1_FPAS_Factoring the cost of water management to estimate agricultural water service fee in tidal lowlands

by Muhammad Yazid

Factoring the Cost of Water Management to Estimate Agricultural Water Service Fee in Tidal Lowlands

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Abstract-Externality has to be considered as part of the cost components in production process to ensure the sustainability of natural resource. Estimation of water service fee is a way of considering the external cost of water utilization in agricultural production. This study attempts to estimate the water service fee in tidal lowland agriculture by factoring the cost of water management. The estimation would describe the full cost components that should be taken into consideration when utilizing the natural resource.

Keywords: water management, water service fee, tidal lowland, agriculture, sustainability

INTRODUCTION

Water management in tidal lowland areas is unique. This uniqueness is not only because it naturally depends on tides, but also because it deals with multi-purposes water needs. Present needs for water in tidal lowland include food crop irrigation, estate crop irrigation, fishery, cattle and livestock, domestic water demands, raw water for drinking, and waterway transportation.

Water management in tidal lowland agriculture is aimed at fulfilling water need for crop production. It, therefore, requires structures for feeding, maintaining, and distributing water. As such, it also requires costs for conducting operation and maintenance of infrastructures. These costs include labor cost for gate operators for proper operation of gates and maintenance costs of canals and gates such as grass cutting, sediment removal, greasing, and rehabilitation of damaged structures.

In the past, most of the costs with regard to operation and maintenance of water structures in tidal lowland areas were born to the central government budget. After severe economic crises in the late nineties, these costs have been becoming burden to the central government. Since that, the government requires that the costs are partially born to local government budget as well as to water users and their organizations as part of the Irrigation Management Policy Reforms (IMPR). In addition, this policy in implementation also requires transfer of authority and share of responsibility to local government and to water users associations (WUAs). Such responsibility reveals the need to set and collect water service fee for which WUAs are authorized.

This study aimed at assessing the cost of water management based on its cost components that provided alternatives in estimating water service fee for agriculture activities in tidal lowlands. The scope of this study was limited to the scope of works of water users' association (WUA) which covered an area of a secondary block of 256 ha farmland.

WATER MANAGEMENT AND ITS COSTS IN TIDAL LOWLAND AGRICULTURE

Despite its various objectives from improving water allocation and pollution control to achieving cost recovery of water resource use (Cornish et al., 2004), water management in tidal lowland agriculture is focused in fulfilling crop water needs. In achieving this objective, besides equipped with canals and structures, proper operation and maintenance of these canals and structures are also required.

Water management in tidal lowland to fulfill crop water needs has two levels, namely macro level and micro level water management. Macro level water management refers to the operation and maintenance of primary and secondary structures (primary and secondary canals and gates), whereas micro level deals with the tertiary structures that directly connect to the farmlands. Therefore, the latter is also known as on-farm water management.

Operation and maintenance of water infrastructures require institutions at all levels. Normally, the management of macro structures is the authority of the government (either central or local), whereas the management of tertiary structures is authorized to water users and water users' associations (WUAs). With this shared authority, responsibility of carrying out operation and maintenance is also shared.

A WUA in tidal lowland irrigation scheme is established to carry out operation and maintenance of tertiary structures within a secondary block of approximately 256 ha, which is bordered by two parallelized secondary canals. This area is considered as one water management unit. Within a water management unit, there are 17 tertiary canals which constitute 17 tertiary blocks. A tertiary block consists of 16 ha farm land lying along the side of a tertiary canal. Operation and maintenance of water infrastructures (tertiary gates and canals) takes place in these tertiary blocks. Considering the average ownership of farmland is 2 ha per farmers, each WUA in tidal lowland has an average of 128 members. Accordingly, the costs of carrying out the operation and maintenance of tertiary structures are born to water users within this association.

