WATER PRICING TO ACHIEVE SUSTAINABLE VALUE IN THE USE OF WATER FOR IRRIGATION IN NORTH COASTAL PLAIN, BALI [1]

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Abstract

TMB-59 is one of 39 irrigation systems under the project of Sustainable Development of Irrigated Agriculture in Buleleng and Karangasem Regencies, Bali (SDIABKA). This system, whose cost is amounting up to Rp 850,848,998.00, has been jointly financed by the European Commission and the Government of Indonesia.

The average of groundwater discharged at TMB-59 was 12.93 l/s and the maximum discharge that was recommended by the project was 14.4 l/s. In case of water availability was limited, it was necessary that the discharge should be less than the recharge and the opportunity cost of water as well as depletion premium should be considered in designing tariff structure of water. Present water pricing by Tubewell User Group (TUG) of Sarining Pertiwi at TMB-59 considered operation and maintenance (OM) only – the costs in amounting to Rp 301.01/CM.

The concept of sustainable value in the use of water fused the full supply cost, opportunity cost and externality cost. It was obtained that sustainable value in the use of water for irrigation in TMB-59 was Rp 1,218.29/CM consisting to full supply cost of Rp 631.26/CM, opportunity cost of Rp 188.74/CM, and depletion premium of Rp 398.29/CM. This amount, which was four times of OM costs or two times of full supply cost, and should be paid by users in order that irrigated agricultural development is to become sustainable.

Keyword : *water, irrigation, cost, depletion, sustainability, Buleleng, Karangasem*

1. Introduction

Background

Irrigation infrastructure facilities have been made possible by govern-ment with heavy investment and the capital of which is derived from government earning or external financial sources in the form of loans (Sugino, 2003). Amounting to 39 irrigation systems under the project of Sustainable Development of Irrigated Agriculture in Buleleng and Karangasem (SDIABKA) have been jointly financed by the European Commission (EC) and the Government of Indonesia (GoI). The total cost is estimated to be €6,625,000.00 (€6,125,000.00 by EC and €500,000.00 by GoI) (Project Management Unit, 2003).

Supply quantity like in the SDIABKA project area, refers to the total volume of groundwater that flows approximately 30 million cubic meter per year (MCM/yr) which consists of base flow and annual recharge approximately 23 MCM/yr and 7 MCM/yr, respectively. An abstraction of 12 percent of annual flow is approximately 3.6 MCM/yr which would be sufficient to supply approximately 50 wells pumping

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at 10 l/s (assuming that wells are operated 10 hours per day for 180 days per year). It seemingly has a minor effect on the position of the interface and likely more environmental-friendly (Project Management Unit, 1995).

Present water pricing systems are usually simple (Abernethy, 1997). Often they are based only on a very rough calculation of the quantity delivered, and the rate is somehow related to the costs of the delivery process. The contribution of users to investment and renewal is usually partial or zero. The water prices do not fluctuate much with the seasons, and do not reflect the reality of scarcity or abundance of water. Thus, in the coming decades it should be expected more sophisticated tariff structure that water prices will be rising to the levels that reflect better the actual cost of water resource development.

In case of limited water availability and high water competition among potential users (domestic and agriculture), high groundwater abstraction can lead serious environmental problems. Therefore, the opportunity cost of water should also high. Depletion premium occurs in a situation where the water resource is depleted. Actually, opportunity cost of water and depletion premium have rarely been considered in water pricing (ADB, 1998). Although, water pricing as a single instrument for controlling water use is not valid means of significantly reducing agricultural water consumption in Spain, it is actually needed to make farmers aware of water resource scarcity and to induce them in adopting water-saving technologies without affecting their selection of crops. If agricultural development is to become sustainable, the economic as well as environmental costs are taken into account (Berbel and Gomez-Limon, 1999; Small, 2003).

This study aims to design the water price structure which reflects the sustainable value in the use of water for irrigation in North Coastal Plain of Bali.

