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Agriculture and Livelihoods in the Flood-prone Ecosystem in Thailand

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ABSTRACT

The study aimed to assess recent changes in agriculture and livelihoods of farmers in the flood-prone ecosystem of Thailand. One thousand two hundred and sixty-six households were randomly interviewed by using a structured questionnaire in twenty provinces under the ecosystem during 2000/2001. The findings revealed that Thailand had a favorable endowment of land with an average size of holding of 4.73 ha. The size of holding varied greatly across regions. Tenancy cultivation has been widespread (41% of the land) because of the high incidence of rural-urban migration. Most of the household heads had only primary level education. High diversity of rice varieties was found due to widespread cultivation of local varieties in the rainfed lands. Irrigation infrastructure has expanded greatly in the flood-prone ecosystem contributing to intensification of cropping. But the monocrop of flood-prone rice was still dominant. The double cropping of rice was found to vary from 5 to 28 percent in shallow flooded areas, and from 10 to 30 percent in deep-flooded areas depending on the regions. The incidence of double cropping of modern varieties was still low. The average rice yield increased from 2.20 to 2.78 t/ha. The costs of rice cultivation was mainly on account of material inputs particularly, chemical fertilizers and machine rental charge. An average household earned about Baht 128,000, mostly from non-farm activities. Agriculture accounted for only 38 percent of the household income, and rice cultivation only 22 percent. The rural household income was highly unequally distributed. Rice cultivation accounted for a small fraction of income inequality. The level of income and rice's share of household income varied greatly across regions, depending mostly on the size of landholding and the opportunity of non-farm employment.

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A system approach must be taken in designing research strategy for the flood-prone ecosystem. Development of modern varieties with high yields, shorter maturity period, tolerance to submergence, and improved grain quality could lead to further intensification of rice farming. In addition, wider adoption of two modern varieties within the year, and reduction in the instability in yield from climatic stresses could make significant impact of the livelihoods of the flood-prone rice farmers than the improvement of the traditional deepwater rice plant.

Key words: flood-prone ecosystem, livelihoods, agriculture, deepwater rice, floating rice, flood-prone rice

INTRODUCTION

The flood-prone rice is grown along the Chao Phraya river in the Central Plain and the adjoining parts of the East and Northeast regions of Thailand. The farmer was growing two types of rice in the ecosystem, a) the deepwater rice (DWR) grown under the average water depth of 50-100 cm for a continuous period of more than two months , and b) the floating rice (FR), an elongating rice plant grown in the water depth of 1 to 5 meter with a flooding period of 3 to 5 months. The area covered was 0.85 million ha in 1982 but had declined to 0.52 million ha in 1992, about six percent of the national rice area. Although the yield is low and unpredictable and the grain quality was poor, the farmer had no choice but to grow the crop in the absence of other alternative use of the land. A survey conducted in 1992/1993 noted that 89% of the farmers wanted to continue growing flood-prone rice (Puckridge *et al.*, 2000).

The ecosystem is however undergoing changes with regard to water management and cropping system, as previously occurred in the ecosystem in Vietnam and Bangladesh (Catling, 1994; Dey *et al.*, 1995; Hossain *et al.*,2001). With investments on dams and irrigation infrastructure farmers have started using pumps for growing an irrigated rice crop in the dry season. In the irrigated areas farmers are growing two rice crops, the first during March to July, and the second during November to February. The land is kept fallow during August to October, when the depth of flooding does not allow raising the dwarf modern varieties. The changes would have implications for agricultural productivity and livelihoods of the farmers. We pose the following questions: a) what is the extent of the change, b) what are its effect on agriculture and farmers' livelihood, and c) what are the implications for research strategies for the flood-prone ecosystem? We have conducted a sample household survey to address those questions. This paper reports the key findings of the survey.

SURVEY METHOLOGY

A household survey was conducted with a structured questionnaire to generate primary information during the cropping season 2000/2001. The study covered two groups of areas under the flood-prone ecosystem: a) eleven provinces under the responsibility of Prachinburi Rice Research Center, and b) nine provinces formerly growing flood-prone rice distributed in the Central and Lower

North and Northeast regions (Figure1). A multi-stage random sampling method was used to select the sample, drawing on samples at the province, district, sub-district and village levels. The total sample includes 1,266 households from 121 villages of 92 sub-districts, belonging to 46 districts of the 20 provinces.

The data for the sample households were collected through personal interviews using a structured questionnaire. A group of researchers and research assistants of the Prachinburi Rice Research Center conducted the interviews. The interviewers were familiarized with the survey method and were trained in conducting the survey by a statistician of the Department of Agriculture. They were instructed to use local terms, local units of measurement of

