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ECONOMIC VALUE AND SERVICE FEE OF IRRIGATION WATER IN THE DISTRICTS BOGOR AND KUDUS, INDONESIA

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ABSTRACT

Water resource is increasingly scarce, while demand for water is continuously increasing with the expanding population and rising prosperity. Increasing water scarcity has constrained irrigated rice production, particularly in the most highly stressed areas of Java island. Rising demand for water from both agriculture and other sectors leads to competition for water, resulting in environmental stress and socio-economic tension. Main objectives of the paper are to estimate the economic contribution of the irrigation water and to identify the farmers' willingness to pay for the irrigation water fee to improve the conditions of the irrigation water infrastructure and services. A survey to 75 farmers was conducted in two villages in the districts of Bogor and Kudus to answers those objectives. The results indicated that thought the estimated economic values of irrigated water on rice farming system were in fact greater than the current irrigation water fees, most of the farmers didn't pay for the water charges set by the water users associations. However, whenever there was a government program to improve the tertiary irrigation infrastructure, to improve irrigation water services, the farmers were willing to pay for this effort. The value of WTP was even greater than the existing water fee, implying that that there was potential farmers' surplus that could be used to improve irrigation water services in the villages.

Keywords: irrigation water value, irrigation service fee, residual method, willingness to pay (WTP), stated preference method, determinant of WTP, logit model

INTRODUCTION

While demand for water for both agriculture and non-agriculture is continuously increasing, water resource is in fact increasingly scarce. These have raised the issue of sectoral water allocation. Irrigated agriculture, particularly in developing countries, plays a vital role in contributing towards domestic food security, labor absorption and poverty alleviation. Therefore, achievement of this objective is dependent on adequate allocation of water to agriculture.

Food and agriculture are by far the largest consumers of water. FAO (2012) reported that volume of water for food and agriculture is one thousand times greater than that of drinking water and one hundred times greater than that of meeting basic personal needs. As population keeps increasing, more food and livestock feed need to be produced in the future and more water applies to this purpose. FAO (2003) projected that water withdrawals for irrigation in developing countries are expected to increase by an aggregated 14 percent until 2030, while irrigation water use efficiency is expected to improve by an average 4 percent.

Rosegrant et al. (2002) reported that irrigated agriculture was the dominant user of water, accounting about 80% of global and 86% of developing country water consumption in 1995. In context of Indonesia, FAO (2012). Aquastat database indicated that agricultural water withdrawal accounted for 93 km^3, about 82% of the total water withdrawal (113 km^3) in 2000, while municipalities (for drinking water) and industries accounted for 13 km^3 (12%) and 7 km^3 (6%), respectively.

Rice is the dominant staple food of Indonesians. Indonesia's rice production increases over time. In 2013, Indonesia produced 69.27 million metric tons (MMT) of rough rice (paddy) from both wetland and upland areas (Ministry of Agriculture, 2014)[1]. Wetland rice (*padi sawah*) production reached 65.44 MMT (94.4%) from 12.31 million ha of harvested areas. Rice is also known as one of the water intensive crops in the agricultural sector. The global average paddy virtual water content is 1,552 liter/kg of paddy, while the global volume of water use for rice production is estimated to be 919 km^3/year (Mom, 2007). Mom added that, for Indonesia, the average paddy virtual water content is 1,531 liter/kg. Increasing water scarcity has constrained irrigated rice production, particularly in the most highly stressed areas such as Java island. Java is only 7% of total land area of Indonesia, but it is inhabited by 65% of Indonesia's total population and contributed about 54% of total national rice production. Rising demand for water from both agriculture and other sectors is leading to competition for water, resulting in environmental stress and socio-economic tension. When rainfall is inadequate and new water development is not feasible, agricultural production is expected to be constrained more by water scarcity than land availability (FAO, 2011).

This paper raises three research questions on the economic value of irrigated water on rice production in Indonesia, particularly in Java. First, since irrigation water is increasingly scarce, while its demand is continuously increasing, it is rational to classified irrigation water as an economic good. Thus, there should be price for water. However, there is no irrigation water "price" in Indonesia. Irrigation service fee (ISF) is the only available reference for the value of water and it is set to meet only operation and maintenance (O&M) costs of the tertiary irrigation canals, whereas the O&M costs of the primary and secondary canals are borne by the central and local government. In addition, this fee is determined based on the area and cropping season (rupiahs per hectare per cropping season), and not volumetric base. The farmers have to pay the ISF to maintain the function and quality of the tertiary irrigation infrastructure. However, most of the farmers in the irrigation areas of Java do not pay, thought the ISF are relatively low. This raised a basic research question: how much is the contribution of irrigation water in creating the total value product *i.e.,* economic value of rice produced by utilizing the water? Is it lower than the ISF, thus they can not afford to pay the service fee?

