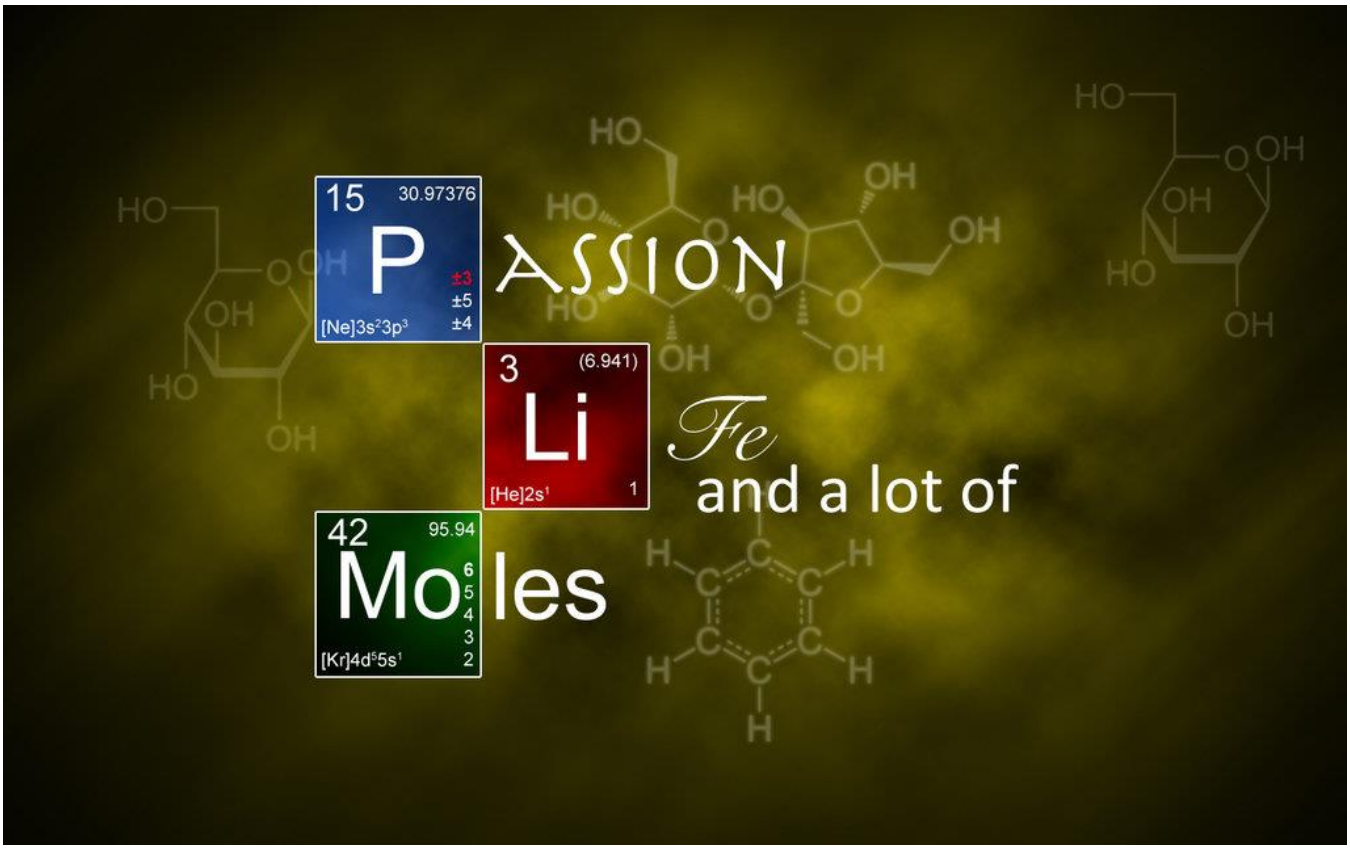

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IMPACT OF ANTHROPOGENIC PRESSURES ON CHANGES OF TROPICAL OXBOW LAKE ECOSYSTEM IN GANGA RIVER BASIN: SOCIOECOLOGICAL SURVEYS, ISSUES AND STRATEGIES FOR SUSTAINABLE MANAGEMENT

