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Impact Of Rudrasagar Lake In The Scenario Of Sustainable Development Of Melaghar Block, Sonamura Sub-Division

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Abstract:

Lakes are the most vital water resources and have a large contribution on human society not only for supply of drinking water but also for its important role in waste removals, fisheries, agriculture irrigation, industrial activity, recreation and hydropower for years and years. So resilience and sustainability of an aquatic ecosystem is very much linked with the sustainable development of our society directly or indirectly. Understanding of environmental degradation of any aquatic ecosystem and trying for it's resilience has becoming successful day by day because of increased power of observation by scientist and engineers for using new and sophisticated instruments. This paper explores the field investigation for searching all the threatening elements of the ecosystem of Rudrasagar Lake along with their relevance solutions. Moreover due to ecological and socio economic importance of Rudrasagar Wetland systematic random sampling method has been adopted to trace out the socio-economic factors along with perception about the conservation of the stakeholders. A validated linear regression model has been applied for getting idea about Willingness to Pay (WTP) of the stakeholders and search model output will certainly be very helpful for framing activities following the improved conservation program of the Wetland.

Keywords: Resilience, Sustainability, Rudrasagar Lake, Linear Regression Model, WTP.

1. Introduction

Water bodies contribute a lot to human society. Lakes and rivers are the key water resource in a region. Lakes have got their own significant throughout the environment for numerous reasons such as, (i) One of prominent resources of water for surface and recharge and discharge of groundwater (ii) work as stream flow maintenance in addition to flood control, (iii) Recreation – swimming, education, boating and other water activities, (iv) Pisciculture, (v) Wildlife habitat, especially birds and fishes, (vi) Emergency water supply for fire fighting or other emergency need and (vii) Rain water harvesting etc. Now days, the reservoirs and lakes are suffering from environmental degradation due to the fact of eutrophication, encroachments and silt. During the last century, there has been a quantum jump in human population. But civic facilities have not been building at equal footing. As a result, now a day's most of the reservoirs and lakes have become dustbin. Most rural and urban lakes have vanished or deteriorated under this

stresses with worldwide environmental issues. However, in those lakes that could tolerate, reduced fish production, flood consumption capacity impaired, biodiversity endangered and mostly drinking water supply is either significantly reduced or is non-potable in those lakes. The major reasons which lead in impaired conditions with the lakes may be classified into two groups namely, (a) pollutants that entering from fixed point sources like, nutrients from sewage, from domestic effluents and even municipal authority; organic, inorganic and toxic pollutants coming from industrial sources and storm water runoff (b) contaminants along with other impurities that entering from non-point sources like, nutrients by means of fertilizers, chemicals and other toxic pesticides, mainly coming from agriculture runoff; organic pollution from human sources spread over the periphery of the reservoirs and lakes.

Rudrasagar Lake is one of the most important lake of north-eastern India. In recent years the lake is also under the capture of civilization resulting degradation of the water part of the lake. Rudrasagar lake has its international importance as a Wetland (declared in convention of wetlands, Ramsar site).The type of Rudrasagar Wetland is naturally Waterlogged. The floodplain wetland within Gomati river basins are basically utilized for the development of fisheries and agriculture. A major portion of wetland is being used for paddy cultivation, horticulture and agro-forestry purposes. Agricultural activities in the surrounding area are increasing the rate of siltation. Department of Forests is working with projects on afforestation of the uplands of catchment areas. Rudrasagar inland wetland is one of the vital place for the tourist attraction as Neermahal(Water Palace) is situated there. So the ecological and socioeconomic importance of this wetland is very important. But now days, both ecological and socioeconomic environment of the lake is degrading day by day. So, not only government, but also fellow stakeholders should take forward step towards the sustainable development of Rudrasagar lake. If we know about the stakeholders who are willing to Pay (WTP) for the development of Rudrasagar lake, then sustainable development of the lake will be easier to establish. So, we have chosen this wetland to study the socioeconomic scenario of the households. A total 100 households have been chosen for the primary data collection. Systematic random sampling method has been adopted for our current study for which concentration has been given to trace out the Socio-economic factors along with perception about the conservation of the stakeholders.