Previous studies (Syaukat and Siwi, 2009) indicated that most of the farmers in Yogyakarta were not willing to pay for the ISF because of unsatisfactory water delivery and services provided by the water users association (*Perkumpulan Petani Pemakai Air* or P3A – agency who is responsible to manage irrigation water services, rather than the first factor, low economic contribution of the irrigation water. If this condition applies in the current research sites, it raises the second question: if the tertiary irrigation canals could be improved to supply sufficient quantity of water to their lands, are they willing to pay for it? If so, by how much they are willing to pay. Finally, what are determinant factors affecting them to pay the irrigation service fee?

Based on the above research questions, there are five specific research objectives to be achieved in this paper: (1) to estimate the economic contribution of the irrigation water, (2) to identify the determinants of farmers' willingness to pay (WTP) for the irrigation water charge to improve the conditions of the irrigation water services, (3) to estimate the values of the farmers' WTP to improve

[1] Online Agricultural Database, http://aplikasi.pertanian.go.id/bdsp/hasil_kom.asp

the conditions of the irrigation water services, (4) to identify the factors affecting the value of farmers' WTP, and (5) to recommend irrigation water fee system that could be implemented in the region to improve the performance of irrigation system and farmers' welfare.

LITERATURE REVIEW

Irrigation Water Pricing Methods

The proclamation of water as an economic good in 1992 was indeed a compromise between those who wanted to treat water in the same way as other private goods, subject to allocation through competitive market pricing, and those who wanted to treat water as a basic human need that should be largely exempted from competitive market pricing and allocation (Perry et al. 1997). The issue of irrigation water pricing has also continuously increased, with increasing awareness of water scarcity and greater appreciation of the opportunity costs of allocating water among competing uses. Irrigation water pricing has an implication on the issue of sustainability. If farmers pay only for the current costs of O&M of the public irrigation facility, revenues will fall short of the amount needed to rehabilitate the system and invest in new features over time (Wichelns, 2010). Water pricing is an important way of improving water allocation and encouraging user to conserve scarce water resources. Water price, which accurately reflects water economic value, could provide information to the water users in making decision regarding water consumption and use. Water pricing will affect the efficiency of water use.

There are some prevailing irrigation water pricing methods, including volumetric, non-volumetric, and market-based pricing methods (Tsur et al. 2004). Under volumetric pricing model, the charge for irrigation water is based on consumption of the actual amounts of water. The requirement for valuing water under this method is a measure of the volume of water consumed from an irrigation system. This information is collected by an authority (in this case P3A), who sets the prices, monitors use and collects fees. Non-volumetric measures are based on output, input, area, and land values. These pricing methods are used in situations where volumetric pricing is either unfeasible or undesirable.

Irrigation Water Pricing in Indonesia

Irrigation water service in Indonesia is managed by the Ministry of Public Works. In Java, the Ministry has developed some big and multipurpose dams for irrigation, electricity generation, flood control, tourism, aquaculture, and to provide raw water for municipalities and industries. The Ministry has also established two state own enterprises to manage the water i.e., *Perum Jasa Tirta* (PJT) I which operates at Brantas River Basin in East Java and PJT II which operates at Citarum River Basin in West Java. These two PJTs are becoming agencies that allocate the basin water to multi users, both agriculture and non-agriculture.

Irrigating farmers in those areas currently pay no volumetric tariff for water. The basin water allocation agencies recover their recurring costs via higher tariffs to municipal water supply companies and industrial users. This policy has a double edge, since when water is scarce, farmers are the first to see supplies curtailed (Pasandaran, 2006 and Rodgers and Hellegers, 2005). The farmers are subject to an irrigation service fee (ISF), payable to the local water users association (P3A). The ISF program was intended to generate operating funds for system maintenance and rehabilitation. Irrigated land is subject to a flat, area based fee calibrated to reflect desired level of operation and maintenance, land productivity, and the ability of farmers to pay. In practice, the target ISF fall in the range of $1.4–1.6 (Rp 12,000–14,000) per hectare per cropping season for wetland crops, mostly rice. From its introduction in the early 1990's through the mid-1990's both ISF area coverage and collection efficiency improved, reaching a maximum in 1994/95 with a collection efficiency of 53.5

percent. Following the Asian Financial Crisis (1997/98), collections were effectively suspended in the Brantas (Rodgers and Hellegers, 2005).

DATA AND METHODOLOGY

Survey Location

Research surveys were conducted in two areas: Irrigation Areas (*Daerah Irigasi* or DI) of Cisadane-Empang in the District of Bogor, West Java and DI Klambu in the District of Kudus, Central Java. Both districts are important contributors of rice in each province. Total area of DI Cisadane-Empang is about 1,052 ha located in the districts of Bogor and Depok, West Java. Pasir Gaok Village in the District of Bogor is selected to be the location of survey since it is the largest agricultural production area, which includes 544 ha of irrigated land. In addition to irrigation, the water is also used for industries and households.

Klambu Kanan Wilalung irrigation area (DI Klambu for short) has a total area of 7,300 ha, and located in 3 districts: Kudus, Pati, and Grobogan, in Central Java. The source of water for this irrigation area comes from Kedung Ombo Dam. The survey is located at Ngemplak Village in the district of Kudus, which has 420 ha of irrigated areas.

