大規模水田灌漑地区における反復水利用システムの導入とその効果
An analysis of characteristics and effects of a water reuse system installed in a large paddy irrigation scheme in Japan

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1-Introduction

The rapid population growth rate these recent decades, especially in Africa countries, faces food security challenges. Since the 1970s, several countries have developed agricultural strategies aimed at maximizing grain yield. Given the finite water resources, in the agriculture sector with the most significant demand, efficient water use is required to improve productivity.

Many efforts have been implemented to increase water efficiency, especially in large paddy irrigation schemes like PIM (Participatory Irrigation Management), water reuse system, etc. Regarding the large paddy irrigation system, Okamoto (1978) has already developed the method for estimating the total water requirement by evaluating the water reuse systems among small irrigation blocks.

Despite valuable research as above, the actual water reuse system analysis for the large paddy irrigation schemes is not so many. The characteristics of the actual reuse units (size, location, etc.) have not been adequately clarified.

In this research, we selected Oka Zeki LID as a large paddy irrigation scheme in Japan, clarified the actual water reuse system among small irrigation blocks in it, classified the types of water reuse system, and analyzed their characteristics. We also evaluated the reuse system's effects for improving irrigation efficiency and water management by the LID.

2-Methodology

Two water reuse systems of Oka Zeki irrigation scheme (previous and current system) were analyzed. The current system has installed much more water reuse units than the previous one. Two conceptual maps were made for each reuse system, respectively, based on the plan for Oka Zeki irrigation scheme rehabilitation project (1960) and the irrigation- drainage-block map of LIDs. We also interviewed LID officials to confirm the irrigation and drainage network.

Using the conceptual maps, we classified the blocks in type according to the location, size, and connections. Additionally, using water balance approach with the conceptual maps, we made a simulation focusing on the maximization of irrigable areas.

3-Outline of the research areas

Oka Zeki irrigation scheme located in Toride city (Ibaraki Prefecture) covers around 1600 ha with a water right of 9.22 m3/s from Kokai River. Due to large withdrawals from the Fukuoka dam upstream, Oka Zeki long suffered from water shortage. Under the scarce water condition, the farmers' water association based on the governance of local village “Mura” has implemented fair water distribution among irrigation blocks. With economic development from the 1980s, many farmers began to work in cities for other jobs, which negatively impacted Mura’s governance. For ensuring the continuity of equal water distribution, the reuse system was installed in the 1980s, putting 704 hectares under water reuse. To date, 852 ha are under reuse.

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4- Results and discussions

According to the conceptual maps, it was clarified that the scheme areas had been divided into 63 blocks based on the Mura boundary with five reuse blocks totaling 148 ha, drawing water from the drainage canals. With the reuse system improvement in the 1980s, LID started extending the reuse system, installing small pumping stations along the main drainage canal. Currently, the system is redivided into 96 blocks, and 21 pumping stations are supplying reuse water to 52 blocks. Based on water available from the drainage canal, the location in Up/Downstream, and the block sizes, the reuse systems were classified into three types, as shown in Table 1.

The simulation with four different available water conditions was executed for each conceptual model, as detailed in Table 2. The irrigation efficiencies of both systems were calculated following the procedure below.

1) The assumption of 20 mm/d of water applied, and 5 mm/day as evapotranspiration
2) Ratio approach: dividing available water according to irrigable areas ratio, from the main canal to secondary canal.
3) Upstream 1st –downstream 2nd approach: Upstream first and downstream the next approach focusing on water distribution from the secondary canal to each block.

The water requirement computation obtained from each system's result shows that 3.35 m3/s is required for the previous system against 2.12 m3/s for the current system. Installing the water reuse system, Oka Zeki has succeeded in decreasing its water requirement by up to 40%. In addition, irrigation efficiency has been improved from 27% to 42%.

5-Conclusions and Perspectives

Based on the Mura boundary Oka Zeki irrigation scheme has been redivided from 63 blocks to 96 blocks. From 5 to 52 blocks water reuse system has been installed with pump stations as a countermeasure for distributing sufficient water to downstream areas.

Table 1 Types of water reuse units in Oka

Types	Areas, location	Characteristics
A 	Downstream 328 ha 16 Blocks	With average size of 20 ha type A (Drainage canal to irrigation canal to several blocks) is in downstream areas to solve the water shortage in downstream. Also, the combination of 2 types A and B is implemented to solve water scarcity problem in the most affected areas
B 	Up and downstream 486 ha 26 Blocks	The type B (drainage canal to blocks), in up and downstream has average size of 20 ha. More located in downstream, around 70 % its is installed regarding the availability and demand of water in downstream drainage canal. Regarding the average size of the blocks, its corresponding to the size of one village. As an established structure water management for each mura is decided according to the availability of water.
C 	Up and downstream 38 ha 10 Blocks	Type C (drainage canal to irrigation canal to one block with average size of 4 ha) is mainly located in the downstream areas within a block. This type is installed to meet a water stress point in a particular big block.

Table 2 Irrigable areas simulation in Oka Zeki

Available water Q (m^3/s)	Previous system areas (ha)		Current System areas (ha)	
4	1598	100%	1598	100%
3	1445	90%	1598	100%
2	1013	63%	1511	94%
1	508	31%	851	53%

Three types of reuse systems have been installed responding to water scarcity conditions, reuse efficiency, available water in the drainage canal, and boundary of each village.

Reuse system in Oka Zeki irrigation scheme improves 1.6 times irrigation efficiency.

The LID and farmers' labor works for water management have been decreased, but the cost of installing and the required energy will become higher. Then the research on energy efficiency should be done.

Reference

Okamoto M (1978), Yojoki no Hitsuyou Suiryou, Suiri no Kaihatsu to Chosei, Jicho-sha, 597-608