COMPREHENSIVE ASSESSMENT OF META-ANALYSIS AND CONTINGENT VALUATION TECHNIQUE FOR SUSTAINABLE MANAGEMENT OF WETLAND OF MIDDLE GANGA PLAIN

Malabika Biswas Roy [1], Abhishek Kumar [2], Debanjana Chatterjee [3], Sudipa Halder [4]

[1] Department of Geography, Women's College, Kolkata, India
[2] Ballia Water Research and Social Welfare Trust, Ballia, Uttar Pradesh, India
[3] School of Water Resources Engineering, Jadavpur University, Kolkata, India
[4] Badamtala High School, Budge Budge, Kolkata, India

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Abstract: In this study, the functions and threats of Suraha Tal Wetland are identified by the stated preference method and weightage is given according to their rank. The objective of the study is to determine the total economic value of Suraha Tal Wetland. The direct value can be drawn from the market price and from a survey of the stakeholders. Suraha Tal Wetland is also famous for the presence of the Jai Prakash Narayan Birds Sanctuary, which makes it a biodiversity-enriched area. The indirect value has been drawn from a review of the literature on Suraha Tal Wetland and the relevance of this literature is justified through the comprehensive meta-analysis (CMA) software. The total valuation of the wetland has been calculated. The paper concludes with suggestions for a few management strategies for better wetland management.

Keywords: Suraha Tal Wetland, comprehensive meta-analysis, total economic valuation, wetland valuation

Corresponding author: Malabika Biswas Roy, Department of Geography, Women's College, Calcutta, P-29, Khirode Vidyavinode Ave, Baghbazar, Kolkata, West Bengal 700003, India; e-mail: malabikabiswasroy@gmail.com

Introduction

Wetlands occupy 6% of the world's surface area. They provide numerous services and goods not only to the local people but also to those who live in far-off areas (Costanza et al. 1997). To the general public, however, the term 'value' is often associated with principles and ethics. Valuation is the process of determining the current worth of things, objects or assets (Report on Wetland Valuation, 2003). Wetlands can be evaluated in different ways such as the valuation of ecosystem services, recreational value, values of wetland function, economic value and biological value (Biswas et al. 2021).

In environmental economics, the 'total economic valuation' (TEV) is a way to estimate the economic value of the environment. TEV comprises use and non-use values. A use value is further classified as (i) a direct use value and (ii) indirect use value. The non-use value includes (i) an option value, (ii) quasi-option value and (iii) existence value (Freeman 1993; Vao et al. 2012; Biswas et al. 2015; Venkatachalam, Jayanthi 2016).

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Table 1. Different types of ecosystem services provided by wetlands.

Ecosystem services	Examples
Provisioning services	
Food	Manufacturing of fish, wild game, fruits and grains
Fresh water	Storage of water for domestic, industrial and agricultural use
Fibre and fuel	Production of logs, fuel wood, peat, fodder
Biochemical	Medicines extraction and other materials from biota
Genetic materials	Genes for resistance to plant pathogens, ornamental species and so on
Regulating services	
Climate regulation	Storages of greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes
Water regulation	Groundwater extraction rate and recharge
Water purification and waste water treatment	Retention, recovery and removal of excess nutrients and other pollutants
Erosion regulation	Retention of soils and sediments
Natural hazard regulation	Management of flood control, storm protection
Pollination	Habitat for pollinators
Cultural services	
Spiritual and inspirational	Source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems
Recreational	Opportunities for recreational activities
Aesthetic	Many people find beauty or aesthetic value in aspects of wetland ecosystems
Educational	Opportunities for formal and informal education and training
Supporting services	
Soil formation	Sediment retention and accumulation of organic matter
Nutrient cycling	Storage, recycling, processing, and acquisition of nutrients

Source: Millennium Ecosystem Assessment (2005).

Studies have discussed the functions and threats of Suraha Tal Wetland, which is located in Uttar Pradesh. The empirical study focused on the importance of this particular wetland. Moreover, it aimed to find the total economic valuation (TEV) of Suraha Tal Wetland.

According to the Environmental Protection Agency (EPA, USA), wetlands are more prolific and valuable ecosystems than rainforests and coral reefs (www.epa.gov/wetlands).They provide a wide range of economic, social, environmental and cultural benefits (Table 1). It forms a core concept of the rapidly developing interdisciplinary field of ecological economics. Ecosystem goods, such as food and services, waste assimilation, represent the benefits which can be derived for human populations, directly or indirectly, from wetlands (Biswas et al. 2020). For simplicity, ecosystem goods and services are together referred to as ecosystem services (Costanza et al. 1997; Biswas et al. 2010). Wetlands play an important role in giving valuable ecosystem services and goods like provisioning, regulating habitat and cultural services. Due to human pressure wetlands are being deprecated, but protection and restoration of wetlands are essential for maintaining the ecosystem balance (Biswas et al. 2012a, b; Biswas et al. 2019; Clarkson et al. 2013).

