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DEEPWATER RICE IN CAMBODIA: A BASELINE SURVEY

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ABSTRACT

The importance of deepwater rice (DWR) production in Cambodia is demonstrated by data gathered from contrasting sites. In Takeo Province, 55% of the land available for cultivating rice is flooded by the Tonle Bassac River. In Prey Veng Province, DWR farmers depend almost completely on cultivating fields flooded by a Mekong River tributary. The data gathered reveal differences in historical experiences, settlement patterns, demography and income sources, field hydrology, challenges in reestablishing DWR cultivation, land allocations, agricultural strategies, and importance placed on DWR culture. Varietal factors and DWR cropping operations are discussed. Research recommendations are offered based on farmers' opinions of the future of DWR production in Cambodia.

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DEEPWATER RICE IN CAMBODIA: A BASELINE SURVEY

The IRRI-Cambodia Project began in 1989 to conduct research aimed at developing technologies adapted to the rice ecosystems of Cambodia; however, until now little effort has been made to understand the relationship between this ongoing research and the deepwater rice (DWR) economy of Cambodia. This report of a baseline survey of DWR culture in Cambodia

- describes events that have set back DWR cultivation;
- examines the current DWR production environment: DWR farms and farmers, cropping operations, and agricultural strategies; and
- indicates needs for future DWR research in Cambodia.

Cambodians have cultivated DWR for centuries. In about 1296, a Chinese visitor to the court of Angkor noted, "There is...a certain kind of land where the rice grows naturally, without sowing. When the water is up one fathom, the rice keeps pace in its growth. This, I think, must be a special variety" (Chou 1987). Delvert (1961) said that, while DWR cultivation is an ancient practice near the plain of the Great Lake, colonial authorities introduced it to low southern areas of the major riverine plain only in the late 19th century.

Estimates of the relative importance of DWR cultivation to Cambodia's recent agricultural economy vary with the source consulted. Delvert (1961) noted that, although DWR occupies only a small percentage of the total rice area, it is economically important because it is grown for sale and export. Walker (1961) said the percentages of rice varieties making up the total Cambodian national production varied yearly, but "floating rice, most of which comes from the provinces of Battambang and Svey Rieng, is becoming less and less important to the economy." Hellei (1970) reported that the area planted with DWR has declined from 540,000 ha before 1930 to 370,000-390,000 ha in the late 1960s.

By the 1989-90 season, DWR was planted in only 108,290 ha of the 1,489,780 ha of wet-season riceland—7.2% of total cultivated area. Yet DWR culture remained important in many parts of Cambodia. Since 1983, DWR has been grown in an average 7.5% of the total cultivated wet-season riceland (Table 1, 2). At the time of this study, DWR cultivation was found to be widely distributed; that is, DWR was grown in parts of Prey Veng, Svey Rieng, and Takeo provinces and, primarily, in the areas around the Great Lake of the Tonle Sap—especially in Battambang and Kompong Thom provinces—flooded by the Mekong and Tonle Sap rivers (Delvert 1961, Coyaud 1950).

Seng et al (1987) noted that the 1970-75 civil war and the subsequent Pol Pot times profoundly affected DWR cultivation. During the civil war, farmers abandoned cultivation of distant ricefields. Then, in 1976, the Pol Pot government announced a target yield of 3 t/ha for rice and a new emphasis on hydrological development (Pol Pot 1977). The development plan for 1977-80 set unachievable goals for yearly increases of land area to be cultivated and of areas to be double cropped for an aggregate yield of 7 t/ha. Another document declared that the country's administrative zones had to achieve the 3-t/ha yield goal in 1976, which was the year the development plan was promulgated, even though the rice crop already had been sown or transplanted (Chandler et al 1988).

Only local resources were available for intensifying production. Chronically low-yielding DWR became a target for conversion or elimination. In some parts of the country,

Table 1. Deepwater rice area in Cambodia compared with total area planted to rice, 1947-89.

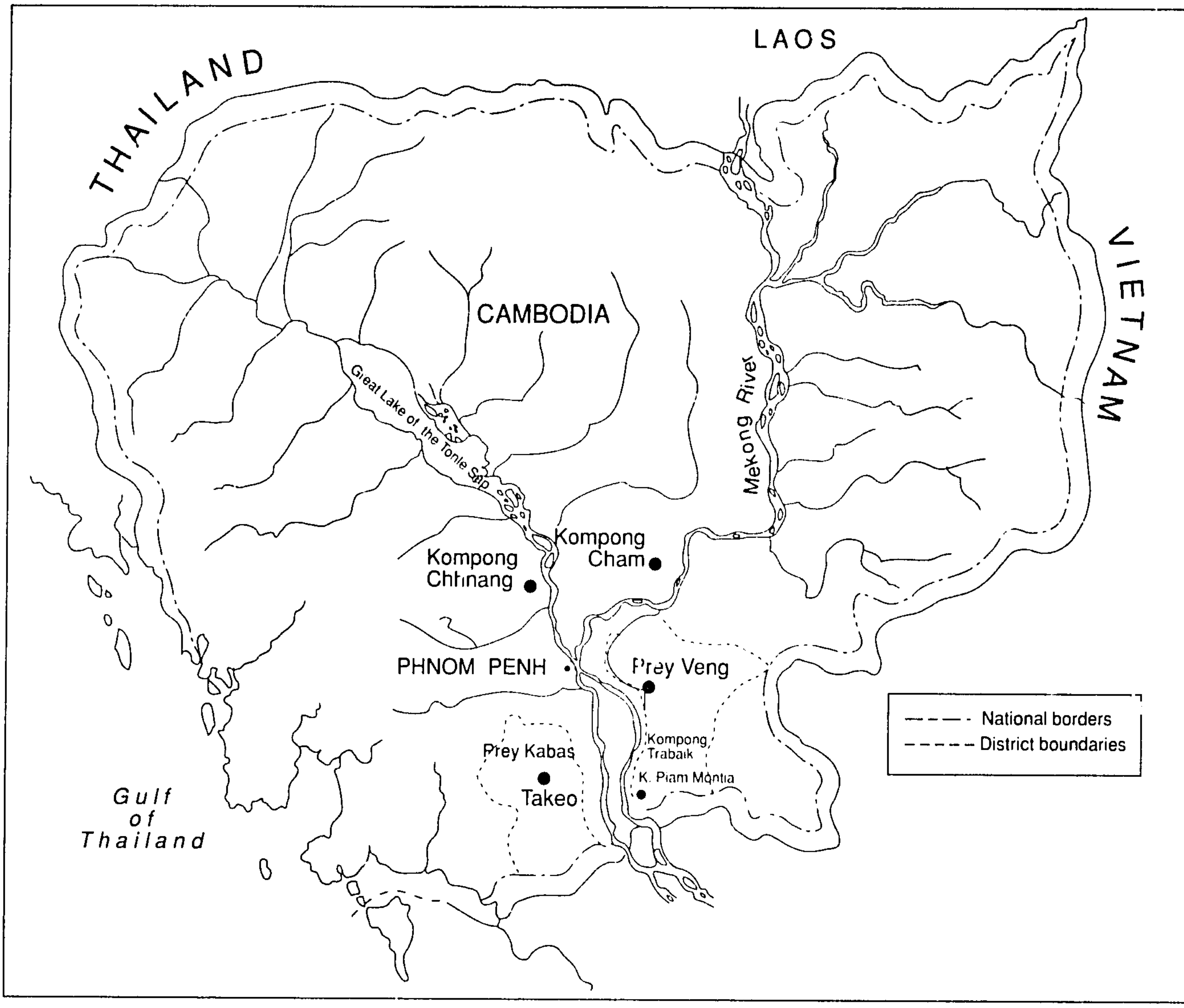
Year	Deepwater rice area (ha)	Total rice area (ha)	DWR percentage of total rice area
1947-49[a]	60,000-120,000	1,000,000-1,110,000	6.0 - 10.8
1958[b]	85,000	2,030,000	4.2
1965-66[c]	376,700	2,398,000	15.7
1966-77[d]	390,300	2,479,100	15.7
1967-68[d]	371,800	2,506,800	14.8
1983[e]	127,700	1,739,861	7.3
1984[e]	111,993	1,416,781	7.9
1985[e]	97,993	1,516,000	6.5
1986[e]	120,914	1,618,143	7.5
1987[e]	125,041	1,428,103	8.8
1988[e]	119,127	1,641,105	7.3
1989[e]	108,652	1,489,780	7.3

[a]Coyaud (1950). [b]Delvert (1961) and citation in Delvert for "Bulletin statistique agricole 31 Janvier 1958" with no explanation of differing figures for area cultivation from other sources, or definition other than "floating rice." [c]Tichit (1981). [d]Heller (1970). [e]Ministry of Agriculture, Phnom Penh, unpubl. data.

Table 2. Deepwater rice area in Cambodia (ha), by province and year.

Province	1982	1983	1984	1985	1986	1987	1988	1989
Kompong Thom	24,290		17,424	22,736	26,436	29,112	30,017	25,890
Takeo	16,330		18,133	17,334	19,585	19,870	20,243	19,597
Banteay Meanchey	0		0	0	0	0	13,137	14,003
Prey Veng	15,012	-	18,375	11,212	13,938	13,709	11,325	9,794
Pursat	8,600	-	6,058	4,903	9,729	10,897	10,684	9,264
Siam Riab	15,640	-	12,690	5,708	8,800	10,300	11,392	8,451
Kompong Chhnang	5,280		5,647	5,327	7,142	7,845	7,575	7,730
Battambang	3[illegible],608		19,817	21,198	25,475	23,371	4,851	4,760
Kandal	8,515	--	8,126	7,667	6,384	5,916	4,899	4,666
Svey Rieng	680	-	1,144	1,502	1,907	2,420	2,987	2,479
Kompong Cham	1,111	--	4,487	233	1,228	869	1,078	1,110
Phnom Penh	0	--	0	17	0	594	760	652
Kompot	60	--	83	107	85	79	137	23[illegible]
Stung Treng	0	--	0	35	16	16	18	1[illegible]
Kompong Speu	38	--	9	14	40	43	24	9
Kratie	0	--		0	149	0	0	0
Total	133,164	127,700	111,993	97,993	120,914	125,041	119,127	108,652

Source: Ministry of Agriculture, Cambodia, unpubl. data



1. Location of research sites in Cambodia.

DWR cultivation was forbidden, and farmers were forced to build elaborate waterworks—canals, dams, and reservoirs—that were intended to make possible the conversion of DWR fields for irrigated dry-season rice culture (Pijpers 1989). In other parts of the country, DWR cultivation was not forbidden outright, but farmers were required to plant marginally adapted varieties in DWR fields. The Khmer Rouge discouraged farmers from planting floating rice, even in its central production area, from 1975 to 1978 (Khush et al 1986).

DWR cultivation was drastically reduced, and farmers lost the seed of most traditional varieties (TVs) adapted to local conditions.

SURVEY LOCATION

To illuminate the current DWR situation, two sites were selected for a socioeconomic case study (Fig. 1). Prey Kabas, a *srok* (district) in Takeo Province, is approximately 42 km southeast of Phnom Penh on Route 3. It formerly was noted for DWR production (Delvert 1961). Its DWR fields are flooded by the Tonle Bassac River and its tributaries. Piam Montia *khum* (village cluster) in Kompong Trabaik District, Prey Veng Province, was chosen as the second research site. Delvert (1961) noted the prominence of DWR cultivation in Prey Veng Province, especially in southern Kompong Trabaik.

The two sites provide contrasting examples of DWR cultivation in southern Cambodia. They differ in the importance their farmers place on DWR culture in their agricultural strategies, the sources and circumstances of floods, and settlement patterns and field situations. Discrepancies are most significant between the experiences of DWR farmers at the two sites during the Pol Pot times and their problems in reestablishing DWR cultivation and reassembling a range of varieties for cultivation.

Prey Kabas District

According to Prey Kabas District statistics, only 20% of the agricultural land is used for growing DWR. All of the DWR land, however, is in 6 of the district's 13 village clusters and is important for rice production in those clusters.

The six DWR-growing village clusters lie along a line running northwest to southeast on the northern and eastern district boundaries (Fig. 2). The DWR fields are approximately 12 km west of the Tonle Bassac River

Household interviews were conducted in four of these clusters: Jar, Snau, Prey Lwia, and Kompong Riab (Table 3). The others—Ban Kam and Po Rom Jak—also grow DWR, but they were not included in the survey because DWR cultivation plays a lesser role in their farmers' agricultural strategies (Table 4).

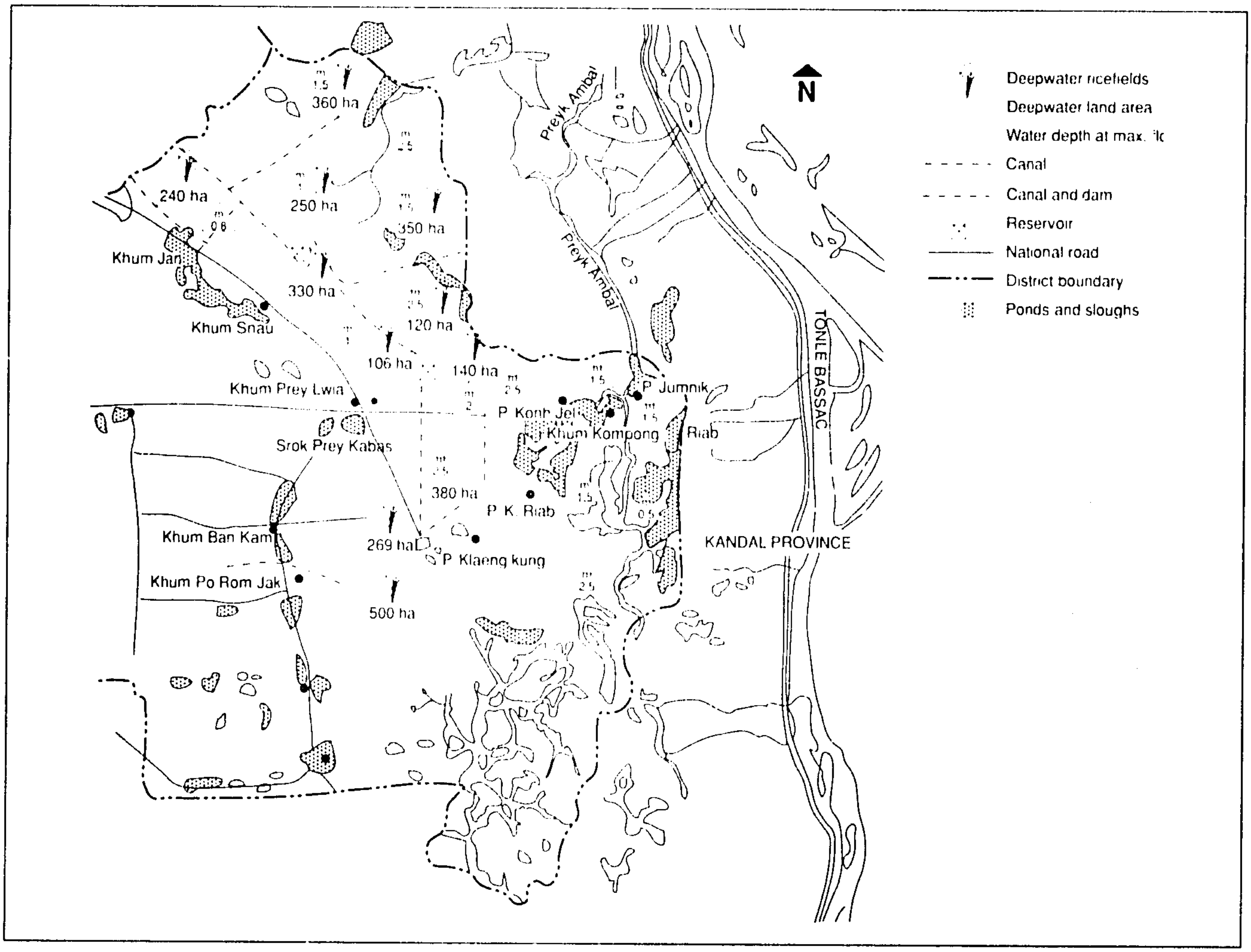
Jar, the northernmost village cluster of Prey Kabas District, has more DWR land than any other cluster in the district. Snau is southwest of Jar. Prey Lwia, the next cluster south, includes the district town. Kompong Riab is a large, low-lying cluster east of Prey Lwia. It depends more on DWR than the other clusters because its areas of rainfed lowland rice (RLR) and irrigated dry-season rice are smaller (Table 4, 5).

