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PHYSICO-CHEMICAL CHARACTERISTICS, BIODIVERSITY ASSESSMENT AND ECONOMIC VALUATION OF KALYANTHAKUR PARA LAKE: A COMMUNITY BASED LAKE OF TRIPURA, NORTH-EAST INDIA

Moitree TARAN, Sourabh DEB, Jaya ROY
Department of Forestry and Biodiversity, Tripura University (A Central University), Suryamaninagar 799022, Tripura, India. Email: *moitree.forestry@tripurauniv.in*

Abstract

Wetland resources are having significant role in the livelihoods of ethnic communities and their involvement in resource management can be used to maintain ecological banance in wetland ecosystem. The objective of this study is to provide some ideas about participation of "*Tripuri*" community and their role in wetland conservation and management. Physico-chemical water parameters of the lake shows suitability of this lake water for fisheries and also its a good storage for carbon. Overall, six genera belonging to four classes of phytoplankton and total four groups of zooplankton have been identified from the lake. Total thirteen aquatic plants belongs to twelve families were identified from Kalyanthakur para lake and most of the plants are used for food, fodder and fencing. The dominant aquatic species were *Enhydra fluctuans* DC., *Sacciolepis* sp. and *Nymphoides indica* (L.) Kuntze. with the Importance Value Index (IVI) 73.53, 61.58 and 50.00 respectively. The lake also provides various provisioning and cultural services. The provisioning services of the Kalyanthakur para lake includes mainly fishes, aquatic plants, crabs, molluscs, domestic uses, collection of timber and fuelwood with a total value of US$ 26263.65/year. Whereas, the cultural services of Kalyanthakur para lake, includes recreational opportunities, aesthetic value and place with natural beauty with a total value of US$ 2605.68/year. Human settlements, negligence of the concerned authority and public effluent are worked as the chief factors for the degradation of this lake. Government should take some planning, managing and monitoring plan to mitigate the anthropogenic stress on this community based lake.

Keywords: Aquatic plants, Community, Ecosystem services, Planktons, Important Value Index, Wetland.

1. INTRODUCTION

Wetland ecosystems are rich in diversity and provide high productivity but unfortunately due to population growth wetlands are degrading day by day. Wetland conservation and management is a new/emerging science as opposed to other disciplines such as forestry or wildlife management which have been around for a long time (Raburu et al., 2012). Globally about 300 million people are considered as indigenous or aboriginals representing 4% of the global population. Indigenous people have immense knowledge of the environment around them and deeply understand man's role in nature (Maiti & Maiti, 2011). This indigenous knowledge of communities not only help to maintain balance in ecosystems also play important role in there conservation. Therefore the community participation in conservation of wetland resources are important to know globally (Williams 2002).

Tripura is one of the North eastern states of India having 19 ethnic communities. Each of these communities are having unique knowledge about nature and natural resources of different ecosystems. But there are limited informations about their conservation and management practices specially about wetlands. Therefore, the present study was undertaken to assess the physico-chemical characteristics, biodiversity assessment and economic valuation of Kalyanthakur para lake, a community managed wetland ecosystem of Tripura.

2. METHODS

2.1. Study area

The present study was carried out in the Kalyanthakur para lake (23° 48′ 56.11′′ N and 91° 27′ 48.48′′ E) situated in West Tripura district of Tripura, Northeast India during the period of 2015-2016. This is a natural lake with a total area of 7.84 ha.

2.2. Field survey and data collection

In this study three sampling stations [Station 1 (S_1), Station 2 (S_2), Station 3 (S_3)] were longitudinally established (Fig. 1) in the lake for data collections in the lake. All samples were collected by seasonal basis (summer, monsoon and winter). The evaluation of seasonal variance in physico-chemical parameters like temperature, dissolved oxygen, conductivity, soil pH, bulk density, moisture etc. were done by following

methodology described by Gupta (2000). Carbon stock in sediment was estimated followed by Ausseil et al. (2015). Collection and identification of plankton samples was done by standard methods following Battish (1992), Anand (1998) and Das & Dutta (2011). For determining the aquatic plant diversity one initial floristic survey was done visually by boat covering the whole lake to know the various aquatic plants species present in the lake. Plants were collected from randomly selected 1x1 m^2 sampling plots (Oosting, 1965) at each station in three seasons. Important Value Index (IVI) were calculated followed by Curtis (1959) and Mueller-Dombois (1974).