Sampling Method

Respondents for this survey are randomly selected from the members of water user association (P3A) in both survey villages. Total respondents consist of 75 farmers, which are selected from the list of members of P3A. Distribution of the respondents is: 45 farmers in Pasir Gaok Village and 30 farmers in Ngemplak Village. The respondents are then classified into three groups based on the land area: < 0.5 hectare; 0.5 – 1.0 hectare; and > 1.0 hectare. The number of respondent in each P3A is in fact relatively high, since the total member of farmers in each P3A is relatively small *i.e.,* 68 and 53 farmers, respectively.

Methods of Analysis

(1) Economic Value of Irrigation Water

A simple approach to valuing water is to impute or assign net profits to water as an input after subtracting from crop revenue all the cost of all agricultural inputs except water (Young, 2005). This method assumes that water is the critical input for production, so that all residual profit is lost if water input is absent, reflecting water's opportunity cost or economic value. It is susceptible to large variations in profitability between crop types and farm sizes.

Farmer objective is assumed to be profit maximization from using some inputs to transform them into agricultural product *i.e.*, rice. A central assumption of the standard model is that a production function serves as the technical description of the farm. Assume that rice production (Y) is a function of five variable inputs: seed (S), fertilizers (F), pesticide (P), labor (L) and water (W). Rice production function is:

$$Y = f(X_S, X_F, X_P, X_L, X_W) \qquad (1)$$

Assuming that the prices of inputs are known and fixed, the profit (income) function of the farmer can be written as:

$$\Pi = Y.P_Y - (P_S.X_S + P_F.X_F + P_P.X_P + P_L.X_L + P_W.X_W) - K \qquad (2)$$

where Y is rice production, X_i is quantity of input i, P_Y is rice price, P_i is input i prices and K is fixed costs. $Y.P_Y$ is the total value product (TVP). Production function Y is assumed to be twice-differentiable in all input argument. Thus, the conditions for profit maximum are:

$$\frac{\partial \Pi}{\partial X_i} = P_Y \frac{\partial Y(.)}{X_i} - P_{Xi} = 0 \quad \text{for all inputs i} \qquad (3)$$

Equation (3) implies that in order to maximize the profit, the farmers have to equate the value of marginal product (VMP) of every input i with its input price. VMP represents the additional value of the product resulted from a change in the use of input i, which is $P_Y\ \partial Y/\partial X_i$, in which $\partial Y/\partial X_i$ is the marginal physical product of the input i.

VMP provides a key measure of producer welfare. For non-market valuation of a producer's good, such as irrigation water, residual imputation method has been the most frequently used approach to approximating VMP. The residual method finds the value of water as the reminder or net income after all other relevant costs are accounted for. The basic residual method can be derived by applying the Wickstead product exhaustion theorem (Young, 2005). It can be adapted to estimate VMP via model of input demand derived in equations (1) to (3). The theorem can be expressed: the sum of the value of marginal products (VMP_i), each weighted by the amount of corresponding input (X_i), will exactly equal the total value of product.

$$Y.P_Y = VMP_S.X_S + VMP_F.X_F + VMP_P.X_P + VMP_L.X_L + VMP_W.X_W \qquad (4)$$

By substituting P_{Xi} for each of the value of VMP_i - from equation (3) - into equation (4) and rearranging:

$$P_W.X_W = Y.P_Y - (P_S.X_S + P_F.X_F + P_P.X_P + P_L.X_L) \qquad (5)$$

$P_W.X_W$ measures the contribution of irrigation water to TVP. When the volume of irrigation water (X_W) is known, a unit value of water (P_W) can be measured. It is usually termed the "value of water" and it can be used to evaluate intersectoral water allocation choices.

(2) Determinants of Farmers' Willingness to Pay for Irrigation Service Fee

Analysis of factors affecting the farmers whether they are willing or not willing to pay the irrigation service fee (ISF) to improve the conditions of irrigation water services can be carried out by using binary choice model. In this model, the individual farmers are faced with a choice between two alternatives and their choices depend on relevant characteristics determining such alternatives. The purpose of this model is to determine the probability that an individual farmer with a given set of attributes will make one choice rather than the alternative (Pyndick and Rubinfeld, 1991).

Pyndick and Rubinfeld (1991) and Gujarati (1988) proposed three approaches to analyze a binary choice model i.e., linear probability model, probit model and logit model. A linear probability model assumes that the probability of an individual making a given choice is a linear function of the individual's attributes A_i. The regression model in determining farmers' WTP for the ISF to improve the condition of irrigation water services is:

$$Y_i = \alpha + \beta A_i + \varepsilon_i \qquad (6)$$

where A_i is value of attribute for the ith individual, ε_i is independently distributed random variable with zero mean, and Y_i is dependent variable. Y_i = 1 if the farmer is willing to pay ISF to improve the conditions of irrigation water services and $Y_i = 0$ if the alternative system i.e., farmer is not willing to pay the ISF, is chosen.

