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**Estimation of Water Requirement for Each Area
and Actual Water Allocation
–Referring to the Thailand gravity irrigation district (3)–**

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In the previous report, a water demand estimation model in upland field and paddy field was developed. In this paper, water demand of whole district where upland field and paddy field, etc. intermingle, namely the technique of water requirement estimation of the whole district, is developed.

As the result, that reuse of water ratio was 10–20% by comparing a water demand by the simulation with actual water supply, almost clarified. Developed gross water requirement estimation model had the good reproducibility.

INTRODUCTION

In the previous report, a water demand estimation model in upland field and paddy field was developed. In this paper, water demand of whole district where upland field and paddy field, etc. intermingle, namely the technique of water requirement estimation of the whole district, is developed. And, a water demand calculated by this technique is compared with actual water supply, and the model is verified.

The object region of district water requirement estimation is Sam Chuk of the Thailand gravity irrigation district. In this paper, Section 1 of the inside is analyzed as example.

By the method for developing in the previous report, irrigation water is calculated to the every crop. Gross water requirement (m^3/d) is obtained by multiplying the planted area in this. Gross water requirement of the whole district is obtained by totaling gross water requirement of the every crop. The gross water requirement is water demand which is necessary in the whole district. Actually, though the irrigation efficiency should be introduced considering conveyance loss of canal, etc., it is 1.0 this time, the efficiency shall estimate it.

PLANTING AREA TOTALING

It is convenient for the water management, if water demand is calculated, in making the block in which a check of water supply is possible to be a unit. In the regulator site, water level and gate opening are observed. It is possible to calculate discharge from the record of water level and gate opening. Therefore, we shall calculate water demand in

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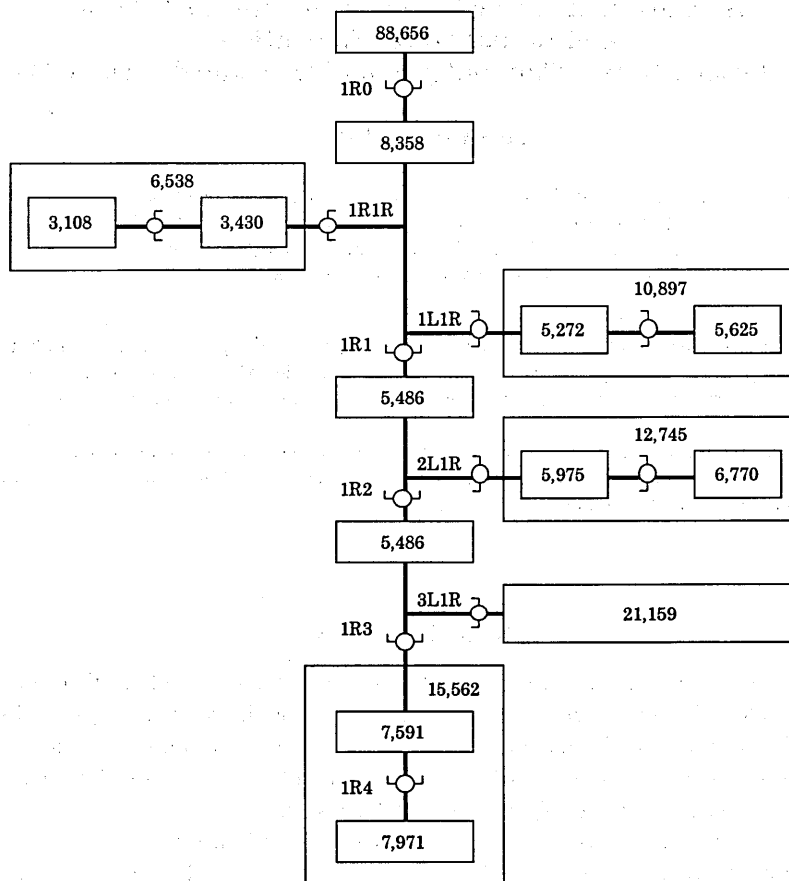


Fig. 1. Command area (rai) of each regulator in Section 1

every command area of the regulator. Section 1 is command area of 1R main canal, and it has been composed of nine zones. Command area (rai) of each regulator in Section 1 is shown in the block diagram in Fig. 1.