The villages of Jar, Snau, and Prey Lwia line the roads near the deepwater fields. The villages of Kompong Riab are dotted like islands in the DWR fields.

The economy of Prey Kabas District is primarily agricultural, and access to nonagricultural livelihoods is limited. Some village women weave the intricate ikat weft silk for which Prey Kabas is famous, but no such weavers were

Table 3. Village clusters and villages sampled in Prey Kabas District.

Village cluster	Village
Jar	Jar
	Svay Jal
Snau	Snau
	Tropeang Reang
Prey Lwia	Prey Lwia Kaod
	Prey Lwia Lech
Kompong Riab	Kompong Riab
	Klaeng Kung
	Jumnik
	Konh Jel



2. Prey Kabas District deepwater riceland area and hydrology.

Table 4. Agricultural statistics, by village cluster or commune, for Prey Kabas District.

Village cluster or commune	Total agricultural land (ha)	DWR land (ha)	Dry-season riceland (ha)	Total land (ha)	RLR land: Early varieties (ha)	RLR land: Medium varieties (ha)	RLR land: Late varieties (ha)	DWR percentage of total riceland
Jar	2,400	1,200	0	1,200	500	500	200	50
Snau	1,400	800	0	600	323	262	15	57
Prey Lwia	1,508	600	143	765	350	315	100	40
Kompong Riab	1,047	560	467	20	20	0	0	53
Ban Kam	1,682	525	180	977	400	477	100	31
Po Rom Jak	1,878	150	405	1,123	423	500	200	8
Kdanh	860	0	0	860	325	495	40	0
Kom Paim	2,150	0	650	1,300	650	500	150	0
Dang Yam	1,250	0	0	1,250	500	550	200	0
Prey Pdao	1,370	0	296	1,074	424	500	150	0
Jom Pa	907	0	17	890	276	434	180	0
Ong Kanh	1,460	0	360	1,000	450	450	100	0
Prey Kabas	1,561	0	299	951	520	370	61	0
Total	19,473	3,835	2,817	12,010	5,161	5,353	1,496	

[a]Source: Prey Kabas District Agriculture Office, unpubl. data. DWR = deepwater rice, RLR = rainfed lowland rice.

Table 5. Agricultural statistics for Prey Kabas villages.[a]

Village or location	Total agricultural land (ha)	DWR[a] land (ha)	RLR land: Early varieties (ha)	RLR land: Medium varieties (ha)	RLR land: Late varieties (ha)	RLR land: Total (ha)	DWR[a] land (ha)	Dry-season riceland (ha)	RLR land (ha)	Cash cropland (ha)
Jar village cluster										
Jar	266	126	52	65	23	140				
Svey Jal	226	116	45	56	11	112				
Svey Po	284	139	58	70	17	145				
Jan Mongkol	210	96	42	60	12	114				
Ang Svey Jek	396	371	0	0	0	0				
Ampol Lech	215	95	43	59	18	120				
Ampol Kaod	194	82	45	56	13	114				
Bang Bat	157	72	21	43	21	85				
Sla	132	59	20	20	24	64				
Station	0	0	0	5	0	5				
Total	2080	1156	326	434	139					
Snau village cluster										
Snau	222	160	62	71	3	136				
Tropeang Reang	260	190	70	54	3	127				
Krang	110	90	20	38	3	61				
Tungke	160	109	51	43	2	96				
Toka	227	150	77	31	2	110				
Toam Wineh	164	121	43	25	2	70				
Wat (Temple)	0	0	0	0	0	0				
Total	1143	820	323	262	15					
Prey Lwia village cluster										
Lwia Kaod	123	135	63	50	10	123				
Lwia Lech	105	125	40	50	29	119				
Lwia Tnaut	45	38	35	6	1	42				
Ong Konlang	127	67	26	76	20	122				
Ta Khon	57	50	38	8	5	51				
Anlong Mias	107	45	73	17	17	107				
Total	564	460	275	207	82					
Kompong Riab village cluster										
Klaeng Kung							192.6	40.6	27.6	15.2
Konh Jel							133.6	40.2		19.1
Kompong Riab							63.9	47.8		34.6
Jumnik							77.6	24.4		5.2
Kompong Liew							29.6	22.0		29.5
Piao							42.5	34.7		24.8
Kompong Samong							29.6	57.9		21.1
Khum Land							15.0	8.2		11.5
Total							584.4	275.8	27.6	161.0

Sources: Jar Administrative Office, unpubl. data; Snau Administrative Office, unpubl. data; Prey Lwia Administrative Office, unpubl. data; Kompong Riab Administrative Office, unpubl. data, village cluster statistics not kept in same format as in other village clusters. [a]Discrepancies in landholding data with Table 4 due to variable statistics provided by village cluster and district-level sources.

encountered at the villages surveyed. Farmers in Prey Lwia villages have the easiest access to the district town and, thus, the greatest opportunity to trade in its market or engage in other nonagricultural activities. Nevertheless, most interview subjects in Prey Lwia derived household income from selling rice and other crops and performing other agriculture-related activities, such as plowing others' fields.

The role of DWR cultivation in the agricultural strategies of Prey Kabas farmers has remained fundamentally unchanged while conditions for growing DWR have altered dramatically. During Pol Pot times, DWR cultivation was forbidden in the district, though a small area was continuously cultivated. In village clusters in which DWR had been cultivated, farmers were forced to build waterworks intended to make possible the conversion of DWR land to irrigated dry-season riceland.

These structures did not achieve their purpose. In some village clusters, they radically altered the floodwater accession rate and the maximum flood depth in DWR fields. Farmers said less floodwater rose from the Tonle Bassac River than in past years and the maximum flood depth in district DWR fields diminished overall by 0.5 m. Furthermore, as a result of Khmer Rouge policy, the farmers lost the seed of all but one of the many locally adapted DWR TVs they had grown before 1975.

When farmers tried to reestablish DWR cultivation after the change of government in 1979, they faced many problems, including reduced landholdings per household. Older Prey Kabas farmers said they had cultivated an average of 1.5-5 ha of DWR land plus RLR and garden land before 1975. Delvert said in 1961 that farmers in Takeo Province, including Prey Kabas District, cultivated an average 2.1 ha of land. At the time of this study, village-cluster agriculture officials said the average family allocation of DWR land was 1 ha or less. Because of scanty floods in recent years and prevailing low DWR yields, farmers had decreased cultivation and care of DWR fields and had turned instead to cash crops and other kinds of rice culture for family subsistence and cash income.

Table 6. Agricultural statistics for Kompong Trabaik District.

Village cluster	Total agricultural land (ha)	DWR land (ha)	Dry season riceland (ha)	RLR land				DWR percentage (DWR land area/total riceland area)
				Early varieties (ha)	Medium varieties (ha)	Late varieties (ha)	Total (ha)	
Piam Montia	4,090	3,705	150	0	0	385	385	91
Kompong Trabaik	1,588	785	50	134	54	615	1,803	49
Jiang Daik	2,056	675	0	282	482	1,516	2,055	33
Jam	2,634	672	0	547	594	821	2,634	26
On Saong	1,866	375	0	269	305	917	1,867	20
Pra Sat	2,113	130	0	259	588	1,036	1,983	6
Jra	1,148	76	0	320	302	450	1,148	7
Trai Cho	1,609	0	0	434	329	847	1,609	0
Konsaom On	2,643	0	0	543	942	1,057	2,642	0
Thkow	1,811	0	0	207	339	1,233	1,811	0
Prothad	1,572	0	0	500	230	842	1,572	0
Koh Kjok	2,760	0	0	531	756	144	2,760	0
Trai Pon	1,208	0	0	889	281	732	1,208	0
Total	27,098	6,418	200	4,915	5,202	10,597	23,477	18

Source: Srok Kompong Trabaik Agricultural Office, unpubl. data.

Table 7. Agricultural statistics for Piam Montia.

Village	Total agricultural land (ha)	DWR[a] land (ha)	Dry-season riceland (ha)	RLR land[b] (ha)	DWR percentage (DWR land area/ total riceland area)
Jomnong Tiak	443	443	0	0	100
Krojap Kraom	251	251	0	0	100
Krojap Leu	426	426	0	0	100
Piam Montia	243	243	0	0	100
Sut Kromuan	285	285	0	0	100
Plum	205	40	0	265	20
Preyk Ta	155	20	54	84	13
Dong Kiad Kdaom	541	447	50	36	83
Takeo	481	425	56	0	88
Sahako	296	296	0	0	100
Ang Ko	234	234	0	0	100
Total	3560	3110	160	385	

Source: Piam Montia Administrative Office, unpubl. data. [a]Discrepancies in landholding data with Table 6 due to variable statistics provided by village-cluster and district-level sources. [b]Only late-duration varieties were planted in RLR fields.

Piam Montia village cluster

DWR cultivation occupies only 24% of the agricultural land in Kompong Trabaik District overall, but DWR land is unevenly distributed among the village clusters (Table 6). Piam Montia cluster was chosen for study because

- its farmers depend on DWR production, which occupies 91% of their total cultivated land, and
- methods of cultivating RLR and the relation of RLR cultivation to DWR cultivation in Piam Montia differ from those of Prey Kabas (Table 4, 7).

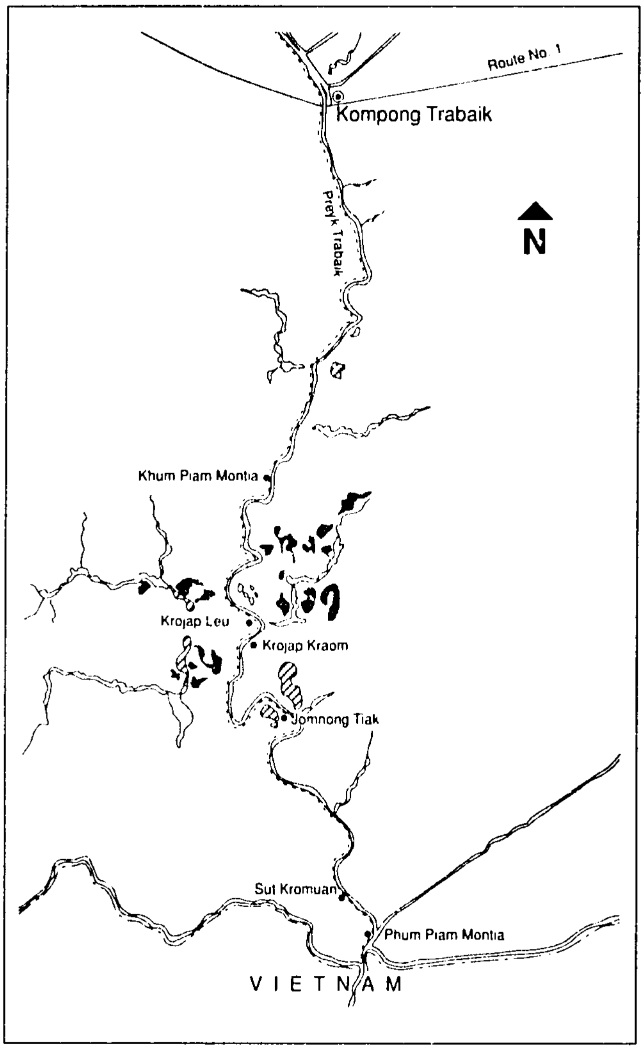
The five villages in the cluster depending most heavily on DWR cultivation were surveyed (Table 8, Fig. 3).

Kompong Trabaik District is approximately 40 km southeast of the provincial capital of Prey Veng on Route 1, the main east-west traffic artery between Phnom Penh and Vietnam. The Preyk Trabaik, a major tributary of the Lesser Mekong River, is the water source for DWR fields in Piam Montia. It branches from the Mekong near the principal ferry crossing, Nyek Leuang, and flows south through the district and into Vietnam, bisecting the district town and flowing through Piam Montia village cluster. The southernmost village in the cluster, Piam Montia, is on the Vietnamese border; only a small canal separates it from the closest Vietnamese village.

Piam Montia cluster comprises 11 villages on the banks of the Preyk Trabaik. The river is the main artery of transport and communication. In places, roads run parallel to the riverbanks, but the many outlets and small streams that channel water to the DWR fields are traversed by wooden bridges that support only bicycle and motorcycle traffic. An overland road provides access for cars and trucks to Sahako, the village in which the administrative office of the village cluster is located; but the road often is impassable during the rainy season. Residents usually use their own boats for transport or hire passage on diesel-powered, long-tailed craft of varying sizes that carry goods and passengers along the Preyk Trabaik and into Vietnam. Except at Piam Montia village, villagers' homes are built in a line near the riverbank and the village agricultural fields flank the ribbonlike settlements.

Table 8. Villages sampled in Piam Montia village cluster, Kompong Trabaik District.

Village cluster	Village
Piam Montia	Jomnong Tiak Krojap Kraom Krojap Leu Piam Montia Sut Kromuan



3. Villages surveyed in Piam Montia village cluster in Kompong Trabaik District.

SURVEY SUBJECTS

At both research sites, heads of household were identified who farmed or had farmed DWR. From their households, 67 were chosen in Prey Kabas and 36 in Piam Montia, at random, for interview. Two households in Kompong Riab village cluster of Prey Kabas District had returned their DWR land to the government in 1988 due to problems with flood accession; thus, they are not included in calculations of percentages having to do with DWR farming practices.

Though the civil war and military conscription reduced the male population, all of the households surveyed had male heads. Data were collected on several characteristics of interview subjects' households, including ages, attainment of formal education, family size, family composition, and sources of agricultural labor (Table 9).

Sources of income

Prey Kabas families acquired cash income (Table 10) from many sources, including

- selling animals (primarily pigs);
- marketing garden crops raised in garden land, in RLR land before the wet-season crop was transplanted, or in DWR land between rice crops;

- selling rice;
- plowing others' fields for pay; and
- engaging in nonagricultural economic activities ranging from selling fish caught during the wet season to civil service employment.