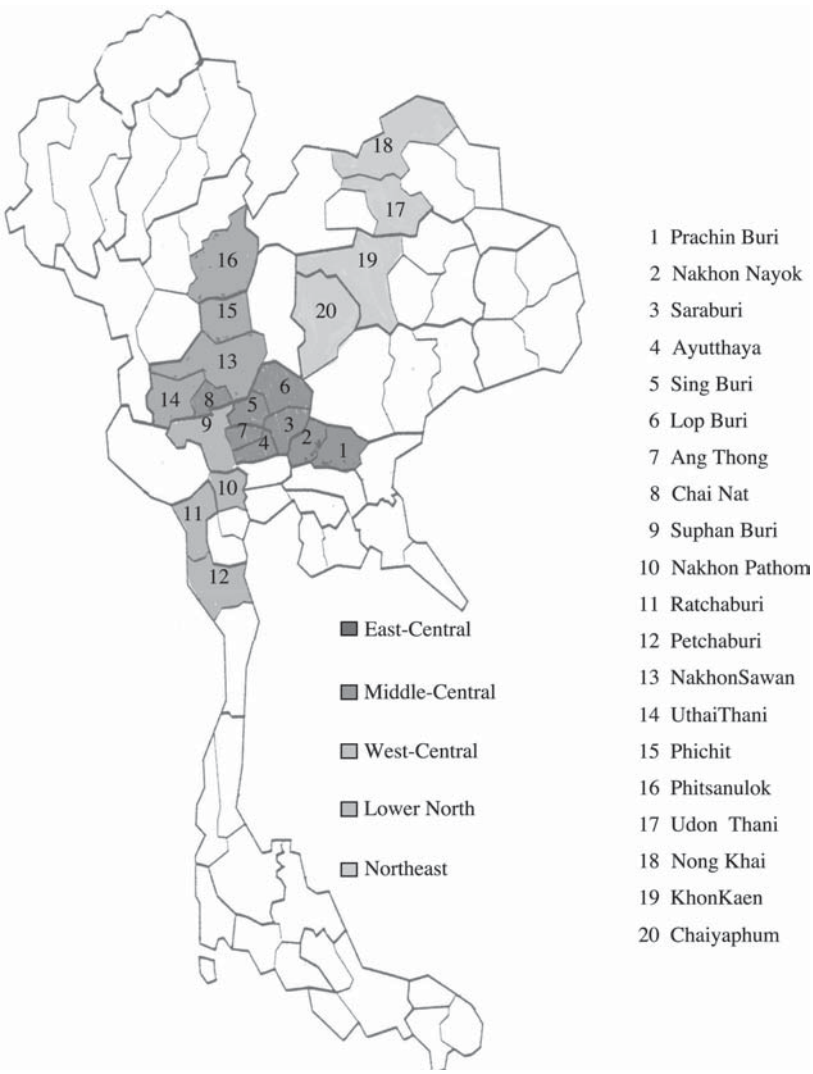

Figure 1 Distribution of flood-prone ricelands in Thailand.

land, inputs and production, and was instructed to avoid lead questions.

The questionnaire was pre-tested with 15 farmers around the Center at Bansang district to get farmers' feedback on the relevance of the questions, and to assess the problems to be encountered during the interview. The data include demographic characteristics of all household members, utilization of all parcels of land owned and operated by the sample household, costs and returns of cultivation of different crops, ownership of non-land assets, earnings from non-farm activities, and perceptions of the households regarding their economic standing in the village and the change in their economic conditions.

The survey data were edited and electronically filed at the Prachinburi Rice Research Center. The analysis and the tabulation of the findings were done at the Social Sciences Division of the International Rice Research Institute.

For analysis of the data we classified the samples into two groups on the basis of the elevation of land, a) parcels flooded at less than 50 cm (**Lowland** sub-ecosystem) and b) parcels flooded at higher than 50 cm (**Deepwater** sub-ecosystem) during the peak of the monsoon season. Each of the above land types was classified into two groups depending on the access of the land to irrigation facilities, i.e., rainfed and irrigated. Thus four ecosystems were classified, 1) **Rainfed Lowland**, 2) **Irrigated Lowland**, 3) **Rainfed Deepwater**, and 4) **Irrigated Deepwater**. The impact of irrigation and the flooding regime was assessed by comparing the value of the relevant variables for the four sub-ecosystems.

RESULTS AND DISCUSSION

Socioeconomic characteristics

An average household consisted of 4.5 members, varying from 4.15 in the Lower North region to 5.21 in the West-Central (Table 1). Nearly 18% of the population were below 15 years of age and another 14 percent over 60. Thus nearly 70 percent of the population was in the working age group. An average household contained on average 3.1 working members. Nearly 14 percent households were female-headed.

The households were well endowed with land. The average size of holding was 4.73 ha, many times higher than most other rice growing countries in Asia. There was a large variation in the size of holding across regions (Table 2). The average size was lower in the Northeast (2.47 ha) and the West-Central (3.31) and was higher in East-Central (5.24) and Lower North (5.87) regions. The average size of holding was higher than the average size of land owned, indicating widespread absentee land ownership, and high incidence of tenancy. Nearly 40% of the land was cultivated under tenancy arrangements; the incidence of tenancy varying from only 5% in the Northeast to nearly 50% in the Middle-Central and the West-Central regions. The size of landholding and the incidence of tenancy were higher in Deepwater areas than in Lowland areas.

Only 5 percent of the households did not operate any land, and another one-third had a holding of less than 3 ha (Table 3). These bottom 40% of the households in the landholding scale operated only 12 percent of the total land. At the other end 8.5 households operated a holding of up to 10 ha in

Table 1 Demographic characteristics of population by region.

Characteristics	East-central	Middle-central	West-central	Lower-north	Northeast	Total
Average size of household	4.48	4.44	5.21	4.15	4.6	4.5
Average number of children per couple	1.92	1.74	2.48	1.65	1.97	1.86
Percent of population up to 15 years of age	17.2	16.2	17.8	18.4	19.8	17.5
Percent of population over age 60	14.5	16.5	13.9	11.1	8.9	13.8
Percent of women in reproductive age group (16-50)	55.3	56.2	61.0	57.2	57.4	57.1
Child - woman ratio (percent)	10	11.9	10.1	15	17.3	12.6
Average number of workers	3.14	3.4	3.55	2.87	3.3	3.1
Dependency ratio	1.42	1.31	1.47	1.45	1.39	1.45
Percent of female headed households	17.7	16.8	11.8	7.9	13.8	14

Source: Sample survey conducted by Prachinburi Rice Research Center

Table 2 Average size of land ownership, land holding and tenancy by region and sub-ecosystem.