There are a number of methods to analyze Willingness to Pay (WTP) data that vary depending on information of age, education, family, income, distance, environment, land etc. Research in this area has been extensive, as indicated by the number of methods proposed or developed for classification, modelling and interpretations of monitoring data. The use of the research data will help us to evaluate the steps that were taken by the authority or will be taken in future to inform the general public and decision-makers about the state of the wetland. This can help the authority to reduce waste materials in the wetland, help to take action regarding waste management. This approach can also help to pro-vide a benchmark for evaluating successes and failures of management strategies at improving wetland's overall quality. It will indicate what actions should be modified. Numerous studies on socioeconomic scenario of Rudrasagar lake will help to build a strong sustainable development policy for the wetland that has a vast international importance. The Rudrasagar lake's water may be used as one of the main water sources for the surrounding people of the Melaghar block of Sonamura Subdivision. Thus this survey holds a strong place in the development scenario of the wetland area and as well as sustainable development of Melaghar block.

2. Materials & Methods

2.1 Description of Study Area:

Our Studied lake Rudrasagar is located in the Melaghar of Sonamura Sub-Division of Sepahijala district of Tripura. The lake forms a geographical area of 2.4 km^2 and situated at a distance of about 52 km from Agartala, the state capital of Tripura, India. The lake is situated in between 23° 29‘ 00’’ N and 90° 01‘00’’ E. Actually this lake is a natural sedimentation reservoir, which receives flow from three perennial streams namely Kemtalicherra, Noacherra and Durlanaraya cherra .After settling the sediment from the received flow, clear

Fig.1 : Rudrasagar Lake site (collected from Google Earth)

water discharges into the river Gumati through a connective channel namely Kachigang. The lake bed has been formed by silt deposition. Surrounding hillocks are of soft sedimentary formation. Annual rainfall is of the order of 2500 mm. Spread over the months of June to September with 4/5 flood peaks. Substantial base flow in streams rounds the year. The soil in lake area is silty clay loam to clay loam. Lake water depth varies from 2 m to 9m. Fluctuation in water level varies from EL 9m to 16m.The downstream area of the lake is 688 ha with a temperature variation from 370C to 50C and rainfall during May 15 to October 15. The area grows initially based on fishing as main form of livelihood. Later on agricultural activity also started including application of pesticides and fertilizers that drained directly or indirectly to the lake. Besides brick kilns also developed in the area.

2.2 Hydrology

Hydrology is the study of water. Hydrologists examine the physical processes involved in the global water cycle, which spans most disciplines in earth and environmental sciences. The hydrological community includes physical scientists engineers and water resource manager in common practise it is distinct from the oceanography and atmospheric science communities, because hydrology concentrates on surface water and ground water in terrestrial environments.Rudrasagar lake has a catchment area of 39.5 sq.km. From the record of last ten years (2006-2015) annually it receives 19.818 centimetres of rainfall at an average whereas peak rainfall remains at around 29.72 centimetres (2007) and minimum rainfall was observed in 2008 which amounted to 13.54 centimetres of rainfall was observed in 2008 which amounted to 13.54 centimetre of

rainfall within that year. From the last ten years data it is found that average peak rainfall occurs at the month of June.

Fig 2: Species of water lilies in Lake Water

Fig.3: Kachingang channel (Outlet of Rudrasagar Lake)

Fig .4: Migratory birds in lake water

3. Study of threatening elements of lakeecosystem& their relevant solutions

The major conservation and management issues as observed from the investigation are reduction of sediment load, restoration of lake water quality, eco zoning of Lake Shoreline,conservation of aquatic biodiversity and more development in ecotourism from existing stage. Moreover during observation period uncontrolled growth of alien invasive species along with excessive algae in the lake water were found. These excessive growths might disturb the aquatic biodiversity of the lake Rudrasagar.

3.1Sediment load reduction

Mechanical dredging is a very common approach to sediment removal. This technique also helps to reduce the levels of toxic substances, macrophyte and phosphorus of lake water (Cooke et al. 1986). But this traditional mechanized dredging is not appropriate concerning its enactment as for this all aquatic life must either be migrated or maybe slain away. During this technique, sediment can release all the toxic gases and nutrients which particular kill away almost all of the existing aquatic life and may leave the lake some sort of dark, mucky chaos. Hefty tools can cause comprehensive harm to the landscape and it is hindered by simply households, strength traces, phone posts, in addition to bushes. Restoration of the natural bottom without disturbing the existing aquatic life of lake can be achieved by high-volume suction pump. Use of high-volume suction pumps is helpful to lowering down the bottom part of the lake and their movement

into the sediment results vacuuming it up. This specific not just removes the sediments, and also the toxic gases and nutrients. The underside can be successfully restored to help its initial detail. This may also take out loose clay, rocks, and crushed stone, emptying in place coated arises, irrigation systems, culverts, and cisterns. However the estimation of rate of sedimentation in this fresh water lake will be attempted in the next phase of investigation.