The objective of the paper is to draw out the direct and indirect value of Suraha Tal Wetland in Uttar Pradesh. Like any other wetland, Suraha Tal is an important wetland in terms of its services and uses. More precisely the study aims to find the importance of Suraha Tal Wetland.

Materials and methods

The economic values of wetlands are concerned with their direct as well as indirect value. To identify the economic value of a wetland, the economic benefits of wetland management by wise use practice is compared with the cost of alternative wetland management (Birol et al. 2006). In environmental economics, TEV is a way to estimate the economic value of the environment. TEV comprises a use value and non-use value. The use value is further classified as (i) a direct use value and (ii) indirect use value. The non-use value includes (i) an option value, (ii) quasi-option value,

and (iii) existence value (Freeman 1993; Vao et al. 2012; Biswas et al. 2015; Venkatachalam, Jayanthi 2016). The impact of land-use on aquatic plants and water quality has been studied through the neurogenetics model by Biswas et al. (2012a, b). Some wetland-related literature is reviewed to trace the way of valuation. Labour participation in three wetland regions has been studied by Biswas et al. (2016). Flood protection efficiency is calculated with the help of an alternative or substitute cost method. The study suggests that communities near the wetland area are willing to pay high prices for flood control in a natural way (Report 1997). By using damage cost avoiding method, an estimated value of indirect use benefits for flood control is in terms of US$ 0.13 billion × sq × km^{-1} in a year (Rafiq et al. 2014).

Valuation techniques like willingness to pay (WTP), willingness to accept (WTA), contingent valuation method (CVM) and choice experiment (CE) are used here (Wattage 2012) to identify the non-use value of the wetland. The studies discuss the functions and threats of Suraha Tal Wetland, which is located in Uttar Pradesh (Fig. 1).

The Ballia district is located in the easternmost part of Uttar Pradesh, in the Central-Gangetic Plain (25°23' to 26°11' N and 83°38' to 84°39' E). Suraha Tal (Fig. 1) Wetland is an oxbow lake located 8 km north of the district headquarters of Ballia at coordinates of 26°40' to 26°42' N and 84°11' to 84°14' E. It covers a catchment area of about 34.33 sq × km^{-1} and spreads its boundary in two blocks of the Ballia district: Beruarbari and Hanumanganj Block. It is a perennial wetland fed by the Ganga and Ghaghara Rivers through three small streams: Kateharnala, Gararai and Madha. In the summer, Suraha Tal Wetland's water area shrinks to about 11.23 sq × km^{-1} and the local people use this area for cultivation. Fishing is the main activity on this lake. There is a pump canal 'Chaudhari Charan Singh Pump Canal' to lift the lake water for the purpose of irrigation. A 52 km long canal connects with this pump canal that drains the lake water in the surrounding areas and people use this water for irrigation. In the Suraha Tal Wetland area, the 'Jai Prakash Narayan Bird Sanctuary' supports the diversity of rich bird species and hence represents this area

