Water balance analysis of irrigation management for the preparation of dry season rice in the Chao Phraya Delta: the case of the Khok Katiem and Roeng Rang Irrigation Projects

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Abstract: *The purpose of this paper is to clarify how the irrigation for paddy preparation is efficiently performed during the dry season when the available water resources are limited. A catchment basin of approximately 23,000 ha, which is included in the project area of Khok Katiem or Roeng Rang, is settled as the survey site. The water input and output in the survey area have been measured and the progress in the paddy preparation have been observed from January to March. The water balance, associated with the progress in the paddy preparation, suggests that the unexpected and unstable irrigation water supply leads to inefficient water use. It concludes the strong need for water management improvement.*

1 Introduction

During the dry season in the Chao Phraya Delta, water resources totally depend on the water left in the Bumipol and Sirikit Reservoirs at the end of the rainy season, so it is important to use the limited water resources as efficiently as possible. Since the irrigation water for dry season rice occupies approximately 70% of the whole water demand during the dry season, it should be discussed as to whether the irrigation water is used efficiently or not.

This paper focuses on the water use and the water balance in an irrigated area during the preparation period from February to March, during which a large amount of water is intensively used. It analyzes the inflow and outflow in a survey area to make clear how efficiently the irrigation water is used based on the survey of both water balance and the development of land preparation.

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2 Method of survey

2.1 Outline of survey area

A drainage basin of the Roeng Rang Yai stream was chosen as the survey site which includes a part of the beneficiary area of Khok Katiem and Roeng Rang Irrigation Projects (Fig. 1). Both projects are located along the Chainat-Pasak main canal. The whole survey area is approximately 23,200 ha.

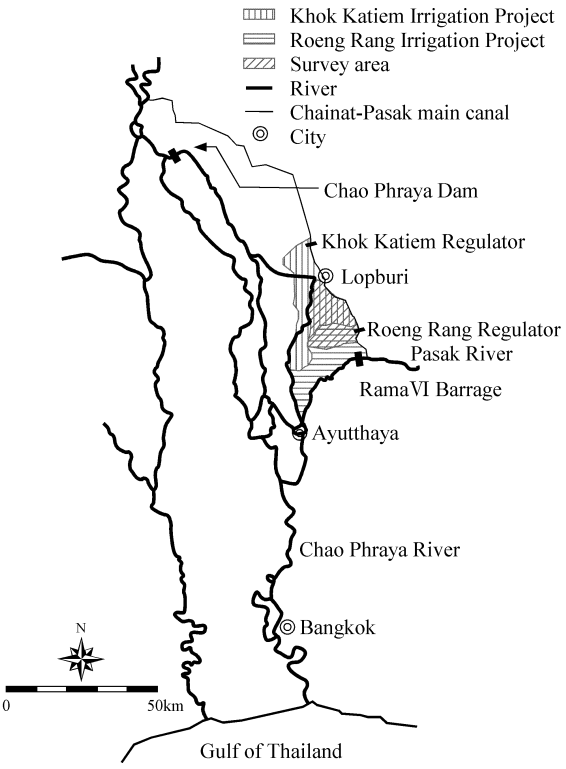


Fig. 1 Location of survey area in Chao Phraya

Three lateral canals of 21R, 22R and 23R feed water to this area (Fig. 2). They take water from the Chainat-Pasak main canal through the intake gate. A short canal of 22R-1 without an intake gate was constructed to supplement 22R and joins 22R a short distance from its intake. The 21R, 22R and 22R-1 belong to the Khok Katiem Irrigation Project, and 23R belongs to the Roeng Rang Irrigation Project. The flow capacity of 21R, 22R and 23R is 3.44 m^3/s, 1.48 m^3/s and 2.92 m^3/s, irrigating the beneficiary area of 4,200 ha, 1,800 ha and 3,600 ha, respectively. This total area excludes the deep-water rice area which is located downstream of the lateral canal in the southwest part of the survey area.

In addition to the three lateral canals, there are 22 irrigation ditches, which take water directly from the Chainat-Pasak main canal. All of them have no intake gate installed. Each of them irrigates a small area along the main canal, totaling to 2,700 ha.

Most of the drainage water from this survey area, except a part of the command area of 2L-21R and 23R, gathers at the Jaksaa through the Roeng Rang Yai drainage canal. The outflow of the survey area can be observed at Jaksaa.