Studies on water management are focused in various aspects from water pricing policies, water use efficiency (Singh, 2007; Gonzalez-Alvarez et al., 2006), cost recovery (Molle et al., 2008) to the environmental and institutional aspects of water charging (Bar-Shira et al., 2006; Esteban et al., 2008). In these studies, some cost concepts are used such as fixed costs and variable costs (Gonzalez-Alvarez et al., 2006), marginal social cost of water delivery (Bar-Shira et al., 2006), "environmentally optimal price" and "socially optimal price" (Esteban et al., 2008), and water demand (Schoengold et al., 2006).

In line with the above focus, the objectives of the study on water pricing and water charging also vary from determining the optimum use of water (Gonzalez-Alvarez et al., 2006), reducing water use (Bar-Shira et al., 2006), internalization of environmental cost of water (Esteban et al., 2008), development of water market (Goetza et al., 2008), estimation of the best allocation of water (Latinopoulos, 2005), to water saving and improvement of efficiency (Molle et al, 2008).

In addition to the above, more specific assessments were directed to obtain the price elasticity of irrigation water demand (Schoengold et al., 2006) and rational pricing of irrigation water to enhance efficiency (Singh, 2007).

Referring mainly to the methods used in the works' of Gonzalez-Alvarez et al (2006), Bar-Shira et al (2006), Esteban et al (2008), and Molle et al (2008), the basis for estimating the cost of water (WSF) in this paper were established to include different cost components that may be factored into a calculation of the cost of delivering water for agriculture. The proposed cost components were operation and maintenance costs, capital depreciation and replacement, management cost, opportunity costs, and environmental costs. Water service fees (WSF) which were intended to cover these costs were estimated accordingly.

METHODOLOGY

This study was conducted in tidal lowland of Telang located at the eastern coast of South Sumatra Province, Indonesia. A field survey was conducted to collect information on agricultural water management practices. Subsequently a focus group discussion was held to estimate the cost of agricultural water service in this tidal lowland area.

Estimation of water service fee (WSF) was based on the cost components applied in delivering water for agriculture. These cost components included operation and maintenance cost, capital depreciation and replacement cost, management cost, opportunity cost, and environmental cost. Three WSF estimates were derived from these cost components. WSF_1 was intended to cover the cost of water delivery (supply cost), WSF_2 was to cover supply cost and the opportunity cost (referred to as the economic cost) and WSF_3 was to cover all the costs including the external cost involved in tidal irrigation management at WUA level (referred to as the full cost). The relationships between WSF estimates and these cost components were discussed below.

Assuming WSF was measured per unit cropping area, WSF_1 was a function of operation and maintenance cost (*OM*), capital depreciation and replacement cost (*D*), and management cost (*M*). *OM* and *D* were applied at the tertiary block, whereas *M* was applied at the secondary block, such that:

$$WSF_1 = a(OM + D) + bM \quad (1)$$

where a = coefficient for tertiary block; b = coefficient for secondary block.

WSF_2 was intended to cover supply cost and the opportunity cost (*Op*). Opportunity cost was applied at every unit of farmland served by the scheme, such that:

$$WSF_2 = WSF_1 + cOp \quad (2)$$

$$WSF_2 = a(OM + D) + bM + cOp \quad (3)$$

where c = coefficient for farmland unit.

WSF3 was intended to cover all the costs including external cost (*Ec*). Similar to *M*, *Ec* was applied at the secondary block, such that:

$$WSF_3 = WSF_2 + b(Ec) \tag{4}$$

$$WSF_3 = a(OM + D) + b(M + Ec) + cOp \tag{5}$$

RESULTS AND DISCUSSION

Operation and Maintenance Cost

Operation of gates is technically carried out by gates keepers. A gate keeper is in charged of opening and closing of two tertiary gates at each end of a tertiary canal. In WUA management a gate keeper is the head of a tertiary block. A gate keeper operates tertiary gates according to the types of crop, crop growth stage, tide, rainfall, and farming activities being held (fertilizing, pesticide spraying, weeding, harvesting). Therefore, in doing so he frequently coordinates with his member farmers prior to operating the gates.