Planting area survey has been made in every zone. Example of result of converting planting area of every zone into planting area of every command area of each regulator is shown at Fig. 2(a) and Fig. 2(b).

ESTIMATION OF GROSS WATER REQUIREMENT

According to the above-mentioned definition, the estimate of district water requirement is shown by the following equation.

$$D_i = 1.6 \sum_{j=1}^n A_{ij} \cdot I_{ij} / \eta_j \quad (1)$$

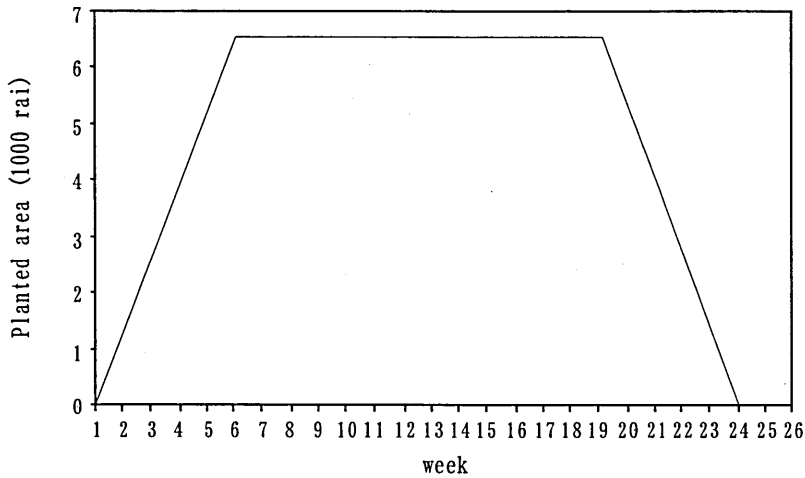


Fig. 2 (a). Change of totaled planted area (1R1R, 1990)

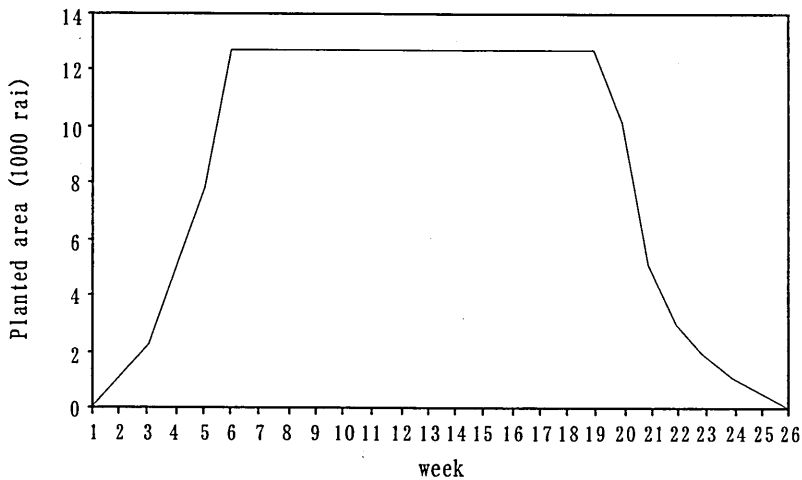


Fig. 2 (b). Change of totaled planted area (2L1R, 1990)

where i : day, j : crop number, n : type number of the crop, D_i : gross water requirement on i^{th} day (m^3/d), A_{ij} : planted area of crop j on i^{th} day (rai), I_{ij} : pure irrigation water of crop j on i^{th} day (mm/d) and η_j : irrigation efficiency of crop j . And, constant 1.6 is a coefficient for converting ($\text{rai} \cdot \text{mm}/\text{d}$) into (m^3/d) ($1 \text{ rai} \times 1 \text{ mm}/\text{d} = 1600 \text{ m}^2 \times 10^{-3} \text{ m}/\text{d} = 1.6 \text{ m}^3/\text{d}$).

