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Farmers' Willingness-to-Pay (WTP) for Water Quality Improvements: Insights from Anuradhapura District of Sri Lanka

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Abstract

Background: Tanks and reservoirs play a significant role in the livelihood of the farmer households in the Anuradhapura district. Over the years, these tanks have been abandoned due to pollution and other socio-economic and political activities. As a result, the villagers lack access to adequate quality water supply. Inadequate estimation of tanks' true value as a multipurpose resource is the key reason behind poor management. Therefore, this study aims to elicit the Willingness-to-Pay (WTP) for water quality improvements of the tanks in the Anuradhapura area.

Methods: Data were collected from a sample of 120 randomly selected farmer households living adjacent to small tanks. A choice experiment was used to elicit the WTP and the preferences for water quality improvement in small tanks.

Results: Results revealed that respondents are willing to pay 10% of the monthly income generated from tank related activities, as a payment for quality improvement. Further, the level of water quality improvements had a significant positive impact on people's WTP, while the reduction of fertilizer level, fine and the payment were not significant. About 85% of the respondents were willing to pay Rs.100.00 as the service charge for tank water quality improvement, mainly as they believe tank management to be their responsibility as a community.

Conclusions: Study highlights the importance and community contribution for small tank rehabilitation programmes in the Anuradhapura District.

Keywords: Choice Experiment, Small Tanks, Water Quality Improvement, Willingness-to-Pay

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INTRODUCTION

Tanks in Sri Lanka, which store and provide irrigation water, mainly to the dry zone, is one of the oldest water harvesting and management systems in the world. Water is a social good, which should be affordable to the poor. In ancient times, water was an ample resource and treated as a free good. Many people living in rural areas and developing countries lack access to an adequate water supply, and in many parts of the world water resources are poorly managed [1]. Even with the rising population and economic growth, it remains the same [2]. The high population and economic growth lead to accumulation of pollutants in water bodies. As a result, many rivers and groundwater sources have become polluted and water has now become a scarce resource [2].

In the dry zone (DZ) of Sri Lanka, the annual average precipitation is low compared to the wet zone and also, the evaporation rate is higher in the dry zone. Therefore, ancient kings built tank systems to enhance the sustainability of water and prosperity of the country. Those cascade systems traditionally named "Ellanga" were built to maintain the water resources in DZ and they are interconnected systems of small tanks. Even today, most of our rural people use these tanks mainly for irrigation. Groundwater resources in the country are estimated at 7,800 million m^3 and it is the major source of water, especially in rural areas. It's estimated that around 72% of the agricultural population relies on groundwater for domestic use [3]. Further, these tanks provide various kinds of indirect and direct services to the people and nature [4].

In ancient time, livelihoods were environmentally friendly, which maintained the sustainability of the natural environment. The farmers had to obey the rules imposed by the king to maintain the quality of tanks and water. Because of these rules and supervision of the government officers of the kingdom, the repairs, maintenance and management of tanks went smoothly and ensuring long-term sustainability. Because of tanks related traditions and customs, the people who lived around the tanks guaranteed the quality of the tanks and water.

After the abolishment of kingdoms, several Departments and Boards hold the responsibility for the maintenance of tanks. But due to various reasons like political instabilities, over exploitation, lack of maintenance and waste accumulations these tanks are now in need of being rehabilitated. Nowadays, most of the tanks are abandoned because of the deterioration of the water quality in tanks. To overcome the negative effects of water scarcity, water quality must be maintained and improved effectively and efficiently. Due to various socio-economic and political reasons, the maintenance of small tanks has been neglected for a long period of time. Key stakeholder participation is crucial for effective and efficient management [5]. Also, a proper valuation will ensure efficient utilization of water [2]. Water pricing is an effective mechanism to manage water use [6]. Payment for water brings an ownership feeling to the farmers [7], which will ultimately lead to better use of available water and increased crop production.