Maintenance of water infrastructures (tertiary gates and canals) consists of the following activities: (1) grass cutting and cleaning of canal banks, (2) sediment removal, (3) gate repair, (4) gate replacements. According to the need, grass cutting and cleaning of canal banks are carried out as many as 3 times per year at the beginning of each planting season. Sediment removal is done once every year. Minor damage on gates is repaired immediately, while replacement of gates is estimated once in 10 year since tertiary gates are made of fiberglass.

Up to now, most of the operation and maintenance of water infrastructures have been carried out by WUA officials and members through so-called 'gotong-royong', which means working together as social responsibility as members of WUA. Within this system, almost no financial means is involved. Financial cost when applies is shared among members. The following costs are estimated to indicate financial cost of operation and maintenance of water infrastructures within a tertiary block.

Table 1. Cost components of operation and maintenance of water infrastructures within a tertiary block per year

Cost Components	Quantity	Unit	Total
Operation:			
Salary of the gate keeper	12	man month	12 man month
Maintenance:			
1. Grass cutting and cleaning of canal banks	3	4 man day	12 man days
2. Sediment removal	1	8 man day	8 man days
3. Gates repair[a]	-	-	-
4. Gates replacement[b]	(1)	(10 year)	(1 in 10 years)

Note: [a]Gates repair is incidental.
[b]Gates replacement is part of maintenance, but its cost is counted in the cost of capital (investment cost). Therefore, number between parentheses is not counted.

Depreciation and Replacement Cost

Capital depreciation and replacement is derived from investment cost of water infrastructures. Investment cost is the amount of money spent at the first installation of tertiary gates. This cost includes provision cost of 2 tertiary gates and 2 culverts for every tertiary canal and construction cost of gates and culverts. Breakdown of investment cost is presented in Table 2. Gates need to be replaced once in 10 year, whereas culverts should be replaced after 20 year installed. Following the replacement of culverts, reconstruction must be done once in 20 year.

Table 2. Annual depreciation and replacement cost of water infrastructures within a tertiary block

Annual Depreciation			
Cost Components	Quantity	Age (years)	Annual Depreciation (%)
1. Gates	2	10	10
2. Culverts	2	20	5
Replacement Cost			
Cost Components	Quantity	Unit	Total
1. Building materials	1	Package	1 Package
2. Labor	112	man day	112 man days

Management Cost

Management cost of WUA is the expenditures made to carry out the organizational functions of WUA which include the salary of officials, administration cost, and spending for meeting and coordination. The breakdown of WUA management cost is presented in Table 3.

Table 3. Breakdown of WUA management cost per year

Cost Components	Quantity	Unit	Total
Salary:			
1. Head	12	man month	12 man months
2. Secretary	12	man month	12 man months
3. Treasurer	12	man month	12 man months
4. Gate keepers[a]	17 x 12	man month	204 man months
Administration cost	1	Package	1 Package
Meeting and coordination:			
1. Meeting of officials	12	Package	12 Packages
2. Plenary	1	Package	1 Package

Note: [a] Has been counted in operational cost

Opportunity Cost

In addition to the above financial costs, an economic cost of water service is also estimated. Economic cost of water service is the opportunity cost of implementing operation and maintenance of water infrastructures at tertiary blocks. In this case, the opportunity cost is the benefit from amount of money forgone due to the payment of WSF, which is the annual interest rate from the total operation and maintenance cost, depreciation and replacement cost, and WUA management cost.

External Cost

External cost is the cost imposed to water users for the internalization of externalities in water management at tertiary blocks. The externalities involved in the operation and maintenance of water infrastructures at tertiary blocks is the negative impacts from fertilizer and pesticide residuals discharged to the secondary canals from the farmland through the tertiary canals. As a result, water in the secondary canals which was previously utilized for drinking is no longer safe. The external cost associated with this is estimated as avoidance cost of not drinking the contaminated water. Therefore, it is the cost of consuming bottled water for at least three months, a period when canal water is undrinkable due to chemical contamination. According to the data, each household with 4 members consumes 6 liter per day. In 3 months for the total of 128 households, the amount of bottled water consumed is 69,120 liters. This amount of avoidance cost is for a secondary block similar to one water management unit.