2.2 Water balance

2.2.1 Inflow and outflow

Water is supplied to the survey area through the following canals; three lateral canals of 21R, 22R including 22R-1 and 23R, 22 direct irrigation ditches and three drainage canals. As for the outflow, water is discharged out of the survey area through the following ways; 1R-21R lateral canal, the command area at the right bank of 2L-21R and at the left bank of 23R, and the Roeng Rang Yai drainage canal.

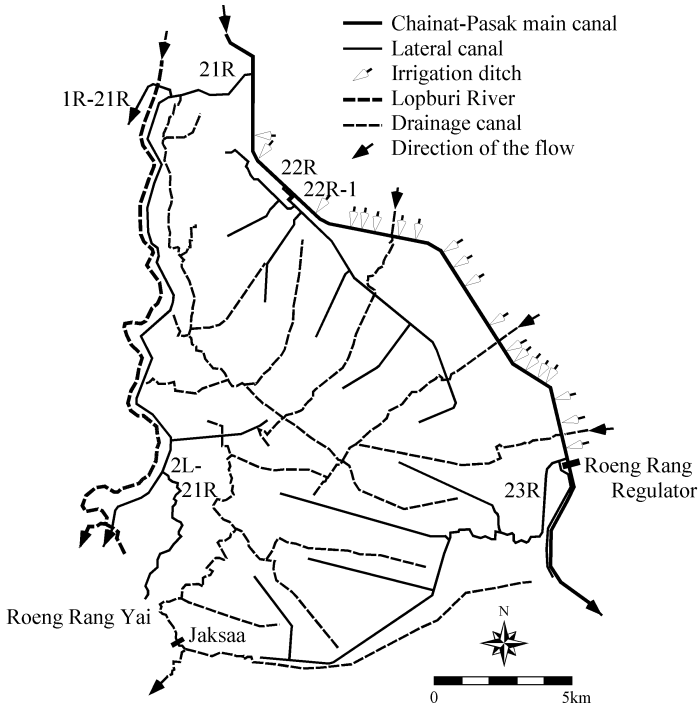


FIG. 2 LAYOUT OF SURVEY AREA

The inflow is estimated by subtracting the discharges in 1R-21R and the water distributed to the left bank of 23R and to the right bank of 2L-21R from the total discharge of supplied water to the survey area. The outflow is the discharge from the Roeng Rang Yai drainage canal at Jaksaa.

2.2.2 Calculation of discharge

The discharge in 21R, 22R and 23R was observed by each Project office every day and was used for the analysis. The discharge in other canals was calculated using discharge-stage relations. The water levels in the drainage canal at Jaksaa, in the main canal at 22R-1 and in the main canal upstream from the Roeng Rang regulator were recorded daily. The measurement of discharge in the related canals including 22 direct irrigation ditches was performed 5 times during the preparation of dry season rice. Based on the results, discharge-stage curves for the drainage canal at Jaksaa, 22R-1 and 22 direct irrigation ditches were developed.

The distributed water to the command area at the right bank of 2L-21R and at the left bank of 23R is estimated as the discharge in 2L-21R and 23R multiplied by the ratio of the command area of the right bank and left bank in the command area of each lateral canal.
The discharge in 1R-21R and 2L-21R was estimated based on the ratio of the measured discharge to the discharge of 21R during the preparation season. The discharge in the three drainage canals was estimated based on the measured discharge during the survey period.

2.3 Progress in rice planting

The authors recorded the area planted with dry season rice every two weeks over the survey area to identify the time the dry season rice was planted. For the area already planted at the survey site, the planting time was judged by the height or state of the rice plant.

3 Results and discussion

3.1 Water balance

Figure 3 shows the inflow and outflow in the survey area during the preparation of dry season rice, from the end of January to the end of March. It is obvious that both the inflow and the outflow are sharply fluctuating. Figure 4 shows the breakdown of inflow. The discharge in 22 irrigation direct ditches fluctuates more than that in the three lateral canals. This indicates that the discharge in 22 irrigation ditches is strongly subjected to the change in water level at the main canal since they have no intake gates.

