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RICE AGROECOSYSTEMS, FARMER MANAGEMENT, AND SOCIAL ORGANIZATION IN KAMPUCHEA: A PRELIMINARY ASSESSMENT AND RESEARCH RECOMMENDATIONS

S. Fujisaka[1]

ABSTRACT

Interdisciplinary research was carried out in Kampuchea to provide basic data for the definition of research priorities for further collaborative efforts by International Rice Research Institute (IRRI) and Kampuchean rice researchers. This paper is based on field visits and farmer interviews by IRRI's agricultural anthropologist in several of Kampuchea's major rice agroecosystems. Rainfed and partially irrigated lowlands, partially irrigated levee lands, and deepwater rice agroecosystems are described, as well as respective farmer management strategies. Rice varieties and yields, and crop and nutrient management are discussed for each agroecosystem. Information on farmer perceptions and technical knowledge is presented. The currently changing *krom samakki* cooperative groups and other aspects of social organization are described. Research recommendations are made concerning integrated soil nutrient management, evaluation of traditional varieties and management, water management, integrated pest management, agroecosystems classification, farm implements, and a farming systems approach. Interdisciplinary, farming systems-based methods for the initial assessment of rice research priorities in Kampuchea were further developed. As a partial indication of progress, the work reported here contributed to a proposal resulting in a $2.3 million Australian International Development Assistance Bureau grant to IRRI for work in Kampuchea over an initial period of 3 yr.

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RICE AGROECOSYSTEMS, FARMER MANAGEMENT, AND SOCIAL ORGANIZATION IN KAMPUCHEA: A PRELIMINARY ASSESSMENT AND RESEARCH RECOMMENDATIONS

Kampuchea covers an area of 181,000 km^2. Up to 74% is forested, 17% is cultivated, and 3% is pastureland. About 1.6 million ha were planted to rice in 1986. Rainfed lowland rice—including shallow drought- and submergence-prone areas, medium-deep waterlogged areas, and more favorable shallow areas, some with supplementary irrigation—accounted for more than 1.3 million ha. An estimated 1 million ha (Khush et al 1986) of these rainfed lowlands are planted to late-season, photoperiod-sensitive traditional varieties (TVs) that flower in December and are adapted to medium to long flood periods and water depths from shallow to more than 50 cm. The 1986 dry season (DS) crop was about 130,000 ha, much of which was planted on partially irrigated levee land after flood recession. Deep-water rice (DWR) was planted on about 120,000 ha. Table 1 lists the rice environments, estimated areas, and respective yields.

People were forcibly relocated, agriculture was disrupted, and up to 2 million Kampucheans died during the 1975-79 Khmer Rouge regime under Pol Pot. Many traditional rice varieties were lost during the period. Since 1979, most farmers have returned to their pre-1975 villages (but usually not to the same fields); a substantial proportion of the TVs have been recovered; and farmers again match varieties, low-input management strategies, and local water and soil conditions. Modern varieties (MVs), especially IR36 and IR42, are being adopted on shallow rainfed areas (along with a few early-season TVs) as a wet season (WS) crop and on partially irrigated levee lands or the few DS irrigated areas. Farmers reported WS yields of MVs of about 2.0 t/ha, DS yields of about 2.5 t/ha, and 1986 TV yields of 0.6-3.0 t/ha.

In 1979, farmers were organized into "solidarity groups" (*krom samakki*) of 10-15 families to share resources and collectively farm up to 15 ha. A complex system of rules, record-keeping, and management was instituted by the Department of Rural Economy of the Ministry of Agriculture. Krom samakki are evolving toward private family production. The government allows the changes, although the krom samakki structure is maintained, including political-awareness lectures to farmers and preferential access to resources for *krom* actually or perhaps only cosmetically maintaining collective activities such as keeping a small portion of commonly managed land or some intra-krom shared labor.

Villages range from having small, temporary houses and few animals or implements to having substantial housing and herds, cottage industries, rice mills, and consumer goods. Given government restrictions and few opportunities, farm families appear to have diversified their activities as much as possible. Income sources include vegetable and fruit cash crops, cottage industries such as silk weaving, pedicab (*cyclo*) driving in Phnom Penh, palm sugar production, and fishing in ricefields and watercourses.

Table 1. Estimates of areas planted to rice types, and yields, Kampuchea, 1987.

Rice culture type	Area planted (ha)		Yield (t/ha)	Comment
	1985[a]	1986[b]		
Early-season	80,000	399,000	0.6-3.0	All photoperiod-sensitive types excluding deepwater rice (farmer-reported)
Medium-season	250,000		0.6-3.0	
Late-season	1,000,000	937,000	0.6-3.0	
Deepwater	160,000	121,000	1.0-2.0	
Irrigated dry season	160,000	161,000	2.5	Modern varieties up to 6.0 t; traditional varieties in receding water
			1.4	
Total	1,650,000	1,618,000		

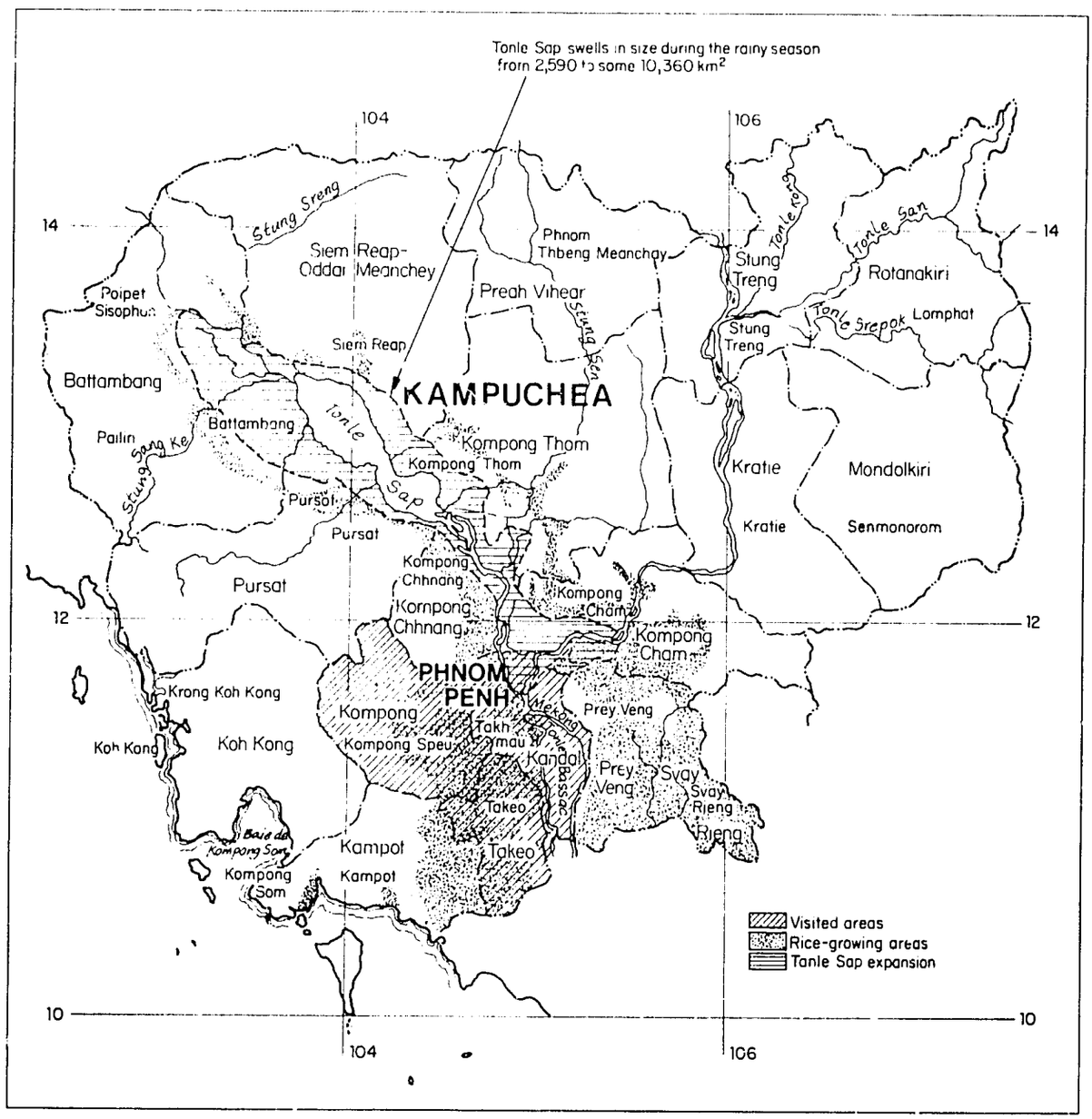
[a]Data from Kampuchean Ministry of Agriculture, quoted in Khush et al 1986. [b]Data from Ministry of Agriculture, quoted in Pingali (1988).