3.2Washing out of algal cell

Dilution as well as Flushing methods are extremely beneficial to slow up the biomass regarding plankton algae for the reason that damage pace in such operations is really a lot beyond their progress pace. Inclusion associated with low source of nourishment normal water and/or large amount normal water, dilutes P concentration and also thus flushes out algal cells. These types of strategies can easily restrict the inner loading, algal biomass and also can easily increase lucidity. Fairly low cost is required when normal water is available ;in addition to, expenses furthermore depends upon cost involving setting up and sustaining syndication facilities along with the outlet framework.

3.3 lake pollution remedy

The waste materials produced as a result of anthropogenic pursuits can be ingested by the living aspects of eco- technological remedy models for example soil scrape filtration system, hydras succession pond and green channel are identified to work pertaining to the treatment of pollution from point places. These technologies can be efficiently accustomed to manage the actual pollution along with sediment ingress from the catchment's section of the body of water. Practical application off these kind of eco- technologies tend to be more inexpensive as well as simple as far as operations are concerned simply because their supply of energy will be sun's rays plus they involve very least machines for that regime method maintenance .

4. Application of remote sensing and GIS

Artificial Neural Network (ANN) method along with remote sensing and GIS are very much effective for prediction of land cover, water quality parameter, productivity of the lake etc. And these are very helpful in sustainable shrimp culture development. From measurement of sunlight reflected from surface of the earth in visible and infrared region, the optical satellite sensors attached with artificial satellites of earth can select the sites appropriate for forestation, agriculture, human activities etc. To ensure the sustainability of shrimp culture of the Rudrasagar lake ecosystem, GIS capabilities can be used to generate a linkage between management policies appropriate for ecosystem sustainability of Rudrasagar lake and ecological information obtained from the analysis of satellite photograph. This is also essential for regulating various human activities near the shore area of Rudrasagar which affects the water parts. Due to the rapid deterioration in the lake's ecosystem, Government of Tripura engaged WISA (Wetlands International - South Asia) for formulation of a Management Action Plan; however it has not been implemented till now.

5. Socio Economic Scenario

The type of Rudrasagar Wetland is Waterlogged (Natural).The floodplain wetland within Gomati river basins are basically utilized for the development of fisheries and agriculture. A major portion of wetland is being used for paddy cultivation, horticulture and agro-forestry purposes. Agricultural activities in the surrounding area are increasing the rate of siltation. Department of Forests is working with projects on aforestation of the uplands of catchment areas. Rudrasagar inland wetland is one of the vital places for the tourist attraction. So the ecological and socioeconomic importance of this wetland is very important and we have chosen this wetland to study the socioeconomic scenario of the households. A total 100 households have been chosen for the primary data collection. Systematic random sampling method has been adopted for our current study for which concentration has been given to trace out the Socio-economic factors along with perception about the conservation of the stakeholders.

5.1 Stakeholders and Rudrasagar wetland

5.1.1 Socio-economic profile of the households:

The main objectives of this section are to investigate the socio-economic dimensions of the stakeholders of the Rudrasagar wetland; To explore the relationship between the socio-economic variables with the perception of stakeholders on the improved conservation of the wetland; to explore the determinants of Willingness to Pay of the stakeholders for the improved conservation; and to evaluate the total economic value of the wetland system within a framework of Contingent Valuation Method.

