

Crop Price Analysis and Dry-Season Land Use Changes: Can It Help Improve Agricultural Planning?*

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Agricultural planning for the dry-season cultivated area in the Chao Phraya basin is at present based mainly on water supply availability and water demand by non-agricultural sectors, and is carried out through the cooperation of the relevant government agencies. But the actual area under cultivation during the dry season is usually much larger than that considered under the plan. As a result, water conflicts are common in the basin. This tends to suggest that some lacunae may exist in the present agricultural planning system due to incomplete information. When taking a decision regarding the choice of crop, the farmer considers not only the input factors, but also the price factors, including the anticipated prices of the output. The objective of the present study is to forecast changes in the land use and cropping patterns in response to rice-price change in the next five and 10 years. The methodology used in this study involves modeling a system of crop share equations with the area share of the crop groups as the dependent variable and output prices, input prices and other factors as the independent variables. The results of the system of crop share equations for the upper part of the Chao Phraya irrigation project indicate a positive effect of the crop's own price. Cross-price effects, on the other hand, can be either positive or negative depending on the substitutability or complementarity with the other crop/s. Based on the World Bank estimates of the world rice prices, the forecasted rice area in the Chao Phraya basin in the dry season shows no noticeable trend of land use change as it tends to change basically in response to the change in the price of rice. It is predicted that the rice area in the basin will reach its largest expanse of 4.56 million *rai* in 2006, which is beyond the maximum potential in the dry season as estimated by the Royal

Irrigation Department (RID). Besides rice prices, changes in rice farming technology, such as the use of the combined-harvester, new planting methods and short-maturity and non-photosensitive varieties, as well as changes in land and water regimes and resource availability can influence the farmer's decision about the crop choice and farming pattern. For instance, these factors can induce the potentiality of growing more than one rice crop in the dry season. Since different outcomes are obtained when the impacts of crop price changes on land use and cropping patterns are taken into account than when they are ignored, as in the present planning system, we feel that price effects do have an important bearing on changes in land use and cropping patterns. Therefore, policy makers should consider incorporating the effects of crop price movements on land use and cropping pattern changes use together with water supply availability and water demand by other sectors in the dry-season agricultural planning system so as to make it more rational and effective.

INTRODUCTION

The Chao Phraya basin covers approximately one-third of Thailand's land area. The Chao Phraya river and its tributaries support Bangkok, which is situated right at the deltaic mouth of the river, and depends on the basin for its dry-season watersupply. In the Chao Phraya basin, water from the two dams, Bhumipol and Sirikit, is regulated to ensure sufficient supply for electricity, agriculture and urban and industrial use, as well as for protection against salinity and seawater intrusion. The explosive growth of Bangkok and its adjacent provinces

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in the last two decades has led to the need for inter-basin water transfer.¹ As water shortages in the dry season have become routine, inter-sectoral water conflicts have intensified: conflicts between upstream and downstream farmers, between the agricultural sector and non-agricultural sectors and even between government agencies. Even though the main water use is for agricultural purposes, the present planning process for the dry season cultivated area is essentially supply-oriented, since it is based mainly on water supply availability. Little consideration is given to other factors that may also affect the change in land use. The objective of this paper is to consider the price effects on land use change, and to forecast land use and cropping patterns in the Chao Phraya basin in the dry season occurring in response to the changes in rice prices in the next five and 10 years. Additionally, the results are compared with similar projections of land use by other studies that do not consider price effects.

The paper is organized in three parts. Part one describes the water resource allocation system in the Chao Phraya basin. Projections of the land use and cropping patterns in the irrigation project areas by considering the impact of rice-price changes is presented in part two. The last section concludes.

WATER RESOURCE ALLOCATION IN THE DRY SEASON

In the Chao Phraya basin, water from the two dams, Bhumipol and Sirikit, is regulated to ensure sufficient supply for all activities in the basin. The supply availability for the dry season (January to June) relies on the water storage behind these two dams at the end of the previous (calendar) year as a result of the water inflow into the two reservoirs and the water use in the wet season.

Supply assessment of surface water is the responsibility of the Electricity Generating Authority of Thailand (EGAT), which controls these two dams. The collection and analysis of hydrological data for the rivers and the two reservoirs that belong to the RID are the responsibility of the Hydrology Division of the RID. The Water Management Branch of the Operations and Maintenance Section of the RID estimates the water budget using, 1) the information on water supply situation given by the irrigation projects in the area; 2) the data given by the EGAT on water budgets of the reservoirs of the two hydropower dams; 3) the estimates on the water requirement for the dry-season agricultural production provided by the Ministry of Agriculture and Cooperatives (MOAC); and, 4) the estimated water use for domestic and industrial purposes as well as for navigation and protection from saltwater intrusion. Then, the RID estimates water uses for inter-sectoral activities during the dry season.