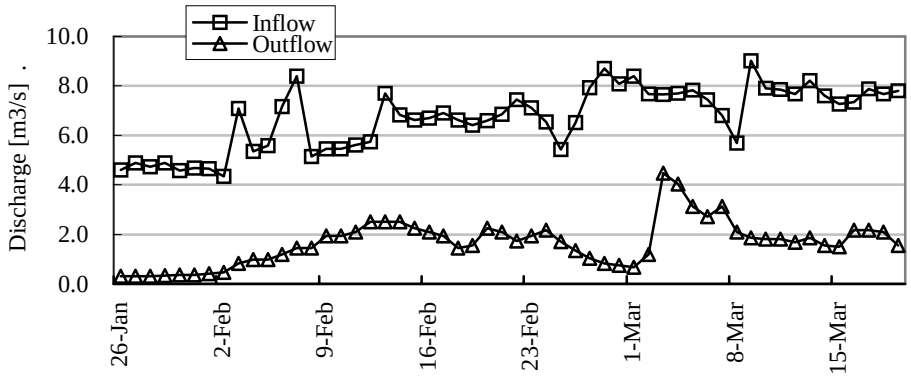


FIG. 3 INFLOW AND OUTFLOW FROM THE SURVEY AREA

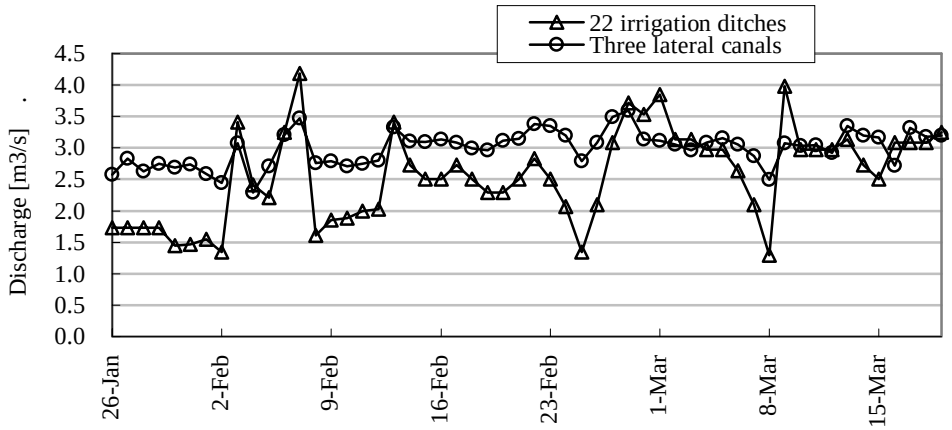


FIG. 4 BREAKDOWN OF INFLOW INTO THE SURVEY AREA

Figure 5 shows the intake intensity, which is the discharge divided by each command area. The total command area of 22 irrigation ditches and the three lateral canals are 2,738 ha and 9,640 ha, respectively. The intake intensity in 22 irrigation ditches is much higher and more widely fluctuating than that of the three lateral canals. The share of irrigation water in these direct ditches is substantial in spite of the small capacity in each ditch. The problem is that the intake for the ditches can not be controlled, while the lateral canals are properly controlled by the intake gates.