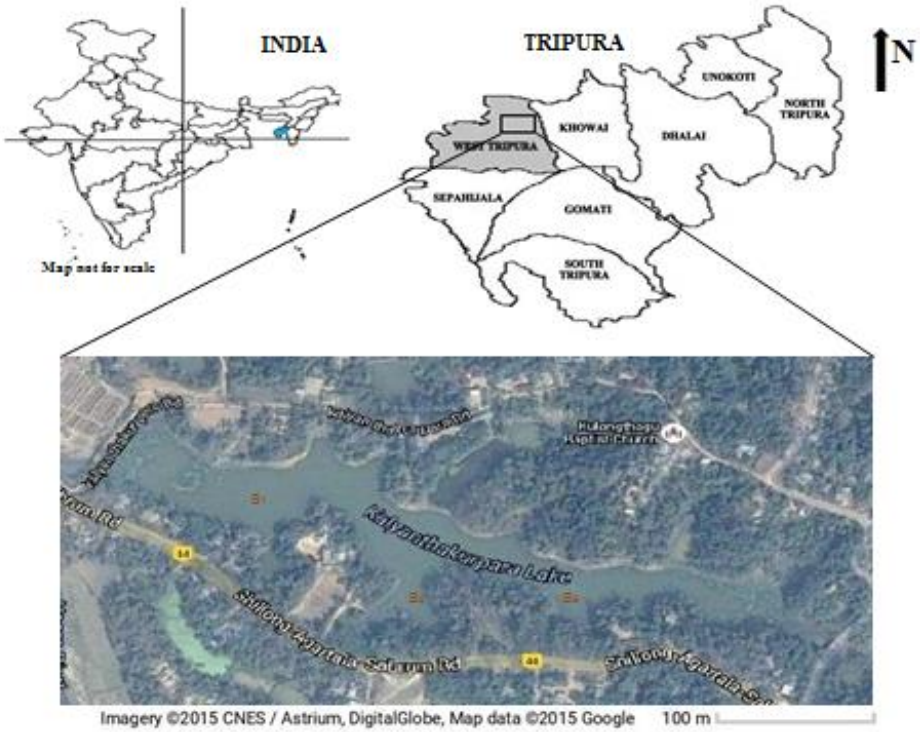

Figure 1. Map of the study area

Note: S_1 = First station near school present in the left site of the lake, S_2 = Second station near main wharf of study site and S_3 = Third station near brick industry present on the right site of study site.

A preliminary survey was conducted in seven villages (Joynagar, Kalabagan, Kalabagan muslimpara, Poschim chintaram para, Maddhya debandra nagar, Kalyanthakur para and Sarat chowdhury para) present near the lake to identify ecosystem services provided by the wetland. A total of 272 respondents were interviewed from different households (56% of total population) for data collection. From the survey it was found that the

services provided by the wetland were mainly provisional and cultural services. So, these services were chosen for valuation. Valuation of provisional services was done by following the methodology prescribed by Kumar (2001), Mukherjee (2008) and Rana et al. (2009). For determining the cultural services contingent value (CV) method was used as given by Maharana et al. (2000) and Ramachandra & Rajinikanth (2003).

All statistical analysis was done using Microsoft Excel 2007 and SPSS.

3. RESULTS AND DISCUSSION

Kalyanthakur para lake is a community based lake and its management and conservation is controlled by "Tripuri" community from a long period. People of these community create a group for its management every year, where both male and female members generally participates. During summer season they usually cleanup nearby areas of the wetland and this activity also include pruning and felling of trees. These plants and plant parts used as timber and fuelwood by local people.

Plantation of trees and bamboos are also done for reducing soil erosion and utilize them in future for various purposes. In monsoon new fingerlings are released for fish cultivation and few parts of the lake are bordered with net where *Eichhornia crassipes* (Mart.) Solms is grown. This aquatic plant protect fingerlings from predators.