The quantities of fish caught, consumed, and sold by rice farmers are not known, but fishing appears to be second only to rice farming in importance to the rural poor.

This paper is based on information collected during a 2-wk visit (5-19 Nov 1987) by P. L. Pingali, an International Rice Research Institute (IRRI) agricultural economist, and the author to Kampuchea. We visited different rice agroecosystems in two of the most densely populated provinces (Takeo and Kandal) and in nearby Kompong Speu.

Fieldwork consisted of 1) informal but structured interviews of individuals and small groups of farmers in the villages mentioned, 2) observations in farmers' fields, 3) visits to the rice research stations at Prey Phdau and Day Eth, and 4) discussions with government officials. A Kampuchean official served as translator from Khmer to English. Dr. Pingali contacted district- to national-level government officials and collected widely scattered and previously unreported statistical data on the rice economy of Kampuchea (reported in a complementary study).

Kampuchea's 1987 population was estimated at 6.5-7.5 million. The crude birth rate was 39 per 1,000, the crude death rate 18 per 1,000, and the annual net increase 2.1%. If the 1986 population is assumed to have been 6.5 million, there will be 8.5 million persons by the year 2000, and 12 million by 2020. About 35% of the population is under age 15; 3% is over 65. Life expectancy at birth is 43 yr. The rural population now makes up 89% of the total (Population Reference Bureau 1987).



1. Kampuchea: provinces visited and rice-growing areas.

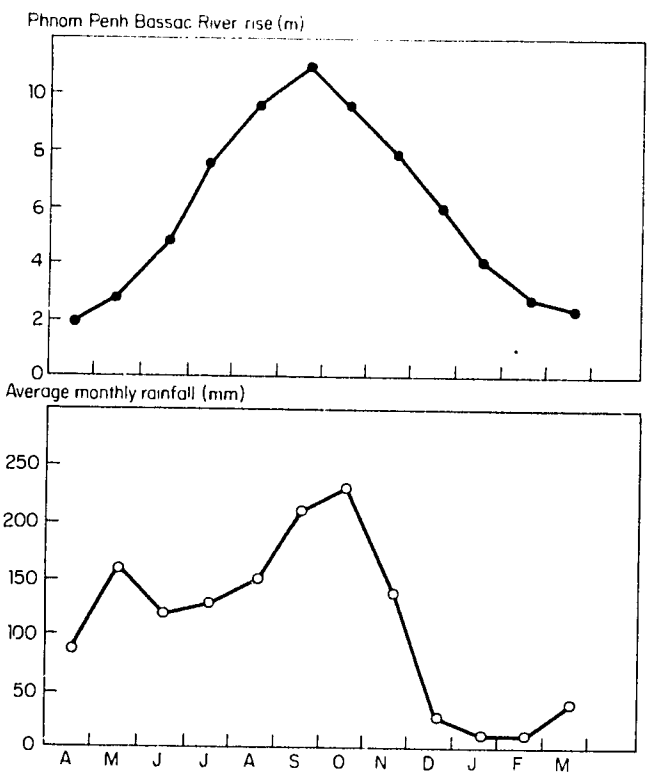
Compared with other provinces, Takeo, Kandal, and Kompong Speu had high MV adoption. These provinces represent about 8% of the national land area, 24% of the population, and 20% of the rice-growing area, and they produce 22% of the country's rice. Figure 1 shows the provinces visited and the rice-growing areas.

This paper describes some of Kampuchea's rice agroecosystems, corresponding farmer management, and farmer access to resources as controlled and facilitated largely by the krom samakki, followed by conclusions and recommendations for future research.

RICE AGROECOSYSTEMS AND FARMER MANAGEMENT

Rainfed and partially irrigated lowlands

Rainfed lowland ricelands are level or nearly level, or are gently undulating terraced areas. Shallow depressions with permanent water in DS and ridges a few meters higher than the surrounding terrace areas cover perhaps 10-20% of the area. The elevations in the areas visited range from 2 to 11 m above sea level. Soils are mostly sandy but range to clayey in the depressions. Topsoil pH is 4.5-6.0 (not including alkaline soils near Takeo, Frey Veng); and fertility is low (Lower Mekong River Basin Committee 1974). Rains start in April-May and average 1,400-1,800 mm annually. Large areas are subject to intermediate flooding by rivers and accumulated rainwater (starting in July-August and receding in October-November). DS starts in December-January. Figure 2 shows rainfall patterns for the three provinces visited and the river flood pattern. Small portions are partially irrigated (called "shallow rainfed with supplementary irrigation").



2. Monthly rainfall (mm) for Kandal, Takeo, and Kompong Speu Provinces and the Bassac River floodwater level (m) at Phnom Penh. From Salle (1984). Data for 33 yr for Takeo and Kompong Speu, 4 yr for Kandal.

We visited Traping Kyang, Prey Phdau, and Kandal villages in Kompong Speu Province; and Thnal Tea Ksen and Chrong Sdau villages in Takeo Province. Farmers discussed land, soil, and water resources; varieties; yields; and crop and nutrient management. Land access ranged from full krom control to private family farming; and land per family was 0.5-0.8 ha. Most farmers and krom groups manage parcels of slightly different land-soil-water types, with varieties and management matched to the differences.

Lands visited were largely rainfed. The villages with partially irrigated areas (e.g., Prey Phdau and Traping Kyang) plant at most only very small areas in DS. Slopes are gentle with field-to-field drops of about 10 cm. Most of the land is higher ricefields (*dey kpous*) with 0-15 cm water depth and sandy (*ksach*) or silty with some sand (*dey lbay ksach*) soils. A smaller amount of "normal" ricefields (*dey tonmada*) have about 15 cm water and soils ranging from sandy to clays mixed with sand (*dey kanding lea ksach*). The deepest areas are considered the most productive. These have earlier and longer lasting floods, water depths of 30-80 cm (*dey trapaing, dey thip*, and *dey chumrau*), and sandy to silty (*dey lbop*) soil or sand mixed with clay (*dey ath leay ksach*). Some of the farmers said that 1 ha of silt loam (*lbay ksach*) would produce as much as the same area of clay (*ath*) plus 2 sacks of 16-20-0 NPK fertilizer (50 kg/sack), or sand (ksach) with 3 sacks of 16-20-0. One sack of 16-20-0 was said to be equivalent to about 750 kg of manure. Table 2 summarizes farmer land and soil classifications.

Table 2. Farmer land and soil classifications.

Kamer term	English translation	Equivalent
	Landscape position; relative water depth	
Kpous	High; shallow, normal for MVs	0-15 cm water
Tonmada	Middle; normal for TVs	10-30 cm
Chumrau, thip, trapaing	Lower; deep	30-80 cm
	Soil texture	
Dey ksach	Sand	Sand
Dey lbop	Silt	Silt
Dey ath	Clay	Clay
	Textural classes	
Dey ksach	Sandy soil	All of the sand group
Dey ath	Clay soil (infertile)	Clay
Dey ath leah ksach	Sandy clay	Sandy clay
Dey kanding leah kasch	Sand-silt clay	Silty clay, silty clay loam
Dey lbay ksach	Silt and sand	Silty loam
	Soil tilth, bulk density	
Reng	Hard; compacted	
Tun	Soft; friable	

Varieties and yields (1986-87). Farmers in each village use different varieties that are adapted to their particular lands and soils. For example, Prey Phdau farmers planted three TVs and IR42. The tall, photoperiod-sensitive variety Chmar Chang Kom was transplanted first on 2 ha of the deepest (50 cm) plots, was harvested in 190-195 d, and yielded 2.8 t/ha.[2] Other deep ricefield (*trapaing, chumrau*) cultivars were Pkasla (1.2 t/ha) and Kong Plouk. The latter was planted on loamy sand (dey lbay ksach) or clayey soil (dey ath), was harvested after 180 d, and yielded about 3 t/ha using 0.6 t manure/ha and no inorganic fertilizer.

Lum Ong Ksak was transplanted next on 2 ha of medium-depth field, was harvested after 180 d, and yielded 1.9 t/ha. Other medium-depth field (*tommada*) cultivars included Srov Sor, which yielded only 0.7 t/ha due to late transplanting and drought at flowering.