If we concentrate on the distribution of Households based on the family size, then it reveals that majority of households lies in the family size varies between 3 and 6.(fig.5).Only 5 per cent of the sample households are in the traditional group family system ,having more than 6

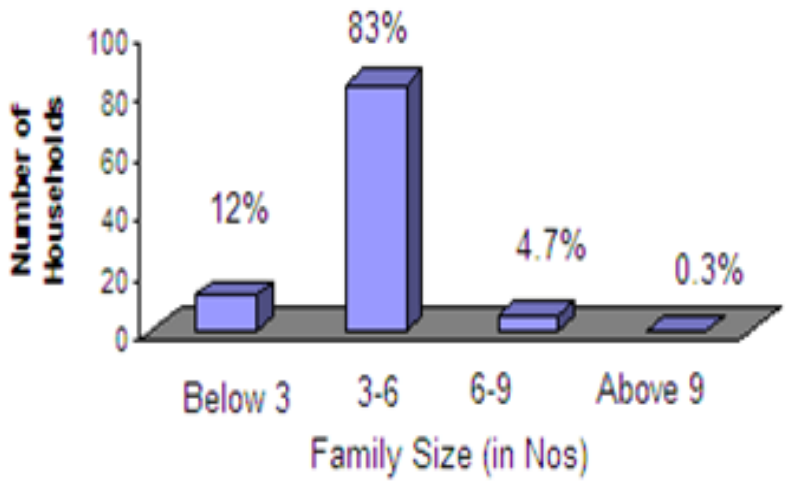

Fig.5: Distribution of Households based on Family size

members and the number of earning members in such family vary between zeros to five.

For estimating willingness to pay for the improvement of Rudrasagar wetland, study has also

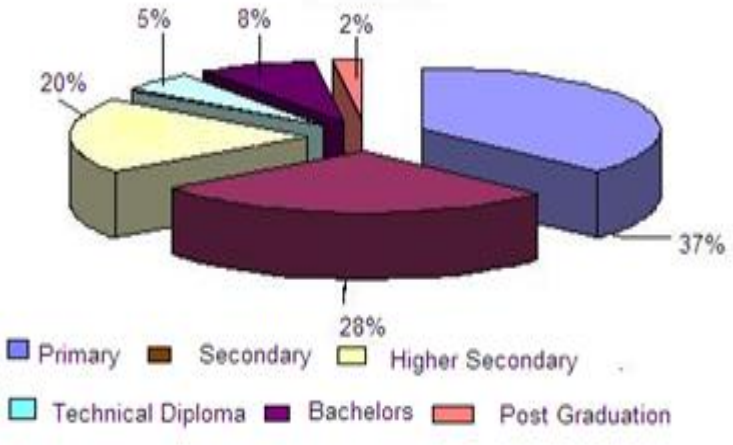

Fig 6: Education wise classification of the households

been carried out considering the literacy level of the head of the family and the corresponding socio-economic profile has been displayed in fig 6 .The corresponding data reveals that maximum percent of households are headed by a person having educational level up to primary. Occupation wise classification of the households profile has been displayed in fig 7

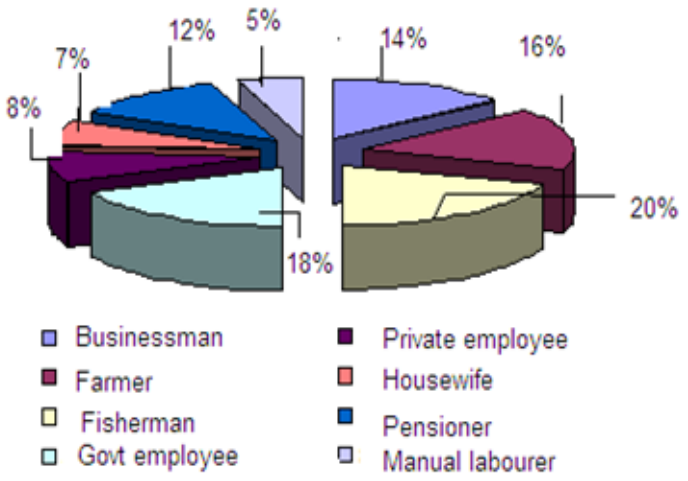

Fig.7: Occupation wise classification of the households

which gives the detailedscenario of the occupation of the head of the family? Highest percent of the households are monitored by a person who is farmer in profession. 5 percent of the households are depending on manual labour whereas 20 percent of the households are depending on fishing activity in Rudrasagar lake area.