The use of avoidance cost, however, tends to be overestimated since the price of bottled water does not only include treatment cost in order to make the water drinkable. It also includes other costs such as packaging cost, marketing cost, and profit of the owners. In order to approach the actual external cost of the contaminated canal water, ideally a treatment cost is used. Treatment cost is the amount of money needed to improve the quality of contaminated canal water to the level that avoids external cost. However, the pollution level of water in irrigation canal was not easy to detect as reported by Bakri et al (2006). As a result, treatment cost can not be easily formulated. Consequently, avoidance cost as has been discussed is used as a proxy for the external cost in case of tidal lowland agriculture.

Water Service Fee Estimation in Tidal Lowland Agriculture

Water service fee is imposed to water users on area basis. In this case, WSF is a fee for every hectare farmland served by the existing water infrastructures. Therefore, WSF is the summation of all cost components that are required to carry out all of water management activities. Table 4 presents the summary of the costs of water management which includes operation and maintenance cost (notified as OM), capital depreciation and replacement cost (D), WUA management cost (M), opportunity cost (Oc), and external cost or avoidance cost (Ec).

As discussed earlier, operation and maintenance cost (OM) is estimated for one tertiary block which covers an area of 16 ha. Similarly, capital depreciation and replacement cost (D) is calculated with reference to a tertiary block. WUA management cost (M) is estimated for the whole area of its service which is a secondary block of 256 ha farmland.

The summation of these three cost components with reference to its respective block indicates WSF of the first type (notified as WSF_1).

Table 4. Summary of cost components and WSF estimates

Cost Components	Block Area Applied			WSF estimates (per ha per year)
	Farmland	Tertiary	Secondary	
OM cost (*OM*)		x		
Capital depreciation and replacement cost (*D*)		x		$WSF_1 = \frac{1}{16}(OM + D) + \frac{1}{126}M$
Management cost (*M*)			x	
Opportunity cost (*Oc*)	x			$WSF_2 = \frac{1}{16}(OM + D) + \frac{1}{126}M + Oc$
Avoidance cost of contaminated canal water (*Ec*)			x	$WSF_3 = \frac{1}{16}(OM + D) + \frac{1}{126}(M + Ec) + Oc$

The estimation of opportunity cost is based on individual farmland. As discussed earlier, opportunity cost is estimated as the interest rate of the amount of money forgone for the payment of WSF_1. Therefore, *Oc* is applied for each unit of farmland. The summation of opportunity cost to WSF_1 indicates WSF of the second type (notified as WSF_2).

External cost (*Ec*) is estimated based on avoidance cost not to consume unsafe water in the secondary canal due to fertilizers and pesticides contamination from the farmlands. Therefore, it is applied for 256 ha farmland served by the secondary canal. The summation of avoidance cost to WSF_2 indicates WSF of the third type (notified as WSF_3).

CONCLUSION

Factoring the cost of water management is a simple approach in estimating the cost of water management. Thus, it is also a simple way for the estimation of water service fee.

Water service fee is simply estimated by employing five cost components in accordance to achieving three-fold water management objectives which are improvement of water distribution, cost recovery, and achievement of efficient water distribution.

Water service fee of the first type is directed towards the improvement of water distribution. Thus, its cost components only include operation and maintenance cost, capital depreciation and replacement cost, and management cost. Second type WSF is meant to recover costs of water management. Therefore, its cost components also cover the opportunity cost in addition to the first three cost components. Finally, WSF of the third type is considered when the efficient water distribution is the target. It, therefore, covers all cost components involved in water management.

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