Five hectares of the highest (shallow water) fields with sandy soils were transplanted to Pram Bae Kour a photoperiod-sensitive TV valued for high yield and good taste and harvested after 165 d; the yield was 1.5-2.0 t/ha. Other higher field (*kpous*) cultivars include Sambok Angkong (1.2 t/ha), Phkar Kgney, and IR36. Reported yields for the widely planted variety Phkar Kgney ranged from 0.6 t/ha, because of empty grains due to drought at flowering, to more than 2 t/ha when using up to 1.5 t farmyard manure (FYM)/ha, 2 sacks 16-20-0/ha, and 1 sack urea (40 kg N/ha without FYM)/ha. Farmers usually said IR36 was better than TVs if fertilized, worse if not. Chrong Sdau farmers reported 2.0 t/ha yield with Phkar Kgney at a slightly lower. IR36 yields on poor clay (dey ath) soils with up to 1.5 sacks (35 kg N) of urea/ha.

Two hectares of partially irrigated land were planted to IR42 (130 d), which yielded 2.0-3.0 t/ha. Two hectares of the poorest lands were not planted. These farmers wanted to try IR64, seen at the nearby research station. (Table 3 lists varieties, corresponding land and soil types, and reported yields; Figure 3 is a topographic cross-section representation.)

Crop and nutrient management. Land preparation consisting of two plowings and one or two harrowings is usually in mid-May to mid-September. Farmers use simple breaking plows called sole ards with or without iron or steel shares, and crude wooden comb harrows. Pairs of oxen harnessed to double-neck yokes are used to draw plows, harrows, and carts. The district government provided tractors for first plowing in some areas for about US$2/ha. Only about half of the land in beneficiary villages was plowed, because some plots were too small and because the government wanted tractor use spread over as large an area as possible. Second plowing required 6 oxen pairs and drivers at the rate of 4.5 h/ha.

TV seedbeds are sown from early June to late July, depending on variety. Transplanting ranges from mid-July to as late as early October. Transplanting was delayed by

Table 3. Respondents' rice varieties, lands and soils, and reported yields.

Variety	Land and soil (Khmer term)	Yield (t/ha)	Comments
	Rainfed		
Pram Bae Kour	Thip-kpous, ksach, dey ath leah ksach	1.5-2.0	Shallow-medium depth, 165 d, photoperiod-sensitive
Lum Ong Ksak	Tommada, ksach	1.9	Medium (15-25 cm) water depth, 180 d
Chmar Chang Kom	Thip, ksach	2.8	50+ cm water, 190-95 d, tall, photoperiod-sensitive
Sambok Angkong	Kpous, dey lbay ksach	1.2	
Phkar Kgney	Kpous, dey lbay ksach, dey ath	0.6-2.0	0.6 empty grains, drought at flowering, 2.0 t/ha if managed like IR36
Srov Sor	Tommada, dey kanding leah ksach	0.7	Late transplanting, drought at flowering
Pkasla	Chumrau, dey lbop	1.2	
Kong Plouk	Trapaing, lbay ksach or dey ath	3.0	40+ cm water depth, 180 d, 0.6 t farmyard manure/ha
IR36	Kpous, dey ksach	2.0-3.0	Inorganic fertilizer at 30-45 kg N/ha
IR42	Kpous-tommada, ksach	2.0-3.0	30-45 kg N/ha
	Partially irrigated levee		
Phkar Phneou	Kpous, dey ath leah ksach, dey kanding leah ksach, dey lbay ksach	2.0	Weak or nonsensitive, medium-duration TVs, no inorganic fertilizer used
Sor Kroop			
Pkar Dong			
IR36	Kpous, dey ath leah ksach, dey kanding leah ksach, dey lbay ksach	1.5-4.8	Usual yield 2.5 t/ha; 70 kg N/ha and pump gave 4.8 t/ha; probable seed dormancy
IR42	Kpous-tommada	1.5-3.0	Shatters

[2]Farmers reported yields in *thang*/are. One thang equals 24 kg. One are equals 100 m^2. FYM applications were calculated by equating ox carts of manure at 300 kg FYM/cart. At the time of our visit, US$1.00 = R130.

drought in 1987. Farmers said that if rains continued, overall yield would drop to at most about 1.2 t/ha; if not, losses would be 20-30%, i.e., about 0.8 t/ha. Inadequate water also meant poor leveling in some areas. Some short-day, highly photoperiod-sensitive varieties were transplanted in November. Farmers said these would not suffer yield losses. Most TVs are harvested in December-January, although shorter- and medium-duration varieties are harvested as early as October.

Farmers in the different villages lamented that the late rains meant not only reduced rice yields, but also delayed fish and frog harvests, smaller fish, and a smaller catch as well. Crabs, a rice pest, are also caught and eaten.

Partially irrigated and more favorable (in terms of water) shallow rainfed areas were being planted to photoperiod-insensitive, short-duration MVs and to weakly sensitive, short- to medium-duration TVs. Limited irrigated areas produce up to two crops per year. A WS crop is transplanted from June to as late as September and is harvested from late September to early February. A DS crop can be transplanted from November to February and harvested from early February to mid-May. Figure 4 presents cropping calendars for the rice types and agroecosystems.

Farmers hand-weed MVs once or twice. TVs in shallow (kpous) fields require 3-4 hand weedings by family members. Deeper water TVs are usually not weeded. Farmers reported problems with "rice-like" weeds (*smao srov* and *sro ngair*, probably *Leptochloa chinensis* and *Echinochloa crus-galli*). Puckridge and Moody (1986) reported a few broadleafs and sedges (*Monochoria hastata, Ludwigia adscendens, Sphenoclea zeylanica, Fimbristylis miliacea, Cyperus ferax*, and *C. iria*) as the most important weed species.

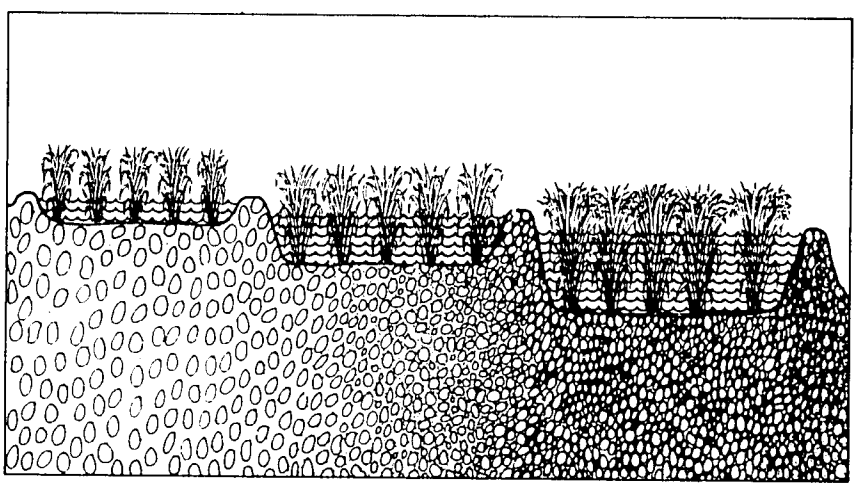
Insect pests are generally not seen as a serious problem. Stem borer *Chilo* spp. or *Scirpophaga* spp. (*dong khao*) is the major IR42 insect pest and elicits spraying up to 3 times with monocrotophos or unnamed pesticides from the USSR. Rat damage is considered serious; but farmers reported no means of control. The Thnal Tea Ksen farmers' medium-deep variety Kong Plouk has few insect or weed problems. Farmers reported some leaffolder *Cnaphalocrocis medinalis* (*dangkov mouslek*), but did not consider it a problem. More serious was an unidentified disease, *kra phung*.