Region/Sub-ecosystem	Size of land owned (ha)	Size of land operated (ha)	Size of rented-in land	Percent of area under tenancy
Region				
East-Central	4.83	5.24	2.04	38.90
Middle-Central	3.60	5.02	2.43	48.30
West-Central	2.81	3.31	1.75	52.90
Lower-North	3.69	5.87	2.11	36.00
Northeast	2.28	2.47	0.13	5.40
Sub-ecosystem				
Lowland rainfed	3.19	4.47	1.54	34.60
Lowland irrigated	3.31	4.51	2.00	44.40
Deepwater rainfed	4.14	5.07	1.76	34.80
Deepwater irrigated	3.90	5.87	2.80	47.60
Total	3.58	4.73	1.93	40.80

Source: Sample survey conducted by Prachinburi Rice Research Center

size and controlled nearly 27 percent of the total land. Households who operated land at more than 5 ha size controlled nearly 62 percent of the total land. Thus the pattern of land distribution was fairly unequal.

Nearly 10 percent of the people in the working age group (16+) reported as unemployed; seven percent among men and 10 percent among women. Agriculture was reported as the major source of livelihood by 72 percent of the working age population, and 13 percent reported agriculture as a secondary occupation (Table 4). Livestock and poultry raising, fisheries and agricultural wage labor were reported as a source of livelihood by only 10 percent of the workers, mostly as a secondary occupation. Farming was mostly a family-based activity. Nearly a third of the workers reported non-agriculture as a source of livelihood, but only 18 percent as primary occupation. Thus, non-farm activities were practiced more as a secondary occupation. Important non-farm activities were agro-processing, sub-contracting for industries located in towns, services, business, transport operations and construction activities (see more later).

Only three percent of the workers reported having no formal schooling, but 70 percent had attended only primary schools. Nine percent were high-school graduates, and eight percent with college or university degrees (Table 5). It appears that the higher educated leaves villages for more remunerative non-farm occupations in towns and cities, while the less educated remains in rural areas to earn a livelihood from land. A quarter of the households reported having a migrant member living in towns and cities, 72% of them having a salaried job or business, 10% as students and the remaining 18% for social reasons, including marriage. Almost half of the migrants household members had more than 10 years' of schooling.

Table 3 The pattern of distribution of operated holdings, 2000.

Size of land operated (ha)	No. of sample households	Percent of households	Percent share of operated land	Average size of holding (ha)	Average size of rented land (ha)	Share of rented-in land (percent)
Nil	57	4.5	0.0	0.0	0.0	0.0
Upto 3.0	411	32.5	12.0	1.7	0.4	6.8
3.01 to 5.0	396	31.3	25.8	3.9	1.4	23.3
5.01 to 10.0	294	23.2	35.4	7.2	3.1	37.7
Over 10.01	108	8.5	26.8	14.9	7.3	32.2
Total	1266	100	100	4.7	1.9	100

Source: Sample survey conducted by Prachinburi Rice Research Center

Table 4 Employment and occupation of rural labor force (% of workers), 2000.

Employment	As primary occupation			As primary or secondary occupation		
	Male	Female	Total	Male	Female	Total
Farmer	71.4	65.6	68.5	76.7	70.7	73.6
Agricultural laborer	1.5	1.7	1.6	7.6	5.9	6.7
Livestock & Poultry raising	1.5	1.1	1.3	3.5	2.2	2.8
Fisheries	0.8	0.7	0.7	1.9	1.5	1.7
Agriculture	75.2	69.1	72.1	89.7	80.3	84.8
Agro-processing	2.5	3.6	3.0	4.9	7.4	6.2
Trade	1.4	2.1	1.7	3.4	5.1	4.3
Services	8.1	7.2	7.6	11.1	8.6	9.8
Non-agricultural labor	6.0	5.7	5.8	14.0	9.9	11.9
Non-agriculture	18.0	18.7	18.3	33.4	31.0	32.2
Unemployment	6.8	12.2	9.6	6.8	12.2	*9.6*
Total	100.0	100.0	100.0	129.9*	123.5*	126.6*

Source: Sample survey conducted by Prachinburi Rice Research Center

Note: The total exceeds hundred because of counting of multiple occupations.

Table 5 Educational background of agricultural and non-agricultural workers (Percent of workers in the group), 2000.

Education level	Unem-ployed	Farmers	Agro-processing	Trade	Services	Non-agric. labor	All workers
No education	13.5	2.7	0.8	1.3	0.0	0.0	3.2
Primary	60.2	82.7	21.2	65.3	21.8	36.3	70.3
Secondary	6.0	8.3	25.6	17.3	13.7	20.3	10.1
High-school graduate	9.6	4.9	37.9	12.0	20.0	19.1	8.7
College & university graduate	4.8	0.6	12.1	1.3	32.7	7.0	4.5
Others	5.8	0.8	2.3	2.7	11.8	17.1	3.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Sample survey conducted by Prachinburi Rice Research Center

Cropping patterns

As mentioned earlier, we classified the area into four sub-ecosystems on the basis of elevation of land and access to irrigation infrastructure. Nearly 50 percent of the land is flooded at a depth of more than 50 cm during the peak of the flooding season, and 49% of the land has access to irrigation facilities, which is very high as compared to the kingdom as a whole. In 1992/1993 only four percent of the area had irrigation facilities (Puckridge *et al.*, 2000). Thus irrigation infrastructure has expanded greatly over the last decade in the flood-prone ecosystem. As a result there has been a substantial change in the area under deepwater rice. With access to irrigation farmers are now growing an early rice crop (mostly modern varieties) under lowland conditions to escape the flood, and raising another rice crop in the post-flood season with controlled irrigation. In 1992/1993 the deepwater rice was grown in about 88% of the total land (Puckridge *et al.*, 2000), but it covered only 52% of the area in 2000/2001.