Recent publications have provided valuable insights into the valuation of water quality improvements all over the world. According to their studies, Willingness-To-Pay (WTP) is affected by the bid price as well as the household's income, education, gender, time spent to fetch water, water treatment practice, quality of water, expenditure on water and age of the respondent [2, 8-9]. The household's WTP for water quality restoration of Sampaloc Lake in San Pablo City within the Philippines has been estimated to be PHP 177.09 /household or PHP 7,102,017/year for the whole number of households [9]. Based on their estimations, the households' WTP is affected by the bid price as well as the household's income, willingness to participate in lake management programmes. Hite *et al*. [10] found that public support exists for water quality improvements and the inclusion of debriefing questions could be effectively used to refine WTP estimates in contingent valuation studies. Therefore, findings of such studies have important implications for programmes to market environmentally friendly agricultural practices. According to an economic valuation study conducted in Yunnan, China, the estimated WTP for water quality improvement by one grade level is roughly like 3% of the typical household income. This study also provides an analysis of the extent of water quality improvements [6].

Hearne and Torpen [5] have studied the stakeholder preferences for water management alternatives within the "Red basin" in Canada to estimate the WTP for extra water management programmes. An equivalent study was conducted by Imandoust and Gadam [11] for the Pavana River in Pune, India to seek out people's WTP for improvement of river water quality using the contingent valuation method. The important variable during this sort of contingency valuation method study is income, which has a positive relationship with WTP. The mean WTP was estimated as Indian Rs 17.6 per family per month (Imandoust and Gadam, 2007).

The Households' WTP for improved rural water service provisioning in Eastern Ethiopia has estimated to be USD 3.72 [2]. Consistent with their findings household income, education, sex, time spent to fetch water, water treatment practice, quality of water and expenditure on the water have shown positive and significant effects on WTP for improved water service provision, while the age of the respondent has featured a negative and significant effect. Since most of the people within the world care about their health, people are more curious about the standard of beverage. Therefore Kwak *et al.* [12] focused to live the economic benefits of water quality improvement through a case study on Pusan, Korea. The results revealed that the monthly mean WTP estimate spike model was KRW 2,124.3 (USD 1.72) per household.

In Sri Lanka, a limited number of studies have been conducted to assess the WTP for water quality improvement. Shantha & Ali [13] have attempted to study the value of irrigation water and identify the most factors behind the WTP decision. The results indicate a universal incontrovertible fact that the degree of scarcity of common-pool resources guides to work out the worth of such resources. One among the foremost important policy implications of this study is that the possibility of restructuring the prevailing freed from a charge irrigation system by taking under consideration the value of irrigation water. When considering the studies associated with the economic valuation of water in Sri Lanka, Sivarajah and Ahamad [14] have investigated the economic valuation of irrigation water under a serious irrigation scheme (*Gal Oya*) in Eastern Sri Lanka. This study has estimated the worth of irrigation water using the principle of Marginal Value Product, through an applied mathematics approach that maximizes net returns for a selected farm plan. The results indicated that the value of irrigation water was Rs. 6,699.2, the quantity by which internet returns might be increased by its additional usage. The analysis focuses on the *Kirindi Oya* irrigation system, located in South-Eastern Sri Lanka, and has broader implications for other multiple-use systems. The ultimate result indicates the mixture value of water in agriculture is bigger than it is for domestic uses [15]. A study conducted by Renwick has valued the water usage of a multiple-use system (irrigated agriculture and reservoir fisheries) to demonstrate the importance of accounting for alternative uses of irrigation water by examining the economic contribution of agriculture, a recognized consumptive water use, and reservoir fisheries, an unrecognized non-consumptive water use.