Fertilizer applications depend on how much is available to the government and how much is then made available to particular krom samakki. Farmers in a level-1 krom we

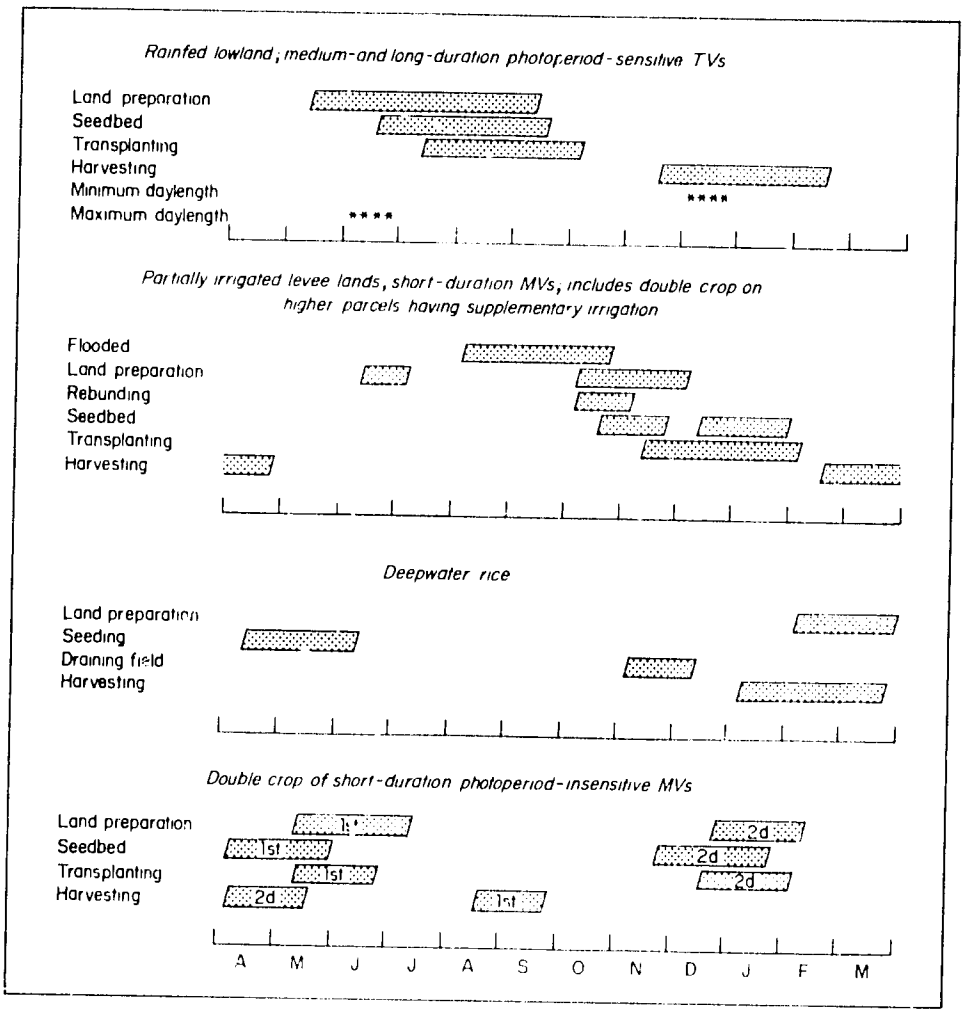
Landform	Kpous	Tommado	Trapaing	Chumrau thip
Water depth	0-15 cm	10-30 cm		30-60 cm
Soil	Sandy	Sandy		Sandy
	Clay		Clay	
	Silt and sand (silt loam)		Silt and sand (silt loam)	
	Silty clay (silty clay loam)			Silt
Varieties:	Pram Bae Kour	Pram Bae Kour		Lum Ong Ksak
	Sambok Angkong	Srov Sor		Chmar Chang Kam
	Pkhar Kgney	IR42		Pkasla
	IR42			Kong Plouk
	IR36			
Duration	120-165 d	150-180 d		170-210 d

More to less manure, fertilizer, and weeds

Better to worse surface and internal drainage



3. Schematic topographic cross-section of rainfed lowland agroecosystem showing farmer land, soil types, and varieties.



4. Rice sequences by agroecosystem.

Table 4. Fertilizer delivered by the Kandal Provincial Agricultural Office, rice area, and N applied, 1981-87.[a]

Item	1981	1982	1983	1984	1985	1986	1987[b]
Fertilizer (t)							
Urea	1,143	2,086	2,087	545	2,932	2,500	1,213
16-20-0	7,037	4,688	1,665	669	1,666	1,567	226
15-15-0	–	–	–	–	108	50	8
Rock phosphate	–	–	–	–	–	200	300
Total	8,180	6,774	3,752	1,214	4,706	4,317	1,747
Rice area (ha)	86,028	82,196	80,577	73,979	78,802	74,970	36,159
Nitrogen (kg/ha)	19	21	15	5	20	19	15

[a]Source: Kandal Provincial Agricultural Office. [b]1987 WS only.

visited were allocated about 1.4 sacks 16-20-0 (ammophos/ammonium phosphate) and 1.4 sacks urea (43 kg N/ha)/ha of MV. Farmers trade 3 kg of rough rice for 1 kg of 16-20-0; and 2 kg rough rice for 1 kg of urea. Farmers from level-2 krom said they receive less fertilizer than those from level-1 krom and reported using about 30-50 kg urea/ha and a very limited amount of 16-20-0. Fertilizer was delivered late in 1987; insecurity of timing of deliveries may have affected MV adoption. Although fertilizer is officially applied only to MVs, some TVs are fertilized at very low (<10 kg N/ha) levels. Table 4 shows fertilizer deliveries and rice areas for Kandal Province in 1981-87.

Farmers use FYM, but management ranges from minimal to intensive. In one village, animals are tethered in home lots at night and dung is swept into a shallow pit or heaped in a pile. Animals are not penned; and leaves, rice husk, or straw are not added. In other cases, the weed *Chromolaena odorata* (*tontrean khet*)—found on bunds and upland fields — is used as a green manure and is added to carefully husbanded FYM. FYM is applied to selected plots —

usually shallower, upper areas — at rates of up to 3 t/ha. Respondents said that water washes manure from upper to lower areas. In Kandal village, up to 1 sack 16-20-0, 1 sack urea (30 kg N/ha), and 0.9 t manure are applied to the shallower kpous and tommada.

At harvest, smooth-edged pulling sickles are used to cut stalks about 10 cm from the ground. Rice is sheaved and threshed by beating against solid, slanted boards. The rice is air-dried on mats. Winnowing is by hand using round, flat baskets with bamboo rims. The rice is stored in large, tightly woven baskets, wattle-and-daub huts built on stilts, and hemp or synthetic fertilizer sacks, and is generally milled in small local mills. Milled rice is redried on mats when necessary.

Women do most of the seedling pulling and transplanting (25 women for 4.5 h/ha or 14 labor days/ha), weeding, harvesting, threshing, winnowing, drying, and seed management. Men do much of the plowing, harrowing, milling, and some threshing. Working-age males made up only 28% of the working-age adults in 2 of the villages visited. The low percentage of adult males throughout rural Kampuchea is due to more male deaths during the Pol Pot period and to males having to serve in the army.

In some areas during the Pol Pot period, water pumped from canals made two crops possible. Most of the pumps have been lost. Some fields adjacent to (now otherwise nonfunctional) canals are irrigated by *snach*, a tripod-mounted single-person water scoop. In other areas, upland crops — watermelon, radish, and cucumber — are grown in ricefields in DS; manure (and fertilizer if available) is applied to these crops.

Throughout the country, families sell rough rice to the state and milled rice on the private market. Rice is exchanged for kerosene, soap, cloth, tools, pots, pans, and bicycles. The state rice price is low (US$0.02/kg), but is compensated by state prices of exchange goods 3-4 times cheaper than open-market prices. Farmers sell milled rice for about US$0.08/kg.

Partially irrigated levee (receding floodplain)

The Mekong Delta in Kampuchea and Vietnam includes large areas of gently sloping levees along main rivers (an estimated 70,000 ha), similar but more undulating areas (95,000 ha), low areas on the riverside of main levees (7,000 ha), and level to undulating backswamps (515,000 ha). Most of the area is flooded for 3-5 mo and drains after the rivers recede (September-October). Portions are transplanted to rice (mostly MVs) as the waters recede. Upper area soils are sandy loams and loams, middle slopes are silt loams and silty clay loams, and the lowest areas are clays. Low dikes have been constructed locally for water storage for DS irrigation (Lower Mekong River Basin Committee 1974). The proportion of total rice area planted to MVs compared with that planted to TVs was highest in Kandal (39,438 ha) and Takeo (40,000 ha) Provinces in 1986; most of this adoption appears to have been in the partially irrigated levee agroecosystem.

We visited Tuol Ampil, Sliang Dey Dos, and Phophil Khay villages in Kandal Province, and areas near Takeo municipality and Prey Yutka village in Takeo Province. Rice cropping in Tuol Ampil and nearby Sliang Dey Dos is described below. The other villages have similar crop management systems but differ slightly in water control. Five hundred hectares near Takeo and 1,000 ha near Prey Yutka (Fig. 5) are gravity-irrigated from lakes formed by dikes kept closed in the rainy season. IR36 is transplanted in November, and water is released several times over the growing season. Phophil Khay riceland (up to 1,900 ha) is similar; about 3,000 ha were serviced in the Pol Pot period, and an Italian project is now installing 5 large pumps along the dike to restore and improve water delivery.