All domestic works like bathing and cleaning clothes within the lake are not allowed in this period. Every winter season fishing is done for sale through auction and community people utilize the auctioned money for the management practices of the lake. Every year this group change so that other people can similarly participate in these management activities. People from other communities are not allowed to participate in any management activities of the lake but are allowed to enjoy its services.

3.1. Evaluation of seasonal variance in physico-chemical parameters

The physico-chemical parameters of water in Kalyanthakur para lake shows variation from one season to another. The pH, dissolve oxygen, conductivity, total CO_2, total alkalinity shows higher value in summer. Whereas, total dissolve solid (TDS) and free CO_2 was maximum in winter season. Movement and depth shows higher value during monsoon (Table 1).

Table 1. Seasonal physico-chemical analysis of water in Kalyanthakur para lake

Parameters	Monsoon	Winter	Summer	Mean ± SD
pH	5.55	6.26	6.56	6.12 ± 0.51
TDS (mg/L)	120.02	182.22	124.44	142.22 ± 34.12
DO(mg/L)	3.17	4.01	4.81	3.99 ± 0.66
Conductivity (µ.mho/cm)	0.13	0.95	1.00	0.69 ± 0.48
Free CO2 (mg/L)	4.33	5.89	3.64	4.62 ± 1.15
Total CO2 (mg/L)	43.34	48.13	49.10	46.86 ± 3.08
Total Alkalinity (mg/L)	14.77	16	17.22	40.89 ± 9.83
Movement (cm/s)	1.42	0.46	1.25	1.04 ± 0.51
Depth (cm)	131.74	117.14	77.44	108.77 ± 28.09
Sediment moisture (%)	46.00	23.81	28.70	32.84 ± 11.66
Bulk density(g/cm^3)	0.11	0.11	0.13	0.32 ± 0.34
Soil Organic Carbon (%)	0.09	0.27	0.11	0.16 ± 0.09

The result of physico-chemical water parameters lies under water class D which indicates the suitability of this lake water for fisheries. Same trend was also reported by Abu et al. (2015) from Chalan Beel of Bangladesh.The physico-chemical analysis of wetland sediment was analysed and found that moisture content (%) of sediment is high in monsoon (46%) and low in winter (23.81%). Whereas, bulk density (g/cm^3) was high during summer (0.13 g/cm^3).

The seasonal carbon stock was high in winter (230.01 t/ha) and low in monsoon (118.01 t/h). The carbon stock of the wetland sediment was determined and it is found that the storage of carbon in winter season is much higher than summer and monsoon season (Figure 2). The average carbon stock in the lake was 171.95 t/ha. Huang et al. (2013) studied soil organic carbon of freshwater lake in China and reported the carbon stock is 128-196 t/ha and this value is comparable with the present study.

Table 2 shows correlation between various physico-chemical parameters. pH shows positive correlation ($r=0.991$, $p< 0.05$) with total CO_2. Whereas, Total dissolve solids shows positive correlation ($r=0.999$, $p<0.05$) with total alkalinity and negative correlation ($r=-0.995$, $p<0.05$) with movement. Conductivity shows positive correlation ($r=0.994$, $p<0.05$) with total CO_2. Shib (2014) also reported positive correlation between pH and free CO_2 (mg/L) ($r=0.699$, $p<0.01$) of Rudrasagar lake in Tripura.