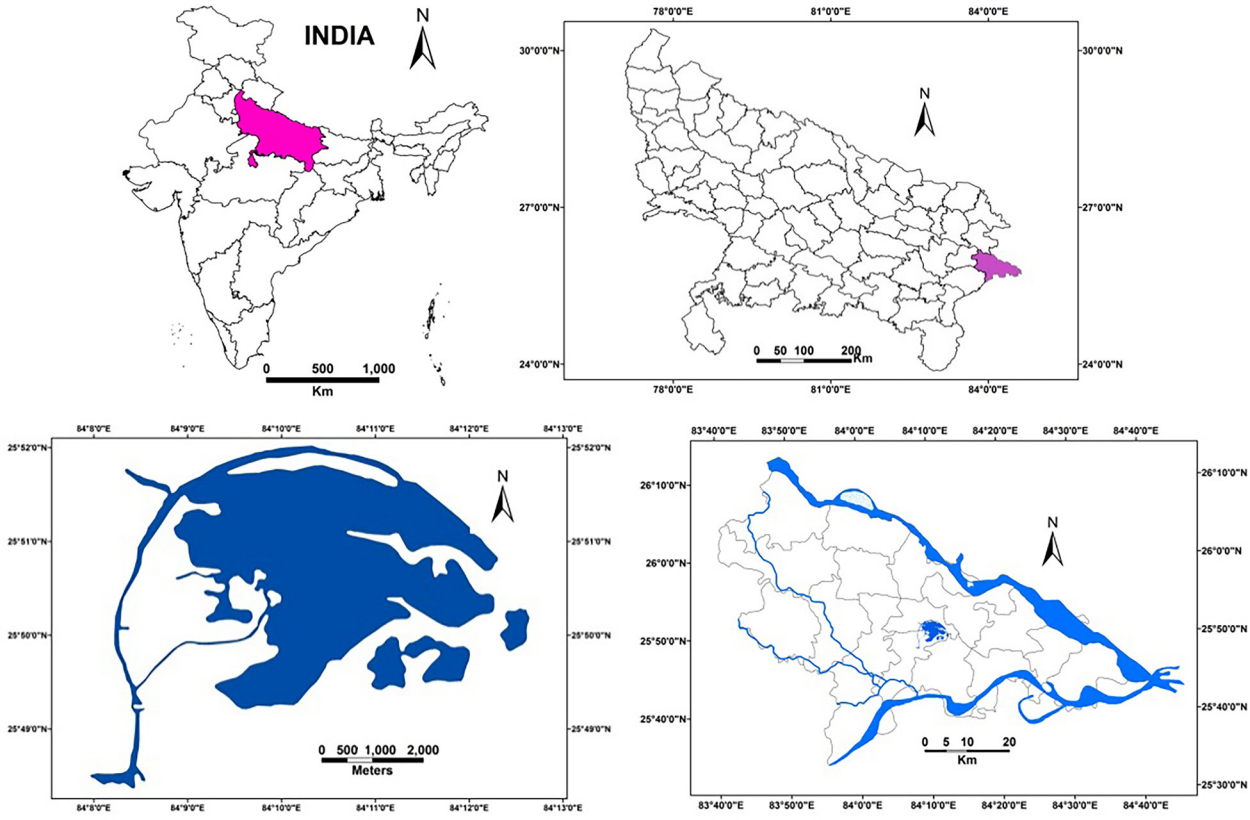

Fig. 1. Location of Suraha Tal Wetland in Uttar Pradesh, India.
Source: own study.

Table 2. Steps followed for the valuation of the wetland.

Activities	Methods
Making checklist of use and non-use values of wetland	Observation of functions, discussions with stakeholders and local communities, review of related literature
Point out important use and non-use values	Ranking of goods, services and threats by stakeholders and local communities
Selection of valuation technique	Review of literature related to wetland valuation and selection of most efficient technique
Questions set up	Preparation of questionnaires for stakeholders, local communities and govt. officials
Collection of data	Survey (household/govt. offices/tourists), market survey for valuation of goods
Quantification of values of goods and services	Analysis

govt. – government
Source: IUCN Report 1998, Basnyat et al.2010, Boral et al. 2016.

as a rich biodiversity zone. Suraha Tal Wetland is presently under the threat of biotic pressures such as over-fishing, weed infestation and drainage for cultivation.

In this study, TEV is applied to find the valuation of the Suraha Tal Wetland. Simultaneously, comprehensive meta-analysis (CMA) is also adopted to find the non-use value of Suraha Tal Wetland. TEV is an efficient technique for valuation of ecosystem services of the environment (Baral et al. 2016). TEV avoids double counting and expresses the economic valuation correctly. On the other hand, CMA is important to point out the non-use value like the cultural aspects and biodiversity valuation. This study went through the steps given in Table 2, which suggests a better management plan for Suraha Tal Wetland.

The functions and threats of the wetland are enlisted by observations and discussions and also through a household survey. The study carried out a simple cluster sampling, where there are different groups of people like local inhabitants, stakeholders and government officials. A market survey was carried out to estimate the values of different goods provided by wetlands in different seasons (Fig. 2). For this reason, the market price is expressed within a range of the highest and lowest price.

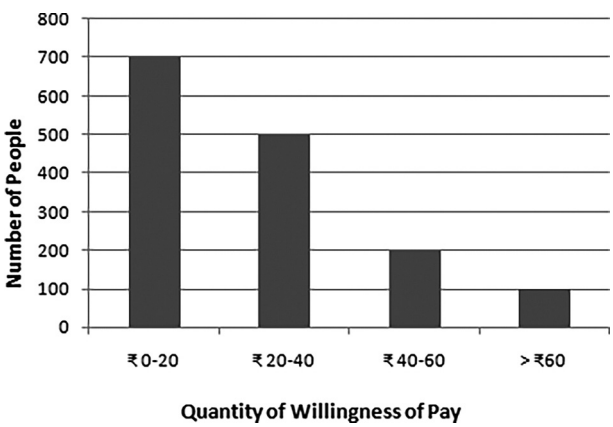

Fig. 2. The number of people willing to pay.

For future use or option value, the householders and stakeholders were asked to pay the amount that they were willing to give in terms of money or labour for conservation and management of the wetland. The relation between WTP and other financial parameters are shown in this study. The seven important financial indicators of lifestyle are chosen and the relationship between WTP and these indicators are calculated (Table 3). The seven indicators are age, education, annual income, family size, land holding size of the respondent and distance from Suraha Tal Wetland, and whether the respondent is a part of the environmental society (Table 3). After considering all the factors, willingness to pay (WTP) is described as:

$$WTP = f\ (AGE, EDU, FAM, INC, LND, ENV, DIS).$$

The linear additive form of the same is:

$$WTP = a + b1\ AGE + b2\ EDU + b3\ FAM + b4\ INC + b5\ DIS + b6\ LND + b7\ ENV$$

where a and b1, b2, b3, b4, b5, b6 and b7 are constants.

Table 3. Explanatory indicators for willingness to pay.

No.	Indicators	Explanation of indicators
1	AGE	Respondent's age
2	EDU	Respondent's education level
3	FAM	Respondent's family size or number of family members
4	INC	Family's annual income
5	DIS	Distance of respondent's home from Suraha Tal Wetland
6	ENV	Whether respondent is part of eco-development community or not
7	LND	Family's total landholding size

Source: own study.