Piam Montia families derived their income primarily from agriculture (Table 11). Travel and communication problems restricted their opportunities for obtaining nonagricultural income—only 17% of the sample had nonagricultural sources of income. One person practiced herbal medicine; the rest were teachers or civil servants.

Sources of power

In both Prey Kabas and Piam Montia, cattle (oxen and buffalo) were an important source of agricultural power. Farmers who owned cattle used them to cultivate their own fields and, often, those of neighbors through hiring or exchange-labor arrangements (Table 12).

Agriculture officials said Prey Kabas farmers seldom give DWR fields a second plowing because they lack animal power. This assertion was contradicted in the interviews: most households in both samples either owned plow animals or had free access to animal power.

Prey Kabas farmers who used their animals to plow others' fields for cash charged 150-400 riels (US$0.29- 0.78) for a morning's work. Those engaged in exchange labor plowed cooperatively with other animal owners or accepted

Table 9. Selected characteristics of households in villages surveyed.

Characteristic	Prey Kabas[a]	Piam Montia
Household sample (no.)	67	36
Family size (av. no. of children)	4-5	5-6
Households with children assisting with agriculture[b]	32 (48)	20 (56)
Households with extended family members[c]	18 (27)	12 (33)
Age (yr)		
Head	51	49
Spouse	42	42
Education of household heads		
No schooling	13 (19)	4 (11)
Buddhist temple	21 (31)	19 (53)
Primary	20 (30)	11 (31)
Secondary	13 (19)	2 (5)
Education of spouses		
No schooling	44 (66)	22 (61)
Primary	19 (28)	14 (39)
Secondary	4 (6)	0 (0)

[a]Figures in parentheses are percentages of the sample. [b]Among these households, only 1-2 children assisted. The rest were too young or were in school. [c]Sample households reported assistance of extended family members in only 10 cases in Prey Kabas and 7 cases in Piam Montia.

Table 11. Household cash income (US$) in Piam Montia.[a]

Village	Av income from non-agricultural sources	Av income from animal sale	Av income from garden crop	Av income from rice sale	Total av income
Jomnong Tiak	1.40	0.50	63.75	24.50	90.10
Krojap Kraom	0	0	19.60	4.05	23.65
Krojap Leu	1.75	3.35	29.60	18.05	52.75
Piam Montia	4.70	11.20	12.20	17.50	45.60
Sut Kromuan	0	2.95	19.60	24.50	47.05
Av	1.55	3.60	28.95	17.75	51.85

[a]US$ = 510 riels, 1989-90.

Table 12. Resource base of farmers in villages surveyed.

Resource	Prey Kabas		Piam Montia	
	No.	%	No.	%
Farms with plow animals	46	69[a]	28	78
Cattle per farm	3.2	-	5.2	-
Farms renting animals for cash payment	10	22	0	0
Farms using animal exchange labor	27	59	15	54

[a]Another 6 households (9%) had given their plow animals to their married children, but could use them without payment.

Table 10. Sources of household cash income (US$) in Prey Kabas.[a]

Village cluster and village	Total no. of samples	Av income from nonagricultural sources	Av income from animal sale	Av income from garden crop	Av income from rice sale	Total av income
Snau						
Tropeang Reang	6	0	22.55	6.50	18.75	47.75
Snau	4	0	0	11.30	19.60	30.90
Jar						
Jar	5	9.80	15.70	19.60	27.10	72.20
Svay Jal	6	40.95	20.40	3.95	35.15	100.40
Kompong Riah						
Kompong Riah	9	26.65	12.95	0	15.35	54.95
Khaeng Kung	4	0	8.25	0	48.40	56.60
Jumnik	9	19.60	23.15	23.35	13.25	79.35
Konh Jel	9	20.20	0	8.00	14.70	42.90
Prey Lwia						
Prey Lwia Kaod	8	19.30	31.40	3.95	25.80	80.40
Prey Lwia Lech	7	107.85	33.35	11.40	26.50	179.00
Av		24.45	16.75	8.80	24.45	74.45

[a]US$ = 510 riels, 1989-90.

2 d of transplanting labor in RLR fields in return for one morning of plowing.

Of the Prey Kabas farmers, 27 (40%) said they routinely hire power for plowing. Seventeen preferred to hire tractors; 10 hired animal power. For the 1989-90 crop, hiring a tractor cost 2,500 riels/ha (US$ 4.90); hiring animal power cost 974-1,989 riels/ha (US$1.91-3.90).

Prey Kabas farmers said they prefer the more thorough plowing of the tractors, which have disc plows and rototiller equipment. The proportion of farmers who owned plows, harrows, carts, and other agricultural equipment was greater in Prey Kabas than in Piam Montia (Table 13, 14).

In Piam Montia, average cattle distribution ranged from a high of 9.8 animals per household in Jomnong Tiak to a low of 1.7 in Krojap Kraom, where three of the eight households that had no cattle were located.

Half of the Piam Montia farmers (18) said they routinely hire power for plowing. Five of the farmers who hired power (29%), all residing in Jomnong Tiak village, used their own animals and equipment and hired laborers to operate them. Two (11%) hired animal power, and 11 (61%) hired tractors.

Piam Montia farmers distinguish between "helping" and formally exchanging labor: an exchange entails keeping a careful count of days used for each task and repaying them. Respondents who participated in exchange labor said they usually helped their neighbors without counting the days worked. Of the plow animal owners, 13 (36%) said they plowed others' fields only in return for help; 6 (17%) said they plowed others' fields in formal exchange for labor.

As in Prey Kabas, owners of plow animals commonly exchanged days of team plowing or harrowing each other's fields. Farmers said using three or four pairs of animals made the work easier, and team plowing was necessary in the sandy soils that compact rapidly after land preparation.

Sources of labor

Exchange labor is important for DWR cropping operations at both research sites.

Most Prey Kabas households (47, 70%) exchanged labor for crop-management operations. Of those who exchanged labor, 30 households (64%) usually exchanged with families of their defunct *krom sammaki* (collective production unit).

Table 13. Number of households in Prey Kabas having agricultural equipment, by village.

Village cluster and village	Total no. of samples	Cart	Plow	Harrow	Rohat[a]	Snaich[b]	Pump	Boat
Snau								
Tropeang Reang	6	4	4	4	1	2	0	0
Snau	4	2	3	3	0	1	0	4
Jar								
Jar	5	3	4	3	2	3	1	1
Svay Jal	6	3	4	2	1	2	0	0
Kompong Riab								
Kompong Riab	9	2	5	4	3	4	0	7
Klaeng Kung	4	4	4	3	0	1	1	2
Jumnik	9	7	8	7	1	2	2	8
Konh Jel	9	0	1	0	4	7	2	8
Prey Lwia								
Prey Lwia Kaod	8	6	6	4	0	5	0	0
Prey Lwia Lech	7	4	4	4	1	3	0	0
Total	67	35	43	34	13	30	6	30
Percentage of sample		52.2	64.2	50.7	19.4	44.8	9.0	44.8

[a]Pedal-driven irrigation wheel. [b]Water shovel for mechanical irrigation.

Table 14. Number of households in Piam Montia having agricultural equipment, by village.

Village	Total no. of samples	Cart	Plow	Harrow	Thresher	Boat
Jomnong Tiak	6	7	7	7	0	4
Krojap Kraom	7	1	3	2	0	0
Krojap Leu	10	6	10	8	0	5
Piam Montia	7	4	6	5	0	0
Sut Kromuan	6	4	6	6	1	0
Total	36	22	32	28	1	9
Percentage of sample		61	89	78	3	25

The remaining 17 households (36%) depended on kin or both kin and krom sammaki families.

Hiring labor for DWR cultivation also is common at both sites. Nearly half of the Prey Kabas interview subjects said they routinely hire labor, most frequently for harvesting but also for transplanting RLR. Few Prey Kabas households hired labor for other tasks.

One day's labor was usually exchanged for the same task in DWR cultivation, although a day's labor weeding could be exchanged for a day's labor harvesting.

Of the Piam Montia farmers, 20 (56%) exchanged labor and 3 "helped" their neighbors and kin. The exchange-labor system in Piam Montia is slightly more kin-based than the system in Prey Kabas. For 11 of the 20 households that exchanged labor, neighbors and kin composed the core exchange-labor group. The remainder usually exchanged labor with members of their former krom sammaki or with both kin and krom sammaki families.

Of the Piam Montia interview subjects, 15 (42%) said they regularly hire labor only to harvest rice and transport it to the threshing floor. None hire labor for any other DWR cropping operation.

HYDROLOGY

The flood—the timing of accession, rate of rise, maximum depth, and timing of recession—affects all Cambodian DWR farmers. The seasonal flood is a principal factor determining the success of the DWR crop. Delvert (1961) noted that, in Cambodia, DWR grows best where the flood rises no faster than 10 cm/d and has a gentle current. Although these circumstances are ideal, De Datta (1981) noted that floating-rice varieties must withstand a rapid rise in the level of the flood and periods of total submergence.

The hydrology of the two research sites reflected their different field forms and levels, proximity to water sources, and effects from Pol Pot agricultural policies.

Prey Kabas District

The Prey Kabas DWR fields cover more than 3,000 contiguous hectares near the eastern and northeastern boundaries of the district, following the slope of the land toward the Tonle Bassac River. When the level of the Tonle Bassac rises sufficiently, the Preyk Ambal, a minor tributary flowing through Prey Kabas, reverses its flow and floods the DWR fields through secondary watercourses.

Before 1976, the flood arrived gradually and regularly in the fields, rising from the Preyk Ambal, smaller tributaries of the Tonle Bassac, and watercourses and swamps fed by these tributaries. Water overflowed into the lowest fields in mid- to late August, reaching its maximum depth between late September and early October of more than 3 m in the lowest fields north of Jar and 1-1.5 m in the highest fields. The flood remained at maximum depth for 2-3 wk and then began to recede. DWR could be harvested in high fields between late November and early December and in the lowest fields by late January.

The Pol Pot government vigorously enforced its hydrological policy in Takeo Province and elsewhere in its Southwest Administrative Zone. After 1976, DWR cultivation was forbidden in all but 50 ha of the fields in Prey Kabas District. Where DWR had been cultivated, villagers were organized into work brigades during the dry season and were required to build water-control structures. In Jar, Snau, and Prey Lwia, the intent was to create a reservoir in the higher portions of the fields, filled by advancing floodwater, to irrigate high-yielding, photoperiod-insensitive rice varieties transplanted during the dry season.

The structures (Fig. 2) disrupted the arrival and altered the maximum depth of the flood in the fields where DWR was cultivated. Canals dug across these fields and watergates built on those canals have reduced the maximum depth of the flood in fields above these structures. The situation is worsened, according to all farmers interviewed in Prey Kabas, by the general diminution of the yearly flood from the Tonle Bassac. District agriculture officials said the average maximum flood level had decreased by at least 0.5 m in the past 10 yr.

Jar village cluster. Jar is the northernmost village cluster in the district (Fig. 2). DWR fields in the cluster are north of the villages. Fields are high in the southwest, sloping to low in the northeast. The seasonal flood rises from Jamlong Kruah, a lake or swamp fed by the Preyk Ambal.

During Pol Pot times, a large canal was dug across the DWR fields in this cluster. The new waterway failed to hold irrigation water in the dry season and adversely affected accession and maximum depth of the flood.

Northwest of the canal, the flood has been reduced to a maximum of 0.8-1.5 m, while to the southeast it is normally 1-2.5 m. The flood advances gradually southeast of the canal, but inundation is rapid and late to the northwest. Water builds up and is pushed through ruined water-control structures along the canal. Currently used TVs, assembled from Cambodia and Vietnam after the change of government in 1979 to replace lost varieties, are not well adapted to the resulting shallow maximum flood. The affected fields occupy about 500 ha; an additional 750 ha receive the normal flood.

Snau village cluster. Snau is on the southeast border of Jar (Fig. 2). Its DWR land is high in the southwest, sloping to low in the northeast. The flood in the Snau fields rises directly from the Preyk Ambal, which runs north-south along the eastern boundary of the DWR fields.

As in Jar, a long canal was dug across the DWR fields in Snau. It, too, failed in holding capacity for dry-season irrigation. In Snau, however, water-control structures were not built on the canal, and the new waterway has been less disruptive of the flood in fields to the southwest than has the canal at Jar. The flood arrives at the normal rate but the maximum depth has been altered: the flood depth is usually 1 m or less southwest of the canal and 1.5-2.5 m on the other side.

Prey Lwia village cluster. Prey Lwia is south of Snau and includes the district town. Only Prey Lwia Kaod and Prey Lwia Lech villages primarily grow DWR. The flood in Prey Lwia rises directly from the Preyk Ambal to the east of the village cluster. Because the fields are near the Preyk Ambal and other secondary flood sources, floodwater often rises more rapidly in Prey Lwia than in other village clusters. A strong current damages DWR stand establishment in parts of the fields.

Extensive waterworks constructed in Prey Lwia include a large reservoir. Its earthen walls encompass an area 1.5 km by 1 km, or about 140 ha. Nevertheless, the water it retains can irrigate only 50 ha of dry-season rice. A large lateral canal leading south from the southeast corner of the reservoir has further disrupted flood accession; thus, lands west of the canal have been diked and converted to RLR fields.

Kompong Riah village cluster. The low DWR fields of Kompong Riah lie east and southeast of the district town. During maximum flood, the villages become islands in the DWR fields, and people can travel only by boat. Kompong Riah farmers have little RLR land. Cash crops such as tobacco, sweet potato, and mungbean are grown on the DWR land from January to April or May. After these crops are harvested, the fields are plowed and DWR seed is sown.

About 50 ha of lowland has been turned into a flood-recession area for dry-season cultivation. Here the dry-season rice is laboriously irrigated with water shovels or the *rohat* (pedal-driven irrigation wheel). This cropping is necessary because rapid flood arrival often damages DWR stand establishment. Due to the severity of damage, two farmers surveyed in Jumnik and Klaeng Kung villages had returned their DWR land to the government and relied solely on their dry-season riceland.

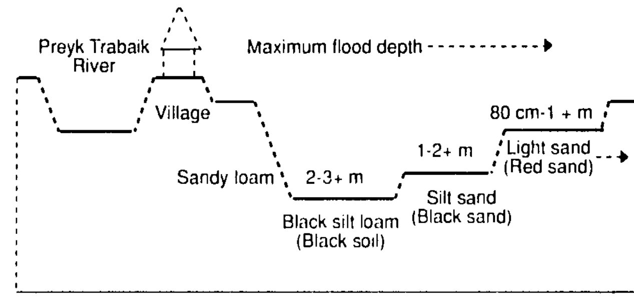
The Preyk Ambal flows into the northern portion of the village cluster and from there into a swamp or small lake. The northeast outflow from the swamp forms the Stung Kompong Liaw stream, and the southern outflow is the Preyk Ambal. The overflow of the two outflows and of secondary watercourses flood the DWR fields in Kompong Riah, Ban Kam, and Po Rom Jak village clusters to the west. The maximum flood depth varies from 50 cm near the eastern boundary to 2.5 m or more in fields near the northern boundary. Because the maximum depth and duration of the flood vary widely, some Kompong Riah farmers harvest early-maturing deepwater varieties in mid-December, but rice in fields where the maximum depth can exceed 3 m is harvested in late January.