RESEARCH ARTICLE

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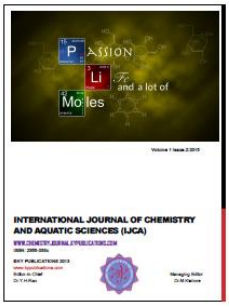

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ABSTRACT

Population pressure, urbanization, industrialization and increased agricultural activity including jute retting have significantly contributed to the pollution and toxicity of aquatic ecosystems including oxbow lakes. The effects of siltation, habitat destruction, macrophyte infestation, isolation from river flow, use of agricultural pesticides in catchment areas, jute retting and inadequate rainfall in changed climate have degraded oxbow lake environments as a whole. Much more detailed analysis of the socioecological, socioeconomical of oxbow lakes in the changed climate in West Bengal is urgently needed. The main objective of the present study was aimed to assess the potential impacts of different anthropogenic pressures on changes of a tropical oxbow lake ecosystem and so the present research was conducted to assess the socio-ecological-economic effects on a tropical oxbow lake ecosystem in Nadia district of West Bengal, India during April 2011-November, 2014 through survey and analysis using continuum scale. Our study showed increase in water pollution, uses of oxbow lake water for agri-irrigation, conversion of oxbow lake in to crop lands, Area of Boro (dry season paddy) rice cultivation, cultivation of oil seeds, abundance of aquatic vegetations used for animal fodder are the most among those of ecological changes taken place during last 30 years in the Chhariganga oxbow lake ecosystem. Jute retting in the oxbow lake by jute farmers, lack of demarcation, and poor socio-economic conditions of fishers are most important issues that need immediate attention. We are of the opinion of development of oxbow lakes through the immediate interventions like de-silting; demarcation; biological and manual control measures for macrophytes infestation; strict prevention and regulation of water lifting, jute retting, indiscriminate uses of fishing gears with varying mesh sizes and chemicals and pesticides; and promotion of organic aquaculture and ecotourism at the oxbow lake ecosystem.

Key words: socioecological monitoring, oxbow lake ecosystem, anthropogenic impact

INTRODUCTION

Population pressure, urbanization, industrialization and increased agricultural activity including jute retting have significantly contributed to the pollution and toxicity of aquatic ecosystems including oxbow lakes. The effects of agricultural runoffs, jute retting, macro-phytes infestations and inadequate rainfall in changed climate often degrade oxbow lake's environment and the biodiversity in oxbow lake has impacted severely because of population pressure, over exploitation and indiscriminate use of fine meshed fishing gears as a whole. The added causes are habitat destruction and defragmentation water abstraction, industries and private use, exotic species introduction, pollution and global climate change impacts (Mas-Marti *et al*. 2010). Oxbow lakes are subject to the impacts of unsustainable fishing practices including harmful fishing methods (e.g. small mesh size), potential overharvesting (small size of fish, possibly collapse the fishery), -limitations to fishery, serious conflicts among local people and government, and social and economical problems in local

communities, - potential impacts of aquaculture including introduction of exotic species, pollution, eutrophication. Additionally, the biodiversity in Oxbow lakes have impacted severely because of high population pressure, over exploitation and indiscriminate use of fine meshed fishing gears. Most of the oxbow lakes of the Nadia district are degrading due to various anthropogenic activities like encroachment, construction of roads, agricultural activities, and siltation due to flood with excessive growth of water hyacinth. Dixon (2008) examined the cases of local community based institutions involved in wetland management in western Ethiopia. Jute retting during monsoon is a common anthropological activity in the rural Bengal. Habitat loss or modification often associated with habitat fragmentation, which includes pastoral development, cultivation and settlement, forestry operations and plantations, fire and pollution. Makombe and Sampath (2003) evaluated the influence of socioeconomic variables on participating in marketing cooperatives on the financial performance of small holder irrigation system in Zimbabwe. Excavation, large scale pit extraction disfigures oxbow lakes landscapes and limits their values for other. Considering the importance of ecological biodiversity and socio-economic aspects of stake holders for sustainable developments of this natural resource, proper management strategies need to be formulated to come out with solutions which are sustainable, eco-friendly and climate resilient to suit the local conditions. Consequently, much more detailed analysis of the socioecological, socioeconomical of oxbow lakes in West Bengal is urgently needed. There lies the justification of the present work. Tiega (2002) mentioned of wetland policies/strategies; legislation and regulation, pollution control, economic valuation techniques, training and environmental education, and public awareness are compulsory and being made to conserve wetland biodiversity in Africa (Thompson, 1996). IUCN, CNRS-Bangladesh (2006) described the values of conserving Hakaluki haor in terms of its economic, ecological and social benefits for local communities and for the nation at large. Biswas *et al.* (2005) delineated a case study of Bhomra Beel, India by assessing people's perception vis-à-vis the utilities and associated threats. Bhaumik *et al.* (2006) reported threats to the continuing functioning of the Ganga and its floodplains as living systems reached a critical level, the key factors of which are pollution, competition for water, habitat alteration, siltation, irrational uses of water, introduction of exotic species and irrational exploitation of fishery. Biswasroy *et al*. (2011) presented a scenario of Mathura Beel, an oxbow lake in the same Nadia district, West Bengal through socioeconomic analyses, and a perception study on wetland use and wetland threat.