To value the connection of the piped water network in South-West Sri Lanka, a hedonic price analysis has been conducted by Berg and Nauges [16], under the title of "The WTP for access to piped water: a hedonic analysis of house prices in South-West Sri Lanka". The findings reveal that the Willingness-to-Pay for a piped water connection is around 5% of monthly household expenditure, which is at the lower end of the range from estimates obtained in case studies in other developing countries. Therefore, the WTP for piped water decreases as a proportion of income when income goes up. Jayasekara and Gunawardena [17] have studied a contingent valuation approach for Bolgoda lake, and the estimated WTP values per household per month for the heavy dependency group were LKR 1,550.00, while for the less dependency group was LKR 514.30. Meanwhile, Aheeyar [18] has revealed that farmers are willing to pay Rs. 599-890 (US$ 6-9) per/ha/year in addition to the current level of resource mobilization to ensure the long-term sustainability of infrastructure and to achieve improved irrigation services. Today Sri Lanka is badly experiencing the threat of silting in reservoirs [19].

There is a scarcity of studies administered on the valuation of water quality in Sri Lanka [17] and a proven gap exists in knowledge about WTP for tank water quality improvements in Sri Lanka. Most of the research projects associated with the valuation of water in Sri Lanka so far specialise in either irrigation water uses or domestic water uses. Based on the highlights of a study conducted by Bogale and Urgessa [2], the failure to take care of the water quality level in tanks may end in inefficient and inequitable water allocation decisions. Access to safe water also supports economic process and supply income benefits for both households and government. This may result from a discount within the costs of health treatment and gains in productivity [20]. The lack of recognition of a tanks' true value as a multi-purpose system and poor social involvement are the key reasons behind poor maintenance. Therefore, this study aims to fill this gap by assessing the preference for sustainable management of small tanks. The specific objective is to elicit the WTP for water quality improvements of the tanks in the Anuradhapura area.

METHODOLOGY

Location and Sample Selection

Anuradhapura is an ancient city that is mainly based on an agricultural economy, and hence, most of the country's tank systems are located in the Anuradhapura district. Most of the people in this area utilize this tank system for their daily use. A sample of 120 farmer households was randomly selected for the survey, from the Thambuttegama Divisional Secretariat Divisions. Additionally, the necessary data were collected from focus group interviews and literature to determine the relevant attributes including payments and community water resources.

Method of Valuation

In developing countries, the choice experiment method is a powerful tool to measure the economic benefits of non-market goods like improved water services [2]. There is much literature on the application of the choice experiment for water quality improvement all over the world [17, 21-22]. Therefore, a choice experiment was adopted to estimate farmers' WTP for water quality improvement.

Choice Experiment

Choice experiment is a stated preference technique that allows analysts to assess preferences and estimate WTP from respondents' responses to a hypothetical market solicitation. Choice experiments are based upon two theoretical foundations, Lancasterian consumer theory and random utility theory. Lancasterian theory posits that utility is derived from the attributes of a particular product. Random utility theory posits that individual utility (U) is unknown, but can be decomposed into a systematic or deterministic component (V) and an unobserved or stochastic component (ε).

Thus, for individual j in scenario i, utility can then be expressed as,

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad [1]$$

Where,

U_{ij} : Total utility from alternative i by individual j

V_{ij} : Explainable component with the assigned attributes

ε_{ij} : Error component

In this study, there are several attributes related to water quality. Therefore, choice modelling approach is used because it is the most appropriate approach to measure the WTP of consumers in multidimensional cases. There is much literature on the application of choice modelling for an estimated WTP for water quality improvement [22-24].

Questionnaire of the Survey

The inclusion of debriefing questions can be used to refine WTP estimates in choice experiment studies [10]. Focus group discussions were carried out with government officials and respondents before designing of the experiment. Thereafter, a pilot-study was conducted with 15 respondents to validate the questionnaire and the choice experiment.

The questionnaire included three sections and it was designed to focus on how respondent values the water quality improvements. Through the initial part of the questionnaire, demographic data were explored. Gender, age, education level, and income levels were collected as demographic data. The questioning formats, such as dichotomous questions and open-ended questions, were used to explore the demographic characteristics of the respondents. Demographic questions were used to understand the reasons for their behaviour on water quality improvements.