Probability of Y_i can be formulated as follows:

$$P_i = \begin{cases} \alpha + \beta A_i & when\ 0 < \alpha + \beta A_i < 1 \\ 1 & when\ \alpha + \beta A_i \geq 1 \\ 0 & when\ \alpha + \beta A_i \leq 0 \end{cases} \quad (7)$$

where P_i is probability distribution of Y_i which can take only 1 and 0. The slope of the line measures the effect of a unit change in profit level on the probability of the farmers of choosing to pay the ISF.

Logistic (logit) regression model is based on the cumulative logistic probability function and is specified as:

$$P_i = F(Z_i) = F(\alpha + \beta A_i) = \frac{1}{1+e^{-Z_i}} = \frac{1}{1+e^{-(\alpha+\beta A_i)}} \quad (8)$$

where e represents the base of natural logarithm, P_i is the probability that an individual will make a certain choice, given A_i. Multiplying both side of equation (8) with $(1+e^{-Zi})$ and then divided by P_i, leads to

$$e^{-Zi} = \frac{1}{P_i} - 1 = \frac{1-P_i}{P_i} \quad (9)$$

Therefore, probability that the farmers are willing to pay for the water charge to improve the tertiary irrigation canals condition is determined by:

$$\log \frac{P_i}{1-P_i} = Z_i = \alpha + \beta A_i \quad (10)$$

where the dependent variable is the logarithm of the odds that a particular choice will be made. The application of ordinary least square estimation to equation (10) is clearly inappropriate (Pyndick and Rubinfeld). Note that the logit model transforms the problem of predicting probabilities within a (0,1) interval into the problem of predicting the odds of an event’s occurring within the range of the real line. The Odds is defined as

$$Odds_i = \frac{P_i}{1-P_i} \quad (11)$$

It is the ratio of the probability to its complement, or the ratio of favorable to unfavorable cases. In this research, the there are five attributes A_i to be considered in the model: A_1 = farmers’ age, A_2 = farmers’ experience, A_3 = farmers’ participation in the P3A activities, A_4 = farmers’ education, and A_5 = condition of the irrigation services.

(3) Values of the Farmers’ WTP to Improve Irrigation Water Service

Contingent Valuation Method (CVM) is a method to elicit willingness to pay (WTP) for non-marketed public good. It involves asking people directly what they would willing to pay contingent on some hypothetical change in the future state of the world (Young, 2005). Estimation of farmer’s WTP for the improvement of irrigation water service is conducted by using expressed preference (stated preference) methods involve asking people directly about the values placed on the proposed or hypothetical improvement in water-related environmental services i.e., improvement of irrigation water services. In this paper, estimation of WTP is implemented by using a modified Hanley and Spash (1993) formulation. The processes are as follows:

a) Set up hypothetical market for the environmental service in question. An assumption is made that the government will improve the irrigation canals. This sets up a reason for payment for the services, where no direct payment is currently exacted.

b) Obtaining bids through a survey. This can be done by face-to-face interview. In this case, the farmers are asked to state their maximum WTP in a bidding game in order to have a better irrigation water services.

c) Estimating the average and/or median WTP. The average WTP is estimated based on the farmers' bid in the previous stage.

$$E(WTP) = \sum_{i=1}^{n} W_i \, P_{fi} \quad (12)$$

where *E(WTP)* is expected average value of WTP, i is the WTP class (interval), W_i is lower value of WTP in the i class, P_{fi} is relative frequency of the i class, and n is the number of WTP class (interval).

d) Estimating the total value of WTP *(TWTP)*. The *TWTP* of the farmers in general is estimated using formula:

$$TWTP = \sum_{i=1}^{n} WTP_i \left(\frac{n_i}{N}\right) P \quad (13)$$

where WTP_i is farmer i willingness to pay for the improvement in irrigation service, n_i is land area of the farmer i for which he/she wants to pay for the WTP, N is total land area of the whole respondents and P is total land area of the whole population (members of P3A).

e) Evaluation of the WTP. This entails the appraisal of the success of the application of WTP has been. To evaluate the implementation of the CVM model can be seen from the reliability of WTP function in reflecting respondents' real WTP.

(4) *Analysis of WTP Function*

What are the factors determining the values of farmers' WTP in improving irrigation water services? The values of WTP are obtained from the previous analysis. These values are then regress on nine variables reflecting the characteristics of the farmers and their farms conditions. Ordinary least square (OLS) estimation is applied to estimate the regression parameters. The WTP regression function is formulated as follows:

$$WTP_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \ldots + \beta_9 X_{9i} + e_i \quad (14)$$

where WTP_i are mid values of WTP for improving water services of the farmer i, β_j are regression parameters of the explanatory variables, and X_i are the explanatory variables, which include: X_1 = land area, X_2 = farm income, X_3 = farmers experience, X_4 = farmers' age, X_5 = farmers' education, X_6 = farmers' knowledge on irrigation management, X_7 = irrigation services, X_8 = farmers' participation in the P3A and X_9 = farmers' number of family members of the farmer i. Variables X_6, X_7, and X_8 are dummy variables.