For the 2 villages, riceland is separated from the Tonle Sap River by a slightly elevated natural levee, on which a string of villages is located, and a parallel, man-made levee plus a narrow, 15-km-long reservoir (Fig. 6). Levee lands flood for 3-5 mo and drain as the river recedes in September-October. Transplanting follows receding waters. Land slopes gently down through an adjoining backswamp to a lowest-point watercourse 2-6 m lower than the riverbank and up to several kilometers away from the dike. The reservoir stores floodwater for later gravity irrigation. During the Pol Pot period, it was replenished by pumps floated on the river and pumping into still-present concrete conduits. The pumps have since disappeared, and in several areas the reservoir has been blocked into individual fishponds. Ricefields next to deeper bengs — semipermanent marshes — are now irrigated at flowering by small (<10 hp), individual or krom-owned pumps.

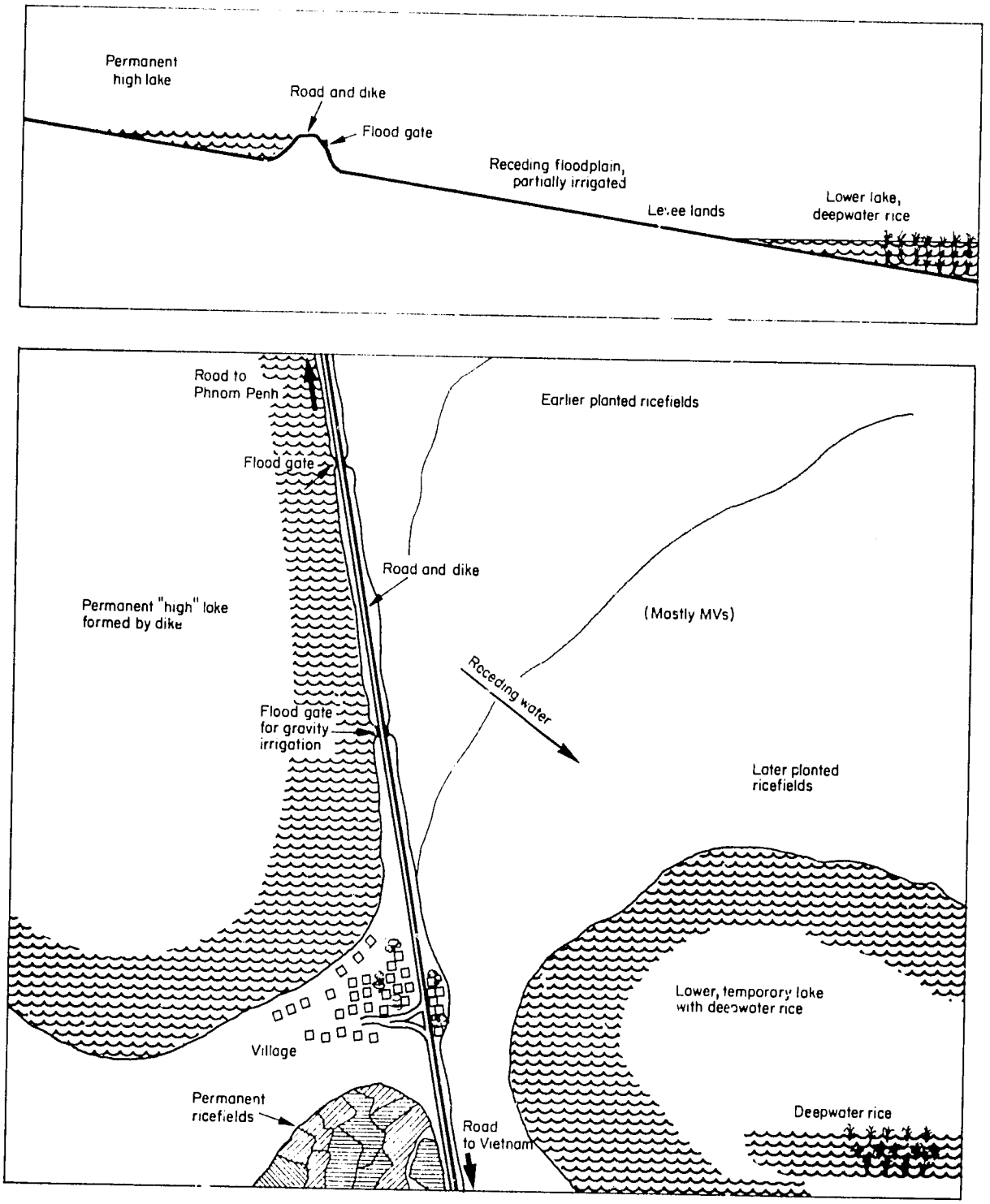
Varieties and yields. Most of the area is planted to IR36, with yields of 1.5-3.0 t/ha. Variable water availability was cited as the main cause of yield differences. One farmer used 70 kg N/ha and pump irrigation, obtaining 4.8 t/ha in 1986. IR42 yields less than IR36 but is adapted to slightly deeper water, and the longer straw is valued for livestock fodder. IR36 is preferred, however, because IR42 shatters and must be threshed in the field. IR36 is hauled to the village for threshing, and the straw is stored in large piles. A disadvantage of IR36 is that grains easily germinate when moist. Farmers have tested IR50, which yielded slightly lower than IR36 or IR42.

The main local TVs are Phkar Phneou, Sor Kroop, and Pkar Dong. Farmers said these are DS varieties (photoperiod-insensitive or weakly sensitive, and medium-duration) planted at the same time as IR36 and having yields of up to 2 t/ha. A few other TVs, including glutinous rices, are grown in deeper water (30-50 cm) areas and are low yielding, but are preferred for consumption.

Crop and nutrient management. Fields are flooded from mid-August to mid-October and are first plowed either after harvest in June or after the waters recede. The bunds are

rebuilt in October. A second plowing and single harrowing follow. Transplanting is from mid-November to mid-January. Fields next to depressions are irrigated using up to 10-hp pumps; about 1 d of pumping per hectare is needed. The highest fields are transplanted in late November, watered in January, and harvested in the third week of February. A second crop is grown in some of these fields. Middle fields are transplanted in December, irrigated in January, and harvested in late March. Low fields are transplanted in early January, irrigated in March, and harvested in April. One or two hand weedings are necessary in poorly leveled plots.

Farmers apply a basal 0.5 t manure/ha (estimated) and up to 2 sacks 16-20-0/ha (16 kg N/ha without FYM). For those who can afford more fertilizer, if it is available, some report adding 2 sacks of urea at 2 and 4 wk after

