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Water reuse and cost-benefit of pumping at different spatial levels in a rice irrigation system in UPRIIS, Philippines

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Abstract

As agricultural water resources in Asia become increasingly scarce, the irrigation efficiency of rice must be improved. However, in this region there is very limited information available about water use efficiency across spatial levels in irrigation systems. This study quantifies the volume of water reuse and its related cost-benefits at five different spatial levels, ranging from 1500 ha to 18,000 ha, under gravity-fed irrigation system in Upper Pumpanga River Integrated Irrigation System (UPRIIS), Philippines. The major sources of water reuse are considered, namely groundwater pumping, pumping from creeks, combined use and irrigation supplies from check dams. The volume of water available from all four sources of water reuse was quantified through extensive measurements. Production functions were developed to quantify water-yield relationships and to measure the economic value of water reuse. This study was conducted during the dry season of 2001, which existed from 19 November 2000 until 18 May 2001.

The water reuse by pumping and check dams was 7% and 22% of the applied surface water at District 1 level. The reuse of surface water through check dams increased linearly with 4.6 Mm^3 per added 1000 ha. Similarly, the total amount of reused water from pumping is equivalent to 30% of the water lost through rice evapotranspiration during the dry season 2001. The results showed that water reuse plays a dominant role in growing a rice crop during the dry season.

The result showed no difference in pumping costs between the creek (US\$0.011/m^3) and shallow pumps (US\$0.012/m^3). The marginal value of productivity (MVP) of water reuse from creek (US\$0.044/m^3) was slightly higher than the water reuse through the pumping ground water (US\$0.039/m^3). Results also indicated that the total volume pumped per ha (m^3/ha) was ranging from 0.39 to 6.93 m^3/ha during the dry season.

The results clearly indicate that the quantification of amount of water reuse is very crucial for understanding and finding of water use efficiency at the irrigation system level. The results also revealed that rice production systems are still profitable despite high pumping costs and other associated expenses at all spatial levels in District 1. More than 1500 farmers, from a total of 10,000, use 1154 pumps to draw water from shallow tube wells (or from drains and creeks) for supplementary irrigation at a District level. Reuse of water plays a vital role in growing a profitable rice crop during the dry season.

Keywords: Cost-benefits; Creeks; Check dams; Pumping; UPRIIS; Water reuse; Philippines

1. Introduction

Asia's food security relies largely on 79 million ha of irrigated rice, which account for 75% of the annual world rice supply (Dawe, 2005). This production consumes a high

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proportion of freshwater available for irrigated agriculture. However, water use efficiency of rice is low, and growing rice requires large amounts of water. Improving water use efficiency and water productivity requires a complete understanding of water balances at various scales such as field, farm, and irrigation system level. Irrigation efficiency is the most commonly used term to describe how well water is being used within a system (Molden and Sakthivadivel, 1999). However, many scientists (Bagley, 1965; Bos and Wolters, 1989; Van Vuren, 1993; Palacios-Velez, 1994; Keller et al., 1996) caution on the possible misconceptions on irrigation efficiency with regard to the broader spectrum of irrigated agricultural systems and river basins. For example, water lost from an individual farmer's field can be reused further downstream and is thus not lost to the whole irrigation system.

Principally, the water that flows out of a field into creeks, groundwater, or downstream areas can possibly be reused. This water can be reused by blocking creeks and diverting the water into new irrigation canals, or by direct pumping from creeks and drains, or by pumping from the (shallow) groundwater. In this way, one farmer's water loss may be another farmer's water gain (Seckler, 1996). In view of this possibility, water use efficiency at the system level is deemed higher than at the individual field level. Molden (1997) pointed out several weaknesses given the existence of scale effects and presented a common water accounting framework.

Reuse of water can be practiced at the farm level, irrigation system level, and regional level, provided the water is of good quality. It is noted, however, that recapture and reuse of water that is "lost" upstream mostly involves additional investments and operation costs, such as pumping or the building of dam's downstream (Guerra et al., 1998). Moreover, the potential for water reuse depends upon a number of factors, such as topography, sub-surface hydrology, and quality issues (Seckler, 1996). Eventually, a complete cost-benefit analysis for water reuse at different spatial levels is required to assess feasibilities of recovery.

Reuse of water offers an effective way to increase the water use efficiency and productivity of an irrigation system. Seckler et al. (1998) stated that recycling of water occurs for both agricultural and non-agricultural uses in irrigation systems and its importance is often ignored. Guerra et al. (1998) reported that recycling is being practiced in rice irrigation systems of many countries, while Zulu et al. (1996) reported that average drainage water reuse was about 14–15% of the original irrigation water inflow in a rice irrigation system in Niigata Prefecture, Japan.

Water accounting concepts have been tested and methodologies developed to quantify the water use and water productivity in surface irrigation systems in India, Pakistan and Sri Lanka (Loeve et al., 2002). Similarly, result of studies carried out at different spatial scales (i.e. micro, meso, main canal section and whole irrigation system) in Zhanghe Irrigation System (ZIS), showed that secondary storage and reuse of water are of crucial importance in increasing the overall system-water productivity (Dong et al., 2001; Loeve et al., 2002). However, literature on the quantification of water reuses from different sources and its associated cost-benefits at different spatial levels in irrigation systems in Southeast Asia is rather limited (Hafeez, 2003). Hardly any estimates exist that quantify and analyze the costs and benefits of water reuse at different spatial levels.

This study focuses on irrigated rice systems in the Philippines, where irrigated rice accounts for 61% of the 3.4 million ha rice production area. This paper concentrates on the estimation of the total amount of water reused and its associated cost-benefit relation during the dry season of 2001, at five different spatial levels in the rice-based irrigation system of District 1 of the Upper Pampanga River Integrated Irrigation System (UPRIIS). Specifically, this study was conducted to: (a) quantify the current level of water reuse from creeks, groundwater, combined use and check dams; and (b) to estimate and compare the costs and benefits of water reuse from pumping groundwater, creeks, combined use and surface water reuse from check dams.

This paper consists of five main sections. The first section provides background information and the problem statement. The second section gives an overview of the study area, water balance, different sources of water reuse, sampling and data collection, and data sources. Section 3 deals with the economical methods for the estimation of costs of water reuse, and cost-benefit relations of pumps. In Section 4, the results, discussion and findings of the models are presented. Finally, Section 5 reports the summary, conclusions and implication of this study.

2. Materials and methods

2.1. Description of study area

UPRIIS lies in central Luzon, the Philippines, and covers an area of 102,000 ha. This system produces an average of 63 million tons of rice every year. The system receives its water from a combination of various run-of-the-river intakes and the large Pantabangan reservoir. UPRIIS is divided into four irrigation districts and this study was conducted in the area known as District 1 (Fig. 1). District 1 has a total area of 28,205 ha including rice fields, upland crops, vegetables, roads, settlements, and water bodies. It is bound by the Talavera River in the east and the Ilog Baliwag River in the west, and consists of an upper part, called the Talavera River Irrigation System-Lower (TRIS-L), and a lower part, called the Santo Domingo Area (SDA). TRIS-L receives its water directly from the Main Diversion Canal No. 1. Part of the water from the Main Diversion Canal No. 1 is diverted into the Sapang Kawayan creek, which also collects drainage water while it traverses TRIS-L. In the lower part of TRIS-L, the De Babuyan check dam raises the water level in the Sapang