2. Research Methodology

2.1 Study Area

One of 39 schemes of irrigated farming system with well code of TMB-59, Tembok Village, Tejakula District, Buleleng Regency at SDIABKA project area was purposively chosen as a representative study area since water pricing analysis to achieve sustainable value in use of water for irrigation has never conducted by independent party. A good performance of mixed-farming system on 20.04 ha effective area which supported by irrigation system with supply quantities is 14.4 l/s in TMB-59 also became an important reason.

2.2 Kind, Source, and Method of Data Collected

The primary and secondary data consists of type of agricultural practices, demand of water, irrigation assets, supply quantity, operation and maintenance activities, and finances in TUG of Sarining Pertiwi (TMB-59); drinking water price classification at PDAM Unit Sambirenteng; and price of water obtained from the neighboring source (superficial well), etc. The primary data were collected by using interview guide from a number of key informants at Project Management Unit level of SDIABKA and management board of tube well user group (TUG) of *Sarining Pertiwi* at TMB-59 which was chosen purposively while secondary data were gathered from appropriate sources.

2.3 Method of Analysis

The general principle for cost of water that involves sustainable dimension promoted by Rogers *et al.* (1998) was used in this analysis. Figure 1 shows schematically the composition of the various components that make up the costs. It can be classified into three levels, i.e.: the Full Supply Cost, the Full Economic Cost, and the Full Cost. Each cost is composed of separate elements that need further explanation.

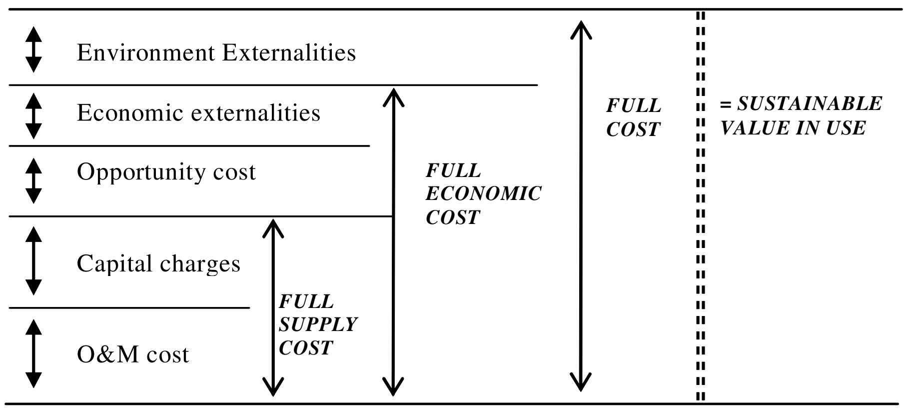

Figure 1. General principle for cost of water (Rogers *et al*. 1998)

The Full Supply Cost includes the costs associated with the supply of water to the consumer that ignored either the externalities imposed upon others nor of the alternate uses of the water. The Full Supply Costs are composed of two separate items: Operation and Maintenance (O & M) Cost, and Capital Charges, both of which should be evaluated at the full economic cost of inputs. O & M Costs are associated with the daily running of the supply system that include purchased raw water, electricity for pumping, labor, repair materials, and input cost for managing and operating storage, distribution, and treatment plants. In practice, there is typically little dispute as to what are considered O & M Cost and how they are to be measured. Capital charges should include depreciation charges and interest costs associated with reservoirs, treatment plants, conveyances and distribution systems.

The Full Economic Cost of water is the sum of the Full Supply Cost as described in the previous section, the Opportunity Cost associated with the alternate use of the same water resource and the economic externalities imposed upon others due to the consumption of water by a specific actor. Opportunity cost addresses the fact that by consuming water, the user is depriving another user of the water. If the competitor has a higher value for the water, then there are some opportunity costs experienced by society due to this misallocation of resources. Opportunity cost of water is zero only when there is no alternative use that is no shortage of water. Ignoring the opportunity cost undervalues water, leads to failures to invest, and causes serious misallocations of the resource between users.