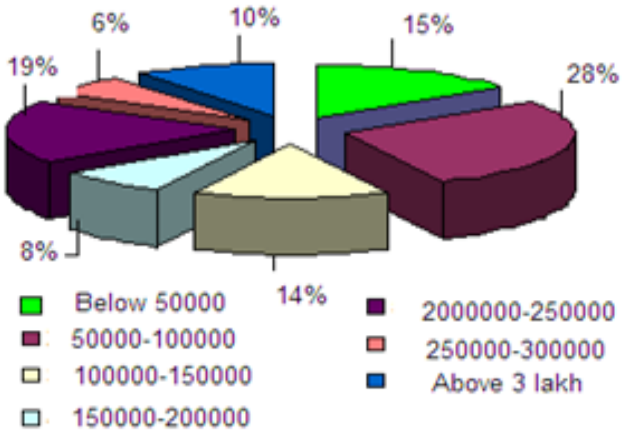

Fig.8: Income wise distribution of Households

As far as income wise distribution is considered, it is observed that level of annual income among the sample households vary between INR 18,400 and INR 580,000. It has been observed that 15 percent of the households are having annual income range below 50,000. The mean income of the household is INR 158,983 with a standard deviation of INR 126,867.20.Only 10 percent of households are having annual income of INR 300,000 and above.

5.1.2 Stakeholder's Perception on conserving Rudrasagar Wetland:

Interest of the sample households on conservation of the Rudrasagar wetland has been investigated in this section. As an outcome of verbal discussion with the sample households, their awareness

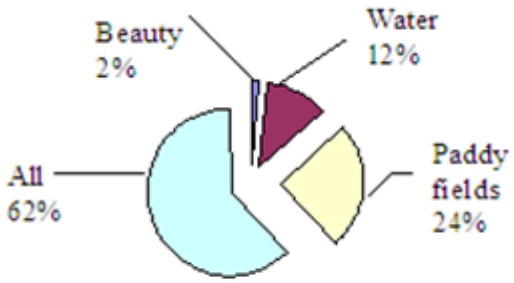

Fig.9: Selected features of Rudrasagar wetland by the households

about the conservation issue of wetland area has been assessed. 2 percent of the sample households suggest that the scenic beauty is the important feature, 24 percent believes that paddy fields preservation is the important issue of the wetland ,12 percent likes to give stress in water preservation issue ;whereas 62 percent households considered all such features of the wetland.

In the next phase when investigation is done on interest wise classification of the households, it reveals that 76 percent of households show high interest in wetland improvement through conservation and management of the wetland, 22 percent show moderate interest while only 2 percent show no interest for improvement of conservation of the wetland zone.

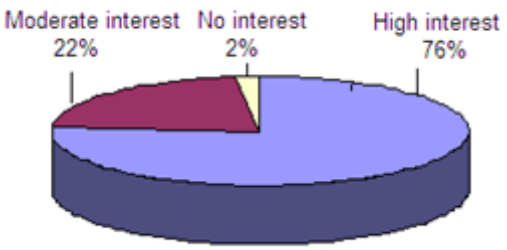

Fig.10: Interest- wise classification of Households

The distance of households from the centre of the wetland is another crucial factor for their interests in conservation issue. So study has been carried out for getting the profile picture of distance wise classification of the perception on wetland improvement (fig 11).High interests among the sample stakeholders residing closer to the wetland is observed for betterment of the wetland and it reduces with their increased distance from the wetland.