The effects of attempts to alter DWR fields have been less permanent in Kompong Riah than in other village clusters. The variable land, with its many natural bodies of water, would not accommodate the building of massive structures. A heavy flood in 1978 destroyed all of the minor waterworks that the farmers had been forced to build—along with the entire rice crop of the village cluster.

Piam Montia village cluster

Farmers in Piam Montia classify their fields largely according to the prevailing soil and cultivation type (Fig. 4). In most villages, a narrow shelf of sandy loam soil lies directly below the riverbank. Most fields with this soil are too high for rice cultivation and are planted mainly with an early wet-season cash crop—usually sesame or maize. From these cash-crop fields, the land slopes sharply down to the lowest-lying DWR fields and then slopes gradually upward, away from the river.

The farmers call the soil in the lowest fields *dey kmao* (black soil) or *dey lbob kandeng kmao* (black silt loam soil). These dark silt loam soils have some clay content and are soft and friable when flooded. At maximum flood, water in fields with this soil is 2.5-4 m deep.



4. Schematic drawing of land form, soil type, and maximum flood depth in Piam Montia's deepwater ricefields near the Preyk Trabaik River.

As the land slopes upward from these depressions, the texture of the soils becomes lighter and sand content increases. The soil directly upslope from the black soil is called *dey ksaich kmao* (black sand soil) or *dey ksaich lbob pong konthaw* (silt sand soil [like a] turtle egg). The name describes light sandy soils that have some silt content—friable when flooded and said to have a rubbery texture like a turtle's egg. Maximum floodwater in these fields is usually 1-1.5 m deep.

At a slightly higher level, the silt sand soils give way to light sandy soils that have a finer texture and, thus, are more subject to compaction when flooded. The farmers call these *dey ksaich krohom* (red sand soil). The maximum flood in some fields with this soil previously were deep enough to support floating-rice varieties. Currently, however, the maximum flood seldom exceeds 1 m in these fields, reaching 50-100 cm in lower areas and 30-50 cm in higher areas.

The DWR fields are near the Preyk Trabaik. As the water in the river rises, it overflows into small streams and outlets that channel it directly into the DWR fields. The flood arrives early in Piam Montia. In early August, the Preyk Trabaik begins to overflow, rapidly flooding the lowest fields near the riverbank. The flood continues to accumulate, attaining its maximum depth by early to mid-September and usually remaining at this level for 15-20 d. Flood recession begins in early to mid-October and is usually complete by early December.

Farmers have diked many of the high fields and switched the varieties they plant from floating types to tall, late-maturing DWR types (which they classify as RLR) that can tolerate water up to 1 m deep. These varieties are direct seeded in lower fields with red sand soil and transplanted in higher fields.

In low fields with black soil and adequate flood, average reported DWR yields were 1.3-1.6 t/ha. In fields with black sand soil and slightly more shallow water, average yields were 1.2-1.4 t/ha. In the highest fields, which have infertile red sand soil, DWR or RLR yielded only 0.8-1 t/ha.

Piam Montia was in the Eastern Administrative Zone of Democratic Kampuchea. The administrators of the Eastern Zone applied Khmer Rouge policies, including hydrological mandates, more leniently than did the cadres in the Southwestern Zone, which included Prey Kabas District (Vickery 1983). Khmer Rouge radio broadcasts reported that large-scale hydrological projects, such as those constructed in Prey Kabas, were built in Prey Veng Province (Ragos-Espinas 1983). The Piam Montia farmers, however, were not forced to build such waterworks to try to transform their DWR fields.

The Khmer Rouge cadres tried to alter DWR cultivation by forcing the farmers to transplant floating-rice seedlings and to substitute for floating varieties the tall, late-maturing DWR varieties that farmers classify as RLR. Administrative purges and border conflict with the Vietnamese in Prey Veng in 1977-78 further disrupted agriculture, resulting in the confiscation of all floating-rice seed in early 1978. Unlike their Prey Kabas counterparts, the farmers of Piam Montia suffered no permanent alteration to the hydrology of their DWR fields and, through fortuitous circumstances, reassembled seed stock of their lost DWR TVs.

VARIETAL FACTORS

Although scientists and Cambodian farmers classify rice varieties differently, they agree that one vital factor in the success of a crop is the use of varieties that are adapted to local conditions and meet local preferences. Efforts of the Khmer Rouge to increase national rice yields ignored this critical consideration and, therefore, not only failed but also caused long-term yield reductions in some areas.

Classifications

DWR is generally defined by the depth of standing water in which it grows, though some scientists also consider planting method and other factors.

De Datta (1981) defined medium-deep RLR varieties as those transplanted in 16-50 cm of water. He classified DWR as rice grown in more than 50 cm of standing water. De Datta criticized an earlier system that classified medium-deep rainfed rice as that grown in 16-100 cm of water because, he contended, RLR is primarily transplanted on puddled soil while DWR is primarily direct seeded on dry soil.

Garrity et al (1986) characterized the medium-deep, waterlogged riceland environment as having 25-50 cm of water for much of the growing season. Like De Datta, they classified DWR as rice grown in more than 50 cm of standing water.

Delvert (1961) noted that RLR is commonly direct seeded rather than transplanted in broad areas of Battambang and Kompong Thom provinces on the Great Lake Plain. He said such cultivation is called *srai srok*: a Khmer term, meaning "local field (cultivation)," that usually is reserved for cultivation of transplanted varieties. In the Great Lake Plain, maximum standing water depth reaches 1-1.5 m. If transplanted, the srai srok varieties often drown; if direct seeded, they grow tall enough to survive. Thus, scientists would classify them as DWR varieties while farmers would classify them as late-maturing RLR.

Seng et al (1987) said, "There is no clear demarcation of DWR areas in Kampuchea, although floating rices are said to be those growing in more than 1 m of water." Seng et al identified *Phca Sla* as a popularly planted deepwater variety—it is not a true floating variety, and it is not commonly direct seeded. Delvert (1961) listed *Pkha Sla* as a late RLR variety. It is commonly transplanted in low RLR fields in Takeo and Kandal provinces and is classified by farmers as a late-maturing RLR variety. It tolerates 80 cm or deeper water and has slight elongation ability. Catling et al (1988) would classify it as a deepwater variety based on water depth and agronomic characteristics, disregarding the question of direct seeding or transplanting.

Cambodian farmers, however, in their classifications and cultural practices for DWR, do not always distinguish between varieties grown in water deeper than 50 cm and direct-seeded floating varieties. In Khmer, seasonal rice categories include *srao wossa* (wet-season rice) and *srao prang* (dry-season rice). In general, the term srao wossa refers to RLR varieties and includes DWR. Srao wossa is further subdivided into *srao sral* (light rice), *srao kandal* (medium rice), and *srao thngon* (heavy rice). These terms refer to transplanted varieties of early, medium, and late maturity, respectively. Floating rice usually is called *srao laong tyk* (rice above water) and, less frequently, *srao wia*. The word *wia* refers to the kneed tillering of true floating-rice varieties as opposed to the upright growth of deepwater varieties.

Farmers in Prey Kabas and Piam Montia cultivate similar varieties. In Khmer, common RLR variety names often are modified to connote special characteristics. The addition of the words *laong tyk* (above water) to a variety name usually indicates a deepwater variety or a longer-duration variety that tolerates deeper water than the variety from which its root name came. At both research sites, varieties with the words laong tyk appended to their names were tall, upright, deepwater varieties with limited elongation ability.

Jong Banlas, for example, is a medium-maturing RLR variety commonly planted in Takeo Province. Prey Kabas farmers cultivate *Jong Banlas Laong Tyk*, a variety that can tolerate water up to 1.25 m but that farmers classify as a late-maturing RLR variety. Similarly, *Niang Manh* is a widely distributed late-maturing RLR variety that tolerates up to 50 cm of standing water. Piam Montia farmers plant *Niang Manh Laong Tyk*, which has similar maturity but tolerates up to 80 cm of standing water. These varieties either can be transplanted in diked RLR fields that have deep standing water or can be direct seeded as true DWR. In both cases, the addition of laong tyk to the variety name connotes DWR characteristics absent in the varieties without the name extension.

Farmers in Prey Kabas said Jong Banlas Laong Tyk was best adapted to a maximum flood of 80 cm but could survive up to 1.25 m. Coyaud (1950) noted similar deepwater varieties that were commonly planted in a region of South Vietnam in which the flood accession was late and the maximum depth shallow. He called them "semifloating" varieties, suited to a maximum flood of 80-100 cm. Varieties such as Jong Banlas Laong Tyk and the entire range of varieties that Piam Montia farmers classify as RLR lack the kneed tillering of true floating varieties but are adapted to deep standing water.

Several of the locally adapted DWR varieties that were lost in Prey Kabas were reported to be well suited to fields with a shallow maximum flood of 80-125 cm. Some may have been upright, elongating varieties, such as Jong Banlas Laong Tyk, rather than true floating varieties. Farmers may have decided whether to transplant or direct seed such varieties according to the water level in the field, as Ban Kam villagers currently do with Jong Banlas Laong Tyk.

Traditional DWR varieties

The reasons for the Khmer Rouge suppression of DWR cultivation are difficult to discern, and some data seem almost contradictory. Hildebrand and Porter (1976) provided cultivation statistics for large areas of DWR in provinces under Khmer Rouge control in 1974. An outright ban probably was not issued until agricultural policy hardened in 1976, when the 4-yr development plan was circulated, and was not implemented until the 1977 cropping season (Chandler et al 1988, Lando 1991).

Prey Kabas District. Before Pol Pot times, Prey Kabas farmers used a wide assortment of DWR varieties, including types suited to various water depths and regimes. They included

- varieties with harvest dates ranging from late November to late January;
- deepwater varieties that had slight elongation ability, suited to fields where the flood was less than 1 m;
- true floating-rice varieties that could be grown in fields where the maximum flood exceeded 3 m;
- varieties that had cooking and eating quality rivaling that of RLR varieties;
- varieties that had high yields; and
- varieties that provided a good cash crop.

Farmers managed the diverse DWR varieties much as they do TVs in their RLR fields. A farmer chose a variety to plant in a field according to the variety's adaptation to the maximum flood depth in the field and its harvest date.

One older farmer said he routinely grew *Srao Jek, Srao Sai Pu,* and *Battambang* on DWR land before 1976. These varieties were suited to the three flood levels prevailing in his fields and, because their maturities differed, he could harvest them serially.

From 1976 to 1979, DWR was cultivated in only 50-60 ha of Prey Kabas' 3,200 ha of DWR fields. Seed of one TV, Battambang, was preserved. All others were lost.

After 1979, attempts were made to reassemble a selection of DWR varieties from many sources. Seed for experimentation was obtained from Vietnam, Battambang Province, and areas in Kandal Province (Table 15). A major problem for Prey Kabas DWR farmers is that none of the varieties assembled from other provinces are adapted to the shallow maximum flood prevailing in several hundred hectares of the district's DWR fields.

Older farmers who had resided continuously in the district were interviewed concerning DWR cultural practices before Pol Pot times. A list of 16 lost varieties with widely differing agronomic characteristics and harvest dates was compiled from seven interviews (Table 16).

Some farmers interviewed did not know the names of the DWR varieties they commonly grew or had grown in the past. Each knew only whether the variety he used was red or white and remembered the variety names only when prompted by neighbors.

Table 15. DWR varieties currently cultivated in Prey Kabas.

Variety	Seed source	Harvest date	Optimum[a] maximum flood depth	Grain shape/ color	Eating quality	Av yield (t/ha)	Agronomic characteristics
Phka Mrom	Unknown	Early Dec	50-70 cm	Short/bold-white	Acceptable	1.1	Cannot tolerate flood > 1 m deep
Sombok Krohom	Kandal Province	Early Dec	1.5-2 m	Long/bold-white	Acceptable-poor	2.0	Survives flood > 2 m; yield loss if flood 80-100 cm deep
Sombok Saw	Kandal Province	Early Dec	2 m	Short/bold-white	Acceptable	1.5	Survives flood > 2.5 m; yield loss if flood 80-100 cm
Kantui Chkai	Unknown	Late Dec	2.5 m	Long/bold-white	Acceptable-poor	1.5-2	Survives flood to 3 m; severe yield loss if flood 80-100 cm deep; slow elongation, cannot survive rapid accession
Samsap	Unknown	Late Dec-early Jan	1.5 m	Short/bold-white	Acceptable	1.8	Cannot tolerate flood > 2 m; tolerates maximum depth 70-80 cm; poor submergence tolerance
Battambang	pre-Pol Pot variety	Early-middle Jan	1.5-2 m	Medium/bold-white	Good	up to 2.4	Tolerates deep flood; 50% yield loss if flood > 1 m
Kua Kronhol	Kandal Province	Early Jan	2.5-3 m	Short/bold-white	Good	1.9-2.4	Tolerates flood 1.5 m deep; severe yield loss if flood < 1 m
Peah Roniam	Unknown	Early Jan	2.5-3 m	Short/bold-red and white	Acceptable	1.8-2	Tolerates flood 1.5 m deep; severe yield loss if flood < 1 m

[a]Maximum flood deep enough to avoid spikelet sterility, shallow enough to avoid drowning.

Table 16. Reported DWR varieties lost in Prey Kabas during Pol Pot times.

Variety	Harvest date	Optimum/ maximum flood depth[a]	Grain shape/color	Eating quality	Av yield (t/ha)	Agronomic characteristics
Niang Wan	Late Nov	2-3 m	Long/short	Excellent	1.9	Spikelets sterile if flood <1 m deep
Srao Mok	Late Nov	2.5-4 m	Short/bold-red	Poor	1.7-1.9	Grown for sale to distillers
Laong Tyk konals	Late Nov-early Dec	70-80 cm	Short/bold-white	Poor-acceptable	1.4-1.7	Intolerant of flood >1.5 m deep
Srao Jek	Early Dec	1-1.5 m	Short/bold-white	Poor-acceptable	1.8	Intolerant of flood >1.5 m deep
Niang Dey	Early Dec	2-3 m	Long/short-white	Acceptable	1.8	Spikelets sterile if flood <1 m deep
Niang Son	Late Dec	1.5-2 m	Long/short-white	Good	1.8-2+	Tolerates shallow water, but not > 2 m of water, desirable for high yield
Srao Sai Pu	Late Dec	1.5 m	Long/short-white	Good	2-2.4	Tolerates > 2 m of water; spikelets sterile if flood <1 m deep; prized for eating quality and volume expansion
Kon Dia	Late Dec	2 m	Short/bold-white	Good	2.4-2.6	Good elongation; yield reduction if flood <1 m
Popiay Thngon	Late Dec	2.5 m+	Long/short-white	Acceptable	1.8-2.2	Tolerates flood >3 m; yield reduction if flood <1 m
Ongkao Saw	Late Dec	2-3 m	Short/bold-white	Acceptable	1.8	Yield reduction if flood <1 m
Ongkao Krohom	Late Dec-early Jan	2-3 m	Late/medium-red and white	Acceptable	1.7	Yield reduction if flood <1 m; good grain weight
Kronheng	Early Jan	2-2.5 m	Short/bold-white	Acceptable	1.2-1.8	Serious yield reduction if flood 80-100 cm deep
Niang Pal	Early Jan	2.5-3 m	Short/bold-white	Average	1.9-2.4	Tolerates deep water; serious yield reduction if flood 80-100 cm deep; good elongation ability
Niang Suan	Middle Jan	2.5-3 m	Short-bold-white	Average	1.9-2.4	Tolerates deep water; serious yield reduction if flood 80-100 cm deep
Kua Kronhol	Late Jan	1-1.5 m	Short/bold-white	Average	1.8-2.4	Tolerates water > 1.5 m deep; yield reduction if water 80 cm deep or less

[a]Maximum flood deep enough to avoid spikelet sterility, shallow enough to avoid drowning.