The standard economic approach to externalities is to define the system in such a way as to "internalize the externalities". Economic externalities occur due to over-extraction from, or contamination of, common pool resources such as lakes and underground water. According to ADB (1998), that in such cases, significant cost increase may take place as the aquifer stock depletes, the appropriate valuation of water has to include a depletion premium in the economic analysis. Depletion premium is a premium imposed on the economic cost of depleting resources, such as ground--water, representing the loss to national economy in the future of using up the resource to day. The premium could be estimated as the additional cost of an alternative supply of the resource or substitute, such as rainwater storage, when the least-cost source of supply has been depleted. In this case, the depletion period is assumed as long as 25 years and the alternative source to replace the groundwater is rainwater storage to be brought from a long distance. The formula to calculate the scarcity rent is as follows:

Depletion premium = $(C_2 - C_1)e^{-r(T-t)}$

where C_2 = cost of water per m^3 of alternative source; C_1 = cost of water per m^3 of exhausting source; T = time period of exhaustion; t = time period considered; rate of discount (r = 0.12); and e = exponential constant = 2.7182. As can be seen, the premium or scarcity rent increase each year as the stock of water diminishes.

Furthermore, Rogers *et al* (1998) explained that the Full Cost of consumption of water is the Full Economic Cost, given above, plus the Environmental Externalities. These costs have to be determined based upon the damages caused, where such data are available, or as additional costs of treatment to return the water to its original quality. Environmental externality is identified as a water pollution that causes public health or ecosystem impacts.

3. Results and Discussions

3.1 Supply Costs of Water

The first component of sustainable value in the use of water is the full supply cost that consists of operation and maintenance (OM) costs and capital cost. Type of financial OM costs is given in Table 1. The total financial OM cost is amounting to Rp40,041,503.47 with the largest cost (60.87 %) is allocated for electricity. Electricity cost is accounted by formula: (23 Kw x Rp32,500) + (11 Kw x Rp440 x number of hour used) + (8 % Tax) (Project Management Unit, 2004). Then, management fee has not been paid yet, it should payable to the management board and head of block as an incentive in management of irrigation system.

Each of the financial OM costs then are converted to economic cost (Table 2) with an appropriate standard conversion factor. Approximately 75 percent operating labor cost are unskilled labor (CF 0.65) and the remaining 25 percent are skilled labor (CF 1.00). The financial labor cost is converted to economic by 0.7375 (75% x 0.65 + 25% x 1.00). The standard conversion factors have often been used by ADB (Budiasa, 2004). The national conversion factor for electricity based on the domestic price is 1.1. The other operation costs such as office utensils, ceremonials materials, and administration is assumed to be half traded (CF 1.1) and half non-traded (CF 1.0). The financial of the other operating costs are converted to economic by 1.05 (=50% x 1.1 + 50% x 1.0).

Table 1. Financial operation and maintenance (OM) costs of irrigation TUG of *Sarining Pertiwi* (TMB-59) in 2005/2006

Month/Year	Electricity (Rp)	Operator Fee (Rp)	Management Fee (Rp)	Maintenance *) (Rp)	Others (Rp)
May 2005	1,205,330	0	500,000	567,937.79	38,000
June 2005	2,172,955	0	500,000	567,937.79	111,000
July 2005	2,619,010	100,000	500,000	567,937.79	102,000
Aug 2005	2,488,795	150,000	500,000	567,937.79	38,000
Sept 2005	2,771,025	150,000	500,000	567,937.79	536,000
Oct 2005	2,908,445	150,000	500,000	567,937.79	40,000
Nov 2005	2,975,580	160,000	500,000	567,937.79	40,000
Dec 2005	3,364,865	160,000	500,000	567,937.79	34,000
Jan 2006	837,365	160,000	500,000	567,937.79	40,000
Feb 2006	915,995	160,000	500,000	567,937.79	38,000
Mar 2006	1,005,205	160,000	500,000	567,937.79	38,000
April 2006	1,108,680	160,000	500,000	567,937.79	288,000
TOTAL	24,373,250	1,510,000	6,000,000	6,815,253.47	1,343,000

*) Counted by monthly average cost of maintenance included redevelopment cost (once of five years).