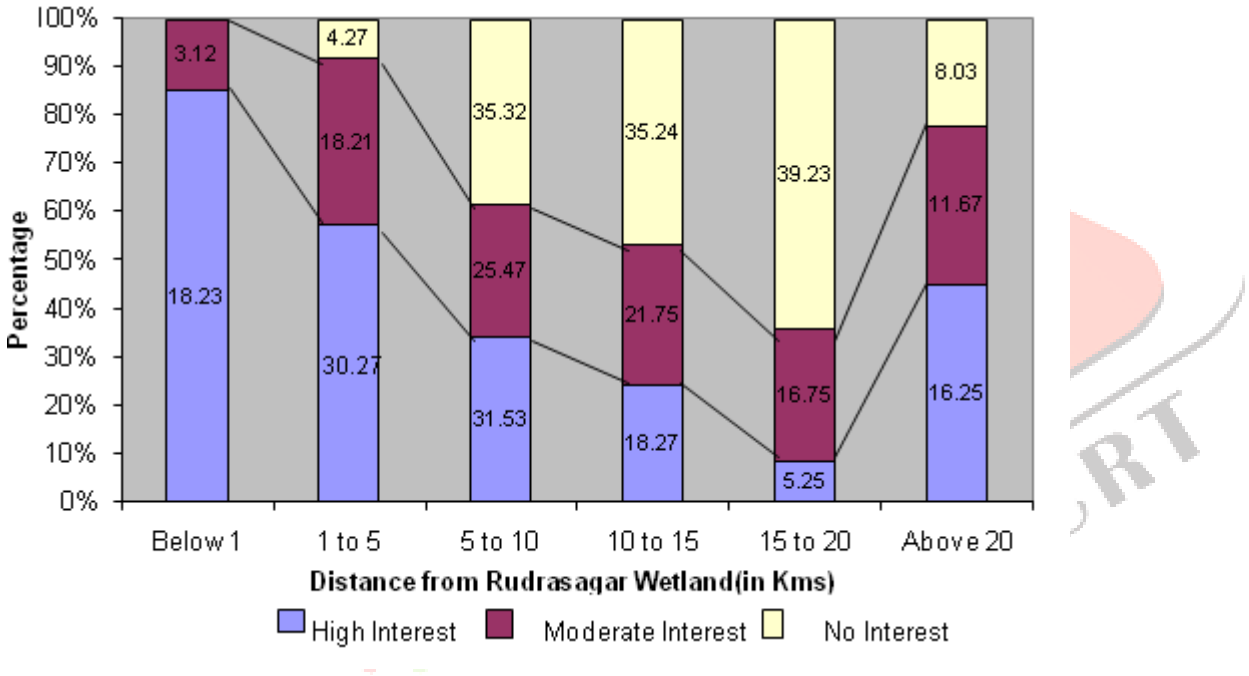

Fig.11: Distance wise classification of the perception on Wetland Improvement

So this issue has an important role for estimating the quantity Willingness to Pay (WTP) for improvement of wetland. Education is another important element which helps people to realize the importance of various positive fronts in our environment. It is expected that there must be direct and positive correlation between the education and their interests for the wetland improvement. Table 1 displays the education wise classification of stakeholders' perception on the improved conservation. A direct and positive association between education and interest for conservation of wetland has been observed in the study. In general, it is noticed that the stakeholders having educational level above the primary stage have shown interest in conservation.

Table.1:Education-wise classification of perception of stakeholders on wetland improvement

Interest for wetland improvement / Education	More Interested	Moderately Interested	Not interested	Total
Primary	24(77.42) [31.58]	5(16.13) [22.72]	2(6.45) [100]	31(100.00) [31]
Secondary	22(81.48) [28.95]	5(18.52) [22.72]	0(0.00) [0.00]	27(100.00) [27]
Higher Secondary	16(61.54) [21.05]	10(38.46) [45.45]	0(0.00) [0.00]	26(100.00) [26]
Technical Diploma	4(80) [5.26]	1(20) [4.55]	0(0.00) [0.00]	5(100.00) [5]
Bachelors	6(85.71) [7.89]	1(14.29) [4.55]	0(0.00) [0.00]	7(100.00) [7]
Post graduation	4(100) [5.26]	0(0.00) [0.00]	0(0.00) [0.00]	4(100.00) [4]
Total	76(76.00) [100]	22(22.00) [100]	2(2.00) [100]	100(100.00) [100]

(Figures in brackets are percentage of the horizontal total; figures in square brackets are percentage of the vertical total)

Level of income of the sample stakeholders must be positively associated with the WTP and this prediction gets support from the table 2 which displays the profile picture of income-wise classification of stakeholders on wetland development.

Table 2: Income-wise classification of perception of stakeholders on wetland improvement

Interest for wetland improvement / Annual Income(in Rs)	More Interested	Moderately Interested	Not interested	Total
Below 50,000	9(60.00) [11.84]	4(26.67) [18.18]	2(13.33) [100]	15(100.00) [15]
50,000-100000	20(71.42) [26.32]	8(28.57) [36.36]	0(0.00) [0.00]	28(100.00) [28]
100,000-150,000	10(71.43) [13.16]	4(28.57) [18.18]	0(0.00) [0.00]	14(100.00) [14]
150,000-200,000	6(75) [7.89]	2(25) [9.09]	0(0.00) [0.00]	8(100.00) [8]
200,000-250,000	16(84.21) [21.05]	3(13.63) [13.63]	0(0.00) [0.00]	19(100.00) [19]
250,000-300,00	5(83.33) [6.58]	1(16.67) [4.54]	0(0.00) [0.00]	6(100.00) [6]
Above 300,000	10(100) [13.16]	0(0.00) [0.00]	0(0.00) [0.00]	10(100.00) [10]
Total	76(76.00) [100]	22(22.00) [100]	2(2.00) [100]	100(100.00) [100]