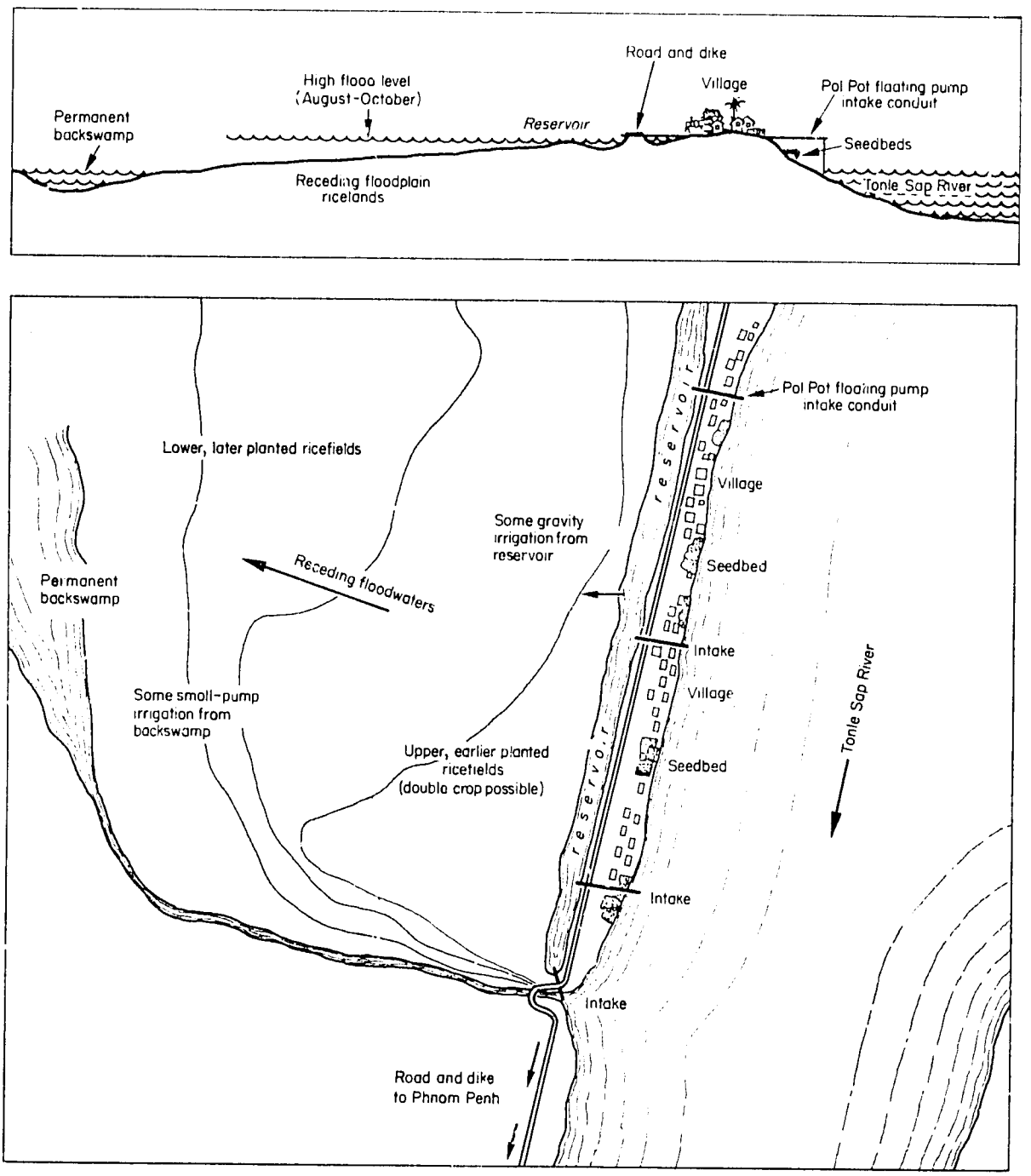


5. Partially irrigated levee lands (receding floodplain) and deepwater rice (Prey Yukta village).

transplanting (WAT), and an additional sack of 16-20-0 at 4 WAT to MVs planted where there are pump irrigation supplements. Thus, the maximum application would be 70 kg N/ha plus FYM. Farmers complained about the effect of the dike on soil fertility. Open river flooding on the other side of the Tonle Sap River has reportedly maintained a richer silt (*lbop*) soil.

Caseworm has infested seedbeds for the last few years. Farmers used to flood the seedbeds and remove the worms by scooping with baskets. They now use monocrotophos (one-half backpack sprayer per seedbed). Leaffolder is a problem (no estimate of loss given); fields were sprayed with monocrotophos and unnamed Russian pesticides.

Higher lands around the villages on levee lands are planted to cash crops like vegetables, sugarcane, and maize. Many farmers fish in the ricefields, the backswamps, and the river, although the technologies differ. Fish is either consumed fresh or dried for later consumption or for sale in Phnom Penh. Not only have parts of the reservoir been cut into private fishponds, but fishponds have been constructed on the riverside of the dike. Toilets (also private) built over the ponds supply nutrients.



6. Partially irrigated levee lands and receding floodplains.

Deepwater rice

DWR is grown in level delta backswamps, where flooding ranges from 0.8 to 4 m. Rainfall is 1,350-1,600 mm/yr. Lands flood in August and dry in December-January. Water is nonsaline throughout the year (Lower Mekong River Basin Committee 1974). Puckridge and Moody (1986) and HilleRisLambers and Puckridge (1987) have also discussed DWR in Kampuchea.

Land is normally plowed in February-March and dry seeded from April to as late as end of May, depending on the rains. Flooding normally starts in August. No fertilizer or manure is used. Fields are drained in November. Harvest is usually from early January to mid-March. Two DWR areas in Takeo Province (20,000 ha) were visited. Both DWR villages also have partially irrigated levee lands (described above); and farmers interviewed cultivate both types of lands and rice. Data from one of the DWR villages, Wath Chhner, are discussed below.

Wath Chhner village is located on Lake Wath Chhner. Farmers plant a few different TVs adapted to water depths of 0.8-4.0 m. Late rains were a problem in 1987, and much of the potential area was not planted; farmers expected up to 50% losses in the areas planted. Flood damage is a major problem in other years; waters in deeper areas rise too quickly and destroy much of the crop. Some farmers reported about 50% losses in 1986-87 due to flooding. Overall, farmers indicated that factors beyond their control — timing of the rains, rapidity of the rise of the floods, landscape position, and water depth — were the main determinants of DWR yields, which at best ranged from 1.0 to 2.0 t/ha. They said that weeds were not a problem (although Puckridge and Moody [1986] report that *Ipomoea aquatica* and *Brachiaria mutica* are potential problems if not controlled). Farmers said complete land preparation was important for good crop establishment.

Wath Chhner villagers also plant three unnamed photoperiod-sensitive TVs on rainfed land, with reported landholdings for DWR and rainfed rice being about equal. The 3 TVs planted correspond to shallow (10-15 cm) water and sandy (ksach) soil, to deeper water (20 cm) and silt and sand (lbay ksach) soil, and to about 40 cm of water and clayey (*dey kanding*) soil. The rainfed crop is regarded as the more important of the two rice crops, possibly because of the greater uncertainty of the DWR.

The village is divided into an area in which families supplement their incomes through fishing, and an area in which families manage more cattle, oxen, manure, and rice straw. Cattle-owning villagers say that they obtain higher rice yields due to the manure. These villagers plow lands for farmers without animals for about US$0.40/d (1 plowing day in this case is about 3 h). Plowing charges were somewhat difficult to establish because the semiofficial rate is an intra-krom exchange of 2 d of transplanting (8-10 h/d) for 1 d of plowing.

Lowland rice plus upland cash cropping

About 10% of the levee lands (discussed above) are usually above normal flood levels with sandy loam and loam soils (Lower Mekong River Basin Committee 1974). These areas are generally about 100-500 m wide and are planted to perennials and 1 or 2 upland cash crops/yr.

Farmers from Phophil Khay village in Kandal Province plant up to two rice crops and up to two upland cash crops in relatively privatized levee lands near Phnom Penh. WS IR36 is transplanted in April and harvested prior to flooding in August. DS IR36 is transplanted from October through December in the lowest areas next to the permanent backswamp, where irrigation by small pumps is possible.

One farmer with 0.09 ha of riceland reported WS and DS IR36 yields equivalent to 6.7 and 8.0 t/ha. High yields (although probably not as high as reported) are made possible by using inorganic fertilizers made affordable by cash income sources. The respondent grew mungbean, cucumber, pumpkin, gourds, string bean, Chinese cabbage, and tomato on 0.15 ha. These were sold to highest-bidding middlemen from Phnom Penh. The respondent plowed

Table 5. Crops, areas, and yields, Kandal Province, 1986.[a]

Crop	Wet season		Dry season		Total		Yield (t/ha)
	Area (ha)	Production (t)	Area (ha)	Production (t)	Area (ha)	Yield (t)	
Rice	42,075	67,033	32,895	64,394	74,970	131,427	1.75
Maize	12,871	13,425	1,117	1,003	13,988	14,428	1.03
Potato	158	1,089	759	3,217	917	4,306	4.70
Vegetables	1,114	4,000	2,114	9,971	3,228	13,971	4.33
Bean	200	80	5,146	1,367	5,346	1,447	0.27
Sugarcane	360	9,000	792	10,454	1,152	19,454	16.89
Tobacco	–	–	3,539	1,944	3,539	1,944	0.55
Jute	66	60	–	–	66	60	0.91
Soybean	5	8	39	17	44	25	0.57
Peanut	71	66	744	572	815	638	0.78
Sesame	1,618	500	20	6	1,638	506	0.31
Castor	–	–	78	77	78	77	0.99

[a]Source: Kandal Provincial Agricultural Office.

1) about 0.5 ha for other krom members over 3 mornings in return for 6 persons transplanting his 0.09 ha in 1 d and, 2) another 0.5 ha on different parcels for a total cash payment of US$3.85. The farmer's family catches about 5 kg/d of fish for 3 mo of the year. About 1 kg/d is consumed (fresh or dried and salted); the rest is sold for US$0.20/kg. Finally, the farmer does off-season work in Phnom Penh for about US$0.35/d. Other villagers from Phophil Khay reported similar resources, management practices, and diversity of income sources. Kandal Province agriculture, like that of Phophil Khay village, is somewhat diversified. Table 5 shows crops, areas, and yields reported for 1985-86. Table 6 lists retail prices from a Phnom Penh market visited.