However the works on the assessment of potential impact of anthropogenic pressures on changes of tropical oxbow lake ecosystem in Ganga river basin through socioecological surveys for sustainable management are scanty. Considering these circumstances, the present research was conducted to understand and assess the socio-ecological-economic effects on a tropical oxbow lake ecosystem in Nadia district of West Bengal, India and the main objective of the present study was aimed to assess the potential impact of different anthropogenic pressures on changes of a tropical oxbow lake ecosystem and propose strategies for its sustainable management.

MATERIALS AND METHODS

STUDY AREA

The Chhariganga oxbow lake, abandoned, fractioned and derived from the river Ganga is located in Nakashipara development block of Nadia district, West Bengal, India. It is situated at 23.5800° N latitude, 88.3500° E longitude, about 90 Km away from Kalyani University Campus, Nadia. It is a fresh water open type semi-closed oxbow lake and receives water from the river Ganga during monsoon through a narrow channel at the North East corner of a loop of the river. The oxbow lake is spread over an area of 145.69 Acres with an annual average depth of 8.5 ft. It also stores rain water. The catchment area of the oxbow lake is 600 hectare (**Figure-1**).

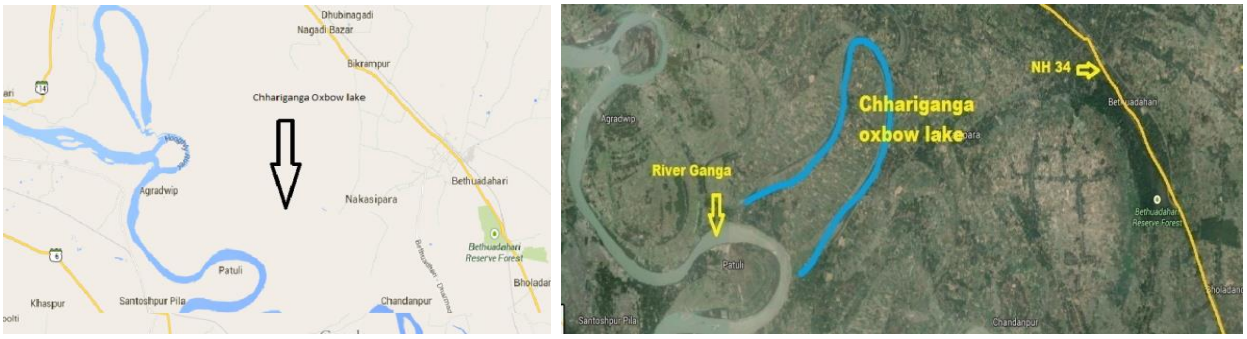

Figure-1: Map showing study area

The selected site was sampled from April 2011 to March 2014 at 6.00 AM during pre-monsoon (PRM, March-June), monsoon (MON, July-October) when jute retting period lies normally during August- September and post monsoon (POM, November-February).