(Figures in brackets are percentage of the horizontal total; figures in square brackets are percentage of the vertical total)

5.2 Willingness to pay

The Willingness To Pay (WTP) is defined by the amount that a consumer is wishing to pay in order to consume a selective unit of a commodity. It is connected with the utility of that particular commodity and is widely used in economics for measuring the consumer surplus. In the present study, it is used to identify the amount of money that the urban stakeholders desire to pay to conserve Rudrasagar wetland and thereby to estimate the economic value of this wetland. It is

Fig.8: The proportion of the stakeholder's on thebasis of their willingness to pay

observed from the study that 95 percent of sample households are expressed their willingness to pay for the improvement of the wetland.(Fig 8).According to sample data 5 percent of sample households

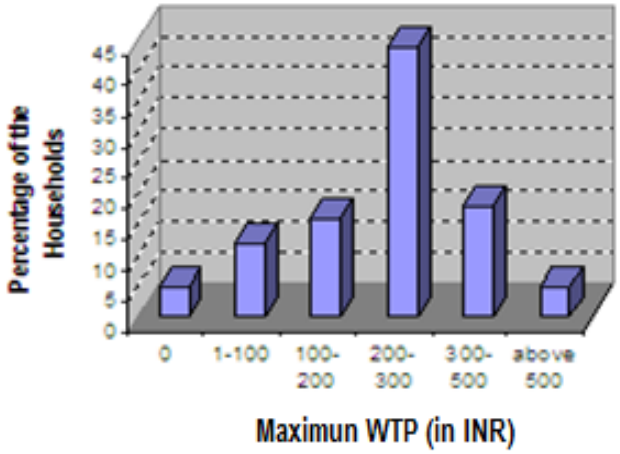

Fig.9: Classification of the household based on the maximum WTP

are not willing to pay for betterment of this wetland.40 percents of households fall under the category where maximum WTP varies from INR 200 to INR 300.(Fig 9)

The predicted degree of association between WTP and income has been displayed in fig 10. It is clear that there exist a positive association between income of a sample household and WTP.