It was assumed that the average depth of fish pond was 50 cm and that the water is changed in every 10 th. Therefore, the water of per day 50 mm was supposed to be sup-

plied.

The calculation example :

Next table is the data on regulator 1R1R, February 25th, 1991. On these data, we try to calculate gross water requirement. Still, rainfall in the day is 0.

Table 1. Calculation example of water requirement (1R1R, Feb. 25th, 1991)

Land Use	①	②	③	④	⑤
	Paddy	Upland Crop	Sugarcane	Fruits etc.	Fish pond
Planted Area(Rai)	379	128	345	40	32
Epenman	5.3	5.3	5.3	5.3	5.3
Kp(=ET/E)	—	0.8	0.9	1.0	0.5
Water Req.(I)	11.0	4.2	4.8	5.3	25.2
Irr. Efficiency (η)	1.0	1.0	1.0	1.0	1.0

$$\begin{aligned}
 D &= 1.6(11 \cdot 379 + 5.3 \cdot 0.8 \cdot 128 + 5.3 \cdot 0.9 \cdot 345 + 5.3 \cdot 1.0 \cdot 40 + 50.0 \cdot 32) \\
 &= 1.6(11 \cdot 375 + 4.2 \cdot 128 + 4.8 \cdot 345 + 5.3 \cdot 40 + 50.0 \cdot 0.32) \\
 &= 1.6(4125 + 537.6 + 1656 + 212 + 1600.0) \\
 &= 1.6 \cdot 8130.6 \\
 &= 13009 \text{ (m}^3\text{/d)}
 \end{aligned}$$

Like this, it is easy to estimate gross water requirement, if we can grasp only the planted area accurately. However, we have to consider irrigation efficiency, so we can expect that upland irrigation efficiency is about 0.6 from the viewpoint of furrow irrigation. If paddy water stored in a canal is used effectively, irrigation efficiency of paddy can be expected to be almost 1.0. Irrigation efficiency as a block which is near for the inlet will be small. It is future problem to clarify this value.

REGULATOR PASSAGE DISCHARGE

Distinction of flow type

Regulator is consists of gate and box or pipe. According to the relationship between up and downstream water levels, several flow conditions appear. Therefore, we have to adopt a suitable discharge formula to correspond with each flow condition. Fig. 3 shows various flow conditions in regulator.

Dimensions of Regulators

Up and downstream water levels, gate opening and the dimensions each regulator are necessary for calculating discharge. Table 2 shows the dimensions of each regulator.

Conversion of discharge(m³/s) to daily discharge(m³/d)

Considering all conditions of the superscription, after calculation of discharge (m³/s) using water level and gate opening data at each time, it is possible to calculate discharge in a day (m³/d) by integrating discharge at each time. We can use Simpson's formula to

Table 2. Dimensions of Regulators

Location	The Number	Size Width*Height (m)	Length of Pipe (m)	Max. of Discharge (m ³ /s)	Elevation of Sill (m)
1R 0.075	1	2.50*2.90		12.000	6.090
1R 13.200	1	2.00*2.40		7.550	5.310
1R 17.660	2	2.00*2.00	9.5	5.440	4.561
1R 22.300	2	2.00*2.00		4.270	4.410
1R 28.800	2	1.25*1.25	5.5	2.620	3.898
1R 35.325	2	ϕ 1.00	7.0	2.060	3.080
1R 11.700	1	ϕ 1.00	9.0	1.330	5.940
1R1R 3.350	1	ϕ 1.00	8.0	0.643	5.330
1R1R 7.000	1	ϕ 0.50	8.0		
1R 13.200	1	1.75*1.50	13.0	2.730	5.458
1L1R 3.950	2	ϕ 1.00	7.0	2.205	5.995
1L1R 7.620	1	ϕ 1.00	8.0	1.245	5.680
1R 17.650	2	ϕ 1.00	14.0	1.547	5.345
2L1R 4.300	2	ϕ 1.00	10.0	1.280	4.770
1R 22.100	2	ϕ 1.00	10.5	3.106	4.968