RESULTS AND DISCUSSION

Cropping Patterns, Water Charges and Water Users Association

Total irrigated land in Pasir Gaok Village, District of Bogor, is 225 ha. Farmers in this village usually plant crops up to three times in a year. However, since water availability was increasingly scarce in the last few years, the farmers practically could plant crop up to twice a year i.e., paddy and secondary crops (maize, groundnuts or others). The farmers should pay the ISF using paddy and/or cash. The fee is Rp 50,000 per ha per cropping season (CS). Since it's voluntarily in nature, not all farmers pay this water charge.

Total irrigated land in Undaan sub-district, District of Kudus, is 550 ha. Most of the irrigated lands in Ngemplak are used for rice. Similar to the farmers in the Pasir Gaok, farmers in Ngemplak also plant crops only in the first two CS. The most popular cropping pattern is paddy - paddy. Determination of planting time in each season is discussed in the P3A Karunia Tani. The P3A has determined that every farmer should pay Rp 25,000 per hectare per CS for the O&M of the tertiary irrigation canals.

P3A is considered to be an agency to supports government programs in agricultural sector. The P3A has many roles, including: to increase irrigation efficiency at farm level, to distribute water equally and fairly at tertiary irrigation canals, to check and maintain the tertiary canals and, to plan infrastructure improvement programs, to manage planting schedule and cropping pattern, to manage irrigation services fee, and to dim the potential conflict in water distribution. Organization of P3A is very simple, consists of only head, secretary and treasurer. Thus, it is very difficult to them to implement all the functions.

Land Area and Productivity

The average land area of the 45 respondents in Ngemplak village is about 0.5 ha. Most of them have land area under the category of less than 0.5 ha (66.7%), then followed by 0.5 to 1.0 ha (22.2%) and more than 1.0 ha (11.1%). Productivity of paddy varies from 4.9 to 5.2 ton/ha, with an average of 5.0 ton of rough (un-husked) rice per ha.

The average land area of the 30 respondents in the Pasir Gaok is less than that of Ngemplak i.e., only 0.3 ha. However, in term of productivity, farmers in Pasir Gaok have a slightly higher rice yield, ranging from 4.5 to 6.0 ton/ha, with an average yield at 5.2 ton of rough rice per ha.

Economic Contribution of Irrigated Water on Rice Production

Based on the technical input-output data and their prices, the estimated total revenues and total costs of rice farming system are presented in Table 1. Both total revenues and total costs of rice farming system in Pasir Gaok village (Bogor) are greater than those of Ngemplak village (Kudus). This occurs since the prices of both input and output in Bogor district are relatively higher than those of Kudus. The economic value of irrigated water is estimated by applying the Wicksteed product exhaustion theorem presented in equation (5). The economic value of the irrigated water is presented in the last column of Table 1. The results indicated that the economic value of irrigated water in Kudus is two-times larger than that of Bogor *i.e.*, Rp 2.67 million compared to Rp 1.16 million per ha per CS. One cropping season is about 100 days.

Table 1. Estimate of the economic value of irrigation water at Bogor and Kudus

Analysis	Land Area	Land Average	Total Revenue	Total Cost (except water)	Value of water
Pasir Gaok Village, Bogor					
Real Land Area (Rp/CS)	< 0.50	0.23	1,501,228	1,263,736	237,491
	0.50 – 1.00	0.70	5,810,750	4,912,250	897,250
	> 1.00	-	-	-	-
	All categories	0.30	1,788,488	1,507,000	281,488
Per Hectare Basis (Rp/Ha/CS)	< 0.50	1.00	6,527,078	5,494,504	1,032,573
	0.50 – 1.00	1.00	8,301,071	7,017,500	1,283,571
	> 1.00	1.00	-	-	-
	All categories	1.00	7,414,074	6,256,002	1,158,072
Ngemplak Village, Kudus					
Real Land Area (Rp/CS)	< 0.50	0.30	1,491,700	713,512	778,188
	0.50 – 1.00	0.62	3,125,000	1,430,525	1,690,475
	> 1.00	1.64	7,780,000	3,437,286	4,342,714
	All categories	0.50	2,553,300	1,175,489	1,377,811
Per Hectare Basis (Rp/Ha/CS)	< 0.50	1.00	4,972,333	2,378,373	2,593,960
	0.50 – 1.00	1.00	5,040,322	2,307,298	2,733,026
	> 1.00	1.00	4,802,469	2,121,781	2,689,687
	All categories	1.00	4,938,374	2,269,150	2,669,224

Note: US$ 1.00 ≡ Rp 9,000.00

These economic values of irrigated water are in fact relatively large. Under the current condition, P3A in Pasir Gaok Village charges ISF at Rp 50,000 per ha per CS, while in Ngemplak village at Rp 25,000 per ha per CS. This implies that the economic value of irrigated water in Pasir Gaok village is 23 times of the average water charge (ISF), while in Ngemplak village is 106 times of the average ISF. These results are consistent with those of Syaukat and Siwi (2009) in Sleman district, Yogyakarta and Rodgers and Hellegers (2005) in Brantas river basin. Unfortunately, even with this relatively low irrigated water charge, most of the farmers do not pay for it. Only 34% of the farmers in both villages pay for the water charges.