The second part of the questionnaire includes questions regarding current water sources, tank water usage, alternative water sources, respondents' judgments of water quality levels, the extent to which water to improve, uses of tank etc. Finally, the questions of WTP for water quality improvement of tanks and willingness to contribute to manage the tanks were explored.

Choice Cards

The attributes and levels of the choice experiment were finalized after successful personal interviews and literature surveys as shown in Table 1. The selected attributes were arranged into choice cards by using a fractional factorial design for convenience [5]. The respondents were asked to choose the option they prefer the most in a water quality improvement programme from the choice cards, as shown in Table 2.

Table 1: Attributes and Levels

Attributes	Levels
Water quality	Increase clarity/transparency Reduce *Salvinia* and other invasive aquatic plants Maintain current quality
Fertilizer/ Chemicals reduction	25% less 50% less Current level
Payment	5% of the total income per month 10% of the total income per month Current amount
Fine	One month payment + Rs. 100.00 One month payment + Rs. 200.00 Current amount

Statistical Analysis

The results of the survey and choice cards were coded and analysed using Stata software. Following the standard practice in the choice experiment literature [5,22], a Conditional Logit (CL) model was used to

Table 2: Designed Choice Card

Attributes	Option 1	Option 2	Status Quo
Water quality	Reduce Salvinia & other invasive plants	Increase clarity / transparency	Maintain the current quality
Fertilizer level	25 % less	50 % less	Do not like to reduce the fertilizer level
Payment	10 % of the total income per month	5 % of the total income per month	Current payment
Fine	One month payment + Rs. 200.00	One month payment + Rs. 100.00	Current payment

analyse the data. The model is given in Equation 2. A linear random utility model was employed for the econometric specification. The general form of the CL model includes attributes as a linear summation in the following general form:

$$V = \beta_0 + \beta_1 X_{water\ quality} + \beta_2 X_{fertilizer\ level} + \beta_3 X_{payment} + \beta_4 X_{fine} + \varepsilon \qquad [2]$$

Where,

X : Attributes associated with relevant alternative

β : Coefficient vector of the attributes

ε : The error component.

RESULTS AND DISCUSSION

Descriptive Analysis of Survey Data

According to the table 3, a total of 120 households were interviewed and from the respondents 73.3% are males and 26.7% are females. In the households, often male respondents are willing to participate and provide information. After all, they are mainly engaging with a tank, because they use tank water for agriculture. The average age of the sample is 54 years and it was a benefit because the information gained from the respondents are enriched with their experience as they have been observing the tanks for years.

All the respondents are year-round residents with an average household size of 4 – 5 members. The majority of respondents (40%) are educated up to O/L.. Therefore, the literacy rate of the respondents is high even though there were no graduates or diploma holders. But 10% of the sample did not receive a school education, since they engage with agriculture without going to school. When considering the income dispersion of the sample, most of the respondents (56.7%) have an income that lies between Rs. 25 000 – Rs. 50 000 and a considerable amount of the respondents received an income between Rs.50 000 – Rs. 75 000 per month. No one gets more than Rs. 75 000 as monthly income.

About 93.3% of respondents live from agriculture, while only 6.7% rely on non-agricultural income sources like selling lotus flowers collected from the village tanks. All most all the respondents are members of farmer associations and pay an average membership fee of Rs. 379.31 per month. All respondents use the village tanks as one of the current water sources. When considering the uses of the tank, the majority of households use tank water for agriculture (87%) and livestock activities (50%). No one used tank water for drinking, bathing, industries, and domestic uses. For drinking and other household uses, most of the respondents tend to use wells and tap lines.