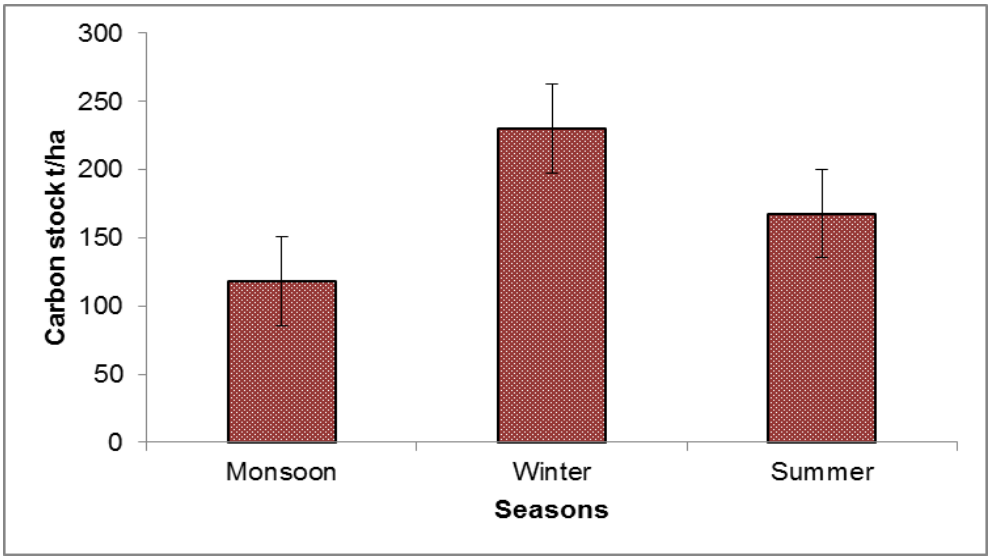

Figure 2. Seasonal carbon stock (t/h) in sediment of Kalayanthakur para lake

3.2. Plankton and aquatic plant diversity

The Kalyanthakur para lake is a good habitat for planktons. Overall, six genera belonging to four classes of phytoplankton (Bacillariophyceae, Cyanophyceae, Mediophyceae and Oocystaceae) are present in the lake (Figure 3). Few dominant species identified up to genus level are Bacillariophyceae (*Cymbella* sp., *Gomphonema* sp., *Pinnularia* sp.), Cyanophyceae (*Gomhosphaeria* sp.), Mediophyceae (*Cyclotella* sp.) and Oocystaceae (*Eremosphaera* sp.). *Gomphonema* sp. indicate about the moderate water quality of the lake (Oeding and Taffs, 2015). *Gomhosphaeria* sp. indicate the oligotrophic condition of the lake. In oligotrophic water lake have a low algal production and offer good drinking water quality (Bellinger and Sigee, 2010). The study shows Bacillariophyceae class as the most dominant in summer and monsoon season whereas, Cyanophyceae is high in winter season (Figure 3). Dalal & Gupta (2013) also reported the presence of Bacillariophyceae and Cyanophyceae class in wetland of Assam.

Table 2: Bivariate correlation between different physico-chemical water parameters of Kalyanthakur para lake

Parameters	pH	TDS (mg/L)	DO (mg/L)	Conductivity (µ.mho/cm)	Free CO_2 (mg/L)	Total CO_2 (mg/L)	Total Alkalinity (mg/L)	Movement (cm/s)	Depth (cm)
pH	1	0.290	0.976*	0.970*	-0.074	0.991*	0.246	-0.384	-0.526
TDS (mg/L)		1	0.076	0.513	0.933*	0.416	0.999*	-0.995*	0.661
DO(mg/L)			1	0.895	-0.289	0.538	0.030	-0.175	-0.698
Conductivity (µ.mho/cm)				1	0.169	0.994*	0.473	-0.596	-0.305
Free CO_2 (mg/L)					1	0.060	0.948*	-0.892	0.887
Total CO_2 (mg/L)						1	0.374	-0.505	-0.407
Total Alkalinity (mg/L)							1	-0.989*	0.695
Movement (cm/s)								1	-0.583
Depth (cm)									1

*Correlation is significant at the 0.05 level (1-tailed).