SOCIAL ORGANIZATION: THE KROM SAMAKKI

Kampuchean rural territorial-administrative levels are the *khyat* (province), *srok* (district), *khum* (subdistrict), *phum* (village), and krom samakki (solidarity group). Except for the krom, which consists of several families, these units date back at least to the 1950s (Ebihara 1974). To illustrate, Table 7 gives numbers of these administrative units and the population for Kandal Province. Each level from khyat to krom has a corresponding set of officials. For the post-Pol Pot period (1979 to present) and for areas visited, most villages have been reconstructed and resettled, largely by the original inhabitants. Some villages were newly constructed, although these villagers generally reported being originally from nearby areas. A few people in each village visited arrived during the Pol Pot period and did not return to previous places, because there was nothing to go back to or because they had married into their current village.

Table 6. Phnom Penh retail market prices, November 1987.

Item	Price (riels/kg)[a]
Milled rice	13-15
Milled sticky rice	15-20
Mungbean	23
Peanut	40
Soybean	20
Cowpea	18
Cassava	10
Cucumber	10
Cabbage	30
Maize	5
Tobacco	100
Lotus	50
Sugarcane	5/stalk

[a]US$1 = 130 riels.

When it came to power in 1979, the Heng Samrin in government introduced the krom samakki. The system is ideally a means by which farmers share land, draft animals, labor, and implements, and by which the less able — widows, orphans, the old, and the disabled — are cared for. The system, regulated and overseen by the Department of Rural Economy of the Ministry of Agriculture, can involve a complex system of rules, regulations, and recordkeeping. There are three krom levels.

Level 1 krom

Level-1 krom comprises 10-15 families, who collectively manage all lands and who share all labor, animals, and farm implements. Lands available per krom vary widely, but are ideally about 20-25 ha. Produce is divided at harvest. Families receive shares according to work contributed, which is basically calculated from the number of member equivalent: Full members are men aged 15-60 and women aged 15-50. Half shares are given to persons aged 10-15 and to active old people. Quarter shares are allocated to persons aged 0-10 and to other nonworkers. A draft team or small pump is equal to a full share. Krom members collectively pay for fertilizer and taxes (80-100 kg rice/ha), and individually trade rice to the government for needed goods.

Traping Kyang village in Kompong Speu Province comprises 3 level-1 krom samakki (K1, K2, K3), 50 families, and 160 persons. K1 has 10 ha and 20 families (equivalent to 0.5 ha/family), K2 has 8 ha and 15 families (0.53 ha/family), and K3 has 12 ha and 15 families (0.8 ha/family). The rice harvest (about 60% TVs and 40% IR42) was distributed after expenses were paid: K1 distributed 288 kg rice/person among the equivalent of 41 full members; K2 distributed 216 kg/person among the equivalent of 39 full members; and K3 distributed 144 kg/person among the equivalent of 28 full members. Table 8 shows krom resources, membership, and harvest allocations for Traping Kyang and level-2 Prey Phdau village, discussed below. Traping Kyang farmers explained share differences among krom in terms of differences in land and water resources. Actually, K3 — with the most land but the smallest rice shares — had the most uncultivated land and the smallest adult (and male) work force.

From level-1 to level-2 krom

Krom samakki are moving from level-1 collectives, such as described for Traping Kyang, to level 2, in which lands are distributed for private use (although ownership remains

Table 7. Administrative divisions and population, Kandal Province, 1987.[a]

Districts (srok)	Subdivisions (khum)	Villages (phum)	Krom	Families	Males 16-60 yr old	Females 16-50 yr old	Labor force	Total population
11	149	1,093	9,773	148,074	88,711	130,906	219,617	744,430

[a]Source: Kandal Provincial Agricultural Office.

Table 8. Resources, membership, and rice shares for three level-1 and one new level-2 krom samakki in 2 villages, 1986-87.

	Traping Kyang (krom (3 level-1 krom)			Prey Phdau (1 of 5 level-2 krom)
	1	2	3	1
Land (ha)	10	8	12	13
Rainfed	3	2	5	11
Partially irrigated	7	6	7	2
Families	20	15	15	28
Hectares/family	0.5	0.5	0.8	0.5
Full members	27	28	18	43
Male	7	6	5	15
Female	20	22	13	28
Half members	7	4	6	10
Quarter members	30	23	17	39
Draft teams	3	3	3	7
Total full shares	41	39	28	70
Full share (kg)	288	216	144	240
Net (kg/ha)	1181	1053	336	1292

with the state) to families according to number of members, and in which labor, animals, and implements are privately owned. Exchange labor (*provas dai knia*) was traditional, and continues in level-2 krom. For example, a day (4.5 h) of plowing may be exchanged for 2 (8-10 h/d) of transplanting.

Prey Phdau village has 5 krom samakki and about 150 families. In 1987, by farmer preference and *khum* approval, K1 members divided the land among themselves. Each person, regardless of age, received 1,000 m^2 (10 are). Land was divided into five types, and each family supposedly got parcels of each type. Animals and manure were already privately managed. Some labor (e.g., transplanting) will still be by krom group. For other villages visited, farmers from Kandal and the 2 other khum villages divided about 300 ha among more than 1,200 persons in 1987; each person received 2,300 m^2. Each krom divided its lands among its own members. Thnal Tea Ksen lands were divided in 1983. Each person received 0.1 ha; 1 ha was kept by each krom for collective farming. Chrong Sdau farmers distributed all of their lands in 1983. Each person received 0.2 ha. Some farmers also cleared additional new lands or expanded into abandoned ricelands.

Level-2 krom

Each of the 2 levee land villages described above now has 8 krom samakki, each with about 15 families. Lands were distributed in 1983. Some regrouping of krom membership and land redistribution took place in 1986. For each krom, 5-7 ha were redistributed among families, and 1 ha was maintained as krom-shared land. Lands were classified as near or far from water sources, and the two types were distributed somewhat proportionally. Some exchange of labor (and draft) was done within krom. Farmers talked mainly about the management of their privately managed plots and said little or nothing about the 1 ha of common land.

The transition from level-1 krom to level-2 krom seems to be accompanied by private income diversification. Phophil Khay villagers, who have a range of cash incomes (described above), are organized into level-2 krom. Similarly, a Kandal village farmer had a total (rainfed lowland) rice yield of 1.6 t, sold a calf for US$23, and worked for 2 mo as a pedicab driver in Phnom Penh for about US$0.23/d (as did about 50 other villagers). Family members caught substantial amounts of fish (consumed or sold for 35 riels [US$0.27]/kg). The same farmer said he paid 840 kg of rough rice to rent a draft team for a year, paid 350 kg in taxes, and traded 100 kg to the state for cloth, soap, and kerosene. He bought 360 kg of milled rice for US$38. Others reported cash incomes from vegetables, perennial crops, fish, palm sugar, silk weaving, or other handicrafts.

Level-3 krom

All means of production are privately managed at krom level 3. These are reported to be common where land and draft animals are plentiful in Prey Veng, Kompong Thom, Kompong Cham, and Battambang Provinces. We did not encounter any krom classified as level 3, although many appeared to fit the criteria. Farmers apparently try to maintain an impression of some collective sharing of resources to keep a level-2 rating. Either 1) all land is distributed but some labor (land preparation, transplanting, or harvesting) is still shared; or 2) about 1 ha/krom is collectively farmed, while the rest of the land is farmed privately. In either case, the krom structure is still very strong and evident in every village because it works to promote "farmer awareness," to "execute the plan," collect taxes, and control resources.

Official figures (Table 9) show that level-1 krom increased from 3 to 19% from 1979 to the present; level-2 krom increased from 27 to 73%; and level 3 decreased from 70 to 7%. This trend appears reasonable. Level-2 krom increases as farmers and government face the level-1 problem of low productivity because of people "waiting for each other to work." Level-3 krom is probably declining because of the government policy to allocate fertilizers, pesticides, MV seed, credit, international aid, and water pumps first to level-1, then to level-2, and finally (but effectively, never) to level-3 krom. Observations of the level-1 krom at Traping Kyang village, and the Boua and Kiernan (1987) report suggest that the level-1 krom are either resource poor and

Table 9. Krom samakki by level, 1979-87.[a]

Year	Level 1		Level 2		Level 3	
	No.	%	No.	%	No.	%
1979	–	3	–	27	–	70
1981	14,297	15	57,188	60	23,828	25
1987	18,942	19	73,417	73	6,844	7

[a]Source: Department of Rural Economy, Ministry of Agriculture.

most in need of state welfare, or they effectively continue as irrigation pump cooperatives once the government has provided a pump and fuel.

CONCLUSIONS AND RECOMMENDATIONS

The data on agroecosystems and on farmer management and perceptions suggest some areas for research.