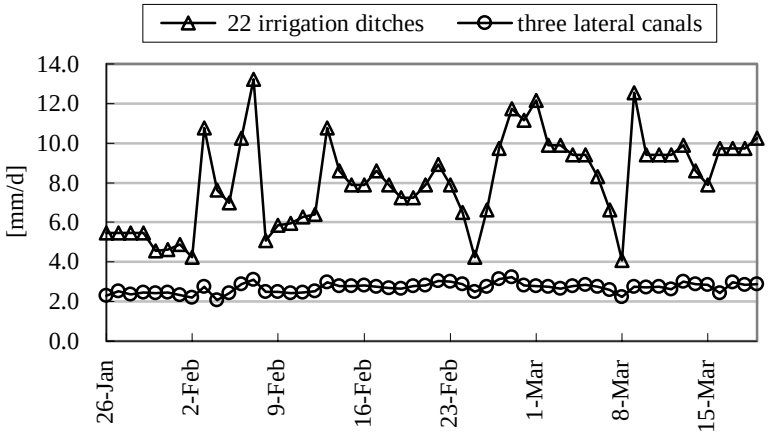


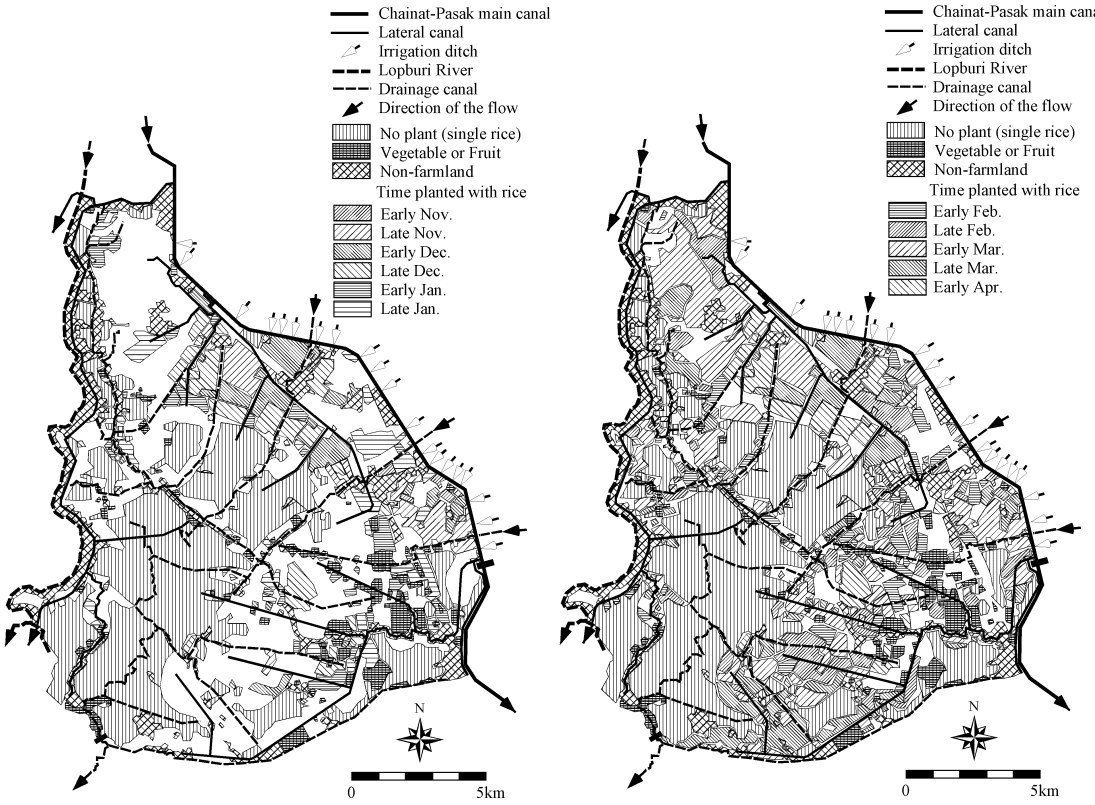
FIG. 5 INTAKE INTENSITY IN 22 IRRIGATION DITCHES AND THREE LATERAL CANALS

3.2 Progress in planting of dry season rice

The areas planted with dry season rice for each period of a half of a month are shown in Fig. 6. It is seen that rice was planted near the main canal before the dry season irrigation started, and the rice was planted there twice during the dry season. The area of the second-dry-season-rice reached 24% of the total area that was planted with rice during the dry season. The land use in the survey area is shown in Table 1. Most of the “No plant” area occupying about 30% of the whole survey area is the area used for deep-water rice that is planted once a year during the rainy season.

TABLE 1 LAND USE IN THE SURVEY AREA

	Rice-planted-area	No plant (single rice)	Vegetable or Fruit	Non-farmland	Total
Area [ha]	13,275	6,563	873	2,472	23,183
[%]	57	28	4	11	100



(As of late January, 2000) (As of early April, 2000)

Fig. 6 The classification of the rice-planted-area for each period of a half of a month

Figure 7 shows the transition of the rice-planted-area for each period of a half of a month. Rice planting proceeded rather constantly before late February and became most intensive in early March. Figure 8 shows the Rice-growing-area classified by the time of planting. Figure 8 gives a good explanation of the second-dry-season-rice. For example, if the rice was planted in late November, it would be harvested in early March and the area would soon be replanted with the second-dry-season-rice in late March.

The inflow and outflow in the survey area, shown in Fig. 3, seem to coincide with each other at the time lag of 4 days (Fig. 9). The fluctuation of outflow may be mainly caused by the fluctuation in the inflow through 22 irrigation ditches. However, the inflow pattern during the preparation season does not coincide with the progress pattern of rice planting. This means that the water intake was not well controlled according to the water demand for land preparation. It resulted in ineffective water distribution because the unexpected and sudden increase in the delivered water could not be effectively used by the farmers and it was discharged out of the project area.