Socio-economic-ecological Survey and analysis

A qualitative research approach (Nelson 1991) supplemented by quantitative data analysis was followed in this study. Several Participatory Rural Appraisal (PRA) tools such as interviews (with semi-structured questionnaires) (Angrosino 2002), personal interviews, focus group discussions (Morgan *et al.* 2008), and mini workshops were used to pursue the research objectives. PRA has been considered very appropriate for its primary goal of promoting real participation and empowerment of people. The methods for data collection were used based on their adaptability to the PRA approach, the complexity of the Fisheries cooperative Societies, and the research objectives. With an interest in promoting real participation, trying to understand a complex socio-economic system, and extreme relevance of the local fishers in building this knowledge, research took place in the community. Serious efforts were made to involve and have close contact with fishers involved directly and indirectly with the Kutirpara primary Fishermen's cooperative Society (KPFCS) based on the Chhariganga oxbow lake ecosystem (COLE).

Participatory Rural Appraisal (PRA)

PRA is one of the important approaches and methods most used in rural development. It has been defined as a family of approaches and methods to enable rural people to share, enhance, and analyze their knowledge of life and conditions and to plan and act (Chambers 1994). It is more than the provision of a number of techniques to apply in promoting rural development. Its ultimate goal is the promotion of real participation and empowerment of the people. The techniques that are commonly used in PRA are semi structured interviews, focus group discussions, participant observation, diagramming and visualizations, ranking and scoring exercises, oral histories, ethno biographies, seasonal calendars, and structured interviews, etc. The PRA approach involves research controlled by participants, therefore community members rather than academics drive the research process.

Semi-structured interviews

In research, sensitive and thoughtful interviewing yields fruitful results and understanding. According to Pretty *et al.* (1995), semi-structured interviewing is a guided conversation in which only the topics are predetermined and new questions or insights arise as a result of the discussion and visualized analysis. In semi-structured interviews the context, the participants, the way the interview is conducted, and when it takes place are as important as the questions themselves. To conduct semi-structured interviews researchers need to be self-critical, aware of biases, open, and a good listener and observer. They also need prior preparation, the use of an interview guide or checklist, use of different visual tools to encourage participation and dialog, to be an attentive listener and humble, to assess and judge responses, and to record responses and observations (Pretty *et al.* 1995). We used semi structured interviews in household surveys, key person's interviews, and focus group discussions.

Focus Group Discussions (FGDs)

Discussion with the local people and stakeholders, acting the researcher as a facilitator is considered important technique for data collection. Focus group interviewing is a strategy that aims to generate discussion and interaction within small groups of local people. Normally, these groups range in size from six to twelve individuals. Through discussions, the researcher attempts to learn about conscious, semiconscious, and unconscious psychological and socio-cultural characteristics and processes within groups. These focus group discussions are different from the consultation and other discussion meetings that the researcher facilitates throughout the research process (especially at the beginning and ending). The participants primarily share their experiences and information. Grenier (1998) mentioned that the truthfulness of the information and the speed of generation are higher when they come from groups. It also helps to identify key knowledgeable persons and explore the limitations provided by the power relationships among participants. Focus Group Discussions were considered an adequate technique to use in women's groups and Community based organizations.

Key informant interviews

Key informant interviews are qualitative in-depth interviews with people who know what is going on in the fishers' community. The purpose of key informant interviews was to collect information from a wide range of people including community leaders, professionals, or residents who have firsthand knowledge about the fishers' community. These

community experts, with their particular knowledge and understanding, can provide insight on the nature of problems and give recommendations for solutions. Before selecting key informants it is important to map out the population of interest, or target population. This target population could include all community residents living in a particular area, or could be a particular portion or group within that geographical region (such as a racial/ethnic minority, adolescents, or women). Once the target population is identified better brainstorming can be possible with the key informants who are knowledgeable and closely linked to the research interest.

This technique was very appropriate in our study to understand the motivation and beliefs of community residents on a particular issue, to get information from people with diverse opinions, and be able to ask in-depth and probing questions. We did 25 key informant interviews with a semi-structured questionnaire; this helped me to get more candid or in-depth answers because sometimes the focus group dynamic prohibited us from candidly discussing sensitive topics or getting the depth of information we needed. Sometimes the group dynamic can prevent some participants from frankly voicing their opinions about sensitive topics. Therefore, we obtained their in-depth ideas, solutions, and overall opinions regarding sensitive topics and problems associated with the fishing operation, KPFCS & COLE operations, sustainability, and organizational capability.

