Environment and Ecology 36 (4) : 1041—1046, October—December 2018
Website: environmentandecology.com ISSN 0970-0420

Quantifying the Total Economic Benefit from the Tank Ecosystem–A Tank in Noyyal Basin

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Received 16 May 2018; Accepted 19 June 2018; Published on 7 July 2018

Abstract Tank, one of the wetland ecosystems provides both tangible and non-tangible benefits to the depending population. Hence it should be conserved and efficiently managed but better management is not possible without valuation. The primary objective of this paper is to analyze the overall economic contribution of attributes viz. irrigation water, habitat for birds, livestock usage and fodder, fish source and carbon sequestration from the Samalapuram tank in Noyyal basin, Tamilnadu. Firstly, the benefits from each and every attribute of the tank are valued. Secondly various valuation methods with particular emphasis to production function method, contingent valuation method, alternate cost method, market price method and carbon price method are discussed. The individual value of the services are estimated by employing the appropriate valuation methods and aggregated to get the total economic value (TEV). Results indicate that the provisioning service contributes the major portion of TEV but regulation and cultural service also contributes a significant portion of TEV i.e. 14%. The total economic value of the Samalapuram tank is found to Rs 3.85 million per year.

Keywords Ecosystem services, Tank, Valuation.

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Introduction

Provisioning service, Regulating service, Supporting service and Cultural services are the four categorises of tank ecosystem services that are basically needed for the well-being of human. To convey the significance of ecosystem and bio diversity, the ecosystem services should be expressed in monetary terms, this in turn guides the policy makers in understanding the user preference and value they place on the sevices. To identify the resource that requires more reclamation and restoration and to use the limited funds more efficiently, ecosystem service assessment is necessary (Crossman and Bryan 2009, Crossman et al. 2011). Services that directly benefit the people are emphasized over the other economics benefits such as recreational uses and regulating services (Mugambi and Mburu 2012, Geleto 2011). Due to various practical problems quantifying the individual values of every ecosystem services in monetary terms is not possible (Carson 2012). Some benefits are directly received by people whereas some are non-tangible and have no market value. As an alternative, the economic values are defined in terms of total economic value (TEV) which includes use values and non-use values. Use value is the benefit or the service that is directly used. Non-use value refers to the option value, quasi-option value and existance value. The non-use values are special category values and adding these values with the use values does significantly increase the TEV of the wetlands.

Materials and Methods

Economic valuation of ecosystem services

The valuation of ecosystem is a complex process that depends on the availability of relevant and accurate biophysical data on ecosystem processes and functions and the appropriate applications of economic valuation methods (Morse-Jones et al. 2011).

Irrigation water

The value of irrigation water was determined by employing quadratic production function approach (Chandrasekaran et al. 2009) with yield (kg/ha) as dependent variable and volume of irrigation water in ha.cm (WATER) as independent variable and the estimated MPP (Marginal physical product of water) is multiplied with the output price used to get the Marginal value product of irrigation water (MVP_{IW}).

The quadratic production function is as follows:

$$Y = \alpha + \beta_1 X + \beta_2 X^2$$

Where, Y is the yield (kg/ha) and X is the volume of irrigation water in ha.cm. The value of irrigation water is calculated by using the formula,

$$V_1 = \sum_{i=1}^{n} (MVP * A1 * WU)$$

Where, V_1 is the value of irrigation water (Rs/year), MVP is the Marginal value of irrigation water used (Rs/ha.cm). AI is the actual area irrigated by tank water (ha), WU is the quantity of water used per season (ha.cm) and i is number of seasons. i=1, 2,3............n (seasons).

Fishing

Market price method was employed (Adeyemi et al. 2013) where the sales price of fish in the market was used to determine the total value of fish from the tanks.

$$V_F = \sum_{i=i}^{n} \sum_{j=i}^{k} Q_{ij} + P_{ij}$$

Where, V_F is the value of fish harvested (Rs /year), Q_{ij} is the toal quatities of j^{th} breed fish harvested in i^{th} season (kg/year), and P_{ij} is the Sales price of j^{th} breed fish in i^{th} season (Rs/kg). i=1,2,3.....................n (different seasons); j =1,2,3,.......... .....k (different breeds).

Recreation- habitat for birds

Contingent valuation, a stated preference approach is frequently used to value environmental amenity (Mitchell and Carson 2013) especially if the service is habitat for birds. CV is a survey based method frequently used for placing monetary values on environmental goods and services lacking market information, by asking the respondents to quote their willingness to pay for the particular service. The factors influencing the Willingness to pay (WTP) are annual income of the households, peoples attitude towards birds habitat, educational level of the head of the household and age of the head of household. The average willingness to pay is determined and extrapolated to the total population of the area by multiplying mean WTP with total population.