FIG. 7 TRANSITION OF THE RICE-PLANTED-AREA FOR EACH PERIOD OF A HALF OF A MONTH

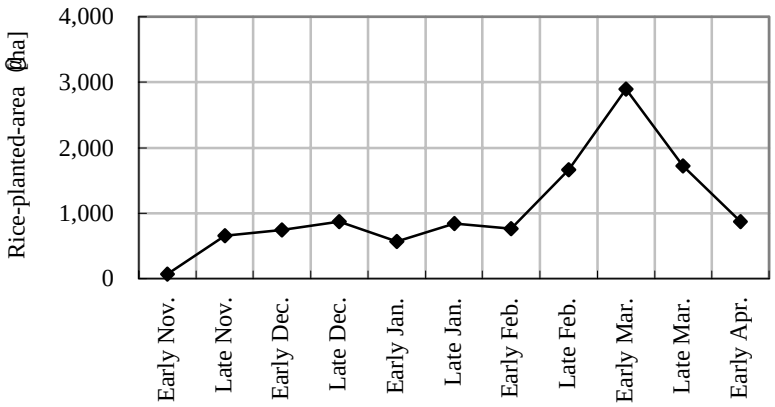
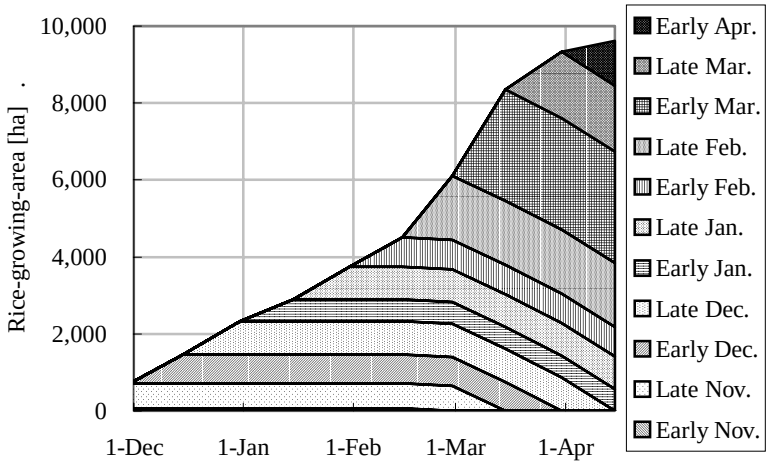


FIG. 8 RICE-GROWING-AREA BY THE TIME OF PLANTING



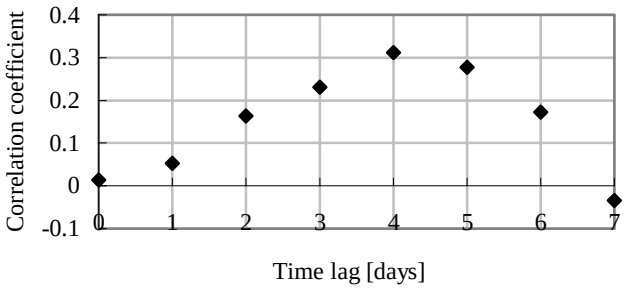


FIG. 9 CORRELATION BETWEEN INFLOW AND OUTFLOW

3.3 Water requirement for the preparation of dry season rice

The water requirement for the preparation of dry season rice in this area is designed at 274.5mm. The authors calculated the actual value based on the field survey mentioned above and the result of the calculation is shown in Table 2.

Total inflow and total outflow are calculated as the total inflow and total outflow from February to March, respectively. According to the Penman method, evapo-transpiration at the Khok Katiem project area for February and March is 152 and 177 mm/month, respectively. Total Evapo-Transpiration in the survey area is calculated by multiplying this value by the rice-growing-area. The stored water in the area is calculated by subtracting the total outflow and total evapo-transpiration from the total inflow. Dividing it by the rice-planted-area from February to March gives the water requirement for preparation.

The result of 120 mm is less than half of the designed value. This result may be informative for the improvement of water management in the irrigation system in the future. One of the reasons why the water requirement was small was that 24% of the planted area during this period was prepared just after the harvest of the first-dry season-rice, when the paddy soil was still wet.

TABLE 2 WATER BALANCE IN THE SURVEY AREA DURING THE PREPARATION OF DRY SEASON RICE, FROM FEBRUARY TO MARCH

Total inflow	[MCM]	36.4
Total outflow	[MCM]	9.6
Estimated Evapo-Transpiration	[MCM]	18.3
Stored water	[MCM]	8.4
Rice-planted-area from Feb. to Mar.	[ha]	7,046
Water requirement for preparation	[mm]	120

4 Conclusions

1) There are a lot of ditches without gates that take irrigation water directly from the main canal. The intake intensity in these ditches is very high and fluctuates sharply because of it being affected by the water level in the main canal. The share of irrigation water in the ditches is large enough to make the water intake unsteady, thus resulting in the difficulty in controlling the water distribution in the main canal.

2) Outflow was also sharply fluctuating. This indicates that the water supply didn't suit the water demand for the preparation of dry season rice.

3) The water requirement for preparation was estimated at 120mm, which was less than half of the designed value. This may contribute to the better understanding of the water use in the project areas.

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