Mini-workshop

Mini-workshops are a common educational format for transmitting information with active participation of the target population. The researcher aims to provide to the community a primary report of the research outcomes in their preferred form of presentation; this could be by holding meetings or by mini-workshops, both of which would be useful in the analysis and verification of data. We arranged five mini-workshops with the help of KPFCS to verify my data and disseminate research findings to the fishers' community.

Synopsis of Data collection methods adopted for this study

Data were collected from randomly selected 25 fishers (about 10% of the KPFCS members) by personal interview (PI) with a well-structured questionnaire. Participatory rural appraisal (PRA) tool such as Focus Group Discussion (FGD) was conducted with the fishermen to get an overview of the management system of the Chhariganga Oxbow Lake and their socio-economic condition. Nearly 80% of the fishermen (**Table-1)** who attended the PI & FGDs belonged to the age of more than 50years who have been observing the oxbow lake with their matured eyes for at least 30 years. The FGDs were conducted with a pre-structured and pre-tested questionnaire involving fishers of the Kutirpara Primary Fishermen Cooperative Society Limited based on the Chhariganga Oxbow Lake of our interest. After collecting the data from the fishermen cross-check interviews were conducted with key persons such as, Assistant Director of Fisheries, Nadia and the relevant stake holders for confirmation of the information.

Table-1: Age group of Fishers attended PI & FGDs

Age group	40-50	50-60	60-70
%	20	08	72

Socioeconomic data Analysis

All the collected data were summarized and scrutinized carefully and analyzed by MS Excel and then presented in textual, tabular and graphical forms to understand the management system of the oxbow lake fishery and the socio-economic-ecological conditions of the fishermen in the study area.

Three point continuum scale

To measure the intensity of constraints faced by oxbow lake, a three point continuum scale is used. These three points are most important, important and least important, which were scored 2, 1, 0 respectively. The mean score is calculated for individual constraint separately and is ranked accordingly (**Table-2)**.

Table-2: Three point continuum scale

Points	Scores	Mean scores	Rank
Most important	2		1
Important	1		2
Least important	0		3

RESULTS

We found total 1240 members involving 270 fisher families and fisher members of the Kutirpara Primary Fishermen Cooperative Society Limited based on Chhariganga Oxbow Lake. The fishers members are illiterate (17.42%), can put sign (14.68%), completed primary education (50.16%), secondary education (16.61%) and rest (1.13%) completed higher education (**Table-3**).

Table-3: Education level of Fishers through PRA

Level		Fishers Family members	Fishers %
1.	Illiterate	216	17.42
2.	Can sign	182	14.68
3.	Primary	622	50.16
4.	Secondary	206	16.61
5.	Higher secondary	7	0.56
6.	Graduate	4	0.32
7.	Masters	3	0.24
8.	Doctorate	-	-
	Total	1240	100.00

Ecological information of Chhariganga oxbow lake environment obtained through PI and continuum scale analysis revealed that water pollution, uses of oxbow lake water for agri-irrigation, conversion of oxbow lake in to crop lands, area of Boro (dry season paddy) rice cultivation, cultivation of oil seeds in embankments and abundance of aquatic vegetations used for animal fodder were increased most among the 18 different ecological changes taken place during last 30 years (**Table-4**). Avenue for fish migration from river to oxbow lake has been decreased in 30 years. Fish Species diversity, soil fertility and cultivation of Pulses have also been decreased during that period. The availability of different birds in the oxbow lake ecosystem, dry season water coverage, abundance of aquatic vegetations used for human fodder, occurrence of different reptiles and the like animals in the ecosystem, availability of large fish (year 1, year 2 and above age group) and production of natural fish have also been decreased considerably and going to be almost extinct. The cultivation of Aus (Kharif-1) paddy and cultivation of Aman paddy (Kharif-2) were surveyed to be extinct from the oxbow lake ecosystem over the last 30 years.