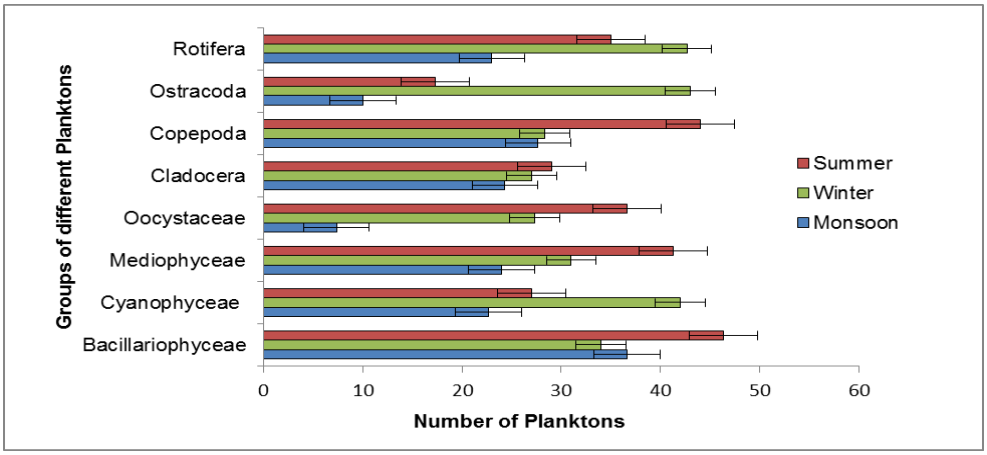

Figure 3. Seasonal abundance of different planktons (phytoplanktons and zooplanktons)

Total four groups of zooplankton are identified from the lake in which Copepoda is high in summer, Rotifera is high in winter, Ostracoda is low in both summer and monsoon and Cladocera is low in winter (Figure 3). The presence of these groups were also reported by Kanagasabapathi & Rajan (2010) in Tamil Nadu. Identified genera from Rotifera groups are *Brachionus* sp. and *Lecane* sp. Three genera identified from Cladocera groups are *Chydorus* sp., *Eurycerus* sp. and *Daphnia* sp. *Cyclops sp.* and *Spicodiaptomus* sp. are the genera identified from Copepoda group. Two genera *Cypris ampla* and *Candonopsis* sp. are identified from Ostracoda group. *Daphnia* sp. is highly sensitive to toxic substances (Tyagi et al., 2007). Presence of this species indicate absence of toxic sustances in the lake water. The seasonal analysis of zooplankton diversity shows an average abundance of species in winter season, lower in monsoon season and maximum in summer season due to different environmental condition of lake water. The same result was also reported by Dede & Deshmukh (2015).

Zooplankton shows positive correlation with conductivity (µ.mho/cm) of water ($y=0.0131x + 20.116$, $r^2=0.991$, $p<0.05$). Bos et al. (1996) also reported positive correlation with conductivity (µ.mho/cm) and zooplankton ($r^2=0.56$, $p<0.05$).

Total thirteen aquatic plants belonging to twelve families are identified from Kalyanthakur para lake in which *Alternanthera philoxeroides* (Mart.) Griseb., *Ludwigia adscendens* (L.) Hara and *Nymphaea nouchali* Burm. f. are edible. *Sacciolepis* sp. and *Ipomoea fistulosa* Mart.ex.Choisy. are used for fodder and fencing respectively.

Enhydra fluctuans DC., is used for medicinal purpose against dysentery. Bhowmik et al. (2008) identified sixty five aquatic plants from wetlands of West Tripura district used for various purposes.

Figure 4 shows the Important Value Index (IVI) of different aquatic plants of Kalyanthakur para lake. The dominant species are *Enhydra fluctuans* DC., *Sacciolepis* sp. and *Nymphoides indica* (L.) Kuntze. with the (IVI) 73.53, 61.58 and 50.00 respectively. Udomsri et al. (2005) reported the IVI of three dominant species of Bung Khong Long in Thailand *viz.*, *Utricularia aureab* (84.66), *Hydrillla verticillata* (54.30) and *Eleocharis dulcis* (31.09).