Village-cluster agriculture officials identified a variety, *Phka Mrom*, as the only locally grown variety adapted to a maximum flood of less than 1 m; however, no farmer surveyed reported growing it for the 1989-90 crop. Farmers routinely plant *Sombok Saw* and *Sombok Krohom*, which are best adapted to maximum flood of 1.5-2 m, in fields that have maximum flood depth of only 50-70 cm.

Farmers frequently commented on the difficulty of maintaining seed for DWR varieties, emphasizing the appearance of red grains in the crop. Delvert (1961) noted that the appearance of red grains in DWR varieties obliges farmers to change seed every 3-4 yr.

Due to the difficulties of DWR cultivation, the shortage of floodwater in many parts of the district for the past 2 yr, and other factors, the people of Prey Kabas expressed little interest in obtaining new DWR varieties.

Piam Montia village cluster. Because the Eastern Zone cadres applied Khmer Rouge agricultural policy leniently, the effects of attempts to transform DWR were milder in Piam Montia than in Prey Kabas. Portions of the Eastern Zone were under Khmer Rouge control as early as 1971; and the early, mild form of collectivized agriculture was well organized by 1975 (Vickery 1983). Officials in this zone took a more gradual approach to transforming agriculture.

In 1976-77, farmers were compelled either to convert 40% of the DWR to transplanted RLR or to transplant seedlings of local deepwater or floating varieties, which commonly were direct seeded. Some lower fields were direct seeded in the usual way for floating-rice cultivation.

In the area designated for transplanted RLR, the farmers were forced to build high dikes to restrain the flood and to transplant seedlings of the local, deepwater varieties *Niang Manh*, *Niang Uad*, and *Niang Niur*. These tall, late-maturing varieties have slight elongation ability and thus can tolerate 50-80 cm of standing water, but they are not adapted to the depths of 2 m or more that are common in DWR fields. These varieties are classified locally as RLR. The seasonal flood damaged most varieties transplanted in fields to which they were maladapted.

The 1977 national rice harvest was poor. The government blamed sabotage by enemy agents for the shortfall. The lenient Eastern Zone cadres were ruthlessly purged in 1977-78 and replaced with strict Southwestern Zone cadres determined to implement the 3 t/ha national yield target (Ragos-Espinas 1983, Kiernan 1980).

In early 1978, before the DWR crop was sown, the new cadres, which controlled all seed storage, inexplicably confiscated all of the DWR seed and transported it out of the province. The government ordered farmers to transplant ordinary RLR varieties into more than 1,000 ha of DWR fields, and the cadres forced the farmers to build more high dikes. The 1978 flood was especially heavy, so the crop was largely destroyed.

Two factors allowed the farmers of Piam Montia to recoup many of their TVs: the proximity to Vietnam and the chance discovery of volunteer TVs.

Before 1975, ethnic Vietnamese lived and farmed in Piam Montia, bordering Vietnam. The Khmer Rouge expelled them from the village cluster in 1975. When they left, the Vietnamese took seed of the commonly grown DWR varieties with them. They returned from Vietnam to trade salt with their former neighbors in 1979, and the Piam Montia farmers learned of the extant DWR seed. A delegation of farmers went to Vietnam and traded RLR seed for 2-3 *thang* (48-72 kg) of the local deepwater and floating varieties planted before 1978 and also acquired new varieties. This seed was multiplied during the three succeeding seasons and distributed so local farmers could reassemble their seed stock.

In another stroke of good fortune, after the heavy 1978 flood receded, farmers of Krojap Leu village found lodged volunteer DWR plants, 4 m or longer, that had not yet entered the reproductive phase. They cut these plants at the nodes and rooted the makeshift seedlings in a field where water was still standing. Farmers examined the mixed crop closely at panicle emergence and ripening and identified familiar TVs. Seed stock of the recovered varieties was separated and carefully multiplied for subsequent distribution.

Since 1979, varieties from Battambang Province, Vietnam, and other sources have been added to the farmers' selection. One variety, now popular because of its good yield and adaptation to a wide range of hydrological conditions, was provided in 1985 to the Kompong Trabaik District agriculture office by a nongovernmental organization—Cooperation International pour le Developpement et la Solidarite—as part of a DWR seed-procurement program. The variety has been tentatively identified as *Khao Puang*, from the central plains of Thailand, and is called *Phka Dong* locally (Table 17, 18).

Traditional RLR varieties in Piam Montia

RLR cultivation, as practiced in Piam Montia, is an extension of DWR cultivation in fields where maximum floods no longer exceed 1 m. The change from DWR to RLR cultivation often involves only a change of varieties. RLR is transplanted

Table 17. DWR varieties currently cultivated in Piam Montia.

Variety	Seed source	Harvest date	Soil type for best yield	Optimum[a] maximum flood depth (m)	Grain shape/color	Eating quality	Av yield (t/ha)	Agronomic characteristics
Chmar Kombot	Traditional	Early Dec	Black silt	1.25-1.5	Short/bold-white	Acceptable	1.2-1.7	No yield loss if flood to 50 cm maximum depth; slow elongation; cannot tolerate > 2 m water maximum depth
Chmar Laong T[illegible]	Local	Early Dec	Black silt sand	1.25-1.5	Long/short-white	Acceptable-good	1.6	No yield loss if flood to 50-80 cm maximum depth; can tolerate > 2 m water maximum depth; slow accession
Battambang	Battambang Province	Middle-late Dec	Silt loam with sand	>2	Medium/bold-white	Good	1.5-1.8	Cannot tolerate > [illegible]-3.5 m maximum depth; slow elongation ability; no yield loss if flood to 50 cm maximum depth
Phka Dong	Nongovernmental organization (1984)	Middle-late Dec	Silt loam with sand	2-3	Medium/bold-white	Medium-good	>2	Tolerates flood of 4 m or < 1 m deep without yield loss; slow elongation; damaged by rapid rise in flood
Jongkong Kmao	Vietnam	Middle-late Dec	Black silt loam	2	Short/bold-white	Medium-good	1.2-1.4	Tolerates flood to 3 m; yield reduction if flood < 1 m deep; good elongation capacity
Ongka Sao	District agricultural office	Middle-late Jan	Black silt loam	1.5-2	Short/bold-white	Good	1.2-1.8	Tolerates flood to 2.5 m; severe yield reduction if < 80 cm
Niang Dom	Vietnam	Late Jan	Black silt loam	2-3	Short/bold-red	Good	1.3-1.5	Tolerates flood of 4 m or < 1 m without yield loss; slow elongation; damaged by rapid rise in flood
Ba Sao	Vietnam	Late Jan	Black silt loam	2.5	Long/short-white	Good	1.5-1.7	Tolerates flood of 3 m or < 1 m without yield loss
Srao Ongka	District agricultural office	Late Jan-early Feb	Black silt loam	2.5	Medium/bold-white	Good	1.9-2.1	Tolerates flood up to 3.5 m; severe yield reduction if flood < 1 m

[a]Maximum flood deep enough to avoid spikelet sterility, shallow enough to avoid drowning.

Table 18. Number of households planting DWR in Piam Montia, and their average yields (t/ha), by variety and village.

Village	Battambang		Phka Dong		Chma Laong Tyk		Srao Ongka		Jongkun Kmao		Niang Dong		Niang Saw		Ba Sao		Niang Mias		Ongka Sao		Chma Kombot		No. of households planting	
	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	No. of house-holds	Av yield (t/ha)	2 varieties	3 varieties
Jomnong Tiak	5	1.3	1		2	1.6							1	1.6	1	1.3		1.3					2	1
Krojab Kraom	6	1.3					1	2.1			1	0.5											0	0
Krojab Leu	6	1.2	1	1.7	2	1.7			3	1.3	1	1.2			1	0.7		0.7			1		3	0
Piam Montia			5	1.3	2	0.7					1		1	0.7								0.7	1	0
Sut Kromuan			1				3	0.9			1	1.2					1		1	1.8			1	0
Av yield		1.3		1.5		1.3		1.5		1.3		1.0		1.2		1.0		1.0		1.8		0.7		
Total	17		8		6		4		3		3		2		2		1		1		1		7	1
Percentage of sample	47		22		17		11		8		8		6		6		3		3		3		19	3

Table 19. Reported yields and frequency of planting common RLP. varieties in Piam Montia villages.

Village	Srao Smao		Phka Ampal		Niang Manh Laong Tyk		Domnawb Jek		Niang Mu		Kantui Domrai		Jong Banlas Laong Tyk		Niang Mias	
	Frequency of planting	Yield (t/ha)	Frequency of planting	Yield (t/ha)	Frequency of planting	Yield (t/ha)	Frequency of planting	Yield (t/ha)	Frequency of planting	Yield (t/ha)	Frequency of planting	Yield (t/ha)	Frequency of planting	Yield (t/ha)	Frequency of planting	Yield (t/ha)
Jomnong Tiak			1	0.7	1	0.8										
Krojap Kraom	1	0.66					1	0.7								
Krojap Leu	1	1.2			1	0.8										
Piam Montia	1	1.2					1	0.6	1	1.2	1	1.1				
Sut Kromuan			1	1.8									1	0.9	1	0.8
Av		1.02		1.25		0.8		0.65		1.2		1.1		0.9		0.8

Table 20. RLR varieties currently cultivated in Piam Montia.

Variety	Duration	Harvest date	Depth of standing water tolerated	Reported yield (t/ha)	Grain shape/color	Eating quality	Agronomic characteristics
Srao Smao	Medium (Srao kandal)	Middle-late Nov	Up to 80 cm	.7-.8	Medium/bold-white	Acceptable	Better yield if transplanted, usually direct seeded, lacks drought resistance
Domnawb Jek (glutinous)	Medium	Middle-early Dec	50-70 cm	1	Glutinous long/short-red	Acceptable	Usually direct seeded in low fields, lacks drought resistance
Phka Ampal	Late (Srao thngon)	Middle-late Dec	Not >50 cm	1.1	Long/short-white	Good	Lacks elongation ability but has drought resistance, suited to higher fields
Niang Manh Laong Tyk	Late	Middle-late Dec	50-80 cm	1.1	Medium/bold-white	Good	Lacks elongation ability, best yield if transplanted in bunded fields
Kantui Domrai	Late	Late Dec-early Jan	50-100 cm	.9-1	Medium/bold-white	Acceptable	Elongation ability, best adapted to low fields, direct seeded
Niang Mias	Late	Late Dec-early Jan	>1 m	1.9	Long/short-white	Good	Good, limited elongation ability, direct seeded in lowest RLR field

from nursery beds only in the highest diked fields. The reported average yield of RLR seldom exceeded 1 t/ha (Table 19).

Piam Montia farmers do not plant a range of early-, medium-, and late-maturing RLR varieties. Village landholding statistics did not show any RLR land planted with early- or medium-maturing varieties. Only two of the six varieties identified by farmers in interviews are classified as medium maturing, and one of these is a glutinous variety (Table 20). Farmers reported that most of the six varieties predate the Pol Pot times. Farmers are more likely to direct seed these varieties than to transplant them.

LAND ALLOCATIONS

Average amounts of total land allocations and types of land available differ between the two research sites, as does the relative importance of RLR and DWR. Thus, it is difficult to compare farmers' landholdings between the two sites except to compare their allocations of DWR land.

In the village clusters where DWR is cultivated, Prey Kabas farmers manage diverse agricultural lands—garden land and three kinds of riceland. Most farmers surveyed had two or, at most, three kinds of land. Only one of 67 households surveyed had all four kinds of land, and only seven (10%) had all three kinds of riceland. The rest grew a combination of DWR and transplanted RLR or irrigated dry-season rice.

Kompong Riab farmers can grow cash crops in garden land or DWR fields. The farmers in the other three village clusters can grow cash crops only in their RLR fields before transplanting the wet-season crop.

Piam Montia farmers have less diverse land types available to them and depend primarily on DWR cultivation for subsistence rice. RLR cultivation mimics DWR cultivation except in the highest, diked fields, where rice is transplanted. Cash cropping is limited to small garden plots near the houses.

Deepwater riceland allocations

Most of the DWR farmers surveyed in Prey Kabas District cultivate rice on the broad expanse of fields northeast of Snau, Jar, and Prey Lwia village clusters. On the higher terraces near the villages, the land is diked and transplanted with RLR. Lower fields, flooded to 80 cm or higher, are direct seeded with DWR. Varieties transplanted in the higher terraces are identical or similar to varieties described by farmers in other parts of Takeo Province who cultivate only transplanted RLR, following the local maturity classifications of early-, medium-, and late-maturing varieties.

DWR land accounts for about 20% of the total agricultural land in Prey Kabas District. Only six village clusters have DWR land; in these clusters, DWR fields account for 40% of the agricultural land. For the farmers surveyed, however, DWR land represented 57% of total land allocation.

The average land allocation was 1.78 ha, ranging from 1.04 ha per household in Snau village to 2.42 ha in Prey Lwia Lech (Table 21). The average amount of DWR land was 1.0 ha for the households surveyed. Forty-one (63%) of the households had one plot of DWR land; the remainder had two to four plots.

Farmers in Klaeng Kung and Kompong Riab villages had cleared 20 ha of new DWR land from secondary forest in the past 4-5 yr. Village-cluster officials said that, because of declining yields and poor floods, people were trying to increase production in any way they could.

According to past land policy, farmers who wanted to clear land had only to file a letter of intent with the village-

Table 21. Total agricultural land area and area by land type in Prey Kabas.

Village cluster and village	Total no. of samples	Average total agricultural land (ha)	DWR land		RLR land		Dry-season riceland		Garden land	
			Area (ha)	Percentage of rice area	Area (ha	Percentage of rice area	Area (ha)	Percentage of rice area	Area (ha)	Percentage of total area
Snau										
Tropeang Reang	6	1.48	0.74	50	0.74	50	0	0	0	0
Snau	4	1.04	0.57	55	0.49	47	0	0	0	0
Jar										
Jar	5	2.18	1.04	48	1.14	52	0	0	0	0
Svay Jal	6	1.7	0.87	51	0.82	48	0	0	0	0
Kompong Riab										
Kompong Riab	9	2.03	0.9	44	0.70	34	0.64	32	0.48	24
Klaeng Kung	4	2.3	2.16	94	0.43	19	0.70	30	0.19	8
Jumnik	9	1.33	0.75	56	0.20	15	0.38	29	0.41	31
Konh Jel	9	1.29	0.96	74	0	0	0.24	19	0.21	16
Prey Lwia										
Prey Lwia Kaod	8	2.01	0.89	44	0.37	18	0.25	12	0	0
Prey Lwia Lech	7	2.42	1.05	43	1.11	46	0.60	25	0	0
Av	67	1.78	0.99	57	0.67	36	0.47	24	0.32	20

cluster agriculture office. Officials surveyed the prospective site and gave permission to clear it. The land then was included in the farmers' land allocations.