The seven indicators are investigated through a household survey. The mean and standard deviations are calculated. To draw up the relationship among the indicators, Pearson's correlation coefficient is applied.

For non-use values, CMA is applied. Meta-analysis is concerned with a quantitative analysis of the statistical summary indicators reported in a series of similar empirical studies. Meta-analysis extends beyond a state-of-the-art literature review. The proponents of meta-analysis maintain that the valuable aspects of narrative reviews can be preserved in meta-analysis, and are in fact extended with quantitative features (Rosenthal, Di Matteo 2002). Some authors even refer to meta-analysis as a quantitative literature review (Stanley 2002). A meta-analysis of the use and non-use values was generated by wetlands across Europe and North America (Brouwer et al. 1999). The study indicated that the relation between economic value and wetland size played a negative role (Chaikumbung et al. 2015; Pal et al. 2021). The values of natural and constructive wetlands were measured through meta-analysis. The values were found to increase with anthropogenic pressure on natural wetlands. In terms of man-made wetlands, they have high values for biodiversity enhancement, water quality improvement and for flood control (Ghermandi et al. 2009). Geographic proximity, ecological similarity and economic similarities were studied. The spatial econometric method was also used in a meta-regression analysis framework for measurement of wetland valuation (Bu, Rosenberger 2014).

The literature related to Suraha Tal Wetland was selected, which made it possible to collect the information about biodiversity and cultural aspects. The collected data were analysed through CMA. Meta-analysis is important to evaluate the economic value of wetlands. The environmental value is drawn through the literature review of Suraha Tal Wetland by the software, CMA. A total of 15 kinds of literature are found on Suraha Tal Wetland and these papers are categorised into four study names—fish diversity, faunal diversity, water quality and cultural aspects (Table 4). Most of the literature are of present times and reflect an environmentally rich picture of Suraha Tal Wetland. All the literature is written in English by Indian authors.

Table 4. List of literature included for CMA.

Study name	Year of publication (number of observation)
Fish diversity	
Singh et al.	2009 (42)
Swarup and Singh	1975 (52)
Singh et al.	2012 (56)
Pandey et al.	2010 (59)
Lakshman Ram	1976 (48)
Srivastava and Srivastava	2009 (53)
Water quality	
Shukla et al.	2015 (20)
Pandey et al.	2015 (20)
Mishra and Sharma	2015 (22)
Mishra et al.	2015 (24)
Sharma and Soni	2013 (96)
Other faunal diversity	
Sharma and Agarwal (a)	2012 (29)
Sharma and Agarwal (b)	2012 (20)
Srivastava and Srivastava	2012(92)
Cultural aspects	
Srivastava and Srivastava	2012 (7)

CMA – comprehensive meta-analysis.
Source: own study.

The gathered data are analysed through the CMA software. After this, the collected data are analysed to draw the scenario of Suraha Tal Wetland and to estimate the importance of this wetland in terms of its value. The empirical study focuses on the importance of the particular wetland. Moreover, the study aims to find the TEV of Suraha Tal Wetland.

Results and discussion

Functions of Suraha Tal Wetland

Suraha Tal Wetland provides a number of environmental, economic and other services,

Table 5. Major functions of Suraha Tal Wetland.

People's perception of functions of Suraha Tal	Strongly accepted	Moderately accepted	Accepted in weak manner	Not accepted
Fishing is one of important functions of Suraha Tal	56	22	18	4
Water of Suraha Tal is used for irrigation puposes	57	31	9	3
Suraha Tal is also useful for agriculture	54	32	8	6
Aquaculture is popular function in Suraha Tal	56	30	10	4
Suraha Tal is useful for water drainage	52	30	8	10
Suraha Tal controls flood	50	33	17	10
Suraha Tal helps to purify air	42	38	12	8
Water of Suraha Tal is used for household works	56	22	18	4
Suraha Tal is popular tourist destination	58	23	17	2
Suraha tal helps to maintain flora and fauna diversity	40	32	31	7
Mean	52.1	29.3	14.8	5.8
Median	54	30	14.8	5.8
Standard deviation	5.754122369	4.810492005	6.393178182	2.586679163

Source: own compilation.

and at the same time many stakeholders depend on this wetland for their daily livelihood. Such stakeholders and the surrounding dwellers are surveyed through the stated preference method and the major functions and threats are ranked according to their preference.

Suraha Tal Wetland is mostly used for fishing (Table 5). Most of the surrounding dwellers are fishermen who are totally dependent on the wetland for their daily livelihood. Suraha Tal Wetland is a natural pond and many influential people have tried to take possession of this natural resource, but the local fishermen fought against them. In 1966 the organisation 'Tal Suraha Nishad Society' was formed with 1,349 members, and this organisation is still working for *Nishads* (a group of people who are active in fisheries) under the leadership of Jamuna Ram. The Uttar Pradesh High Court gave judgement in favour of the Nishads, so that they can develop fisheries in the 289-hectare black ponds (deep water) without paying any charge; since then they have been involved in such primary activities. The second most popular function here is agricultural irrigation (Table 3). The surrounding dwellers are poor and they depend on agriculture for their daily needs; the waters of Suraha Tal Wetland have proved to be useful for irrigation. Most of the dwellers do a subsistence type of cultivation to fulfil their daily needs. As seen in Table 3, aquaculture, for example, the cultivation of water lilies and lotus is ranked third in value as an important function of Suraha Tal Wetland. Recreation is the fourth rated value followed by domestic use, which is ranked fifth (Table 5).