The cropping pattern for the different sub-ecosystems can be seen from Table 6. In the lowland, if no irrigation facilities are available farmers mostly practice the rice-fallow system with 80% of the area under traditional varieties (TVs) or improved traditional varieties (ITV). With the availability of irrigation the system changes dramatically in favor of the cultivation of modern varieties (MV) with 46% of the area under the MV-fallow system, and another 23% under double cropping of MVs, at the expense of both TV and improved traditional varieties (ITVs). For the

Table 6 Cropping patterns (% of land) in flood-prone sub-ecosystem, 2000.

Cropping pattern	Lowland rainfed	Lowland irrigated	Deepwater rainfed	Deepwater irrigated
Permanent fallow	1.0	3.0	0.7	0.3
Upland crops - fallow	0.0	2.5	0.7	0.5
TV rice - fallow	55.4	13.8	58.2	42.8
ITV rice - fallow	25.3	7.0	22.9	8.4
MV rice - fallow	13.2	46.3	8.5	16.1
MV rice - TV rice	0.0	4.2	4.9	12.8
MV rice - ITV rice	0.0	2.2	3.4	3.6
MV rice - MV rice	5.1	20.8	0.7	15.2
Rice - Upland crops	0.0	0.2	0.8	0.3
Total	100.0	100.0	100.0	100.0
Cropping intensity	105.1	127.4	105.8	131.9

Source: Sample survey conducted by Prachinburi Rice Research Center

Note: TV = Traditional variety, ITV = Improved traditional variety, and MV = Modern variety17

Deepwater sub-ecosystem the change is less dramatic but substantial. With access to irrigation, the area under TV/ITV fallow system declines from 81 to 50% while the area under MV-fallow or MV-MV system increases from nine to 31%. Presumably, in the Deepwater sub-ecosystem, the longer crop maturity period for the rainy season crop (mostly traditional varieties) imposes a constraint on expansion of double cropping of rice compared to the lowland sub-ecosystem.

Rice cultivar diversity and yields

We encountered 120 rice varieties grown by farmers in the ecosystem during the wet season but only 18 varieties grown during the dry season. Table 7 provides information on top ten rice varieties grown and the average yields at the farmer level for those varieties for the two seasons. These 10 varieties account for only 53 percent of the total land area in the wet season, but about 98 percent of the total land area for the dry season. All of the popular varieties were modern varieties in the dry season, but for the wet season only two of them were modern varieties. The above information suggests that irrigation and good water control in the dry season facilitates widespread adoption of modern varieties in the dry season, while the farmers continue to grow mostly traditional varieties in the wet season because of the risk of flooding. The expansion of irrigation has had a negative effect on cultivar diversity. Only two varieties (Suphanburi1 and Chainat1) accounted for about 84% of the total rice area in the dry season when the rice is grown with irrigation, while these two varieties accounted for only 15% of the total rice area in the wet season which is rainfed.

The popularity of rice varieties was also found to vary greatly across regions. The five most popular varieties in regions were as follows:

East-Central: Plai Ngahm Prachinburi, KTH 17, Leuang Tawng, Tawng Mah Eng, Khao Luang;

Middle-Central: Leuang Tawng, Gon Gaew, Suphanburi1, Khao Leuang, Chainat1;

West-Central: Leuang Pratew 123, Suphanburi1, Chainat1, Leuang Awn, Suphanburi 60;

Lower North: Leuang Pra Tahn, Suphanburi1, Chainat1, Leuang Pratew 123, and Leuang Pahn Tawng;

Northeast: RD6, KDML 105, Jao Loi, Hawm Mali Thammada, and E-Leuang.

The varieties mentioned above, can be divided into two groups based on photoperiod sensitivity. Suphanburi1, Suphanburi60 and Chainat1 are insensitive to photoperiod, high yielding varieties (HYV) or modern varieties which can be grown throughout the year with an access to irrigation. Whereas the other are photoperiod sensitive varieties with tall stature, that are suitable for growing the flooded fields, in the wet season. All varieties are non-glutinous endosperm type except RD6, a famous glutinous rice widely grown in the Northeast.

The highest yielding modern variety was found to be Puang Nagern, C-5 and Suphanburi90 with an average yield at the farm level at about 5 t/ha. The yield for the modern varieties was in general higher in the Middle-Central and West-

Table 7 Popular rice varieties in wet and dry season, 2000.