WTP=f (INCOME, HAPPY, EDN, AGE)

Carbon sequestration

Carbon price method was employed to estimate the carbon sequestrated by the trees in the tank bed. The quantity of carbon dioxide sequestrated was taken from the study of Lales. The conversion factor from carbon dioxide to carbon is 3.67. The estimated quantity of carbon sequestrated is 24.1 tonnes of carbon per hectare per year (Lales et al. 2001). The value of carbon sequestrated by the trees in the tank bed is,

$$V_c = (Q_c * 3.67) * P_c$$

Where, V_c is the Value of carbon sequestered (Rs/year), Q_c is the Quantity of carbon dioxide sequestered (tonnes/year), P_c is the Price of carbon (Rs/

tonnes of Co_2).The price of carbon sequestered is determined by the IPCCC market price of sequestered carbon. The price of carbon per ton ranges from 10-30 US dollars (Tandug 2007). The mean price (20 US dollar) is considered for valuation of carbon sequestrated per ton.

Livestock usage and fodder

The value of water for livestock use and fodder grazed by livestock nearby the tank was calculated by using alternate cost method in this method, the sales price of the fodder in the nearest local market is used to calculate the value of fodder and the alternate source to tank water was identified and its price was applied to tank water (Hussain and Badola 2008). This method is applicable only in situations when the natural service can be suitably and equivalently replaced with a man made alternative, the costs of that substitute are known or estimable (WRI 2009).

$$V_{FODDER} = (H_{FODDER} *Q_{FODDER} * N *N_D)* AC_F$$

$$V_D =(N * Q_D + N_D) * AC_{WATER}$$

$$V_C = (N * Q_C + N_D) * AC_{WATER}$$

$$V_{LU} = V_D + V_W$$

The value of fodder per year (V_{FODDER}) is estimated by multiplying the Grazing hours of a livestock in a day (H_{FODDER}), Average quantity of fodder grazed by a cattle in a hour (Q_{FODDER}), Number of cattle (N), Number of days grazed in a year (N_D) and the Alternate cost of fodder (AC_F). Value of water for livestock use per year (V_{LU}) is derived by the summation of value of water for drinking (V_D) and cleaning (V_C). V_D and V_C in turn are estimated by the multiplication of average quantity of water required for drinking (Q_D) and washing (Q_W) respectively with number of livestocks (N), number of day water used for usage (N_D) and alternate cost of water (AC_{WATER}).

Description of study area and respondents

The Noyyal basin comprises of about 31 system tanks out of which Samalapuram tank located in the Tiruppur district in Tamil Nadu, providing multiple services like irrigation water, water for livestock usage, fodder, habitat for birds, carbon sequestration was studied.

Table 1. Profile of respondents.

Socio economic profile	Mean
Age of the head of the household	52.06
Family size of the respondents	3.45
Education (no. of schooling years)	10.02
Annual income of the households (Rupees/household/year)	262,152.52
Distance of the tank to the residents (km)	1.85

Samalapuram tank has a command area of about 121 acres benefiting the population of about 5938 households. 100 farmers residing around the tanks with in the radius of 5 km were randomly drawn as sample respondents. The profile of the respondents was presented in Table 1.

Results and Discussion

Livestock use and fodder

Livestock owners in the village benefit prominently from the tank ecosystem as the tank water is used for both livestock usage (drinking and cleaning) and for grazing purpose. The tank is filled with water, for 9 months in a year and is used for livestock usage, the remaining 3 dry months is let for livestock to graze. The alternate rate of water and fodder is Rs 0.5 and Rs 3.0 respectively. The total value of tank in terms of livestock usage and fodder services are presented in Table 2.

Table 2. Value of livestock usage and fodder.

Particulars	Livestock drinking	Livestock cleaning	Fodder use
Number of livestock using tank water	39	39	39
Average quantity of water used for livestock (liters/day/livestock	25.2	70.5	–
Number of days	252	252	84
Alternate cost water used for drinking (Rs/liter)	0.50	0.50	3.00
Grazing hours in a days by the cattle (hours/day)	–	–	7
Average quantity of fodder grazed by the cattle (kg/hour)	–	–	1.5
Total value	124,225.92	346,437.00	103,194.00

Table 3. Value of fishing in the Samalapuram tank.

Name of the fish species	Price per kg of fish harvested (Rs/kg)	Quantity of fish harvested (kg/year)	Value of fishing (Rs)
Catla	120	7500	900000
Roghu	120	7500	900000
Jelabi	110	3000	330000
Cat fish	70	3000	210000
Total value of fishing (Rs/year)			23,40,000

Table 5. Parameter estimates of willingness to pay for habitat for birds. ***indicates significance at 1% level, **indicates significance at 5% level. *indicates significance at 10% level.

Variables	Regression coefficient	t ratio
Constant	-30.07	-1.69
Income	17.09***	5.91
Happy	33.64***	4.09
Edn	11.91***	7.01
Age	-0.46**	-2.06

Fishing

Fishing is one of the major income sources from the Samalapuram tank. The economic value of fishing from the tank is assumed as the gross income by fishing and sale of fish. Fishes are grown and harvested from the month June to February. The yotal value of fishing attribute is estimated by the product of total quantity of fish harvested in a year and its prevailing market price (Table 3). The total income received by inland fishing in the Samalapuram tank is Rs 2,340,000 per year.