In the years when water demand exceeds supply, solutions—ranging from engineering to political—are sought for reallocating water (by priority or rationing) among the users. For example, a limited amount of water will be distributed to the rice farmers (Table 1). Contrary to the expectation, the actual area under rice cultivation is always higher than the planned area.

In the past decade, the demarcation of the planned rice cultivation area was done through the cooperation of the relevant government institutions concerned with dry-season crop planning. The failure of the command and control system in water resource management can be observed from the fact that the actual rice area and the water release are higher than planned. One of the major reasons for the overuse of water in agriculture is that there is, in effect, open access to irrigation water supplied from the two dams and groundwater. Furthermore, social and economic factors induce the intensity of rice

Table 1a Dry Season Water Allocation in the Chao Phraya Basin, 1994-2000

	Unit: Million cubic meters							
Year	1994	1995	1996	1997	1998	1999	2000	
Water availability on 1 Jan.	2,048	12,733	14,582	12,107	8,200	3,879	11,930	
1. Domestic water use	700	1,100	1,800	1,650	1,600	700	1,600	
2. Dry season crops	500	3,300	4,950	4,200	3,400	1,900	3,000	
3. Navigation	0	300	400	300	300	0	300	
4. Piped water production	550	700	750	750	750	650	750	
5. Protection against salinity & seawater intrusion	250	600	600	500	450	350	350	
Planned water release	2,000	6,000	8,500	7,400	6,500	3,600	6,000	
Actual water release	1,894	7,216	9,643	8,556	6,656	2,575	6,513	
6. Pasak Dam								
Planned water release								500
Actual water release								762

Source: RID.

Table 1b Planned and Actual Dry-season Rice Area in the Chao Phraya Basin, 1994-2000

	Unit: Million rai							
Year	1994	1995	1996	1997	1998	1999	2000	
Planned rice area in Phitsanulok & Chao Phraya basin	0.00	2.80	3.50	3.30	2.70	1.90	3.10	
Actual rice area	1.77	3.19	4.15	4.06	3.79	3.49	4.90	

Source: RID.

cultivation in the dry season. The farmer’s decisions about his/her farm activities depend not only on the water distribution from the irrigation projects, but also on other factors, such as expectations of the prices of rice and other crops.

LAND USE PROJECTION

As there are differences in the irrigation systems, the organization of the systems, cropping patterns and data availability, it is not possible to apply the same methodology in forecasting the land use for the whole area of the Chao Phraya basin. Instead, the basin can be divided into four areas, namely, 1) the lower Ping river basin, 2) the lower Nan river basin, 3) the upper part and 4) the lower part of the Chao Phraya irrigation project. Due to data constraints, some assumptions and estimates have been employed (see Table 2). Only the methodology for estimating a system of crop area share equations will be presented in this paper.

We applied the econometric method pioneered by the Rotterdam school (Theil 1980, cited in TDRI 1988) that was used by the TDRI in its study of the “Dynamics of Thai Agriculture, 1961-1985.” In the present study, a system of crop area share equations was applied to the 14 sub-projects with a gravity irrigation system in the upper part of the Chao Phraya irrigation project. The model is applied for dry season crops in three groups, namely, rice, field crops, and vegetables. Fruit-tree areas are excluded due to their low flexibility in changing to other crops. It is assumed that the crop area share is a function of the crop’s own price, of the prices of the other crops, of the prices of the inputs and the irrigated area.

$$S_j = a_j + \sum_i a_{ij} \cdot \ln(p_j/p_{na}) + \sum_k a_{kj} \cdot \ln(p_k/p_a) + \sum_h a_{hj} \cdot \ln z_h, j = 1..3$$

- Where; S_j = the area share of the crop j
- p_j = the price of the output j
- p_k = the price of inputs (fertilizers, wages)
- z_h = the other variables
- p_a = price of the agricultural sector
- p_{na} = price of non-agricultural sector

To be consistent with the economic theory, a few cross-equation restrictions have to be imposed, namely:

$$\begin{aligned} \sum_j S_j &= 1 \\ \sum_i a_{ij} &= \sum_j a_{kj} = 0 && \text{for all } i \text{ and } k, \\ a_{ij} &= a_{ji} && \text{for all } i \text{ and } j. \end{aligned}$$

The first two sets of restriction are to ensure that the shares s_j always sum up to one, and the last symmetry requirements flow ultimately from the symmetry of the bordered Hessian matrix which is obtained at one step in the derivation of the optimal supply functions. This last condition means that the share of each product supplied is homogeneous degree zero in the prices of the variables.