Rank from top	Wet season Names	Group	Yield (t/ha)	Percent of parcel	Percent of riceland	Dry season Names	Group	Yield (t/ha)	Percent of parcel	Percent of riceland
1	Suphanburi1	MV	4.16	7.70	8.82	Suphanburi1	MV	4.39	50.96	50.43
2	Leuang Pahn Tawng	TV	2.59	5.22	6.76	Chainat1	MV	4.34	32.26	33.37
3	Chainat1	MV	4.30	6.14	6.72	Pathum Thani1	MV	4.30	5.59	5.16
4	Luang Pratahn	TV	2.29	4.49	4.47	Suphanburi90	MV	4.99	4.52	5.13
5	Gon Gaew	TV	2.34	6.87	5.53	Pathum Thani4	NMV	4.08	1.50	1.10
6	Leuang Pratew 123	ITV	2.71	4.95	4.57	Suphanburi60	MV	4.52	1.07	1.03
7	RD6	ITV	2.27	7.79	4.22	Puang Ngern	NMV	5.45	0.21	0.65
8	Khao Luang	TV	2.54	2.38	3.97	Puang Tawng	NMV	3.96	0.43	0.61
9	KTH 17	ITV	2.38	3.30	2.96	C 5	NMV	5.12	0.64	0.52
10	Irradiated KTH 17	ITV	2.85	1.83	2.60	Suphanburi2	MV	4.48	0.43	0.45
Total of top ten varieties				50.67	52.52				97.61	98.45
Total of other varieties				49.33	47.48				2.39	1.55
Number of parcels and areas(ha) of all varieties				1091	4831.50				465	2143.92

Source: Sample survey conducted by Prachinburi Rice Research Center

Note: Total number of varieties grown in wet season = 120 Total number of varieties grown in dry season = 18.

TV = Traditional variety

ITV = Improved traditional variety

MV = Modern variety

NMV = Non-approved modern variety

Central regions than in the East-Central and Lower North regions. With Suphanburi1 and Chainat1, two modern varieties that were popularly grown in both the wet and the dry season, the yield difference between the two seasons were very small.

For the traditional varieties, the yield was the lowest for the glutinous varieties at 1.5 t/ha compared to floating rice at 2.2 t/ha and deepwater rice at 2.4 t/ha. The yield for the improved traditional varieties was not significantly different compared to traditional floating rice varieties.

The yields in the modern and traditional varieties under different seasons and different sub-ecosystems are reported in Table 8. An average yield of all seasons was 2.78 t/ha, close to the national average for Thailand. (Ministry of Agriculture and Cooperatives, 2002) The yield of modern varieties in dry season was slightly higher (4.40 t/ha) than that in wet season. There was no difference between the yield of traditional and improved traditional varieties.

Costs and returns

The estimates of costs and returns in rice cultivation are reported in Table 9. The average rice yield for traditional varieties (grown mostly in the wet season) was 2.2 t/ha, and for modern varieties 4.0 t/ha for the wet season and 4.2 t/ha for the dry season. These estimates from the survey are similar to the ones reported in national statistics. The average rice yield for all varieties for the sample was 3.1 t/ha, which is higher than the national average because of larger proportion of area (49%) under modern varieties in this ecosystem than for the country as a whole.

The major components of the costs are machine rental (22.7%), chemical fertilizers (13.6%), seeds (7.4%) and hired labor (7.4%); the figures within parentheses are the costs as percent of the gross value of output. Pesticides, herbicides and irrigation account for a relatively small fraction of the total cost- these three inputs together comprised

Table 8 Average rice yield (t/ha) at farmer level by sub-ecosystems 2000.

Parameters	Lowland rainfed	Lowland irrigated	Deepwater rainfed	Deepwater irrigated	All
All seasons	2.54	3.29	2.54	2.89	2.78
Wet season					
MVs	4.15	4.27	3.87	4.35	4.15
ITVs	2.26	2.69	2.46	2.42	2.42
TVs	2.41	2.45	2.49	2.50	2.47
Dry season					
MVs	4.38	4.28	4.81	4.49	4.40

Source: Sample survey conducted by Prachinburi Rice Research Center

only eight percent of the gross value of production. The amount of chemical fertilizers used was almost double in the cultivation of modern varieties compared to traditional varieties. And farmers used irrigation and pesticides mostly in the cultivation of modern varieties. The use of other inputs was almost similar in the two groups of varieties. The out of pocket expenses (paid out cost) accounted for 59% of the value of production- 63 percent for traditional varieties and 57 percent for modern varieties. For an owner farmer the cost per ton of output was Baht 2,441 (US$ 61), but for a tenant farmer who has to pay a rent for the use of the land the unit cost would be Baht 3,600 (US$90). With the price in the range of Baht 3,600 to 4,100. The tenant farmer makes very little profit.

Table 9 Costs and returns from rice cultivation in modern and traditional varieties.

(Baht per hectare)

Items	Modern varieties		Traditional varieties in wet season	All varieties in both seasons	Percent of gross value of output
	Wet season	Dry season			
(% of rice area)	(21.8)	(27.6)	(50.6)	(100)	
Material inputs	4,292	4,294	2,006	3,137	26.2
Seeds	1,041	1,035	741	888	7.4
Fertilizers	2,248	2,268	1,009	1,627	13.6
Pesticides	612	604	45	323	2.7
Herbicides	391	387	211	299	2.5
Irrigation charge	436	719	58	323	2.7
Machine charge	2,914	2,693	2,636	2,712	22.7
Hired labor	745	851	966	887	7.4
Family labor	261	245	255	254	2.1
Interest charge	419	428	283	353	3.0
Paid-out cost	8,387	8,557	5,666	7,059	59.0
Total Cost	9,067	9,230	6,204	7,666	64.1
Yield (ton/hectare)	4.0	4.2	2.2	3.1	-
Gross Value	14,693	15,339	8,933	11,957	100.0
Family income	6,306	6,781	3,267	4,898	41.0
Operational suplus	5,626	6,109	2,729	4,291	35.9
Unit Cost (Baht/ton)	2,257	2,213	2,817	2,441	-
Price (Baht/ton)	3,657	3,677	4,057	3,807	-

Source: Sample survey conducted by Prachinburi Rice Research Center

The family income (the difference between gross revenue and paid-out cost) from rice cultivation was estimated at Baht 6,308 (US$ 157) per ha for modern varieties compared to Baht 3,267 (US$ 81) for traditional varieties for the wet season. Thus, the cultivation of modern varieties gives a substantially higher net returns (93%) than in cultivation of traditional varieties, although traditional varieties fetch higher price in the market because of superior grain quality.