Assuming the recommendation discharge for TMB-59 is 14.4 l/s (Project Management Unit, 2004:75) but the actual average discharge is 12.93 l/s so that the water volume is 135,920.16 CM/year (12.93 l/s x 43,200 s/day x 240 days/year plus 12.93 l/s x 1,200 s/day x 120 days/year). Therefore, the economic OM cost is approximately Rp301.01/CM.

The economic capital costs, which are part of full supply costs, have converted from financial costs (Table 3). The conversion factors are traded component 1.1, unskilled labor 0.65, and the other non-traded component 1.0 (Budiasa, 2004) with the premium of exchange rate is approximately 10 percent (Gittinger, 1986).

Table 2. The financial and economic OM costs of irrigation system, TUG of *Sarining Pertiwi* (TMB-59) in 2005/2006

Operation and Maintenance Components	Financial cost (Rp)	Economic cost (Rp)
Labor	7,510,000.00	5,538,625.00
Electricity	24,373,250.00	26,810,575.00
Maintenance	6,815,253.47	7,153,699.83 *
Other	1,343,000.00	1,410,150.00
Total	40,041,503.47	40,913,050.83
OM cost (Rp/CM)	294.59	301.01

* Counted by 0.9 percent economic value of pump house, main system, on-farm system, and pump and panel plus redevelopment cost (80 percent traded components and 20 percent unskilled labor) in every five years.

Table 3. Economic capital cost of water at TMB-59

Type of asset	**Financial value (Rp)**	**Economic value (Rp)**	**Useful life (years)**	**Depreciation (Rp/year)**
DRILLING				
Drilling Work 57.5 m in depth	171,601,275.00	93,135,987.52	25	*
ASTM Black Style Blank Casings 39.5 m	16,458,333.00	17,198,958.99	15	1,146,597.12
Low Carbon Screen Casing 18.0 m	18,000,000.00	18,810,000.00	15	1,254,000.00
IRRIGATION SYSTEM				
Pump house (construction & land acquisition)	76,699,330.00	76,699,330.00	20	3,834,966.50
Supply pipes and accessories				
a. Main system	203,376,500.00	221,680,385.00	15	14,778,692.33
b. On-farm (pipe and flexible hose)	129,423,000.00	141,071,070.00	15	9,404,738.00
Construction irrigation works	94,004,000.00	98,234,180.00	15	*
Submersible Pump & pump panel (supply and install)	52,196,000.00	54,544,820.00	10	5,454,482.00
Electrical Connection 11 KW	11,074,000.00	11,572,330.00	8	1,446,541.25
Water tanker asset 4 CM 67 unit	78,016,560.00	75,676,063.20	10	7,567,606.32
Total investment/asset	850,848,998.00	808,623,123.70		44,887,623.60
Economic Capital Cost (Rp/CM)				330.25

* It will not be counted on.

The financial cost of drilling work is Rp40.207.000 in 1997 has been converted to economic by compounding factor 1.1275 (discount rate 12.75 percent) up to 2004. The financial cost of drilling work in 2004 is amounting to Rp2.984.370/m. Supply materials such as ASTM black style blank casing, low carbon screen casing, and submersible pump are traded internationally. It is assumed that 80 percent costs to the drilling and construction irrigation works, pump and panel installation, and electrical connection would represent the traded component. The other 20 percent costs are consisting of 10 percent unskilled labor, and 10 percent non-traded component such as local transport and storage, which requires no adjustment. The economic cost for pump house construction is converted by 70 percent traded component, 20 percent unskilled labor, and 10 percent the other non-traded component. The economic value of supply pipes and accessories for main system and on-farm are converted by 90 percent traded component and 10 percent the other non-traded component. Then, the economic cost for construction of water tankers are converted by 40 percent traded component, 20 percent unskilled labor, and 40 percent the other non-traded component.

With the actual discharge for TMB-59 is 12.93 l/s, the water volume is approximately 135,920.16 CM per year, therefore the economic capital cost is Rp330.25/CM based on depreciation of economic value (Table 3).