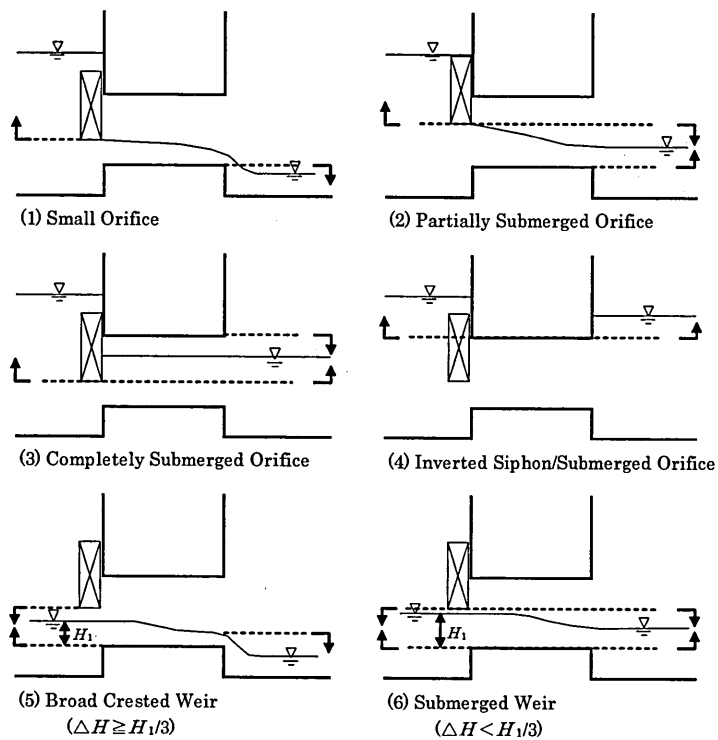


Fig. 3. Various flow conditions in regulator and applicable formulas
 ΔH : the difference in water level between up and downstream.
 H_1 : overflow depth upstream.

integrate discharge.

$$Q = \frac{\Delta t}{3} (q_1 + 4q_2 + q_3)$$

where q_1 , q_2 and q_3 are a series of discharge. Δt is a time interval, and it is 3 hours in this case. There are 5 measured data, which are taken data 6, 9, 12, 15 and 18 o'clock. By interpolation between yesterday's and tomorrow's data, it is possible to calculate discharge at 0, 3, 21, 24 o'clock.

WATER DEMAND AND ACTUAL WATER ALLOCATION

Referring to command area of 1R1R and 2L1R, the comparison between water demand by the simulation and actual water allocation is shown in Fig. 4(a) and Fig. 4(b). In these figures, July–October is a rainy season, and November–December is the dry season. Only the paddy rice is almost cultivated in Section 1.

We adopted intermittent irrigation system as paddy field irrigation system in the simulation of Fig. 4(a) and Fig. 4(b). In this district, this system is general.

According to Fig. 4, simulation and actual condition agree almost by August–October. In Fig. 4, there is the slippage in which some between simulation and actual condition is time-related in August–September, and it agrees with averagely observing, almost. In short, the supply shortfall in August seems to have been solved in September.

In Fig. 4(a) and Fig. 4(b), there is actual water supply after the middle of month November, but water demand by the simulation becomes 0. Though the cultivation of the field crop is carried out, after the paddy rice is harvested, actually, it is a cause that the data of the planted area is insufficient.