The estimates of costs and returns from rice cultivation in different sub-ecosystems are presented in Table 10. Under rainfed cultivation the yield, costs of production and family incomes are almost the

Table 10 Costs and returns in rice cultivation by sub-ecosystem.

(Baht per hectare)

Items	Lowland rainfed	Lowland irrigated	Deepwater rainfed	Deepwater irrigated
Material inputs	2,628	4,043	2,440	3,014
Seeds	736	1,038	822	927
Fertilizers	1,494	2,100	1,234	1,448
Pesticides	155	509	140	358
Herbicides	243	396	244	281
Irrigation charge	155	518	165	342
Machine charge	2,373	2,821	2,554	2,922
Hired labor	1,074	833	938	793
Family labor	294	297	182	245
Interest charge	312	411	305	354
Cash-cost	6,230	8,215	6,097	7,071
Total Cost	6,836	8,923	6,584	7,670
Yield (ton/hectare)	2.6	3.8	2.7	3.3
Gross Value	10,522	13,919	10,459	12,356
Family income	4,292	5,704	4,362	5,285
Operational suplus	3,686	4,996	3,875	4,686
Unit Cost (Baht/ton)	2,629	2367	2,418	2,338
Price (Baht/ton)	4,047	3,693	3,841	3,766

Source: Sample survey conducted by Prachinburi Rice Research Center

Note: Family income = Gross value - Cash cost

Operational surplus = Gross value - Total cost

Unit cost = Total cost / yield

same under the lowland and the deepwater ecosystem. The yield is however substantially higher when grown under irrigated conditions. This result is obvious because irrigation facilitates adoption of modern varieties that give higher returns. The differences in yield in irrigated over the rainfed system was higher for the rainfed lowland sub-ecosystem (1.2 t/ha) that in the Deepwater sub-ecosystem (0.6 t/ha). As noted earlier, on parcels at lower flooding depth the farmer has opportunity to grow modern varieties in both the wet and the dry season, while in the deeper flooding depth the farmer can grow modern variety only in the dry season. Assuming that in under irrigated conditions the farmer grow two rice crops a year while under rainfed conditions only one rice crop, the net increase in family income from irrigation is estimated at Baht 7,116 (US$177) per ha in the lowland sub-ecosystem and Baht 5,285 (US$132) per ha under the Deepwater sub-ecosystem.

Livelihoods systems

How important is rice cultivation in the livelihood systems of the farmer in the flood-prone ecosystem? In order to answer the question, the survey collected data on employment and income obtained from different economic activities. Accurate estimation of income is difficult because farmers do not keep records of transactions of inputs and marketing of products. We collected detailed information on input-output only for rice cultivation. Earnings and expenses from other economic activities were obtained from memory recalls of the respondents. So the income the data must be taken with a grain of salt.

The composition of household incomes obtained from the survey can be seen from Table 11. As can be gleaned from the Table total income for an average rural household was estimated at Baht 128,277 or US$ 3,198 at the prevailing exchange rate. The per capita income was estimated at Baht 28,506 or US$ 710. The per capita income of Thailand for the year of survey was estimated at US$ 1,940. The per capita income for rural households was 37 percent of the per capita income at the national level, reflecting a substantial rural-urban disparity in incomes.

Rice cultivation was found to be the most important source of livelihood with almost 84 percent of the households reporting income from the source. Incomes from rice cultivation accounted for 22 percent of the household income. The other major sources of livelihoods were rural industry and processing, and services. About one-fifth of the rural households reported receiving income from the agricultural labor market, and another 16 percent from the non-agricultural labor market (transport operation, construction work etc). But the wage income from the labor market accounted for only 14 percent of the rural household incomes. Although only about 20 percent rural households reported incomes from rural industry and processing, this source of livelihood accounted for almost the same share of household incomes as from rice cultivation. About eight percent of the households reported receiving income from remittances, which comprised 10 percent of the rural household incomes.

Although Thailand is better endowed with

land compared to other countries in South and Southeast Asia, the major portion of rural incomes in fact comes from non-agricultural sources. Agricultural activities accounted for only about 38 percent of the rural household income.

The rural income was also found highly unequally distributed (Table 12). The top 10 percent of the households in the per capita income scale controlled nearly 36 percent of the total incomes, while the bottom 40 percent of the households got a share of only nine percent. The concentration ratio of income as measured by the Gini coefficient (Sen, 1973) was estimated at 0.53. The income from rice cultivation was found much less unequally distributed (Gini= 0.29) than incomes from non-agricultural sources (Gini=0.63). A Gini decomposition analysis (Shorrocks, 1983) shows that rice cultivation accounts for only 13 percent of inequality in rural household

Table 11 Composition of rural household incomes, 2000.

Source of income	Households reporting income from the source(%)	Average income earned from the source (Baht/year)	Share (%) of income obtained from the source
Agriculture	96.7	50,108	37.8
Rice cultivation	83.6	28,130	22.4
Cultivation of other crops	36.4	8,003	6.4
Livestock & fisheries	25.5	5,047	4.0
Agricultural labor	19.0	8,904	5.0
Non-agriculture	55.4	78,169	62.2
Industry and processing	20.2	26,962	21.5
Trade & business	8.9	9,795	7.8
Services	11.9	18,346	14.6
Remittance	7.6	12,086	9.6
Non-agricultural labor	15.7	10,980	8.7
Total income	100.0	128,277	100.0
Per capita income		28,506	

Source: Sample survey conducted by Prachinburi Rice Research Center

incomes, while industry, services and trade accounts for two-thirds of the concentration of income (Table 13).