All lands could be cleared except those reserved by the Department of Fisheries as fish spawning grounds. Consequently, only 8 ha of clearable land remained.

In Piam Montia, farmers plant a range of similar varieties in fields they classify as suitable for RLR. Elongating, late-maturing RLR varieties, as farmers classify them, are transplanted or direct seeded according to the depth of water in the field. (They usually are direct seeded in unbunded fields.)

Piam Montia farmers depend almost entirely on DWR cultivation for their annual rice crop and have large landholdings overall. Land allocations averaged 3.2 ha for the households surveyed, ranging from 1.9 ha in Krojap Kraom village to 4.4 ha in Jomnong Tiak village. An average 82% of the farmers' total holdings was DWR land (Table 22).

Most of the DWR landholdings of Piam Montia farmers were continuous. Of the farmers surveyed in Piam Montia, 22 (61%) had only one plot, 11 (31%) had two plots, and only 3 (8%) had three or more plots.

Of the 75 ha of DWR land cultivated by the 36 farmers surveyed, only 12.5 ha (17%) had black silt loam soil; average reported floodwater in these fields was 2.2 m at maximum depth. Forty-nine hectares (65%), including all deepwater holdings of farmers in Sut Kromuan and Piam Montia villages, had black or silt sand soils; average reported floodwater in these fields was 2.6 m at maximum. Only 13.5 ha had red sand soil; the average maximum flood was 1.8 m.

Rainfed lowland riceland allocations

Of the 10 villages surveyed in Prey Kabas District, only farmers in Konh Jel had no RLR land (Table 21). All households surveyed in Snau, Jar, and Prey Lwia village clusters and in Klaeng Kung village in Kompong Riab cluster had some RLR land.

Table 22. Total agricultural land area and area by land type in Piam Montia.

Village	Av total agri-cultural land (ha)	DWR land		RLR land		Garden land	
		Av area (ha)	Percent	Av area (ha)	Percent	Av area (ha)	Percent
Jomnong Tiak	4.4	4	91	0.2	5	0.16	4
Krojap Kraom	1.9	1.5	79	0.4	21	0.07	4
Krojap Leu	3.7	3.4	92	0.3	8	0.07	2
Piam Montia	3.1	2.2	71	0.8	26	0.11	4
Sut Kromuan	2.9	2.2	76	0.7	24	0.03	1
Av	3.2	2.7	82	0.5	17	0.09	3

Rice from RLR fields is the favored subsistence rice. Cash crops grown in the same fields from May to July or August are an important source of income.

Unlike other RLR farmers in Cambodia, Prey Kabas farmers do not classify their RLR fields into *srai leu* (high fields), *srai kandal* (middle fields), and *srai kraom* (low fields). The RLR fields in the village clusters surveyed are principally on the upper margins of the DWR fields. To Prey Kabas farmers, all high fields are RLR fields and all low fields are DWR or floating-rice fields.

Despite the small average size of RLR holdings, farmers cultivate a selection of early-, medium-, and late-maturing TVs suited to fields with differing maximum depths of standing water. The range of RLR TVs grown is similar to that grown in adjacent Bati District.

One-third of the Piam Montia farmers said they planted RLR. The average amount of RLR land per family was smaller in Piam Montia than in Prey Kabas (Table 21, 22). The 12 who farmed RLR, however, had 16.5 ha of RLR land, or an average of 1.4 ha. The trend toward converting higher DWR land to RLR land may account for the 501-ha discrepancy in land statistics between the district office and village-cluster office (Table 6, 7); that is, local land statistics may not have kept abreast of conversions of farmer-classified DWR fields into RLR fields.

All of the RLR land cultivated by the farmers surveyed were upslope, away from the river, in fields where infertile red sand soil predominated. The area now used for RLR cultivation once grew the floating varieties still planted in the lower fields nearby. As average water depth at maximum flood dwindled, more fields were planted with deepwater varieties that farmers classify as late-maturing RLR varieties, though most have some elongation ability.

Most varieties grown in these fields can be direct seeded or transplanted, but farmers tend to direct seed them, using cropping operations nearly identical to those used for DWR. Farmers said many of the varieties they define as RLR, if transplanted, cannot survive a rapid rise in standing water. If direct seeded, however, most can elongate to keep up with the water level. Delvert (1961) described a similar situation for direct-seeded RLR in Battambang and Kompong Thom provinces.

Irrigated dry-season riceland

Average reported holdings of irrigated or water-recession dry-season riceland were small (Table 21), but the production of irrigated dry-season rice is important to some households surveyed in Prey Kabas. Of the households surveyed, 68% in Kompong Riab and 48% in Prey Lwia clusters had some dry-season riceland; none of those surveyed in Snau or Jar clusters had such land. The largest holding exceeded 1.5 ha and was allocated to the Prey Lwia village-cluster chief, an important party official.

Although government land statistics show 150 ha of dry-season riceland in Piam Montia, none of the households surveyed had any.

Garden land allocations

Most of the Prey Kabas District farmers surveyed were limited to planting garden crops in their house yards. Only farmers interviewed in Kompong Riab village cluster had small parcels of garden land for cash cropping (Table 21). They said they grow diverse crops in these plots or in their DWR fields before sowing—maize, tobacco, sweet potato, mungbean, cucumber, bottle gourd, and squash—through the dry and early rainy seasons.

In Piam Montia, farmers plant cash crops in garden land or in RLR fields. While the cash crops do not play a major role in cropping activities, they are economically important. Fourteen heads of household (39%) had garden plots, which averaged only 0.5 ha. Most farmers grew only maize or sesame, sown in May and harvested in July or August. A few farmers also grew cucumber or squash.

DWR CROPPING OPERATIONS

Labor requirements for DWR cropping operations frequently conflict with those for other crops. In Prey Kabas, for example, labor often is required for plowing DWR fields at the same time it is needed to prepare for early wet-season cash cropping in RLR fields or to do the first plowing for RLR cultivation. In Piam Montia, farmers have only a minor conflict in land preparation between cash cropping in their garden plots and DWR cropping.

The cropping operations typical for DWR cultivation at the study sites are burning straw, plowing, sowing and harrowing, weeding, harvesting, threshing, and applying farmyard manure or fertilizer (Figures 5 and 6).

Burning straw

DWR cropping operations begin with burning the straw and stubble in the fields. The straw of varieties adapted to especially deep water may exceed 2 m in length.

Some Prey Kabas farmers begin burning the straw as early as late February—a time when some farmers in Prey Lwia and Kompong Riab village clusters usually harvest dry-season rice. Most farmers reported burning the stubble in late March to early April. Some Piam Montia farmers began burning the stubble as early as late February, although most performed this task in March.

Plowing

Farmers usually did the first plowing after the first substantial rainfall.

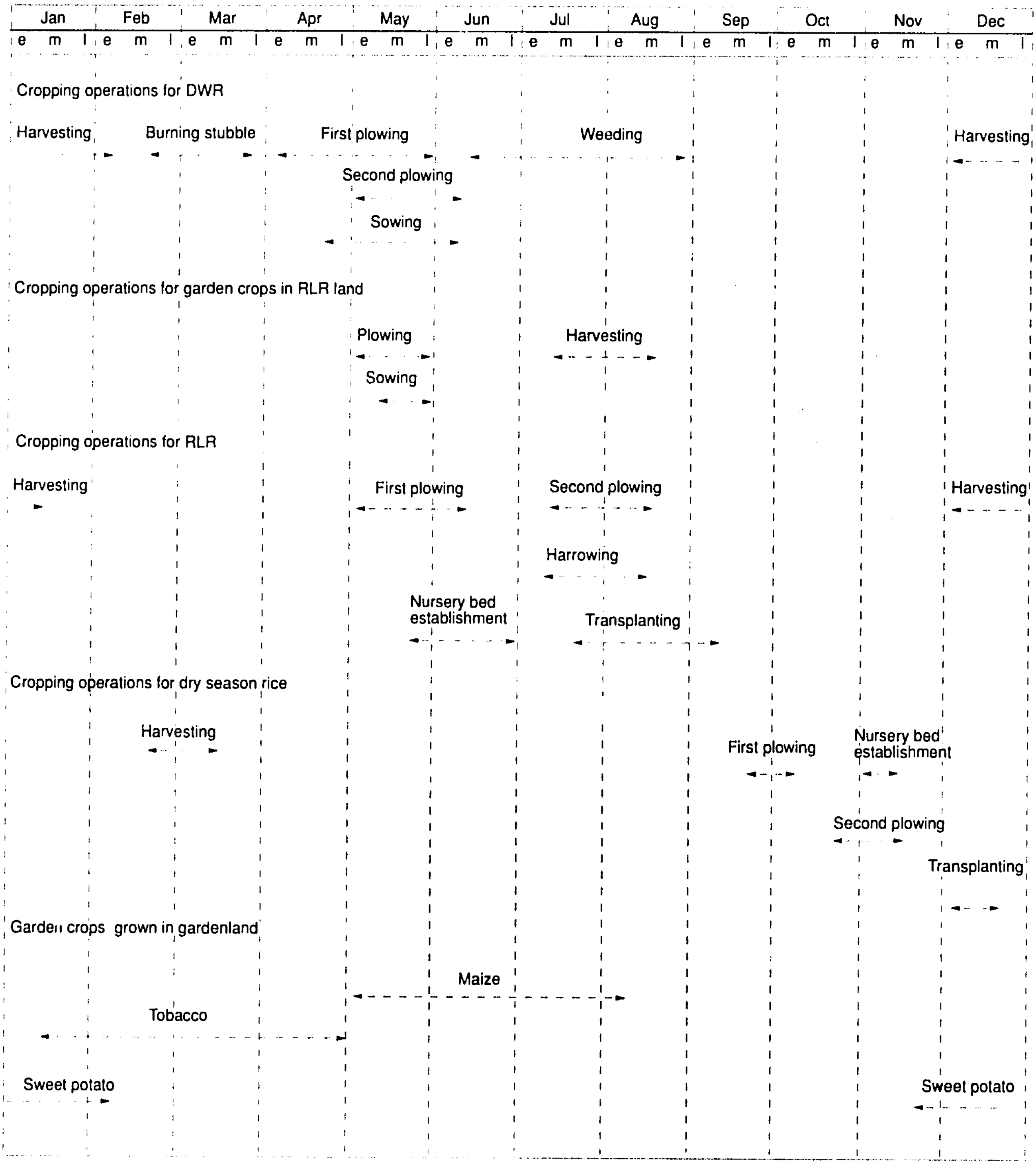
In Prey Kabas, owners of draft animals not only plow their own fields but also exchange days of plowing with other animal owners and hire out to plow in others' fields. For the 1989-90 crop, 47 (72%) of the farmers surveyed plowed using their own animals or those borrowed from kin. Twenty-one of these (45%) plowed cooperatively with other animal owners so the work was finished in 1 d, while 26 (55%) plowed individually.

Farmers who do not own draft animals must hire others who have tractors or animals to plow their fields. In 1989-90, farmers paid 150-300 riels (US$0.29-0.59) or worked 2 d transplanting RLR for a 3- to 5-h morning of plowing. Seventeen farmers (26%), residing mainly in Prey Lwia and Kompong Riab village clusters, hired tractors for plowing. The cost of hiring a tractor was 2,500 riels/ha (US$ 4.90). The first plowing required 6.6 d/ha of labor, based on a 3- to 5-h morning of work.

Piam Montia farmers did the first plowing of the 1989-90 crop from early April to late May. Twenty-five of the farmers surveyed (69%) performed the first plowing between late April and late May. Two of the eight heads of household lacking draft animals hired tractors; the remaining six repaid hired plowing through exchange labor or "helping." An average of 8.7 d/ha of labor was required for the first plowing.

Labor percentages for plowing were nearly the same at both sites: half of the heads of household plowed individually, 44% plowed cooperatively, and 6% repaid hired plowing with exchange labor.

District agriculture officials in Prey Kabas commented that farmers in the district had generally ceased to plow their DWR fields a second time before sowing. The officials said

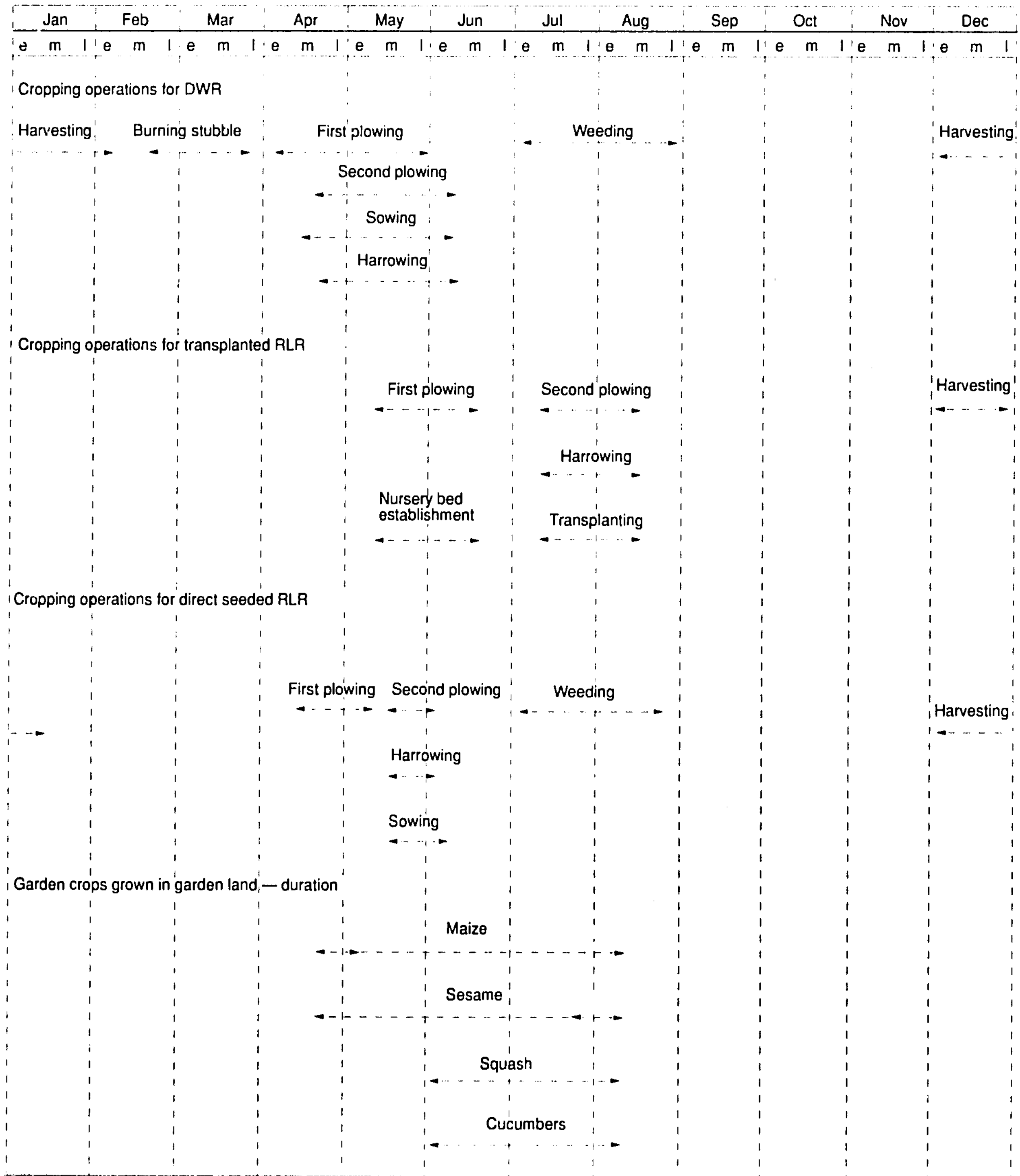


5. Calendar of cropping operations for Prey Kabas. e = early, m = middle, l = late.

they considered this change in practice to be detrimental because failure to plow a second time leads to poor stand establishment, forces farmers to increase seeding rates, and allows weeds to increase.