And, actual water supply surpasses a water demand by the simulation in both of Fig. 4(a) and Fig. 4(b) by July the middle of month. It is because it is changed to a water demand generation from the planting start in the simulation, in spite of taking water from the stage of puddling actually. Then, considering this fact, by assuming that the planting time was made early week, the simulation was carried out. The result is shown at Fig. 5(a) and Fig. 5(b). According to Fig. 5(a), there is the coincidence in which water demand by the simulation and actual water supply are good in July. According to Fig. 5(b), the time-related slippage was solved in July, but water demand by the simulation increased from actual water supply.

Generally, diversion requirement for paddy area is shown by the following equation.

$$\begin{aligned} &(\text{Diversion requirement for paddy area}) = (\text{Net water requirement}) \\ &+ (\text{Conveyance loss}) + (\text{Delivery water requirement}) - (\text{Reuse of irrigation water}) \end{aligned}$$

Water demand by present simulation and actual water supply agree almost. It is indicated that (water conveyance loss + delivery water requirement) is almost equal to reuse water for this fact. Return flow was 10–20% of paddy field water requirement from the observation result of paddy field percolation of previous report. It becomes 10–20% also reuse ratio return flow using ratio 100% reuse water assume.

In this district, the weir is established at the drainage canal end, and by piling sand-

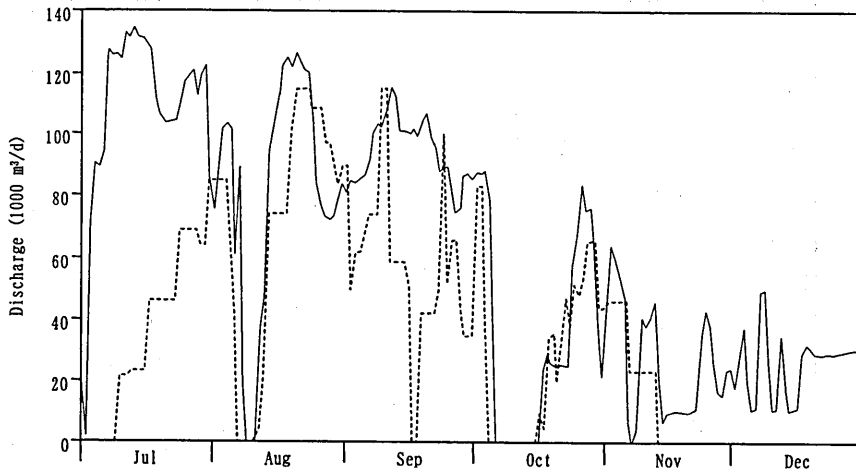


Fig. 4 (a). Water demand by simulation and actual water allocation (1R1R, 1990)
(solid line : Actual water supply, broken line : Simulated water supply)

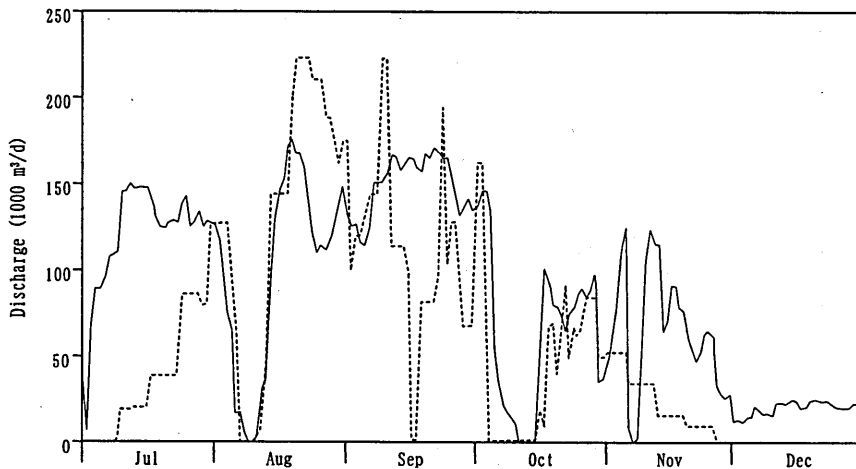


Fig. 4 (b). Water demand by simulation and actual water allocation (2L1R, 1990)
(solid line : Actual water supply, broken line : Simulated water supply)

bag, it would not flow in the downstream, it is stored in the drainage canal, and in the drainage canal side paddy field, reuse of water of taking water from the drainage canal has been made. The result that water demand and water supply are almost equal is an appropriate result, when that advanced reuse of irrigation water has been made is considered. And, the simulation can be also called considerably reproducing the actual condition well.