Threats of Suraha Tal Wetland

Currently, Suraha Tal Wetland is facing many environmental and social threats. This wetland is connected to the River Ganga through Kathahal Nala and the availability of water is uncertain. Lack of sufficient inflow creates increased sedimentation, which is ranked as the first threat to Surha Tal (Table 6). The second ranked threat is the overuse and mixing of domestic and agricultural effluent resulting in eutrophication, which is followed by mixing of agricultural washout (Table 6). The increasing population and tourism, both of which increase pollution of the wetland, is ranked third and dumping of solid waste is ranked fourth (Table 6). The mixing of wastewater and sewage has deteriorated the water quality and enhanced threats like eutrophication. The mixing of sewage is ranked as the fifth most critical threat of Suraha Tal Wetland. These threats affect both the water quality and biodiversity, and these in turn have a direct economic impact on the fishing and aquaculture of Suraha Tal Wetland.

Table 6. Major threats of Suraha Tal Wetland.

People's perception	Strongly accepted	Moderately accepted	Accepted in weak manner	Not accepted
Water holding capacity is decreased by sedimentation of Suraha Tal	45	30	20	5
Household sewage increases eutrophication in Suraha Tal	52	30	8	10
Overfishing destroys the fish diversity in Suraha Tal	42	33	18	7
Excessive aquaculture destroys the balance of ecosystem of Suraha Tal	40	32	31	7
Solid waste is dumped in Suraha Tal	46	28	19	7
Agricultural washout decreases water quality	55	25	12	8
Flora and fauna diversity of Suraha Tal is at risk	32	35	1	20
Suraha Tal is shrinking by size	52	28	12	8
Mean	45.5	30.125	16.625	9
Median	45.5	30	15.5	7.5
Standard deviation	7.55929	3.18198	7.13017	4.65986

Source: own compilation.

Valuation of Suraha Tal Wetland

Suraha Tal Wetland is very useful to its surrounding dwellers; at the same time it is an important resource in respect of its biodiversity and environmental services. The wetland sustains some important flora and fauna which have economic value in the market. The water helps in agriculture and is also used for domestic purposes. These uses identify the value of Suraha Tal Wetland.

All natural resources have both direct and indirect values. The direct value can be derived from the products that are placed in the market. The indirect value is more precisely an environmental value in terms of biodiversity, air and water quality maintenance. In this paper, the two types of values of Suraha Tal Wetland are discussed.

Direct value

Fishing

Table 7 shows the specific monetary value of fishing in Suraha Tal Wetland. It is rich in fisheries and is able to supply plenty of fish every season. The main source of fish is the Ganga River, and the surrounding dwellers, particularly fishermen, depend on this resource for their daily livelihood. But the fishermen have not started pisciculture in this wetland. The major species of fish available are Rohu *(Labeorohita)*, Katala (*Catlacatla*), Bhakur (*Catlacatla*), Nainee *(Cirrhinusmrigala*), Singhi (*Heteropneustesfossilis)* and Saur (*Cololabissaira)* and their production in the monsoon is about 5,000 kg at a market price of about INR 250–300 × kg^{-1}. The total production and its total market price in the year 2015 are shown in Table 7. So, in terms of fish production, Suraha Tal Wetland is a valuable resource.

Table 7. Valuation of the market price of fish production in Suraha Tal Wetland in 2015.

Season	Production of fish	Total market price of fish
Pre-monsoon	2,000 kg	INR 250,000
Monsoon	5,000 kg	INR 2,250,000
Post-monsoon	3,000 kg	INR 750,000

Source: own compilation.

Aquaculture: Lotus

Suraha Tal Wetland is famous for aquaculture. One of the most important aquacultures is cultivation of the lotus plant. The lotus flower is produced in the pre-monsoon period, and most of the produce is exported to other states or countries. In 2014, INR 23 lacs were earned by selling only the lotus flower. Other than this, the petals, stamen and roots of lotus are also produced and sold in the pre-monsoon. The market values of these products are given in Table 8. It is observed that lotus is very profitable for aquaculture and

Table 8. Total value of lotus and associated parts in Suraha Tal Wetland in 2015.

Ingredients of lotus	Market price	Production of last year	Total price
Lotus flower	INR 2 × piece^{-1}	650,000 flowers	INR 1,300,000
Petals	INR 30 × kg^{-1}	74 kg	INR 2,220
Stamen	INR 200 × kg^{-1}	43 kg	INR 8,600
Leaf	INR 300 × hundred leaves^{-1}	2,700 leaves	INR 8,100
Root	INR 25 × kg^{-1}	62 kg	INR 1,550

Source: own compilation.