Contrary to agriculture officials' observations, 43 of the farmers surveyed who were growing DWR (66%) said they had done a second plowing. Three farmers in Kompong Riab village cluster said they hired tractors; the remainder used animal power—17 farmers (26%) plowed cooperatively with other draft-animal owners, and 20 (31%) plowed individually. Usually, the second plowing followed the first by 15-20 d; the farmers sowed immediately afterward.

In Piam Montia, 13 farmers (36%) sowed seed after the first plowing and then plowed again and harrowed. These



6. Calendar of cropping operations for Piam Montia.

farmers said that, in fields with black silt loam soil, if seed were sown after the second plowing and incorporated using only the harrow, then the rice stand would not be deeply rooted enough to withstand the rapid arrival of the flood in August. This practice was not encountered in Prey Kabas.

Twenty-nine Piam Montia farmers (81%) plowed a second time at an average of 20 d after the first plowing. Nineteen farmers plowed individually, 10 cooperatively. The second plowing required an average of 6.8 d/ha of labor.

Sowing and harrowing

Farmers at both research sites sowed dry, unpregerminated seed immediately after the second plowing. The average seeding rate for the 1989-90 crop in Prey Kabas was 136 kg/ha, close to the 120 kg/ha cited by Delvert (1961) as usual for DWR cultivation in Cambodia. The highest average seeding rate for any village, 166 kg/ha, was reported in Kong Jel village in Kompong Riab cluster, where fewer than half of the interview subjects did a second plowing. Older farmers said they increased their seeding rate 20-40 kg/ha if they plowed only once.

Farmers did not transplant DWR. During stand establishment and before flood accession, however, they filled gaps in the stands by transplanting seedlings within plots.

Older Prey Kabas farmers said that, 25 yr ago, DWR fields were routinely harrowed after sowing. They recognized the benefits of harrowing as better incorporation of the seed into the soil; better aeration of the soil; and, some said, protection of the seed from bird predation. However, only three farmers surveyed (5%) harrowed after sowing the 1989-90 crop. Instead, farmers prepared their RLR fields for cash crops.

In Piam Montia, the reported seeding rate was 112 kg/ha for 1989-90. Older farmers said the usual seeding rate for DWR fields is 94 kg/ha. In local terminology, this was one *tao* of seed per *kong* of land. A tao is a basket, holding about 12 kg of paddy, used to carry and measure rice. A kong is a traditional land measure. Delvert (1961) reported that a kong is 0.16 ha—there are 6.25 kong per hectare. Piam Montia farmers, however, said that a kong is a 36-m square—there are 7.7 kong per hectare.

In Piam Montia 34 of the farmers surveyed (94%) harrowed after plowing and sowing. Harrowing required an average of 3.1 d/ha of labor.

Weeding

Between land preparation and harvesting, weeding is the only major labor-intensive cropping operation.

In Prey Kabas, 12 households growing DWR (18%) did not weed their fields. Of the 53 households (82%) that weeded DWR, only 2 (in Jar village cluster) used herbicide.

The timing of weeding varied greatly from mid-June, or about 45 d after sowing, to late August, when standing water began to accumulate in the lowest fields. Fields were weeded 6-8 h/d (3-4 h in the morning and again in the afternoon). Labor input varied greatly but averaged 16.2 d/ha.

Most Prey Kabas farmers used family or exchange labor for weeding. Only 16 households (25%) hired labor. In 1989, the wage for weeding was 30-50 riels/d (US$0.06-0.10).

Herbicide use was more common in Piam Montia than in Prey Kabas. Fifteen households (42%) used herbicide on the 1989-90 crop. Farmers received herbicide from the village-cluster office or purchased it in the market. Those who used herbicides knew neither brand nor chemical names. The remaining households hand weeded using family labor as needed, usually beginning 55-60 d after sowing. Weeding required 10.3 d/ha of labor. No farmer surveyed hired labor for weeding.

Harvesting

The harvest date of the DWR crop depends entirely on the variety grown.

Of the Prey Kabas farmers, 62 (95%) harvested between late December and early February. The farmers use sickles to cut the stems 50-60 cm below the panicle. The remaining straw is left in the fields. As for weeding, the workday for harvesting is 6-7 h. Harvesting required an average of 24.2 d/ha of labor in 1989-90.

Nineteen Prey Kabas households (29%) hired labor for harvest. In 1989-90, laborers were paid 50 riels (US$0.10) for 40 bundles of rice harvested. Farmers estimated that an adult laborer could harvest 120-240 bundles/d. Households hiring harvest labor paid an average 1,645 riels/ha (US$ 3.22).

Harvesting of the 1989-90 DWR crop in Piam Montia extended from mid-November to late January. Most farmers (81%) harvested from early December to early January.

Harvesting was the only DWR cropping operation for which Piam Montia farmers hired labor. Harvest labor in Piam Montia is paid in kind rather than in cash, and payment is based on the land area harvested. Harvest laborers receive one thang of paddy (approximately 24 kg) per kong of land (1,296 m2) harvested; thus, in 1989-90, payment was equivalent to 2,532 riels/ha (US$ 5.00). Of the households surveyed, 64% hired labor for the 1989-90 harvest and paid an average 170 kg/ha of paddy. The labor required averaged 17.5 d/ha.

Threshing

Farmers at both research sites dried rice on the stubble in the fields for 2-3 d before transporting it to the threshing site.

Delvert (1961) noted that only farmers in Kandal, Kompong Speu, and Takeo provinces threshed by hand-beating rice bundles against a slanted board. The farmers of Prey Kabas District, which is in Takeo Province, hand threshed their rice in this way.

For threshing, family or exchange labor were used almost exclusively. Only two Prey Kabas households (3%) hired threshers for the 1989-90 crop; threshers earned 50 riels (US$0.10) for 500 bundles. Threshing usually occupies 2-3 h in the evening after harvesting or, less frequently, 3-5 h the next morning. In 1989-90, threshing took an average of 9.7 d/ha, based on a 3- to 5-h workday.

In areas outside Kandal, Kompong Speu, and Takeo provinces, farmers thresh by having their cattle or buffalo tread on the rice. This is the practice in Piam Montia village cluster, which is in Prey Veng Province.

Farmers prepare a threshing floor by smoothing and tamping a circular space in the fields and allowing it to harden in the sun. The floor is then coated with a mixture of cow manure and water that, when hardened, provides a smooth surface. Harvested bundles of paddy are laid in a circle on the floor. One or two groups of three to four cattle or buffalo, yoked abreast, are driven slowly around the threshing floor. One or two people guide the animals while another turns the shocks of paddy so they are completely threshed. Periodically, the threshing floor is cleared, the paddy is swept up and set aside for winnowing and cleaning, and new paddy is set on the floor for threshing.

Farmers reported using 2-20 animals at one time for threshing, but the average was 6-7. Usually two to three people are required for the operation. Threshing usually takes

3 h in the morning and another 3 h in the late afternoon. In 1989-90, labor required for threshing averaged 15.8 animal-d/ha and 4.5 person-d/ha.

Applying farmyard manure and fertilizer

No farmer surveyed in Prey Kabas had ever applied farmyard manure (FYM) or chemical fertilizer to the DWR crop; these inputs were reserved for RLR nursery beds and, less frequently, the transplanted crop. In 1989-90, farmers in Prey Kabas applied an average of 13 cartloads (3.5 t) of FYM, of which about 2 cartloads (0.6 t) were reserved for garden land or cash crops growing in RLR fields.

Despite the importance of DWR cultivation for Piam Montia farmers, only four (11%) used FYM on the 1989-90 DWR crop, applying an average of 6-7 cartloads (1.6-1.9 t) basally to fields with nutrient-poor sandy soil. Other farmers reserved their FYM for RLR fields with similarly poor soils. None of the farmers surveyed in Piam Montia used chemical fertilizer.

FARMERS' AGRICULTURAL STRATEGIES

The farmers surveyed at both research sites still, as in the past, view DWR primarily as rice for sale and RLR as the preferred eating rice. Overall agricultural strategies, however, vary between the two sites because land allocations, effects of the Khmer Rouge agricultural policies, hydrology, and importance of DWR to the economy differ.

In Prey Kabas, farmers must grow DWR and RLR or dry-season rice because their land allocations are dispersed. Since 1975, farmers must deal with new problems that include altered hydrology in their DWR fields and a lack of varieties adapted to the altered maximum flood depth.

Average DWR yields are chronically low (Table 23). Many of the farmers interviewed said they had harvested adequate amounts of DWR only in the 1987-88 cropping season. Older farmers said that before 1975 they could harvest up to 2.4 t/ha of DWR when the flood was good; however, yield data from 20 or more years ago indicate DWR harvests were sometimes poor. Average yields of floating rice in Takeo Province, which includes Prey Kabas, were 1.03 t/ha in 1965, 0.12 t/ha in 1966, and 0.96 t/ha in 1967 (Hellei 1970). These figures are lower than average reported DWR yields in the district of 1.01 t/ha in 1987-88, 0.81 t/ha in 1988-89, and 1.03 t/ha in 1989-90. Farmers said reduced flooding from the Tonle Bassac is causing soil fertility to decline—less silt and organic matter are being deposited on the fields.

Piam Montia farmers depend far more on DWR cultivation to produce rice for family subsistence and for sale than do Prey Kabas farmers. Compared with their Prey Kabas counterparts, farmers in Piam Montia have larger land allocations overall and a greater selection of reassembled varieties adapted to different maximum flood depths. The farmers surveyed planted an average of only 17% of their land (ranging from 5 to 26%) with RLR, as locally defined. RLR cultivation is deemphasized because smaller landholdings, inferior soils, and water problems cause RLR to yield less than DWR.

Piam Montia farmers similarly complain that the flood rising out of the Preyk Trabaik has diminished. Average reported DWR yields for 1989-90 and the two preceding crops were stable (Table 24). Average yields in Prey Veng Province were 1.37 t/ha in 1965, 0.11 t/ha in 1966, and 0.74 t/ha in 1967 (Hellei 1970).

Among the relative advantages of Piam Montia farmers is the availability of RLR varieties, as locally defined, that tolerate standing water of 80-100 cm and can be transplanted or direct seeded in fields where the water is now too shallow for floating-rice cultivation. If standing water in the fields diminishes further, the fields can be diked and medium-maturing RLR varieties can be transplanted.

Subsistence

Nearly two-thirds of the Prey Kabas farmers said they could not grow enough rice for family subsistence (Table 25). The mean reported amount of paddy required for family subsistence was 2.2 t/yr. The average Prey Kabas farmer in the interview sample had 1.07 ha of DWR land yielding 1.2 t/ha; 0.6 ha of RLR land yielding 1.9 t/ha; and 0.47 ha of dry-season riceland yielding 3.6 t/ha. Thus, the average farmer could expect to harvest approximately 1.2 t of DWR, 1.1 t of RLR, and 1.7 t of dry-season rice, for a total of 4 t/yr.

However, most Prey Kabas households do not fit the averages: only seven households surveyed (10%) had all three kinds of ricefields in their land allocations. Farmers in Snau and Jar village clusters, who rely on both RLR and DWR for subsistence rice, could expect to harvest approximately 2.4 t/yr. Farmers in Kompong Riab, who depend more on DWR and dry-season rice, could expect to harvest approximately 3 t/yr. Aggregate yields such as these provide little surplus over subsistence needs.

Forty-two Prey Kabas farmers (63%) said they had to buy rice for up to 4-5 mo/yr. Farmers who grew enough rice for subsistence often had above-average land allocations or were older heads of household whose grown children had left home.

In Piam Montia, farmers are better off. The village-cluster chief said most families in the village cluster cannot grow enough rice for yearly subsistence and have to buy rice for 2-3 mo/yr; however, most farmers surveyed said they grew enough rice to meet subsistence needs.

The average amount of paddy needed for a year's subsistence in Piam Montia was 2.4 t. With average landholdings of 2.7 ha of DWR land alone and an average yield for the 1989-90 crop of 1.1 t/ha, a family can expect to harvest more than 3 t/yr of DWR.

Rice sales

Older farmers in Prey Kabas said DWR formerly was grown almost exclusively for sale. This practice was common throughout Cambodia (Delvert 1961, Tichit 1981). Of the lost

Table 23. Average rice yields (t/ha) in Prey Kabas villages, by ecosystem and cropping year.

Village cluster and village	DWR (av for all varieties)	DWR 1989-90	DWR 1988-89	DWR 1987-88	RLR 1988-89	Dry-season rice 1988-89 Variety	Dry-season rice 1988-89 Yield
Snau							
Tropeang Reang	1.6	.96	1.1	1.3	1.5	-	
Snau	1.4	.82	.81	1.3	1.7	-	
Jar							
Jar	.85	.91	.94	1.4	1.5	-	
Sval Jal	1.1	1.2	.40	.45	1.5	-	
Kompong Riab							
Kompong Riab							
Klaeng Kung	1.2	.75	.50	.90		IR36, IR42, traditional variety	3.1
Jumnik	1.3	1.1	.73	.81	2.6	IR36	2.5
Konh Jel	1.6	1.5	.97	1.5		IR36, IR42, Cuba	4.6
	.91	1.0	1.0	.38		IR42	5.9
Prey Lwia							
Prey Lwia Kaod	1.1	1.1	1.0	.86	1.9	IR36, IR58	2.8
Prey Lwia Lech	1.2	.99	.68	1.3	2.5	IR36, IR66	2.9
Av	1.2	1.0	.81	1.0	1.9		3.6

Table 24. Average rice yields (t/ha) in Piam Montia villages, by ecosystem and cropping year.

Village	DWR 1989-90	DWR 1988-89	DWR 1987-88	RLR[a] 1989-90	RLR[a] 1988-89	RLR[a] 1987-88
Jomnong Tiak	1.2	1.4	1.6			
Krojab Kraom	1.3	1.3	1.4	.50	.30	.30
Krojab Leu	.90	.89	.93	.95	.60	1.0
Piam Montia	99	.70	.95	.41	.40	.25
Sut Kromuan	1.5	.90	.84	.80		
Av	1.3	1.0	1.1	.66	.43	.53

[a]Rainfed lowland rice is a long-duration variety, either direct-seeded or transplanted.

Table 25. Subsistence-sufficiency and rice-sale data for Prey Kabas villages.