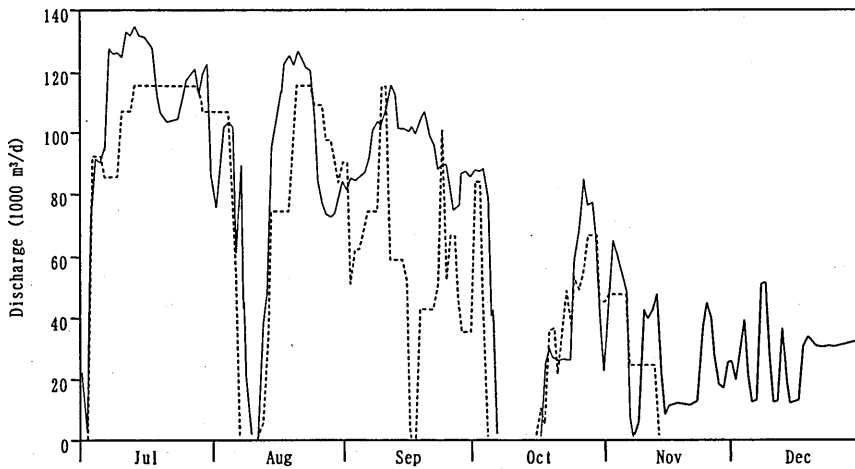


Fig. 5 (a). Water demand by simulation considering paddling season and actual water allocation (1R1R, 1990) (solid line : Actual water supply, broken line : Simulated water supply)

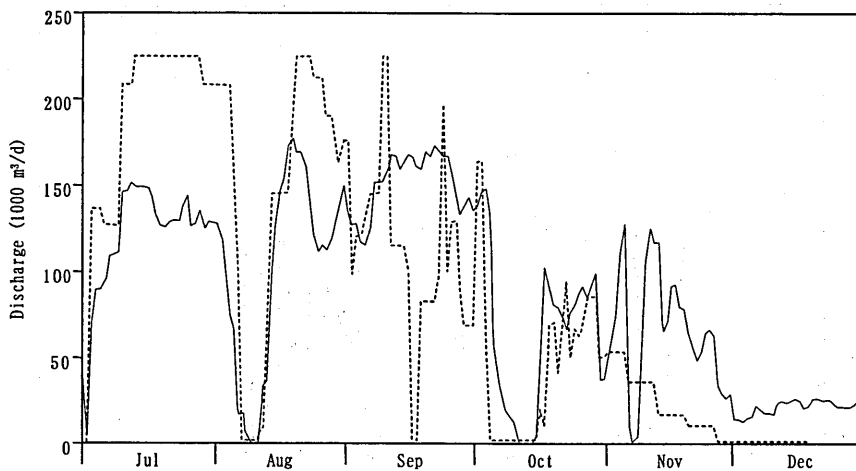


Fig. 5 (b). Water demand by simulation considering paddling season and actual water allocation (2L1R, 1990) (solid line : Actual water supply, broken line : Simulated water supply)

CONCLUSION

Estimation technique of gross water requirement and calculation technique of actual water supply were established. That reuse of water ratio was 10–20% by comparing a

water demand by the simulation with actual water supply, almost clarified.

And, that developed gross water requirement estimation model had the good reproducibility clarified.

It is important to raise the accuracy of the planted area of each cultivated crop in the water requirement calculation in the district where the cultivated crop changes.

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