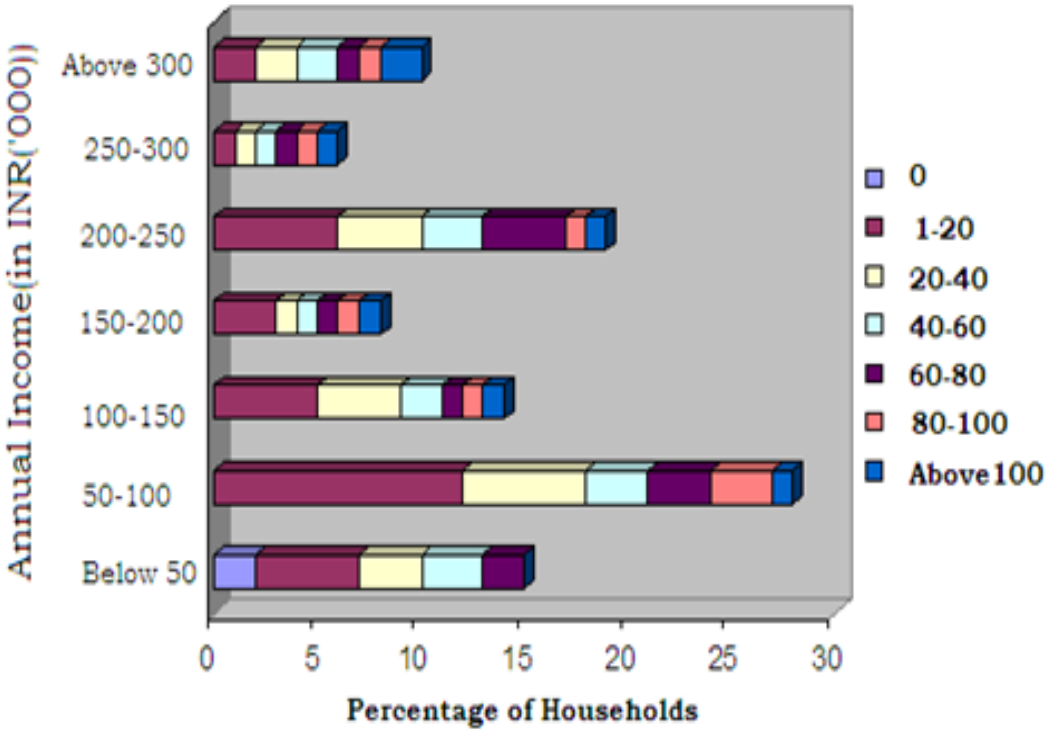

Fig.10: Income wise classification of the maximum WTP

5.2.1 The Model:

The WTP may be expressed as the function of the socioeconomic attributes of the analysis households and distance from wetland and expressed as

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

The linear additive form of the same is

$$WTP = a + b_1AGE + b_2EDU + b_3FAM + b_4INC + b_5DIS + b_6LND + b_7ENV$$

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

The explanatory variables along with their notations and expected signs of causal relationships are reported in Table 3.

Table 3: Explanatory Variables in the model

Sl. No.	Variable	Definition	Exp. Sign
1	AGE	The age of the decision maker of the household	+ve
2	EDU	Education level of the decision maker	+ve
3	FAM	Family size of the household	+ve
4	INC	Logarithm of annual income of the household	+ve
5	DIS	Distance of the households from Rudrasagar Wetland	-ve
6	ENV	Whether the respondent is a part of any Environmental organization (1-Yes, 0-No)	+ve
7	LND	Total landholding size of the household	+ve

The descriptive statistics of the variables used in the regression is given in Table 4. The standard deviation of WTP is very high indicating variation in the distribution of variable across households.

Table 4: Descriptive Statistics

Sl. No.	Variable	Mean	Standard
1	WTP	181.677	71.201
2	AGE	42.22	7.124
3	EDU	5.54	1.876
4	FAM	4.54	1.515
5	INC	7.68	0.891
6	DIS	5.524	2.348
7	ENV	1.84	0.71
8	LND	4.3	1.418

Table 5: Linear regression Results

n	R	R-Square	Adjusted R-Square	SE of estimate	F	df
50	0.998***	0.995	0.995	5.205	1303.772	7,42

Predictor	Coefficient	SE	t
Intercept	-554.136***	9.762	-56.764
AGE	0.923***	0.154	6.009
EDU	4.266***	0.519	8.226
FAM	9.809***	0.806	12.173
INC	85.340***	1.059	80.56
DIS	-6.771***	0.417	-16.252
ENV	6.184***	1.224	5.052
LND	-0.169	0.553	-0.306

6. Conclusion

In the scenario of sustainable development of Melaghar block,Rudrasagar lake has huge impact. So, regular monitoring and protection of this valuable water resource is an essential task. The calculated linear regression results while studying the socioeconomic status shows that all the variables AGE,EDU,FAM, INC, ENV and DIS expect LND are relatively more important determinants, with expected signs, of the WTP of the households. It is found that although the coefficient values of LND has the expected signs, it is not significant. It can be further seen that income is the most important variable which determines the WTP of the household .As expected, there exists negative influence of distance (DIS) and landholding (LND) upon WTP. It is found that the mean WTP of the household is INR 181.677 with a standard deviation of INR 71.201. This finding may be very helpful for farming activities following the improved conservation programme of the wetland. Effective implementation and monitoring of plans are needed to ensure management and sustainable conservation of this precious freshwater resource. Due to the unsustainable practices followed by the stakeholders including the farmers and other inhabitants, the lake Rudrasagar and its wetland is facing a serious threat of degradation more rapidly. All anthropogenic activities which alter the hydrological regimes should be regulated immediately in an emergent basis by the respective authority.

For boosting the ecology of the precious area integrated management plan is to be implemented as early as possible. Conservation and management of the lake ecosystem also demands multidisciplinary –trained professionals who can circulate the importance of lake-ecosystem at clubs, local schools and colleges by initiating educational programs related to this.

7. Acknowledgement

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