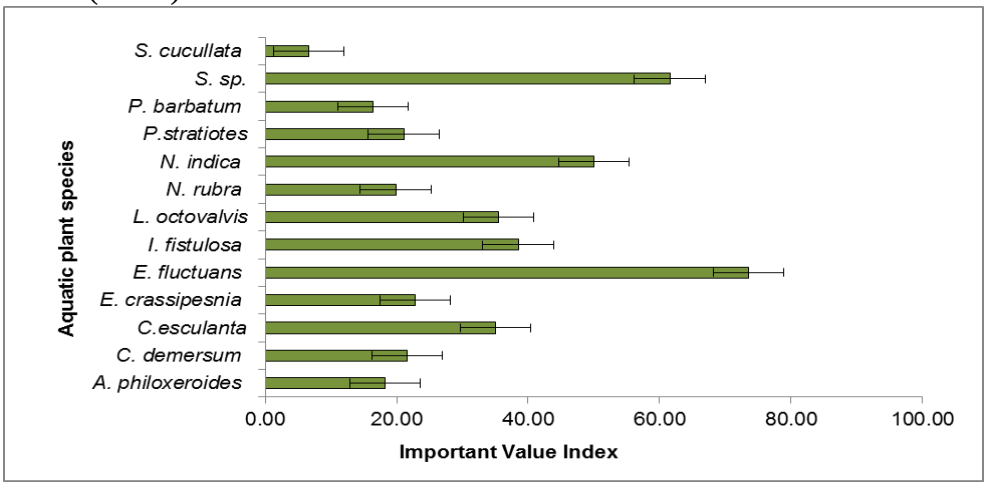

Figure 4. Important Value Index (IVI) of aquatic plants in Kalyanthakur para lake

3.3. Economic valuation of the lake

Total seven villages are situated around the Kalyanthakur para lake. The villagers are dependent in agriculture, fishing and other occupations for their income. The valuation of ecosystem services provided by the wetland were analysed and it was observed that total 370 households are directly or indirectly dependent on the lake.

The provisioning services of the Kalyanthakur para lake were mainly obtained from fishes, aquatic plants, crabs, mollusc, domestic uses (washing, bathing), collection of timber and fuelwood. The highest estimated value of provisioning services comes from fishes whereas, lowest from aquatic plants (Figure 5). This lake is a great source of income for fishermen present near the lake. Some of the common fishes are *Channa punctate*, *Colisa fasciatus*, *Esomus danrica*, *Nandus nandus*, *Ompak pabda*, *Puntius sophore*, etc. The annual revenue of this lake from fishes was US$

175/household/year which falls within the range of income obtained from Rudrasagar lake (US$ 112 to US$ 798/household/year) as reported by Saha (2015). These villagers also collect crabs and molluscs for food which cost US$ 67.34 and US$ 59.15/household/year respectively. The lake support various timber and fuelwood plant species. Fuelwood is used for cooking food and burning bricks and plants collected by the villagers as fuelwood are *Cassia fistula* L., *Shorea robusta* C. F., *Toona ciliata* M.Roem., *Trewia nudiflora* L., *Trema orientalis* Blume, etc. Few timber yielding plants like *Tectona grandis* L.f, *Shorea robusta* C. F. Gaertn and *Gmelina arborea* Roxb. are also used for construction and furniture making. Timber and fuelwood utilized by the villagers nearby the lake cost US$ 72.62 and US$ 122.59 per household per year respectively. The average revenue of the lake from irrigation, aquatic plants, duck keeping and domestic uses are US$ 154.11, US$ 33.91, US$ 35.76 and US$ 126.93/household/year respectively. Overall, the total provisioning value of the Kalyanthakur para lake was US$ 26263.65/year. Das et al. (2000) reported the average economic benefit from fisheries, irrigation and jute retting is INR 2,484, INR 1,105 and INR 483 per household per year respectively from ten wetlands of West Bengal, India.These values of services are diverse from present study due to the unlike market value of provisional services in different states of India.

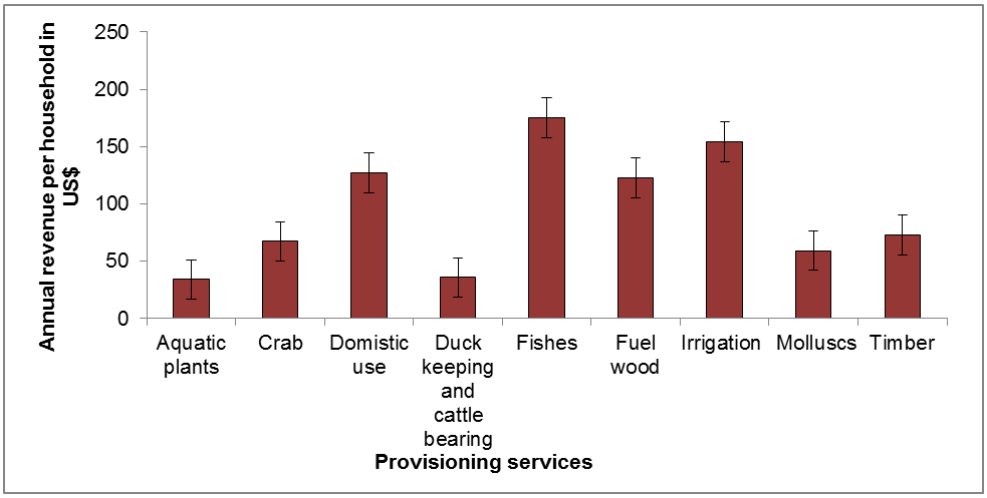

Figure 5. Item wise annual revenue from provisioning services of Kalyanthakur para lake