Since the number of the farmers who pay the ISF is relatively low, the P3A could not implement their full functions in maintaining the quality of the tertiary irrigation canals. Consequently, the quality of tertiary canals is degrading from time to time. Sedimentation of the canals is the greatest problem faced by the farmers, followed by the leakage. These problems have reduced the flows of irrigated water into the paddy fields. In dry season, the flows of irrigated water significantly decline, thus the farmers can’t plant any crop during dry season to avoid crop failure. The farmers claim that this unsatisfactory water delivery and service becomes farmers’ main reasons for not paying the ISF. The other reasons are: the farmers consider themselves as poor, so they do not need to pay it, and they think that water is a public good that has to be freely served by the government.

Determinants of Farmers' WTP for Improving Irrigation Water Services

The reasons of why only low percentages of the farmers who pay for the ISF are important in determining the option for irrigation service improvement. When the respondents are asked whether they are willing to pay the ISF if the government could improve the tertiary water canals, the result is quite surprising. About 78% of the farmers in Ngemplak are willing to pay, while in Pasir Gaok the rate is 83%. Analysis of logit regression model (equation 10) is carried out to answer the question why they are willing or not willing to pay for irrigation service improvement program.

Table 2 provides information on factors determining farmers' WTP for improving water services. The logit model was estimated using a maximum-likelihood estimation procedure and run with *Minitab* program. The usual R^2 statistic can't be determined from logistic regression. It is almost always rather low, since observed values need to be either 0 or 1. One method to measure the goodness of fit (analogues to R^2) is using G statistic. The G statistics indicate that all explanatory variables significantly affect the probability of the farmers' willingness to pay (or not to pay) the ISF. Similarly, the statistic tests (Pearson, Deviance and Hosmer –Lemeshow (H-L)) also resulted in P-values which are bigger than α=10%, indicating that both models are statistically satisfied. Since the purpose of the models is to see which variables are important, then much attention will be concentrated on this issue.

Table 2. Factors determining willingness of the farmers to pay irrigation service fee

Variable	Pasir Gaok Village			Ngemplak Village		
	Coef.	P-value	Odds Ratio	Coef.	P-value	Odds Ratio
Constant	-3.56295	0.383	-	8.66345	0.090	-
Farmers' age (year)	0.0000002	0.570	1.00	-0.09758	0.177	0.91
Farmers' experience (year)	0.111747	0.244	1.12	-0.4781	0.044*	0.62
Farmers' participation (active)	3.70191	0.077*	40.52	2.4895	0.035*	12.06
Farmers' education (year)	-1.72634	0.116*	0.18	-0.4781	0.044*	0.62
Irrigation services (good)	1.35967	0.429	3.89	3.0105	0.028*	20.30
	Log likelihood = -7.821 Test: G=11.39; P-value =0.044			Log likelihood = -14.663 Test: G =18.34; P-value =0.005		
	Method Chi-Sq DF P Pearson 17.6630 24 0.819 Deviance 15.6428 24 0.907 H-L 4.6789 8 0.791			Method Chi-Sq DF P Pearson 30.6109 32 0.537 Deviance 26.5538 32 0.739 H-L 10.8864 8 0.208		

Out of five considered explanatory variables, farmers' experience, farmers' education, farmers' participation, and irrigation services are becoming significant factors in determining farmers' WTP for improving irrigated water services. In Pasir Gaok, the significant factors are only farmers' participation and farmers' education, while in Ngemplak the significant factors are farmers' experience, farmers' participation, farmers' education and irrigation services. Farmers' participation and farmers' education are significant factors in both villages, but they have different signs. Farmers' active participation in P3A has positive coefficient and is the most important factor in determining farmers' WTP to improve water services, as indicated by the high values of odds ratios (40.52 and 12.06). Probability of the farmers to pay the ISF significantly increases when the members actively participate in P3A activities. However, farmers' education level has negative sign, indicating that probability of the farmers to pay the ISF tends to decline when their education years increase. This occurs since the average education years of the farmers who pay the ISF are relatively lower than that of those who don't pay it (5.1 years compared to 6.4 years).

Variable of irrigation service and farmers' experience are significant only in Ngemplak, and the coefficient is positive. Value of Odds ratio is 20.30, indicating that the probability of the farmers to pay for the ISF will significantly increase if the conditions of irrigation service could be improved in the future. Alternatively, under current situation, the farmers who obtain good water services have probability 20.3 times in paying the ISF compared to those who obtain unsatisfactory water services. With this result, it is clear that irrigation service condition is very important factor in determining farmers' WTP for ISF. Thus, improvement of irrigation water service has to be seriously considered by P3A as well as local government in pursuing production increase and sustainable operation and maintenance of irrigation canals.