Village cluster and village	Total no. of samples	Grow enough rice to subsistence? Yes	Grow enough rice to subsistence? No	Reported subsistence needs (t/yr)	Average family size	Grow enough rice to sell? Yes	Grow enough rice to sell? No	Type of rice sold DWR	Type of rice sold RLR	Type of rice sold Dry season	Av quantity sold in 1990 (t)	Av income from rice sales (US$/yr)[a]
Snau												
Tropeang Reang												
Snau	6	3	3	2.0	5	6	0	6	-	-	0.6	18.75
	4	0	4	2.1	7	2	2	4	-	-	0.7	19.65
Jar												
Jar												
Svay Jal	5	2	3	2.5	7	3	2	5	-		0.9	27.10
	6	2	4	2.3	7	3	3	5	-		1.0	35.15
Kompong Riab												
Kompong Riab												
Klaeng Kung	9	4	5	2.5	7	4	5	8	-	9	0.5	15.35
Jumnik	4	3	1	1.6	5	3	1	3	-	1	1.6	48.40
Konh Jel	9	3	6	2.0	6	6	3	7	-	4	0.5	13.25
	9	0	9	2.3	7	1	8	9	-	8	0.5	14.70
Prey Lwia												
Prey Lwia Kaod	7	3	4	2.1	6	5	2	6	3	1	0.9	26.50
Prey Lwia Lech	8	2	6	2.3	6	5	3	6	1	1	0.9	25.80
Total/av	67	22	45	2.2	6	38	29	59	4	24	0.8	24.45
Percentage of sample		32.8	67.2			56.7	43.3	88.1	6.0	35.8		

[a]US$1 = 510 riels, 1989-90.

Table 26. Subsistence-sufficiency and rice-sale data for Piam Moatia villages.

Village	Total no. of samples	Grow enough rice for subsistence? Yes	Grow enough rice for subsistence? No	Reported subsistence needs (t/ha)	Grow enough rice to sell? Yes	Grow enough rice to sell? No	Type of rice sold DWR	Type of rice sold RLR	Av quantity sold per year (t)	Av quantity sold in 1990 (t)	Av income from rice sales (US$/yr)[a]
Jomnong Tiak	6	6	0	1.9	6	0	6	0	1.0	0.9	24.50
Krojap Kraom	7	5	2	2.1	4	3	7	0	0.1	0.2	4.05
Krojap Leu	10	9	1	2.1	8	2	10	1	0.4	0.6	18.05
Piam Montia	7	5	2	2.4	6	1	7	0	0.5	0.6	17.50
Sut Kromuan	6	6	0	3.5	6	0	6	0	1.0	1.0	24.50
Av/total	36	31	5	2.4	30	6	36	1	0.6	0.7	17.75
Percentage of sample		86	14		83	17	100	3			

[a]US$1 = 510 riels, 1989-90.

Table 27. Cash crops produced in Prey Kabas

Village cluster and village	RLR land: No. of households sampled	Cucumber: No. of households planting	Cucumber: Av area (ha)	Mungbean: No. of households planting	Mungbean: Av area (ha)	Bottle gourd: No. of households planting	Bottle gourd: Av area (ha)	No. of households with crop income	Average garden crop income (US$)[a]	Garden land: No. of households sampled	Av area (ha)	Crop	Av annual income (US$)[a]
Snau													
Tropeang Reang													
Snau	6	5	0.20	3	0.16			6	5.95	0			
	4	1	0.06	2	0.07	2	0.07	4	11.25	0			
Jar													
Jar													
Svay Jal	5	5	0.40	2	0.04			2	19.60	0			
	6	2	0.09	4	0.19			1	3.95	0			
Kompong Riah													
Kompong Riah													
Klaeng Kung	9							0		9	0.48	Tobacco, maize, mungbeans	11.00
Jumnik	4							2		2	0.19	Sweet potato, maize tobacco	16.65
Konh Jel	9			1	0.10			9		9	0.41	Sweet potato, maize, tobacco	23.30
	9											Cucumber, gourd, pumpkin	
Prey Lwia								4		9	0.21	Maize, mungbean, sweet potato	8.00
Prey Lwia Kaod	8	6	0.13	3	0.21			2	3.95	0			
Prey Lwia Lech	7	4	0.13	5	0.20			3	11.45	0			
Total/av	67	23	0.17	20	0.14	2	0.07	33	8.95	29	0.32		14.75
Percentage of sample		34.3		29.9		3.0		49.3		43.3			

[a]US$1 = 510 riels, 1989-90.

DWR TVs, only *Sai Pu* was thought to have eating and cooking quality equal to that of RLR varieties. Other floating varieties, such as *Srao Mok*, were grown specifically for sale to distillers. Despite their diminished landholdings and the difficulty of growing enough rice for family subsistence, Prey Kabas farmers still prefer to sell DWR.

Only slightly more than half of the Prey Kabas households grow enough rice to sell some each year, but 65 of the 67 households surveyed reported selling some rice from the 1989-90 crop. Amounts reported as sold ranged from 80 kg to 5 t, but most households sold more than 100 kg of rice to the government.

Of all Prey Kabas farmers surveyed, 59 (88%) regularly sold DWR if they could sell rice, and 24 (36%) sold dry-season rice. Farmers who sold rice but did not grow enough for subsistence said they used the cash income from DWR and other sources to purchase RLR for eating. Only four households (6%) said they commonly sell RLR.

In Piam Montia, 30 farmers (83%) reported they grow enough rice to sell some each year (Table 26); all said they sold some from the 1989-90 crop. Rice sales averaged 34% of the farmers' mean cash income.

Cash cropping

Cash cropping has become an increasingly important component of production strategies in Prey Kabas. Farmers in Jar, Snau, and Prey Lwia village clusters routinely plant small amounts of cash crops, usually mungbean and cucumber, in their RLR land (Table 27). The crops are grown from May to July, so they are harvested before RLR is transplanted. In 1989-90, average areas were 0.17 ha for mungbean and 0.14 ha for cucumber. Farmers minimize expenses for growing these crops: capital outlay usually is only for seed. Many farmers use some of the cash-crop harvest for family subsistence.

Kompong Riab farmers have garden land allocations. They plant a diversity of cash crops, beginning with sweet potato or tobacco planted in garden land (Table 27) or DWR fields in January. Early wet-season crops include mungbean, cucumber, maize, bottle gourd, and squash. In 1989, Kompong Riab farmers cultivated 250 ha of sweet potato, 130 ha of tobacco, and 20 ha each of mungbean and peanut.

Some DWR intercropping is developing. Two farmers interviewed had begun independently to intercrop mungbean in their DWR fields:

Prey Lwia's village-cluster chief is a resourceful farmer with substantial landholdings. Through experiments in his fields, he is trying to improve agriculture in the cluster. Older farmers had told him they intercropped mungbean with DWR in the past, but the disruptions of the civil war had stopped this practice. The chief observed his DWR fields to find areas where the accession of the flood was slow and not too early. He broadcast 10 kg of mungbean seed and 250 kg of DWR seed in a 1.4-ha field in early May. He harvested 100-120 kg of mungbean from the field with no reduction in DWR yield. The chief has intercropped mungbean and DWR since 1987, and four Prey Lwia farmers have emulated his example.

A farmer in Kompong Riab village attempted a similar experiment during the 1990-91 DWR cropping season. He was unaware of other experiments but had heard intercropping was once a common practice, and he wanted to intensify production because his DWR yields had been poor for the past 2 yr. He carefully sowed 9 kg of mungbean in rows in a 0.3-ha DWR plot and then broadcast 60 kg of DWR seed. Thirty days after sowing, both the DWR and mungbean crops were doing well.

Cash cropping plays a small-scale but important role in Piam Montia farmers' agricultural strategies. Fourteen of the farmers surveyed (39%) had some garden land for cash cropping, and another 12 (33%) planted cash crops in their RLR fields. Farmers who planted cash crops on RLR land cultivated an average 1.1 ha. Almost all of the farmers surveyed engaged in some form of cash cropping.

The principal cash crops are maize and sesame, both sown from late April through May and harvested from late July through August. Sale of cash crops accounted for 56% of the farmers' reported average cash income.

CONCLUSIONS

Prey Kabas farmers said making a living from agriculture, including DWR, is increasingly difficult. The altered hydrology in their DWR fields and the lack of varieties adequately suited to the shallow flood prevailing in many district fields make it difficult to harvest enough rice for family subsistence or to have a marketable surplus. Farmers said they find it nearly impossible to acquire new agricultural land. Thus, their only option for improving their situation is to intensify production in their current land allocations.

Prey Kabas farmers' RLR fields have more productive soils and obtain much higher average yields than do those of Piam Montia farmers. Farmers in Prey Kabas also can plant a full range of early-, medium-, and late-maturing RLR varieties.

Piam Montia farmers depend more on DWR than do Prey Kabas farmers, and they are in a slightly more advantageous position to do so. They share the problem of diminished floods in their DWR fields. Data from the district agriculture office indicate that the amount of DWR land in Kompong Trabaik District has declined due to the reduced flood rising out of the Preyk Trabaik. The land is now classified as suitable for RLR, either direct seeded or diked and transplanted.

However, flood accession in Piam Montia fields has not been altered permanently by the construction of waterworks, as it has in Prey Kabas. The farmers have reassembled many of their floating-rice TVs and added new, well-adapted ones to the selection available. Piam Montia farmers surveyed had larger land allocations than did farmers in Prey Kabas, and a significantly greater percentage could grow enough rice yearly for family subsistence.

Despite poor soils in the RLR fields in Piam Montia, RLR is a natural extension of DWR cultivation, and farmers have a good selection of varieties that are well-adapted to shallow maximum flood or deep standing water. If the flood volume continues to diminish, fields can be converted to RLR cultivation, as has been done in the past.

Thus, Piam Montia farmers view DWR cultivation as a productive part of their agricultural strategies. They too, however, require means to intensify production in these fields through using improved varieties, improving the soil, or increasing cash cropping.

The problems and successes of the farmers of Prey Kabas and Piam Montia in trying to rehabilitate DWR cultivation after the disruptions of the civil war and the Khmer Rouge administration of Democratic Kampuchea are unique in detail but not in kind. Due to security problems, data could not be gathered from Cambodia's principal areas of DWR cultivation—Battambang, Kompong Thom, and Siam Riab provinces. However, the difficulties of dealing with altered floods and using maladapted varieties as replacements for lost seed stock are shared by DWR farmers outside Prey Kabas District.

Agriculture officials in Kompong Chhnang Province complained that, while the accession of the flood in deepwater ricefields in their province had not changed substantially, the loss of all of the locally adapted varieties during Khmer Rouge control of the province had impaired DWR culture. Upland rice farmers, moved to the DWR areas by the Khmer Rouge cadres, ate the stored seed in 1975-76. The officials blamed most of the major problems with DWR cultivation in the province on this loss. They said more than 10,000 ha of DWR land had been cultivated in the province before 1975, and farmers routinely harvested 1.5-2 t/ha in good years. The replacement varieties brought from Kompong Thom, Siam Riab, and Battambang provinces and from Vietnam lack the rapid elongation ability of the lost varieties and are frequently damaged by submergence.

The officials said the rate of rise of the floodwater in the DWR fields in Roliab Piul and Boribow, the principal DWR-growing districts in the province, could exceed 10 cm/d in August and September. Data show the floodwater in DWR fields in nearby Kompong Cham Province rises at a rate of 12.5-15 cm/d (Delvert 1961). Seed was irretrievably lost for all five of the locally planted DWR varieties that had the ability to elongate quickly enough to stay ahead of such rapidly rising floodwater.

More than 7,000 ha of DWR land had gone out of cultivation since 1979, according to the officials, and only 4,000-5,000 ha were being cultivated at the time of this study. Farmers cultivate only about 0.5-1 ha of DWR land per household. The average DWR yield is about 1 t/ha in the best fields and 0.4-0.5 t/ha in the remainder. Uncultivated DWR land is available, but farmers are not claiming it because the currently cultivated varieties have poor yields.

The DWR situation in Cambodia must be better understood. Research on intensifying DWR culture in Cambodia should address a range of issues including soils, soil improvement, and farming systems. The principal problems, however, are hydrology and varieties.

Short-term problems, such as the use of maladapted varieties, must be addressed before researchers move on to long-term solutions. One of the lost DWR varieties in Kompong Chhnang Province was the well-known *Konlong Phnom*. Seed of this variety has recently been reintroduced from IRRI's Germplasm Center at Los Baños, Philippines. All farmers informed of this development await seed multiplication and dispersal with high expectations.

RESEARCH RECOMMENDATIONS

Additional research is needed in Cambodia to complete the baseline assessment of DWR culture and to provide more in-depth knowledge about varieties, hydrology, soils and soil fertility, and farming systems.

Baseline research

Further baseline research should be conducted when security conditions permit. A survey of DWR cultivation should be undertaken in the area of the Great Lake of the Tonle Sap and in Battambang and Kompong Thom provinces. This survey should complete the description of the Cambodian DWR environment, identify alternative constraints, and recommend appropriate research.

Varietal research

Researchers should conduct a baseline historical survey of DWR TVs similar to that in the current work. The survey should involve interviews with older farmers or knowledgeable agriculture officials in areas where DWR culture is prominent. It should ascertain the range of formerly grown varieties and their adaptation to local water regimes. The survey should be correlated with a hydrology survey. Former and current varieties should be compared.

From interviews with farmers and agriculture officials, researchers should determine which of the other lost TVs the interview subjects would like to be reintroduced. Germplasm holdings at IRRI should be surveyed to see if seeds of desired varieties are available. If they are, the germplasm should be multiplied and supplied to the requesting province or district for further action.

A germplasm collection of DWR varieties currently planted should be undertaken nationally. Screening trials of the collected samples should be established. In addition to morphological descriptions and other information noted during variety assessments, data should be taken at the time of collection on the source of the seed, farmers' and officials' assessment of its suitability to the local DWR environment, reasons farmers maintain it, and its agronomic characteristics.

The germplasm of locally cultivated varieties should be screened in multilocational trials in each area. Seed should be assessed for suitability to the prevailing hydrological regime, climatic conditions, and local cultural practices. It should be screened for yield, tolerance for environmental stress, and other factors.

Varieties that are successful in one area should be screened for suitability to other areas that need varieties with the same characteristics.

Trials should be established using improved varieties or TVs to identify other sources of the desirable characteristics reported in the lost varieties. These introduced varieties should be tested for suitability to the local hydrological regime and other factors before being multiplied and distributed to farmers.

Further research is needed on deepwater varieties that have slight elongation ability or submergence tolerance. In areas such as Prey Kabas, where the maximum depth of the flood has been drastically altered, trials should be conducted of floating and deepwater varieties suited to the 50-100 cm maximum water depth. Trials should include experimentation with locally adapted deepwater varieties (such as Phka Sla) and advanced lines from other sources and testing under direct-seeded and transplanted conditions. One objective could be to recommend converting marginal DWR fields for diked RLR cultivation.

Hydrology

A hydrological study should be made of the major Cambodian DWR-growing areas. Older farmers should be interviewed to ascertain changes in flood accession and maximum depth. The data obtained could help breeders and agronomists identify the varietal needs of localities and design trials.

Soils and soil fertility improvement

Trials should be conducted to find ways of increasing DWR yields through cost-effective use of chemical fertilizers.

Trials should determine whether green manure application and technology is feasible for DWR cultivation. Farmers' field size, labor and power supplies, and other problems should be considered.

Farming systems

Trials should be designed to test the feasibility of intercropping in DWR fields. Crops such as mungbean, tested independently by farmers in Prey Kabas, should be included.

To increase field productivity, trials also should be designed to test the feasibility of growing crops before sowing or after harvesting DWR.

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