Table 9. Total valuation of water lily in Suraha Tal Wetland in 2015.

Ingredients of water lily	Market price	Production of last year	Total market price
Water lily flower	INR 20 × kg^{-1}	244.75 kg	INR 4,895
Water lily root	INR 30 × kg^{-1}	326.34 kg	INR 9,790

Source: own compilation.

due to the natural wetland environment, the stakeholders do not need to invest much. The total calculated value of lotus in Suraha Tal Wetland in the pre-monsoon was about INR 2,320,445 in 2014.

Aquaculture: Water lily

In 2014, approximately 500 kg of water lily was produced in Suraha Tal Wetland. The market price of water lily flower was INR 20–30 × kg^{-1} (Table 7). The root of the water lily was sold at INR 20–30 × kg^{-1} (Table 9). The total market price of water lily was about INR 24,685.

Valuation: Fertile soil for cultivation

Suraha Tal Wetland covers about 9,450 acres, but in the pre-monsoon and winter seasons the wetland gets dry and covers an area of only 2,774 acres (Pandey et al. 2010). The remaining area of 6,676 acres is cultivated during the dry spell of winter and summer (Pandey et al. 2010). The soil of the wetland bed is very fertile due to the accumulation of humus. The main crops in this area include wheat, legumes like peas, gram, arahar and rice. Most of the people cultivate on a small scale and use the cultivated products for their own needs. Some of them sell the crops on the market. Another valuable resource that Suraha Tal Wetland provides is fertile soil, which makes the surrounding people take part in cultivation. The total profit for agricultural production is given in Table 10.

Table 10. Total valuation of cultivated crops.

Cultivated crops	Production in last year (in kg)	Total profit (INR)
Wheat	242	40,522
Arahar	247	23,269
Peas	265	32,466
Maize	229	20,795
Gram	222	27,284

Source: own compilation.

Indirect value

Willingness to pay of Suraha Tal Wetland

The villagers around the wetland use it for their daily needs, for example, bathing, washing and so on. Besides this, the wetland provides them with a number of benefits and services. They ask how much compensation they should pay if they cannot avail the facilities for their daily life. Most of the villagers are poor and depend only on fishing and cultivation. Fig. 2 depicts the willingness to pay of the surrounding villages of Suraha Tal Wetland. About 47% villagers have WTP of up to INR 20 (Fig. 2). According to Fig. 2, about 33% of people have WTP of up to INR 20–40 and only 8% people wanted to pay more than INR 60. The average calculated willingness to pay for Suraha Tal Wetland is about INR 54,820. The contingent valuation thus proves that Suraha Tal Wetland is important for daily use and also has a high indirect value.

The relation between WTP and other financial parameters is shown in this study. The seven important financial indicators of lifestyle are chosen and the relationship between WTP and these indicators are calculated.

It is observed that the seven indicators are positively related to WTP. But education, total annual income and the landholding size of

Table 11. Pearson's correlation among the indicators.

	WTP	AGE	EDU	FAM	INC	DIS	ENV	LND
WTP	1	0.42	0.95	0.31	0.84	0.34	0.75	0.82
AGE	0.42	1	0.72	−0.34	0.68	−0.22	−0.18	0.82
EDU	0.95	0.72	1	−0.25	0.86	−0.64	0.21	0.75
FAM	0.31	−0.34	−0.25	1	0.76	0.66	0.81	0.92
INC	0.84	0.68	0.86	0.76	1	0.97	−0.35	0.89
DIS	0.34	−0.22	−0.64	0.66	0.97	1	−0.51	0.64
ENV	0.75	−0.18	0.21	0.81	−0.35	−0.51	1	0.56
LND	0.52	0.82	0.75	0.92	0.89	0.64	0.56	1

Source: own compilation.

a household are related in a strongly positive manner. In Table 11, it is observed that age and education are negatively related to family size. Another noticeable trend is that people who live near Suraha Tal Wetland are members of the eco-development community. But again, there is a weakly positive relation between education and the number of members of the eco-development community. It is observed that less educated people are mostly prone to be members of the eco-development community (Table 11).

Environmental value

The environmental value is classified as fish biodiversity, faunal biodiversity, water quality and cultural value. The environmental value is assessed through the literature review. CMA is used to figure out the weightage and relevance of previous studies.

Biodiversity value

Suraha Tal Wetland is famous for different types of fish and helps to sustain not only aquatic creatures but also those people who depend on fish for their daily livelihood. About six studies are found on fish diversity in Suraha Tal Wetland. Singh et al. (2009) found 42 fish species in Suraha Tal Wetland, whereas 59 species were found by Pandey et al. (2010). In 1976, Lakshman Ram found 48 fish species but in 2012, 56 species were found by Singh et al. (2012). The review of the literature suggests that the fish diversity in Suraha Tal Wetland has increased and the wetland is rich in fish diversity.