Integrated soil nutrient management

Kampuchean farmers interviewed distinguish among several land and soil categories, especially in soil texture, water depth, flood duration, and soil fertility. They have matched available TVs and MVs and their management with plot-by-plot differences and with overall low and sometimes uncertain levels of purchased inputs. They traditionally and currently use and manage organic nutrients — green manures, FYM, and rice straw.

Farmers use the upland weed *C. odorata* as a green manure. Research on *C. odorata* as a green manure of irrigated rice is ongoing at the Day Eth Research Station. Earlier research in Kampuchea estimated that 20 t fresh *C. odorata*/ha provides 112 kg N/ha, 12 kg P/ha, and 87 kg K/ha; and rice yields were higher with the green manure than with inorganic fertilizers plus FYM (Litzenberger and Ho Tong Lip 1961). Farmers produce grain legumes, although mostly on upland plots in areas near Phnom Penh.

Farmers carefully manage FYM in areas where the draft herd has been reestablished and where these resources have been effectively privatized. Some farmers incorporate rice straw, a practice that may have long-term soil fertility benefits but depends on having an adequate flooding period prior to transplanting.

Farmers use small amounts of inorganic fertilizers, mostly on MVs. Poor N uptake due to NH_3 volatilization and denitrification is recognized as a major problem by the Vietnamese in neighboring rice areas of the Mekong Delta and is likely to be a problem in Kampuchea.

Overall, the apparent technical soundness of their current practices suggests that Kampuchean farmers would readily adapt and adopt nutrient management innovations, and that building on farmer practices makes sense. Appropriate research is needed on: 1) both grain legumes used as green manures and purely green manure legumes within improved cropping systems, 2) possible legume substitutes for *C. odorata*, 3) improved FYM management, 4) rice straw incorporation, and 5) fertilizer management practices (e.g., urea incorporation prior to field flooding, slow-release N fertilizers, deep placement) leading to improved N fertilizer efficiency.

Evaluation of traditional and modern varieties, and management

IRRI scientists visiting Kampuchea have stressed the need for varietal evaluation (HilleRisLambers and Puckridge 1987, Mackill 1987, Puckridge and Moody 1986). Farmers have rematched (since the Pol Pot period, when many TVs were lost) a considerable number of TVs with specific local conditions. Research needs to build upon the process. Farmers have adopted IR36 and IR42 in appropriate agroecosystems. Some have tried IR50 and would like to test IR64.

IRRI scientists are already considering varietal needs in terms of the local agroecosystems. For example, "It appears that an ideal variety for much of the rainfed lowland areas would be photoperiod sensitive with a flowering date in late November or early December, have intermediate plant height, and be submergence tolerant" (Mackill 1987). Observational yield trials followed by replicated yield trials using both local and introduced entries are being established at Prey Phdau, Day Eth, and other research stations with the assistance of IRRI. Observational trials need to be located throughout Kampuchea, given the diversity of cultivars and agroecosystems and the need to evaluate specific locally adapted varieties.

The more productive and better adapted TVs need to be identified. Corresponding agroecosystems and farmer management need to be understood. Crop-cuts from farmers' fields and monitoring of farmer practices are needed. At the same time, evaluation of promising entries (local and introduced traditionals, and improved and modern varieties) should continue. Farmer-managed on-farm research using existing farmer practices and knowledge as a starting point should follow. Research on varietal improvement and improved management of TVs should be simultaneous.

Water management

Rice in the rainfed areas suffers from drought, flooding, and waterlogging. Farmers with plots next to watercourses may use manual water-lifting devices (e.g., the pedal *rohat* and the tripod-mounted water shovel snach). Few areas are irrigated. When we visited the villages, some rice-growing areas were awash; and irrigation, drainage, and water control systems were clearly being overtaxed. Infrastructure built during the Pol Pot period included main canals, reservoirs, dikes, and drainage systems. Some of these have proven to be ineffective due to poor design; others have since become inoperable due to lack of maintenance or the disappearance or breakdown of pumps.

Water management systems in Kampuchea need to be systematically assessed. Technical and managerial deficiencies and potentials for cost-effective improvements or appropriate interventions need to be identified and tested. Some of these are currently being undertaken by the Department of Hydrology of the Ministry of Agriculture, with the assistance of nongovernment organizations. Farmers demonstrated an intimate knowledge of the hydrologies of their village lands; such knowledge should be elicited and incorporated into the evaluation of needs and potentials.

Integrated pest management

Farmers reported few insect or weed problems. The use of chemical pesticides is currently limited. Awareness of a future need for integrated pest management (IPM) is probably not present at the farmer level. Knowledge of natural enemies is perhaps limited: Farmers working as laborers at the Prey Phdau Research Station identified a lady beetle *Harmonia octomaculata* as a harmful insect. On the other hand, they were well aware of the possible problem of pesticide poisoning of the wild fish population in the ricefields. An awareness of IPM technologies at the national, provincial, district, krom, and farmer levels will be needed as new varieties and management practices are adopted.

Agroecosystems classification

This paper briefly described some of the Kampuchean rice agroecosystems. Much more work is needed. Agroecosystems need to be completely characterized. Actual land areas need to be established (in place of current estimates). IRRI staff discussed the issue with government officials and will be permitted to work with existing satellite imagery followed by "ground truthing." This research needs to begin as soon as possible to help establish research priorities and to locate representative field sites.

Farm implements

As described above, farm implements are rudimentary. Improvements in plows (e.g., from sole ard to moldboard plow), harrows (e.g., from crude comb harrow to box harrow), and water-lifting devices may be appropriate. Postharvest technologies are similarly rudimentary. Research is needed on current farm implements to make appropriate improvements or substitutions.

A farming systems approach

All these efforts must be integrated with future social, biophysical, and agronomic research. On-station and on-farm research, as well as further research on farmer practices, should be coordinated. On-station varietal and component research will be assisted by IRRI scientists. On-farm efforts to improve management systems might best start with a more complete understanding of existing farmer practices, perceptions, and circumstances. Research will need to consider 1) how farmers manage and make decisions concerning various but limited farm resources; 2) other sources of existing or potential farmer income, from fish to cash crops and off-farm income; 3) constraints and opportunities implied by an on-farm population dominated by women and children; and 4) potentials for effective farmer participation and possible innovation in light of a changing krom samakki structure or other manifestations of national policy.

The Kampuchean economy used to be based on rubber, rice, maize, cattle, fish, and timber. Kampuchea is still mostly forested, and international corporations are interested in redeveloping the forest industries. Kampuchea needs foreign exchange. The country now cuts as much as 20,000 m^3 of timber/yr. As of late November 1987, a Japanese company was negotiating with the government to build a mill near Phnom Penh that would handle 60,000 m^3/yr. European companies are exploring possibilities for rehabilitating or expanding the now long-neglected rubber plantations. Care will be needed in the future to prevent damaging and degrading the upland watersheds that feed the Great Lake (Tonle Sap) and the central rice-growing plains. Rice self-sufficiency would appear to be an important and worthy present goal.

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REFERENCES CITED

Boua C, Kiernan B (1987) Oxfam America's aid program in Babong village, Kampuchea. Department of History and Politics, University of Wollongong, N.S.W., Australia. (mimeo.)

Ebihara M (1974) Intervillage, village-town, and village-city relations in Cambodia. Ann. New York Acad. Sci. 220(6):358-375.

Hille Ris Lambers D, Puckridge D W (1987) Report of a trip to Kampuchea, 3-10 Dec 1987. International Rice Research Institute. (mimeo.)

Khush G S, Puckridge D W, Denning G L (1986) Report of a trip to People's Republic of Kampuchea, 23-30 Jan 1986. International Rice Research Institute. (mimeo.)

Litzenberger S, Ho Tong Lip (1961) Utilizing *Eupatorium odoratum* L. to improve crop yields in Cambodia. Agron. J. 53:321-324.

Lower Mekong River Basin Committee (1974) Annex IV, Description of land units. *In* Recommendations concerning agricultural development with improved water control in the Mekong Delta. Working paper VA: agricultural land resources. The Netherlands Delta Development Team, Bangkok, Thailand.

Mackill D J (1987) Report of a trip to Kampuchea, 26 Nov-3 Dec 1987. International Rice Research Institute. (mimeo.)

Pingali P (1988) Kampuchean rice economy: an overview of the constraints to output growth. Ag. Econ. Dep. Pap. (unpubl.)

Population Reference Bureau (1987) World population data sheet. Washington.

Puckridge D W, Moody K (1986) Report of a trip to Kampuchea, 12-19 Jun 1986. International Rice Research Institute. (mimeo.)

Salle J-C (1984) Kampuchean humanitarian assistance programmes: final report on the food situation in Kampuchea. (mimeo.)

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