3.2 Opportunity Cost of Water

The opportunity cost of water is determined by the other uses of water in the economy. An assessment of the opportunity cost of water (OCW) indicates that the economic value of raw water used for drinking water is approximately Rp188.74/CM. Financial water charge for drinking water more than 30 cubic meter per month based on the water use classification of "social B" is Rp1,000.00/CM (PDAM Buleleng Regency, Unit Sambirenteng, 2006). With contribution of 30 percent traded component (CF 1.1), 60 percent unskilled labor (CF 0.65), and 10 percent the other non-traded component (CF 1.0), the economic water charge of social B classification at PDAM Unit Sambirenteng is approximately Rp820.00/CM. The contribution of traded component and non-traded component and conversion factors have often been used by ADB (Budiasa, 2004). Furthermore, based on the economic full supply cost for TMB-59 is Rp631.26/CM, so that OCW is obtained amounting to Rp188.74/CM.

3.3 Depletion Premium

In such case, significant cost increase may take place as the aquifer stock depletes, the appropriate valuation of water has to include a depletion premium in the economic analysis. The depletion premium is a premium imposed on the economic cost of depleting resources, such as ground--water, representing the loss to national economy (economic externality and environmental externality) in the future of using up the resource to day. The premium could be estimated as the additional cost of an alternative supply of the resource or substitute, such as neighboring source, when the least-cost source of supply has been depleted. In this case, the depletion period is assumed to be 25 years and the alternative source to replace the groundwater to be brought from a long distance. The formula to calculate the depletion premium is $(C_2-C_1)e^{-r(T-t)}$ (ADB, 1998), where C_2 = cost of water from neighboring source; C_1 = cost of water at TMB-59; T = time period of exhaustion; t = time period considered; r = 0.1275; and e = 2.7182.

Based on primary information from farmers at TMB-59, the cost to collect water from neighboring well is Rp12,500.00/CM or Rp250.00/20 l. An assessment of economic supply cost of water assumed that the financial cost has distributed 10 percent traded component, 80 percent unskilled labor, and 10 percent equipment and the other non-traded component. In this case, the conversion factors are 1.1 (traded component), 0.65 (unskilled labor), and 1.0 (other non-traded component) with the premium of exchange rate is approximately 10 percent. Therefore, the economic supply cost from neighbor (C_2) is Rp9,125.00/CM as well as the economic supply cost from TMB-59 (C_1) is Rp631.26/CM. Furthermore, based on the ADB formula, the depletion premium is approximately Rp398.29/CM in the first year. As can be seen, the premium or scarcity rent increase each year as the stock of water diminishes.

3.4 Sustainable Value in Use of Water

The concept for irrigation water pricing in the future has attempted to internalize full supply cost, opportunity cost of water, and externality costs. Based on descriptive analysis in TUG of *Sarining Pertiwi* (TMB-59), it is obtained that sustainable value in the use or full cost of irrigation water is approximately Rp1,218.29/CM. This value consists of economic OM costs Rp301.01/CM, economic capital cost Rp330.25/CM, the opportunity cost of water Rp188.74/CM, and depletion premium representing the economic and environmental externalities Rp398.29/CM. The full cost of water is approximately four times the economic OM costs or two times the full supply cost.

4. Conclusion and Recommendation

4.1 Conclusion

Water pricing by using The General Principle for Cost of Water (Rogers *et al.,*1998) in order to achieve sustainable value in the use of water for irrigation in TMB-59 is obtained approximately Rp1,218.29/CM. This value consists of economic OM costs Rp301.01/CM, economic capital cost Rp330.25/CM, the opportunity cost of water Rp188.74/CM, and depletion premium representing the economic and environmental externalities Rp398.29/CM.

4.2 Recommendation

The water price should be paid by users representing willingness to pay (WTP) in order to make users aware of water resource scarcity. Any watershed conservation activities can be done by stakeholders, independently, such as reforestation, development of infiltration well, etc. All activities can be funded by using the opportunity cost of water and depletion premium.

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