Suraha Tal Wetland is also rich in other faunal diversity, which has been proved by three studies. According to Sharma and Agarwal (2012), 29 types of species of insects are found in this wetland; 20 types of molluscan fauna species were found by Sharma and Agarwal in 2012, while Srivastava and Srivastava in 2012 found 92 types of bird species or avifaunal diversity in Suraha Tal Wetland. It is visited by migratory birds as well.

Water quality

The water quality of a wetland is an important criterion of environmental value. The water quality of Suraha Tal Wetland has been tested by five studies previously. Shukla et al. in 2015 analysed the water through 20 water samples based on 12 water quality parameters. Most of the studies were conducted in 2015. In 2010, Sharma and Sony tested 96 water samples based on 20 water quality parameters. These studies showed that the water quality of Suraha Tal Wetland was good for different floral and faunal diversity.

Cultural value

Surah Tal helped to grow a group of fishermen called 'Nishad', who depend solely on fishing for their daily life. The wetland and associated fish diversity are their main resource. The wetland not only serves them as a resource, but also helps to cultivate a unique culture of fishermen. It sustains the culture and fishing practice of the surrounding villages. In 2012, Srivastava and Srivastava found that the fisherman of Suraha Tal Wetland used seven types of fishing gear which are indigenous. These fishing gears were inheritable. These indigenous processes do not harm the biodiversity of the wetland and that makes it one of the valuable resources of Suraha Tal Wetland.

Comprehensive meta-analysis

The null hypothesis is that each study and its referred literature have shown the same results.

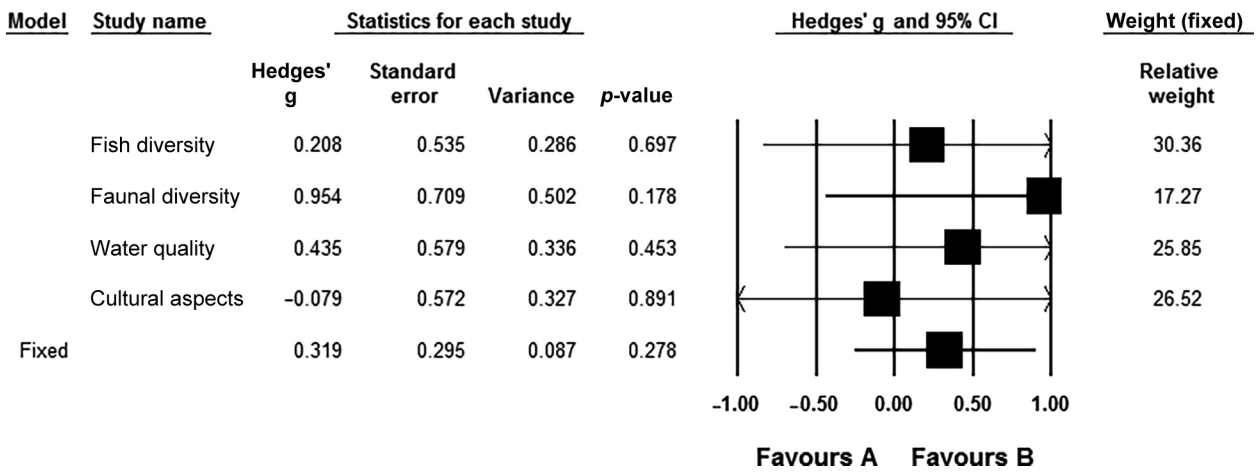

Fig. 3. The application of CMA to draw out the environmental value.
CMA – comprehensive meta-analysis.
Source: own study.

Based on this hypothesis the mean and standard deviation of the particular study and of the referring literature is calculated. The CMA runs an analysis to get the effect size of the sample. This analysis shows the relevance of the previous study, which is reviewed for environmental value (Fig. 3). The fixed effect model is only analysed in this study. Hedges' g is selected as a displayed effect size index. The Hedges' g index and forest plot in Fig. 3 suggest that the effect size of fish diversity, faunal diversity and water quality studies fall on the positive size of zero ranging from 0.5 to 2.0. Only the study of cultural aspects falls on the negative side of zero because of its small effect size (Fig. 3). The combined effect is 0.329 with a 95% confidence interval (CI) 0.500–2.000. CMA first calculates the standardised mean difference (*d*) and then multiplies (*d*) by a correction factor (*J*) to compute Hedges' g. So first, the pooled standardised deviation is calculated as follows:

Raw difference = $\text{Mean}^1 - \text{Mean}^2$

$$\text{SD}_{\text{pooled}} = \sqrt{\frac{\sigma_1^2(N_1 - 1) + \sigma_2^2(N_2 - 1)}{(N_1 - 1) + (N_2 - 1)}} \quad (1)$$

(Mangal 2012)

where $\sigma_1^2(N_1 - 1)$ is deviation of scores of the first samples from its mean, $\sigma_2^2(N_2 - 1)$ deviation of scores of second sample from its mean; N_1 is the first sample size and N_2 is the second sample size (Mangal 2012). After this, standardised mean difference (*d*) is also calculated as

Standard difference = raw difference / $\text{SD}_{\text{pooled}}$

Standardised mean difference (*d*) =

$$\sqrt{\frac{1}{N_1} + \frac{2}{N_2} + \frac{Stddiff^2}{2 \times (N_1 + N_2)}} \quad (2)$$

(Borenstein et al. 2007).