Since a contemporaneous correlation occurs in the error terms for the equations for these crop area shares, a seemingly unrelated regression technique is used to estimate the relationship with two restrictions, namely, the adding-up and the symmetry conditions. Own- and cross-price elasticities (ϵ_{ij}) can be estimated from the following formula:

$$\epsilon_{ij} = a_{ij}/S_j$$

The data used in estimating the system of crop area share equations is pooled from the 14 irrigation sub-projects in the Chao Phraya irrigation project for the period 1987-1999. All price factors are based on the wholesale prices in the Bangkok area. Projection of the land use is based on the information of world rice prices forecasted by the World Bank (2000) for the next five and 10 years (Table 3).

The share of the crop area is assumed to depend on the anticipated crop price, variable input prices and other variables that affect the area share. The crop’s own price affects the area share since revenue is a function of price so that a change in price causes a proportional change in the farmer’s revenue; also, price motivates the farmer to increase the area share. Prices of other crops also have a considerable impact, as their extent show the substitution and complementarity effect in crop area share or crop production. We assumed that the farmers’ decisions follow a nested structure. First, the farmers make crop choices by allocating resources among the three crop categories (i.e., rice, field crops, vegetables); then they choose the crops within each category.

Table 2 Methodology Used in Projecting the Land Use in the Chao Phraya Basin

Location	Irrigation projects	Remarks
Lower Ping river basin	- small-scale irrigation projects and pumping irrigation projects	- using previous land use information
Lower Nan river basin	- Phitsanulok irrigation project - Naresuan dam and pumping irrigation projects	- estimating rice area supply function because rice is a major crop - using previous land use information
Upper part of the Chao Phraya project	- Gravity irrigation distribution system	- estimating a system of crop area share equations
Lower part of the Chao Phraya project	- Conservation irrigation distribution system	- using previous land use information, with a maximum area of 1.3 million <i>rai</i> for rice

Note: For more details see the final report (TDRI 2001).

Table 3 Wholesale Rice Prices Forecasted by the World Bank

Year	Rice prices (US\$/ton)	
	Current	Constant 1990
1997*	303.5	280.0
1998*	304.2	291.9
1999*	248.4	239.9
2000	250.0	235.5
2001	260.0	239.0
2002	270.0	241.8
2005	315.0	263.6
2010	345.0	255.4

Notes: Prices are for Thai 5% broken WR, milled, f.o.b. Bangkok in calendar years.

* Actual prices.

Source: World Bank 2000.

The results of the system of crop area share equations for the upper part of the Chao Phraya irrigation project indicate, as expected, a positive effect of the crop's own price (Table 4). Cross-price effects, on the other hand, can be either positive or negative depending on the two crops' substitutability or complementarity. In this case, a substitutability exists between rice and field crops and between rice and vegetables, while a complementarity exists between field crops and vegetables. The own-price elasticity for the rice area is more than one (Table 5). It is quite reasonable that in the irrigated area farmers tend to grow rice as a commercial venture, making use of the accessibility to the modern technology used in rice cultivation. The own-

price elasticity for the field crop area share by considering sugarcane prices shows a quick response to the change in prices, since field crops generally need less water.

The cross-price elasticity for the rice area tends to be higher than for the field crops area. If the price of rice increases by 1 percent the reduction of the field crops area is about 2.5 percent, while for 1 percent increase in the price of sugarcane the corresponding reduction in the rice area is only 0.8 percent. This is understandable since the technology used in rice cultivation can reduce labor use, water use and time; moreover, the deep alluvial soils in the Chao Phraya basin are more suitable for rice farming.

Table 4 Results of the System of Crop Area Share Equations for the Upper Part of the Chao Phraya Irrigation Project

Variables	Rice area share (0.71259)		Field crops area share (0.2307)	
	Coefficient	t-statistics	Coefficient	t-statistics
Dependent variable: area share				
Independent variables				
Rice price (t-1)	0.8423	5.927***	-0.5688	-4.732***
Sugarcane price (t-1)	-0.5688	-4.732***	0.2649	2.000**
Groundnut price (t-1)	0.5593	1.368	-0.5692	-1.549
Mango price (t-1)	1.1891	6.695***	-1.0010	-6.370***
Cabbage price (t-1)	-0.0175	-0.797	-0.0175	-0.797
Chinese kale price (t-1)	-0.3405	-3.766***	0.3060	3.857***
Wage rate (t)	-0.6861	-3.945***	0.5482	3.499***
Fertilizer price (t)	-0.1479	-1.321*	0.2239	2.171**
Ratio of the planned area to the total irrigated area	0.0325	2.499**	-0.0206	-1.780*
Dummy variable for the western part of the area	0.1679	2.373**	-0.0895	-1.437
Adjusted R ²	0.5504		0.5524	
Durbin-Watson statistics	1.9509		1.9754	
Log-likelihood	208.4960		208.4960	
N	145		145	

Note: *** significant at 0.01, ** at 0.05, and * at 0.10.