There is also considerable inequality in the distribution of income from different regions (Table 14). The household income was the lowest in the Northeast (Baht 90,985) and the highest in the Middle-Central regions (Baht 160,052) reflecting the difference in land endowments and proximity to Bangkok that provides income-earning opportunities

Table 12 Degree of inequality in the distribution of household incomes, 2000.

Rank of households in per capita income scale	Share (%) of the group in total income		
	Agricultural income	Non-agricultural income	Household income
Bottom 40%	17.1	3.4	8.9
Middle 40%	42.0	31.6	35.6
Ninth decile	16.5	21.5	19.6
Top 10%	24.4	42.8	35.9
Gini concentration coefficient	0.24	0.68	0.52

Source: Sample survey conducted by Prachinburi Rice Research Center

Table 13 Concentration of income and its decomposition by source of income, 2000.

Sources of income	Income share(%)	Pseudo-Gini ratio	Absolute contribution to income inequality	Relative contribution to income Inequality (%)
Agriculture	37.8	0.358	0.135	25.8
Rice farming	22.4	0.292	0.065	12.5
Non-rice & non-crop farming	10.4	0.532	0.055	10.5
Agri-labor	5.0	0.293	0.015	2.8
Non-agriculture	62.2	0.626	0.390	74.2
Industry & business	29.2	0.624	0.182	34.7
Services and remittances	24.2	0.708	0.171	32.6
Other non-farm sources	8.7	0.410	0.036	6.8
Total income	100.0	0.525	0.525	100.0
Per capita income (Gini ratio)		0.533		

Source: Estimated from the household level data estimated from the sample survey

Note: Pseudo Gini coefficient is the concentration coefficient of income from the source when the households are ranked in the scale of per capita income rather than in the scale of income from that source.

from non-farm sources. Almost 69 percent of the rural households in the Middle-Central region reported earning incomes from non-agricultural sources, receiving an average annual income of Baht 157,000 from them. Rice cultivation accounted for nearly 42 percent of the income in the Lower North region, but only 13-15 percent in the East-Central and the Northeast regions.

The income from rice cultivation is marginally higher for the Deepwater sub-ecosystem compared to that for the Rainfed Lowland sub-ecosystem. Rice incomes increases substantially with the development of irrigation facilities and the adoption of modern varieties. Compared to rainfed systems, the income in the irrigated system was about 65 percent higher for the Lowland sub-ecosystem. For the Deepwater sub-ecosystem, the income from rice cultivation was about 58 percent higher when irrigation in available than under rainfed conditions. Households earn more income from non-rice economic activities in the Deepwater sub-ecosystem than in the Rainfed sub-ecosystem.

The effect of irrigation and MV adoption on household incomes

For a more rigorous estimate of the impact of irrigation and the adoption of modern varieties, we ran a multiple regression model on the determinants of household incomes. The income function related the household incomes (dependent variable) to the endowment of assets such as landholding, non-land fixed assets, and the number of family workers engaged in agriculture and non-agricultural activities. Since most of the family workers had primary level

Table 14 Contribution of rice cultivation to household incomes, by region and sub-ecosystem.

Region/sub-ecosystem	Household income (Baht)	Rice income (Baht)	Share (%) of rice in household income
Regions			
East-Central	116,178	15,661	13.5
Middle-Central	160,052	32,511	20.3
West-Central	139,364	22,625	16.2
Lower North	101,093	42,082	41.6
Northeast	90,985	13,900	15.3
Sub-ecosystems			
Lowland rainfed	97,269	21,434	22.0
Lowland irrigated	125,845	35,540	28.2
Deepwater rainfed	131,316	23,078	17.6
Deepwater irrigated	157,464	36,427	23.1
All regions	128,277	28,130	21.9

Source: Estimated from the sample survey conducted by the Prachinburi Rice Research Center

education we did not include the level education of the worker as a separate variable that would have captured the effect of accumulation of human capital. Some of this effect will be subsumed in the variable representing non-agricultural worker, as education facilitated occupational mobility from agriculture to non-farm activities. Since the educated members sometimes migrate to urban areas to avail of the opportunities of non-farm jobs, we used a dummy variable in the equation for households receiving remittances from members living outside the household. Another dummy variable was used to represent households who are engaged in rural industry and processing. The opportunity for getting sub-contracts for manufacturing operations may depend on social networks i.e., connections with industrial entrepreneurs operating from urban areas. This variable may thus capture the effect of social capital. The effect of irrigation and the adoption of modern varieties were estimated by including them as shifter variables in the income function. The coefficient of the variable "landholding" would show the reture on the margin from the cultivation of rainfed land (equation 1) or from the cultivation of traditional variaties (equation 2). The coefficients for the variables "irrigation" and "modern variety" would show the additional income earned per ha if the land is irrigated or cropped with modern varieties. Since these two variables are highly correlated, we used them alternatively in two separate equations.

The estimates of the income functions are reported in Table 15. The most important factor affecting household income appears to be the household's engagement in rural non-farm activities. A non-agricultural worker earns on the margin Baht 63,000 (US$ 1,590) per year compared to only Baht 8,000 (US$210) for an agricultural worker. Households engaged in rural manufacturing and processing activities earned on average Baht 41,000 higher income than households who did not have those opportunities. Similarly, household receiving remittances from members living outside earned an additional income of Baht 41,000.