After this, the standardised mean difference is multiplied by a correction factor (*J*) to find the G value.

Correction factor *J*

$$J = 1 - (3 \,/\, (4 \times df\text{-}2)) \quad (3)$$

(Borenstein et al. 2007)

where *df* is a degree of freedom and total sample size (N) <2, that is {(N1 + N2) − 2}.

Computation of Hedges' g helps to understand the measurement of effect size. Effect size is a measurement of difference between an experimental and control group (Borenstein et al. 2007).

$$G = d \times J \quad (4)$$

(Borenstein et al. 2007)

where *d* is the standardised mean difference and *J* is the correction factor.

$$\text{Variance } (g) = (g^2) \quad (5)$$

(Borenstein et al. 2007)

According to Fig. 3, the most weighted study is fish diversity and water quality, and cultural aspects study have nearly the same weightage. The study on faunal diversity is recorded as the least weighted study (Fig. 3). The higher *p*-value (Fig. 3) is acquired through the *z*-value, which suggests that the results of this particular study and its referred literature have different results. Thus, the above-mentioned null hypothesis is rejected.

Calculation of *z*-value is as follows:

$$Z = \text{point estimate} / \text{standard error} \quad (6)$$
(Borenstein et al. 2007)

Computation of *p*-value is as

$$p = 2[1-\{\phi\ (|z\ \text{value}|)\}] \quad (7)$$
(Borenstein et al. 2007)

Using CMA, it is found that the literature on Suraha Tal Wetland is relevant and many studies are conducted on the environmental value of this wetland. Each study has different results and significantly differs from the studies prior to it. The study on fish diversity and water quality are more frequent rather than other studies. The research on the cultural aspects of fisherman by Srivastava and Srivastava (2012) is a unique and very significant study. The review of the literature through CMA proves that Suraha Tal Wetland is not just environmentally rich with biodiversity, but also enriched with unique cultural resources.

Total valuation of Suraha Tal Wetland

The total valuation of Suraha Tal Wetland includes the direct value and the contingent valuation of the wetland. The environmental value and cultural aspects are not included in this valuation. The direct value consists of valuation of fishing, aquaculture like lotus and lily, and cultivation. The total valuation of fishing in 2014 is INR 3,250,000. In aquaculture, the production of lotus and lily is valued at INR 1,335,155 in 2014. Cultivation is done only in the dry season, showing a profit of about INR 144,336 in 2014. Based on the survey, the CVM shows the value of Suraha Tal Wetland to be about INR 54,820. From the above information and data, the total value of Suraha Tal Wetland only in 2014 is calculated to be about INR 4,784,311. So, without doubt, Suraha Tal Wetland is rich with natural and environmental resources and continuously serves as a lifeline to its surrounding villages.

Conclusion

Suraha Tal Wetland is a part of the River Ganga and it is one of the important wetlands in Uttar Pradesh. This wetland is also famous as a bird sanctuary. Many surrounding villages depend on this wetland not only for their daily livelihood, but also for their daily use. The most dreadful threat of this wetland is the lack of sufficient water. The water scarcity results in vanishing of aqua flora and fauna, which is harmful for the wetland ecosystem and also for the surrounding villages. The wetland has plenty of fish, birds and insect species. The aquaculture and cultivation during summer also raises its value. Based on the previous production, the total value of the wetland was INR 4,784,311. CMA is used to find the relevance of environmental valuation, based on the literature review and the valuation of the environment also justify the importance of Suraha Tal ecologically and economically. For more development and better management, some steps are suggested below:

- Development of eco-friendly tourism and involve the surrounding villages to stay away from over-fishing.
- Aquaculture like waternut cultivation should be introduced.
- Development of an eco-development community to take care of the wetland for their own interests.
- To find a final solution for water scarcity with the help of the government.
- Educate traditional fishermen, so that they do not lean on overfishing and work in a more scientific way.
- Public awareness programmes should be conducted by government bodies for better restoration and management.
- Scientific technique and proper training for floriculture should be started for the local inhabitants.
- Culture-based fishing training that is environmentally friendly and also enhances the cultural heritage should be carried out.

- Discourage the use of artificial pesticides and chemicals in cultivation during summer that may be harmful for aquatic biodiversity and water quality.
- Water-based poultry farming like duck farming should be introduced.
- The above-mentioned steps need to be taken for a better management of this wetland in a sustainable manner.

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Conflict of interest/competing interest

On behalf of all the authors, the corresponding author states that there is no conflict of interest.

Availability of data and material

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Code availability (not applicable)

Author's contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Malabika Biswas Roy, Abhishek Kumar, Debanjana Chatterjee and Sudipa Halder. The first draft of the manuscript was written Abhishek Kumar, Debanjana Chatterjee and all authors commented on previous versions of the manuscript. All authors read and approved of the final manuscript.

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