The lake has been recognized as a place of cultural importance by the local people. The villagers highly agreed that this lake is a place with

natural beauty but they deny about having historical value of the lake. By the help of perception of the cultural services its value was determined. The economic value of cultural services of Kalyanthakur para lake, in terms of money from aesthetic value, place with natural beauty and recreational opportunities is estimated to be US$ 24.69, US$ 13.44, US$ 48.72/household/year respectively (Figure 6). The total cultural value of the Kalyanthakur para lake is US$ 2605.68/year which is less compare to the cultural value of Sundarbans Reserve Forest (US$ 42000/year from tourism, traditional/spiritual festive, symbol of World Heritage site, admired as national forests in Bangladesh, education and research, and tradition of livelihoods) reported by Uddin et al. (2013). Ecotourism, special events and festivals in Kalyanthakur para lake can increase the annual revenue from cultural services.

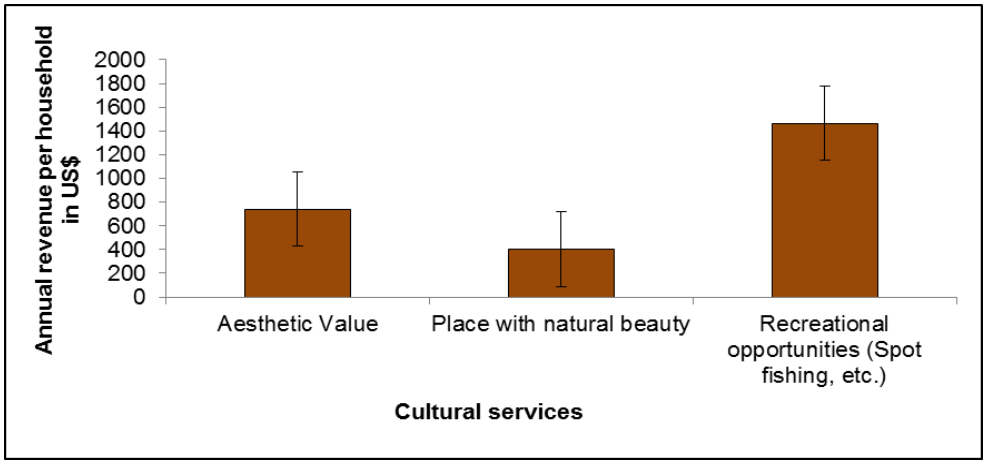

Figure 6. Annual revenue estimated from cultural services of Kalyanthakur para lake

4. CONCLUSION

The Kalyanthakur para lake is classified under Class D on basis of physico-chemical analysis which concludes about its suitability for fishing only. This wetland has the average carbon stock of 171.95 t/ha, bringing the necessary attention for its proper management. Besides, this lake provides a wide range of provisioning and cultural services from rich diversity of planktons, aquatic plants, fishes and other animals in the lake. The aquatic plants are having high value as they are utilized by local people for various reasons. The income generation from the lake is exclusively enjoyed by the

villagers around the lake. To meet the fuelwood and timber demand, more species based plantation can be encouraged, which will otherwise mitigate soil erosion. The water quality of Kalyantakur para lake is decreasing due to brick industries present near the lake. Government should take some management plan to monitor and mitigate the anthropogenic stress on this lake for its conservation. It is important for various stakeholders along with the local community to come together for an effective management plan. As the conservation and management of this lake is done by both men and women of the "Tripuri" community, so this wetland can similarly act as a model for wetland conservation in other potential lakes in the state or in other states of India as well as in other countries.

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