Table 3: Descriptive Analysis of Survey Data

	Level	Percentage (%)
Gender	Male	73
	Female	27
Family size	2 Members	6.7
	3 Members	6.7
	4 Members	33.3
	5 Members	33.3
	6 Members	10
	7 Members	6.7
	8 Members	3.3
Educational Level	Graduate	0
	Diploma holder	0
	A/L	30
	O/L	40
	Pass grade 8	20
	No	10
Income Dispersion	<Rs.25000	3.3
	Rs.25000 – Rs.50000	56.7
	Rs. 50001 – Rs.75000	40
	>Rs.75000	0
Income source	Agriculture	93.3
	Non-agriculture	6.7

Note: N: 120

The respondents stopped using tank water for drinking and other domestic uses, because the tank water was polluted severely by invasive aquatic plants and chemicals. The respondents rated water for agriculture as the most important benefit of tanks, while using for fishing as the least important benefit.

WTP for Water Quality Improvements

When considering the uses of the tank, the majority of households use tank water for agriculture and livestock activities because the current water quality was not much affected for agriculture and livestock activities. The respondents highlighted that villagers move away from drinking tank water, since they found out about the kidney damages due to the water in the area. The respondents rated water for fishing as the least important benefit by indicating that the fish harvest is low in the tanks as the fish population decrease due to the hazardous chemicals accumulated in the tank. The water used for livestock rated as the second most important benefit since most of the households raised cows.

From the total of 120 households, 90% responded "yes" for WTP for a service fee for water quality improvements of tanks. They indicated that "protecting the tank is their responsibility" as the major reason behind their WTP for water quality improvement of tanks. During the direct contingent valuation analysis, about 85.2% of respondents were willing to pay Rs.100.00 as the service charge for tank water quality improvement. The reasons behind the respondents' WTP a service fee for water quality improvement are given in Figure 1.

The results of the CL model are presented in Table 4. The coefficient of water quality attribute is positive and significant.

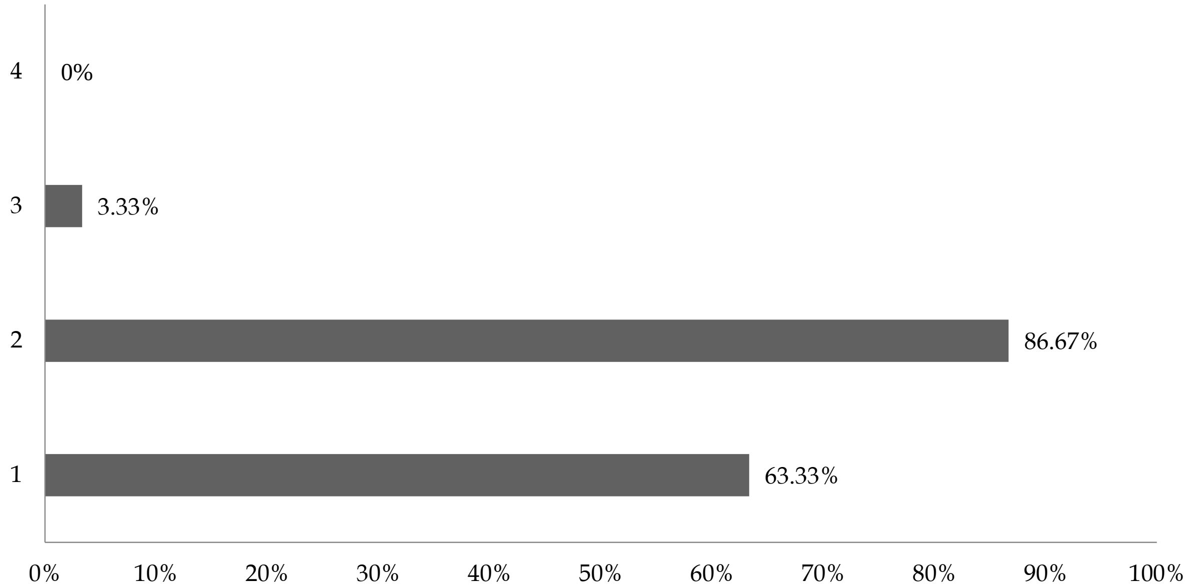

Figure 1: Reasons for Willingness-To-Pay

Note: *1: This programme is important to me, 2: I think it is our responsibility to protect the tank, 3: I want to contribute to a good cause, 4: Other reasons*