Values of the Farmers' WTP for Improving Irrigation Water Services

Based on the methodology developed by Hanley and Spash, these are five steps to estimate the value of farmers' WTP to improve irrigation water services. The results of CVM method in estimating the WTP are as follows:

a) Hypothetical market. In this study, the farmers are asked with the current situation of the irrigation infrastructure and service and their WTPs for the current water charges. Then, they are asked again with the situation if the infrastructure can be improved and their associated WTP related to it.

b) Farmers' bids values. Direct interviews with the respondents are carried out to obtain the information regarding farmers' WTP in association with the improvement of irrigation water services. With this approach, the estimate of WTP values can be obtained. In Pasir Gaok, the median of WTP is about Rp 12,750 per block of land per cropping season (CS) or equivalent to Rp 76,500 per ha per CS; while in Ngemplak, the median of WTP is about Rp 6,179 per block per CS or equivalent to Rp 44,136 per ha per CS.

c) The estimate of average WTP. Based on the data on Table 3, it can be shown that, in Pasir Gaok, the largest percentage of the respondents are in class of Rp 15,000 to Rp 20,000, with the estimated WTP at Rp 11,500 per block per CS, or equivalent to Rp 70,000 per ha per CS. In Ngemplak, the estimated WTP is carried out for the two CSs. The estimated WTP value is about Rp 6,607 per block per CS or Rp 47,196 per ha per CS. These estimated WTPs are in fact bigger than the existing ISFs, which are Rp 50,000 and Rp 25,000 per ha per CS in Pasir Gaok and Ngemplak, respectively.

d) The estimate of total value of population's WTP. By applying equation (14), the estimated Total WTPs are Rp 2,045,750 per CS in Pasir Gaok, and Rp 4,078,625 per year (or Rp 2,039,312 per CS) in Ngemplak (Table 4). The values are far above the current level of water charge set by P3A in each village. These indicate that the potential consumer surplus of the farmers are available and can be exploited to improve irrigation water services in the villages.

e) Evaluation of CVM Survey. The accuracy of CVM survey can be judged whether the answer to the questions reflect the realm preference of the respondents. Reliability test of the bids can be evaluated from the coefficient of determination (R^2) of the models. According to *Whittington et al.* (1993), the CVM survey is failed if the R^2 of the model is less than 0.15. Based on Table 5, the R^2 of these model are greater than 0.15 thus, the survey can be judged as reliable.

Table 3. Estimation of individual WTP to improve irrigation water service

No	WTP Class (Rp/block)	Frequency (person)	Percentage	E(WTP) (Rp/block)
Pasir Gaok village				
1	2,500 – 5,000	3	12.0	300
2	5,000 – 10,000	4	16.0	800
3	10,00 – 15,000	6	24.0	2,400
4	15,000 – 20,000	8	32.0	4,800
5	20,000 – 25,000	4	16.0	3,200
		25	**100.0**	**11,500**
Ngemplak Village				
Cropping Season I				
1	2,500 – 5,000	4	11.4	286
2	5,000 – 7,5000	28	80.0	4,000
3	7,500 – 10,000	3	8.6	643
		35	**100.0**	**4,929**
Cropping Season II				
1	5,000 – 10,000	13	37.1	1,857
2	10,000 – 15,000	21	60.0	6,000
3	15,000 – 20,000	1	2.9	429
		35	**100.0**	**8,286**
	Total Two Seasons			**13,215**

Determinant of the Value of WTP for Improving Irrigation Water Services

Different than the previous analysis, this analysis is carried out to identify factors affecting the value of farmers' WTP for the improvement of irrigation water services. Nine variables are included, as shown in Table 5. Ordinary least square estimation is used in this analysis. R-squares are relatively low (0.56 and 0.47), suggest that a good deal of variance in the models are still unexplained. However, in general, statistical indicators are quite good and no multicollinearity problem.

Out of nine explanatory variables, only three and four variables are significant (up to α=15%) in Pasir Gaok and Ngemplaks villages, respectively. In Pasir Gaok, there are four significant variables, including land area, farm income, farmers' knowledge on irrigation management and farmers' family members; while in Ngemplak village are: land area, farm income and farmers' age. The coefficients of land area are positive and significant in both villages, indicating that the values of WTP tend to increase with the size of land area. However, their marginal values are relatively low (Rp 7,203 and Rp 23,335) if the land area could increase by one block. Farm income has significant impact, but its coefficient is inconsistent with the expectation in both villages. This occurs since in the survey areas, the respondents with lower farm income have relatively higher consciousness in paying the water charge compared to those with higher farm income.