The regression coefficient of landholding indicates that the household earns on the margin Baht 3,357 (US$84) from each ha of land (after dissociating the contribution of other inputs). With an average size of holding of 4.73 ha, the annual net income from land is estimated at Baht 18,880 (US$ 470), which is only about 15% of the rural household income. If the land is irrigated the household will have an additional income of Baht 13,983 (US$ 385), 82% higher than the income from land under rainfed conditions. If the land is cropped with traditional varieties (the coefficient of land holding in equation 2) the net income from landholding would be Baht 3,225 (US$80) per annum. If the land is cropped with modern varieties, the household would earn an additional income of Baht 15,765 (US$ 393). Thus, investment in irrigation that facilitates the adoption of modern varieties appears to have a very high return. But, landholding gives substantially lower income than engagement in rural non-farm activities.

Table 15 Determinant of household incomes, regression estimates.

Determinants	Mean value	Equation I		Equation II	
		Regression coefficient	t-value	Regression coefficient	t-value
Landholding (ha)	4.73	3,357	4.14**	3,225	3.97**
Irrigation coverage (%)	49.6	13,983	2.25*		
Modern variety	47.2			15,765	3.33**
Agricultural capital (Baht)	33,450	0.099	2.35*	0.096	2.28*
Non-agricultural capital (Baht)	115,597	0.085	5.08*	0.088	5.28**
No. of agricultural worker	2.51	8,479	3.24*	8,338	3.19**
No. of non-agricultural worker	0.63	63,640	18.43**	63,558	18.45**
Household receiving remittance (%)	7.6	41,584	3.33*	43,632	3.50**
Households engaged in industrial activities	20.0	38,743	4.70*	41,115	5.01**
Households with land in deepwater sub-ecosystem	45.4	14,003	2.23*	16,830	2.65*
Constant term		6,811	0.74	5,190	1.57
R^2			0.36		0.37
F-value			78.21		79.25

Note: The regression model was estimated with the household level data for 1,266 randomly selected households. **denoted that the regression coefficient is significantly different from zero at one percent probability error, and *denotes that the coefficient is significantly different at five percent probability error.

CONCLUSIONS AND RECOMMENDATIONS

Thailand has a favorable endowment of land with an average size of holding of 4.73 ha, which is many times higher than that for the neighboring rice growing countries. The size of holding however varies greatly across regions with larger holdings in Lower North, and Middle-Central regions, and smaller holdings in the Northeast. The tenancy cultivation is widespread (41% of the land) because of the high incidence of rural-urban migration. The high incidence of tenancy may be a factor behind low-incomes from farming and may act as a constraint to adoption of innovations. Most of the household heads had only primary level education. The higher educated leaves rural areas in search of more remunerative non-farm occupations.

Irrigation infrastructure has expanded greatly in the flood-prone ecosystem, which has contributed

to intensification of rice cropping. The adoption of improved varieties remains low under the rainfed system, and the rate of adoption of modern varieties depends on the flooding depth of the parcel. Only 18 percent of the land is grown under modern varieties, and 23 percent under improved traditional varieties on deep-flooded land. With irrigation facilities in place, the double cropping of rice increases from 5 to 28 percent in shallow flooded areas, and from 10 to 30 percent in deep-flooded areas. But the incidence of double cropping of modern varieties is still low. It increases with irrigation, but more in shallow flooded areas than in deep-flooded areas. Shorter maturity of rice varieties may be needed to increase the area under double cropping of modern varieties.

Farmers grow only a few modern rice varieties in the dry season when there is good water control, but continues to grow many traditional and improved traditional varieties in the wet season because of the constraints imposed by the depth of flooding and the duration and intensity of rainfall. The yield and profitability difference between traditional and improved traditional varieties are marginal which explains the low adoption of improved traditional varieties. Modern varieties however give higher yields and net incomes, but the farmer has to incur substantially higher cost on account of chemical fertilizers and pesticides. Irrigation and the adoption of modern varieties almost doubles the income from land, after dissociation the contribution of other factors.

An average household in the flood-prone ecosystem earns about Baht 128,000 (US$3,200). But the major portion of the income comes from non-farm activities. Agriculture accounts for only 38 percent of the household income, and rice cultivation only 22 percent. The rural household income is highly unequally distributed. The inequality in income distribution is mainly on account of income from manufacturing and services, and non-rice agricultural activities. Rice cultivation accounts for a small fraction of income inequality. The level of income and rice's share of household income varies greatly across regions, depending mostly on the size of landholding and the opportunity of non-farm employment. The income in the Northeast region was only about 56% of the income in the Middle-Central region. Rice cultivation accounts for about 42% of the household income in the Lower North region, but only 13 to 15 % in the East-Central, West-Central and the Northeast regions.

The above findings imply that unless improved technologies promise large increase in yields and incomes, they may not have much appeal to the farmers. Rice research for improving traits of traditional varieties (such as elongation, kneeing ability etc) on which much attention has been given in the past may not be of much value to farmers, because the adoption of these varieties would contribute so little to improving farmers' livelihood.

A system approach must be taken in designing research strategy for the flood-prone ecosystem. Development of modern varieties with high yields, shorter maturity period, tolerance to submergence, and improved grain quality could lead to further intensification of rice farming. Wider adoption of two modern varieties within the year,

and reduction in the instability in yield from climatic stresses, which could make significant impact of the livelihood of the flood-prone rice farmer than the improvement of the traditional deepwater or floating rice plants.

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