Table 4: Results of the Choice Experiment

Effect	Coefficient	SE	P-value	MWTP
Water quality				
Reduce invasive plants	0.600	0.275	0.029	60
Increase clarity transparency	1.713	0.243	0.000	171.3
Fertilizer level				
25 % less	0.799	0.186	0.000	79.9
50% less	0.141	0.212	0.505	14.1
Payment	0.003	0.005	0.544	3
Fine	-0.010	0.025	0.990	

Note: P-value for model: 0.000, SE: Standard error, MWTP: Marginal Willingness to Pay,; log likelihood: - 2058.244

It is clear that respondent's most preferred choice, which contained the level of water quality attribute to reduce *Salvinia molesta* and other invasive aquatic plants, as they observed tank water pollution from invasive aquatic plants. So, they are willing to pay for a programme that reduces the invasive aquatic plants in the tanks to improve water to drinkable quality. The level of reducing fertilizer and chemicals usage by 25% is also, positively significant. However, reduction of fertilizer and chemicals usage by 50%, the payment attribute and fine attribute are not significant.

Marginal WTP

Marginal WTP (MWTP) for each attribute of the choice set gives the amount that respondents are willing to pay for an attribute of the water quality improvement programme. The MWTP is calculated as indicated in the Equation 3 for each attribute by dividing the coefficient estimate for each attribute with the coefficient estimate for the payment term. The Fine attribute was taken as the price attribute as it is the direct monetary attribute. According to the calculated MWTP values, respondents are willing to pay for all the attributes of a water quality improvement programme.

$$MWTP_{attribute} = -1\ (\beta_{attribute}\ /\ \beta_{monetary\ attribute}) \quad [3]$$

Where,

β : Coefficient of relative attribute

When considering the water quality attribute, the respondents are ready to pay Rs. 60.00 to reduce invasive aquatic plants, as they wish to see a tank without pollutants. People are more likely to pay Rs. 171.30, if the water quality improvement programme increases the transparency of the tank water, because they would like to observe drinkable water quality, which goes beyond the reduction of pollutants, in tanks. The respondents are willing to pay Rs. 79.90 for the water quality improvement project that suggests a reduction of 25% of fertilizer and chemical use of farmers, along with Rs. 14.10 for the reduction of 50%, as they observe the contribution of those chemicals to tank pollution. Farmers preferred 25% of reduction compared to 50%, because applying fertilizers and pesticides are crucial when it comes to agriculture. They were willing to pay a service fee to protect the tank because of the ownership feeling and as gratefulness for the services received from the village tank.

Even if there are farmer societies, they did not do much services or practices to protect the village tanks and manage the water quality level in the village tank, even they knew that protecting the tank is a responsibility of villagers also. Therefore, this programme is a great opportunity for the villagers to do their part of the responsibility of protecting village tanks.

CONCLUSIONS

Almost all the people using small tanks in the Anuradhapura district rely on ground water sources, such as lakes, tanks and rivers. Therefore, the quality of the water resources directly affects the well-being of the people.

The results obtained from the choice experiment are in line with the responses received for the questionnaire. All the respondents who engaged with the study observed pollution of tank water, due to major pollutants like invasive aquatic plants and chemicals. Further, they were willing to pay for a programme that improves the water quality of tanks. The most important finding of the study is that the respondents are willing to pay 10% of their monthly income, which is generated from tank related activities. The findings conclude that the respondents did not much consider a payment or a fine, if the programme will improve the water quality of the tank. A clear interest was seen among the respondents to engage in multiple uses. Thus, it is important for policymakers to set up an appropriate service fee for water quality improvement and to improve the sustainability of the current tank restoration programmes in Anuradhapura District.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHORS' CONTRIBUTIONS

HD and MU: carried out the investigation and data curation and wrote the manuscript. MU: Conceptualized, designed the research, supervised the study, performed statistical analysis and interpretation of data, PR: Coded and analysed data. All authors read and approved the manuscript.

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