Economic valuation of irrigation water

The major area in under sorghum and coconut cultivation in the command area. The tank ecosystem provides irrigation water to the crops in the tank command area of 121 acres. To assess the value of tank in terms of irrigation water attribute, value of irrigation water for both the crops is determined. The economic value of irrigation water is determined by employing quadratic production function with yield (kgs/ha for sorghum; nuts/ha for coconut) as dependent variable and volume of irrigation water used per ha.cm (WATER) as independent variable. It can satisfactorily be used when compared to other production function approach, because it shows ranges of both increasing and decreasing function. The price of output of sorghum grain is Rs 25 per kg and the average price per nut is Rs 18.2. The estimates of quadratic production function in Table 4, were used to derive the marginal value product of water,which in turn is multiplied with actual area irrigated get the value of irrigation water and is presented in Table 4.

Table 4. Parameter estimates of quadratic production function. Figures in the parentheses indicated estimated t ratio. *** indicates significance at 1% level, **indicates significance at 5% level, *indicates significance at 10% level.

Variables	Sorghum	Coconut
Constant	708.50	13412.2
	(15.81)	(16.19)
Water	25.565**	97.87*
	(2.07)	(1.70)
Water squared	-1.09*	-1.90**
	(-1.92)	(-2.08)
Adj. R-Squared	0.3	0.4
No. of observations	92	100
MVP of water (Rs/ha.cm)	390.56	202.00
Actual area irrigated by tank water/(ha)	48.4	48.4
Quantity of water used for crop cultivation (ha.cm)	431.29	2433.849
Value of irrigation water (Rs/year)	1,72,434.93	2,04,957.76

Recreational - Habitat for birds

Migratory birds visit the tank in every season providing happiness in the minds of the people. The estimated results of bivariate logit regression model on socio-economic factors, influencing the respondents willingness to pay for birds habitat are found to be significantly influencing the respondents WTP (Table 5). It is evident from Table 5 that the highly educated and higher income people are willing to pay more for the bird watrching and habitat for birds. When the happiness towards the bird watching is high the willing to pay will be more. Younger people are more willing to pay than the aged people. 89% of the sample respondent is willing to pay and maximum quoted amount is Rs 200 per year with the mean WTP of Rs 84.25. When extrapolating, the total value of habitat

Table 6. Value of carbon sequestrated.

Particulars	Carbon sequestrated
Quantity of carbon sequestrated (tonnes/year)	43.78
Price of carbon (Rs/tonnes of CO_2)	1340.00
Value of carbon sequestrated (Rs/year)	58,665.20

for birds is Rs 500,276.50 as the number of households is 5938.

Carbon sequestration

Another vital service provided by the tank is carbon sequestration. In general trees store carbon in the atmosphere and release oxygen. The presence of trees in the bunds of the tank regulate atmosphere by storing the carbon which may be released as carbon dioxide when they are cut down, as it prevents the emission of greenhouse gas into the atmosphere the carbon sequestered by the tree should be valued. For which, carbon price method was employed. There are approximately 150 trees in the tank bunds of Samalapuram tank and it accommodates about 0.49 ha. The mean price of 20 US$ is considered as value of a ton of carbon sequestrated and the approximate exchange rate of US dollars to Indian rupees is Rs 67. Therefore, the price of the carbon per ton is Rs 1,340. It could be seed from the Table 6 that the quantity of carbon sequestrated is 43.78 tonnes per year. The value of carbon sequestrated is Rs 58,665.20 per year.

This section shows the results of the valuation studies considered in this paper, providing a comprehensive picture of ecosystem services esteemed and valued. The individual value of services viz. water for irrigation is Rs 3,77,392.69, fishing is Rs 23,40,000.00, livestock use is Rs 4,70,662.92, fodder is Rs 103,194.00, carbon sequestration is Rs 58, 665.20, and habitat for birds is Rs 5,00,276.50, is aggregated. The total value of Samalapuram tank is estimated to be Rs 38,50,191.31 per year. The economic value of the Samalapuram tank per hectare is arrived by dividing the value with the total command area and is estimated to be Rs 79, 549.40, where the command area of the tank is 48.4 ha. The overall oconomic contribution of some of the direct benefits from Chilika Lake in Odisha, India, was assessed to be at Rs 200 crore per annum (Kumar 2010). Here, the overall economic contribution of attributes from Samalapuram tank was about Rs 3.85 million. This implies that in absence of Samalapuram tank, the people would have lost the advantage of the evaluated worth. The tank in addition to provisional services also supplies with significant amount of regulation and cultural services i.e. 14.51% of total value of tank thereby the services are also valid in capturing the total economic value of the tank. But the non-tangible benefits are mostly not captured by the policy making bodies. Not only the direct benefits derived from the tank but also the non-tangible benefits can be accounted and taken into consideration while policy decisions regarding the ecosystem services.

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