Source: TDRI 2001.

Table 5 Own and Cross-price Elasticities

Crop area	Crop prices		
	Rice	Sugarcane	Chinese kale
Rice	1.182	-0.798	-0.478
Field crops	-2.466	1.148	1.327

Source: TDRI 2001.

The above results show positive effects of fertilizer price and the wage rate on the field crop area but negative effects on the rice area. The ratio of the planned area to the total irrigated area in the dry season has a positive impact on the rice area but negative effect on the field crops area. This is because growing rice requires more water than the field crops. This indicates the possibility of the actual rice area being higher than the planned area, as the RID experiences each year. The experimental data suggests that the water requirement for rice is less than 2,000 cubic meter/rai; however, the RID uses a fixed water requirement of 2,000 cubic meter/rai along with the water supply availability to estimate the planned rice area (also taking into consideration the water demand by other sectors). Moreover, some farmers have open access to groundwater supply that might influence their decision to go for rice cultivation.

The land under rice in 1997 was about 95.2 percent as a result of higher rice prices in the recent years. Applying the World Bank estimates on the world rice prices, the land use under different crops can be estimated using the system of crop area share equations described above. The results indicate that the change in the land use and crop types is in response to the change in rice prices; for example in 1997 the rice area was 4.47 million rai and is expected to shrink to 4.02 million rai in 2001 (Table 6). In the year 2006 the rice area will be the largest, at 4.56 million rai. The rice area tends to be smaller in the year 2016, because the impact of the change in rice prices is relatively less than the impact of the other crop prices. We predict the rice area to be as high as 4.56 million rai, which is beyond the RID-estimated maximum potential of 4 million rai (pers. comm. the RID staff) for the dry season in the Chao Phraya basin. However, it might be possible if farmers grew rice twice in the dry season. As the farm surveys in 2000 revealed, this practice is not uncommon (TDRI 2001). It can be concluded that there is no noticeable trend in the change in the rice area in the Chao Phraya basin during the dry season in the next five to 10 years as the area change is in response to the changes in the rice prices.

Various other studies have projected the future land use and cropping pattern in the Chao Phraya basin,

sometimes using simple assumptions, but none considering the impact of price changes in agricultural commodities. For instance, Binnie & Partners (1997) assumed a fixed irrigated area and cropping pattern for the next 30 years using the average land use in 1994/95. This assumption does not seem to have any rational basis. Moreover, the demand and supply for individual crops were not taken into account. While Pal Consultants and Panya Consultants (1999) reported an increasing trend for the crop area by applying a fixed growth rate and taking into account future irrigation projects. When compared with the TDRI estimates, it is evident that applying different approaches and assumptions can produce different outcomes. Such a comparison might provide a significant insight for policy makers that may help identify the missing elements in the current process of agricultural planning and water management for the dry season. Eventually, the process can be improved further to reflect more and more closely the ground reality.

CONCLUSION

Agricultural planning for the dry season in the Chao Phraya basin currently depends mainly on water availability. Ignoring the impact of price changes on the structural change in the land use and cropping pattern might lead to inefficient agricultural planning and water allocation management. However, crop prices are not the sole factor affecting land use and cropping patterns; other factors, such as farming technology may also matter. Taking the price effects together with other factors into consideration may provide more accurate information and thus help further improve agricultural and water allocation planning for the dry season.

ENDNOTE

- ¹ The inter-basin water transfer project, currently under construction, involves transferring water from the Mae Klong river basin to the Chao Phraya basin for producing piped water by the Metropolitan Waterworks Authority.

Table 6 Comparison of Dry-season Land Use Projections by Various Studies for the Chao Phraya Basin

Unit: rai

Year	Binnie & Partners (1997)	Pal Consultants & Panya Consultants (1999)				TDRI estimate			
	1996-2026	1996	2001	2006	2016	1997	2001	2006	2016
Rice	2,822,331	3,374,789	3,429,021	3,525,225	3,646,252	4,466,293	4,016,459	4,556,238	3,980,259
Field crops	765,078	219,931	240,868	263,229	301,828	178,742	172,770	152,987	189,221
Vegetables	134,740	104,897	106,685	107,974	110,721	47,640	44,232	32,525	45,561
Total	3,722,149	3,699,616	3,776,573	3,896,427	4,058,801	4,692,675	4,233,461	4,741,750	4,215,041

Sources: Binnie & Partners 1997; Pal Consultants & Panya Consultants 1999; TDRI 2001.

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