Table 4. Estimation of the total WTP of the population to improve irrigation water service

No	WTP Class (Rp/block)	Frequency (person)	Land Areas of Samples	Land Areas of the Population	Total WTP
Pasir Gaok village					
1	2,500 – 5,000	3	3.6	10.8	40,500
2	5,000 – 10,000	4	6.4	19.3	144,750
3	10,00 – 15,000	6	9.6	29.0	362,500
4	15,000 – 20,000	8	15.8	47.8	836,500
5	20,000 – 25,000	4	9.7	29.4	661,500
		25	**100.0**	**136.3**	**2,045,750**
Ngemplak Village					
	Cropping Season I				
1	2,500 – 5,000	4	6.0	10.8	40,500
2	5,000 – 7,5000	28	112.2	202.2	1,263,750
3	7,500 – 10,000	3	11.5	20.7	181,125
		35	**100.0**	**233.7**	**1,485,375**
Cropping Season II					
1	5,000 – 10,000	13	48.9	88.1	660,750
2	10,000 – 15,000	21	68.3	123.1	1,538,750
3	15,000 – 20,000	1	12.5	22.5	393,750
		35	**100.0**	**233.7**	**2,549,250**
	Total Two Seasons				**4,078,625**

Table 5. Factors determining the value of WTP for irrigation water services

Variable	Pasir Gaok Village			Ngemplak Village		
	Coef.	**P-value**	**VIF**	**Coef.**	**P-value**	**VIF**
Constant	10360	0.408	-	82132	0.000	-
Land area	7203	0.004*	1.5	23335	0.007*	2.1
Farm income	-0.0038	0.131*	1.8	-31.24	0.0008*	2.1
Farmers' experience	-12.1	0.930	1.6	-166.1	0.173	2.2
Farmers' age	-33.8	0.826	1.4	-456.7	0.088*	3.0
Farmers' education	-1180	0.544	1.3	-3775	0.662	7.1
Knowledge on irrigation Management (D)	5151	0.071*	1.5	-2647	0.539	1.1
Irrigation services (D)	-3247	0.231	1.3	12862	0.169	7.4
Farmers' participation (D)	3957	0.378	1.9	-2499	0.569	1.2
Farmers' family member	-1874.5	0.007*	1.6	-378.9	0.666	1.3
	S=6061.27; R-Sq=56.4%; R-Sq(adj)=36.7%			S=8269.39; R-Sq=47.4%; R-Sq(adj)=25.4%		
Analysis of variance	DF=9; F=2.87; P=0.024			DF=10; F=2.16; P=0.059		

The number of farmers' family member is negatively affected the value of WTP in Pasir Gaok, indicating that the bigger the number of family members, the farmers will decrease their WTP for the water charge. Similarly, the coefficient of farmers' age is also negative in Ngemplak, implying that the older the farmers, they will decrease their WTP. In addition, farmers' knowledge on irrigation management positively affects the farmers' WTP in Pasir Gaok. This occurs since the farmers in this village are relatively active in P3A activities, thus they understand how to manage water irrigation.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The estimated economic values of irrigated water on rice farming system are in fact greater than the current water charge (ISF) applicable in both villages. However, most of the farmers didn't pay for the ISF set by the water users association (P3A) because the farmers were unsatisfactory with the water services provided by the P3A and they believed that water was considered to be free good that has to be served by the government.

Whenever there was a program to improve the tertiary irrigation canals to improve irrigation water services, however, the farmers are willing to pay for this effort. The value of WTP is even greater than the existing water charge (ISF), but both the existing water charge and farmers' WTP values are only small percentage of the economic contribution of the water found in the previous objective. Thus, there is potency that the farmers will pay for the ISF.

Farmers' experience, farmers' participation, farmers' education and irrigation services are significant factors in determining the farmers' WTP to improve the irrigation water services. Farmers' active participation in P3A has positive coefficient and is the most important factor in determining farmers' WTP to improve water delivery and services. Probability of the farmers to pay ISF significantly increases when they actively participate in P3A activities. In addition, in Ngemplak village, irrigation service variable is positive and significant. Thus, improvement of irrigation water service has to be seriously considered by P3A as well as local government in pursuing production increase and sustainable operation and maintenance of the tertiary irrigation canals.

The estimated average values of WTPs are in fact bigger than the existing irrigation water fees applicable in the surveyed villages. The estimated total values of population's WTP are also high, indicating that there is potential farmers' surplus that can be exploited to improve irrigation water services in the villages.

Recommendation

The current version of irrigation water "pricing" system i.e., the irrigation service fees, can be maintained in the future. However, their rates should be gradually increased, since the existing water economic contributions are in fact far greater than these fees. The increase water charge has to be followed by the improvement in P3A services to the farmers, in both water delivery and services and other activities, such as extension and other skills improvement programs.

Thought the farmers' WTP are in fact relatively low compared to the current water economic contribution, they can be a potential source of funding to cover the operation and maintenance costs of the infrastructure. However, to achieve this objective, P3A institution should be revitalized and improved by increasing members' active participation, improve their understanding on irrigation services, and increase P3A activities to support their farms.

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