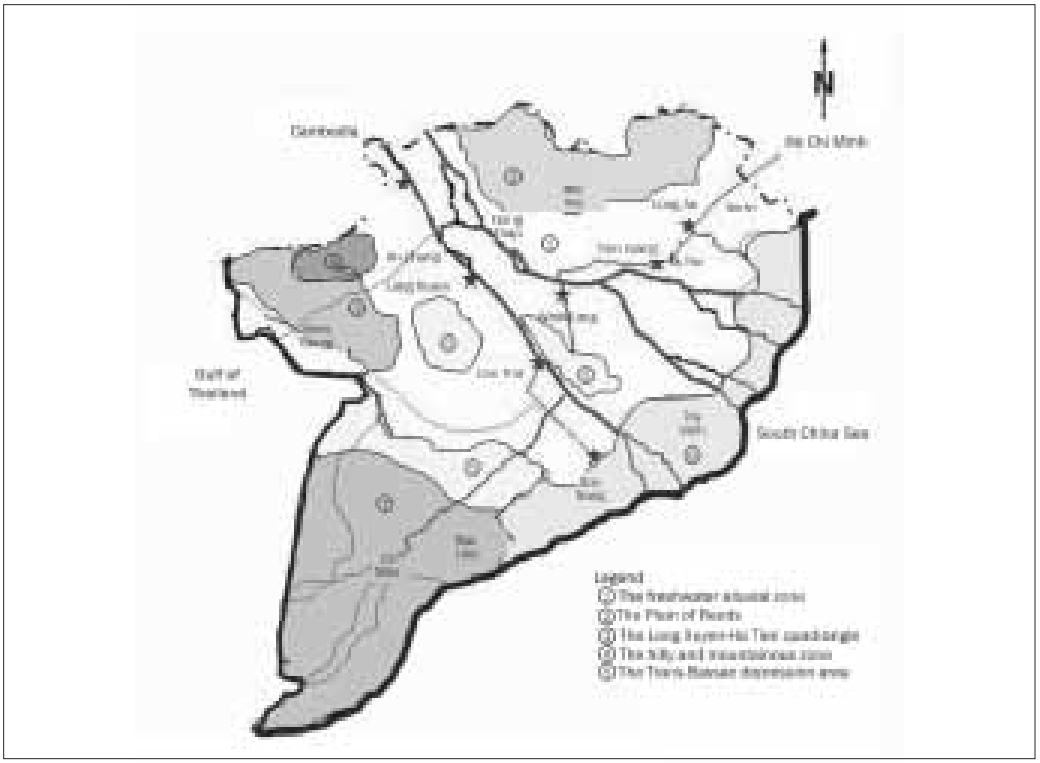

Fig. 2. Agroecological zones of the Mekong Delta.

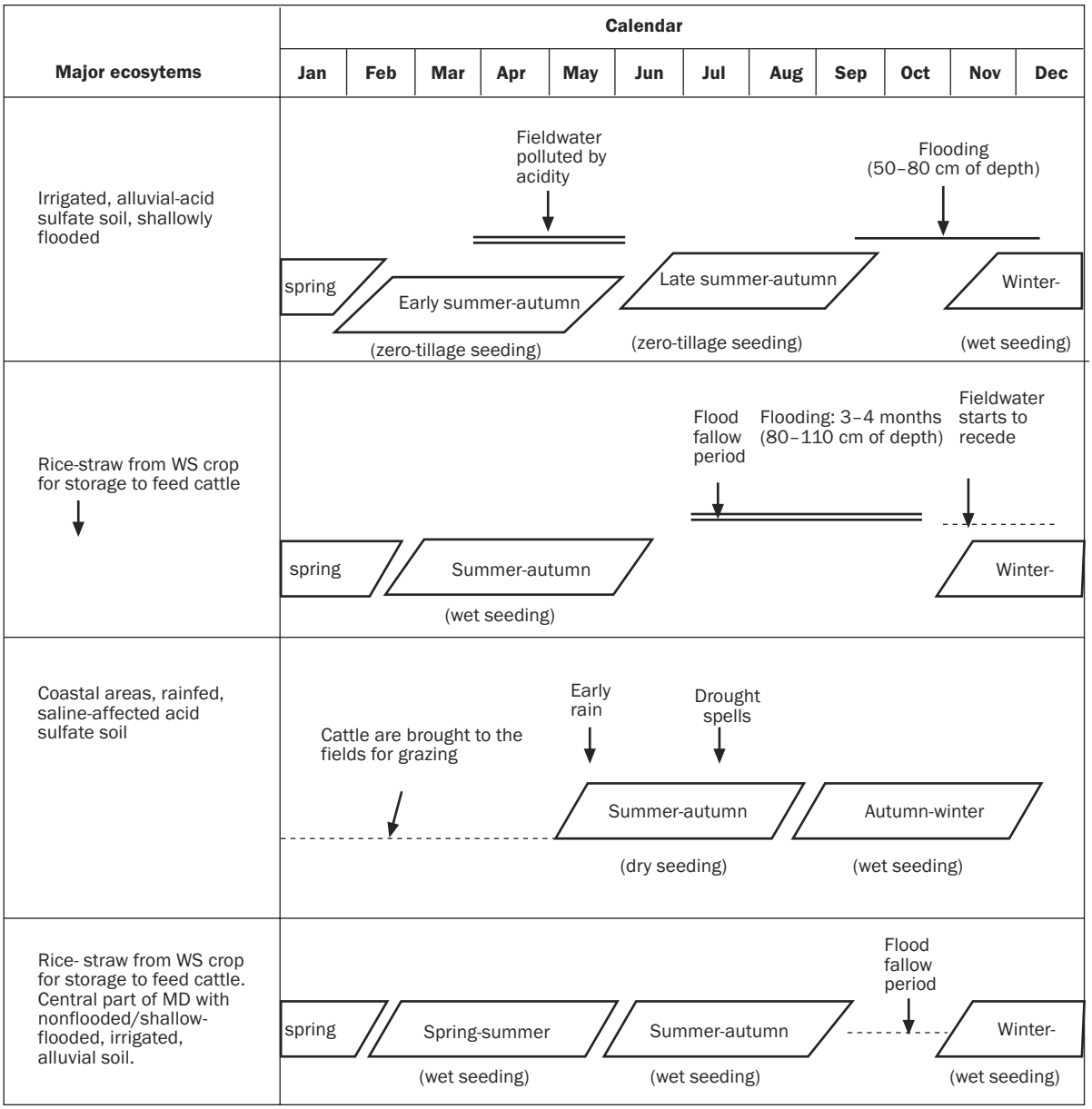

Fig. 3. Cropping calendar of rice in various ecosystems in the Mekong Delta, Vietnam.

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.

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Notes

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