Table-4: Ecological Changes taken place during last 30 years through PI

	Indicator	Increased	Decreased	Almost extinct	Individual score	Mean score	Average Mean score	Change indicato Ranking
1.	Water pollution	25	-	-	50	16.67	0.93	1
2.	Uses of oxbow lake water for agri-irrigation	25	-	-	50	16.67	0.93	1
3.	Conversion of oxbow lake in to crop lands	25	-	-	50	16.67	0.93	1
4.	Area of Boro (dry season paddy) rice cultivation	25	-	-	50	16.67	0.93	1
5.	Cultivation of oil seeds	25	-	-	50	16.67	0.93	1
6.	Abundance of aquatic vegetations used for animal fodder	25	-	-	50	16.67	0.93	1
7.	Avenue for fish migration from river to oxbow lake	-	22	3	22	7.33	0.41	2
8.	Fish Species diversity	-	19	6	19	6.33	0.35	3

9.	Soil fertility	-	19	6	19	6.33	0.35	3
10.	Cultivation of Pulses	-	19	6	19	6.33	0.35	3
11.	Availability of different Birds in the oxbow lake ecosystem	-	12	13	12	4.00	0.22	4
12.	Dry season water coverage	-	12	13	12	4.00	0.22	4
13.	Abundance of aquatic vegetations used for human fodder	-	10	15	10	3.33	0.19	5
14.	Occurrence of different reptiles and the like animals in the ecosystem	-	7	18	7	2.33	0.13	6
15.	Availability of large fish (year1, year2 and above age group)	-	6	19	6	2.00	0.11	7
16.	Production of natural fish	-	6	19	6	2.00	0.11	7
17.	Cultivation of Aus (Kharif-1) paddy	-	-	25	-	-	-	8
18.	Cultivation of Aman paddy (Kharif-2)	-	-	25	-	-	-	8
	Total	150	132	168	432	144.00	8.00	

We tried to evaluate the knowledge base of the fishers' community of oxbow lake ecosystem and its management through PI and found that statements like aquatic resources are declining, most of the Fishers are poor, siltation contributes to the degradation of oxbow lake habitats and there should be some rules for aquatic resources management were strongly agreed upon by all the participants of the FGDs. Statements like dry season water management is important for crop and fish production, people get only crop and fish from oxbow lake, only fishers and landowning farmers are the beneficiaries of oxbow lake resources, wet season water management is important for crop and fish production and number of full time fishers declined in the area were generally agreed by the respondents. Disagreed were the statements like information on the Chhariganga oxbow lake not known, knowledge of fishery limited, and Rabi crop diversification can contribute to protection and maintenance of oxbow lake fish stock. But respondents were observed to be mixed in response for statements like oxbow lake (fish) sanctuaries will contribute to the rejuvenating fish stocks and protecting biodiversity, limiting fishing effort is one way of reverting declining fish catch, overall well being of your household improving, oxbow lake ecosystem includes only seasonally inundated water, household income increasing, the community should manage biodiversity and people grow Boro rice in oxbow lake areas as other crop is not suitable there (**Table-5**).

Table-5: Knowledge of oxbow lake ecosystem management through PI and FGDs

	Statement	Strongly Agreed	Agreed	Disagreed	Individual score	Mean score	Average Mean score	Agreed knowledge Ranking
1.	Aquatic resources are declining	25	-	-	50	16.67	0.88	1
2.	Most of the Fishers are poor	25	-	-	50	16.67	0.88	1
3.	Siltation contributes to the degradation of oxbow lake habitats	25	-	-	50	16.67	0.88	1
4.	There should be some rules for aquatic resources management	25	-	-	50	16.67	0.88	1
5.	Dry season water management is important for crop and fish	24	1	-	49	16.33	0.86	2

	production							
6.	People get only crop and fish from oxbow lake	18	7	-	43	14.33	0.75	3
7.	Only fishers and landowning farmers are the beneficiaries of oxbow lake resources	14	11	-	39	13.00	0.68	4
8.	Wet season water management is important for crop and fish production	12	13	-	37	12.33	0.65	5
9.	Number of full time fishers declined in the area	10	15	-	35	11.67	0.61	6
10.	Oxbow lake (fish) sanctuaries will contribute to the rejuvenating fish stocks and protecting biodiversity	13	7	5	33	11.00	0.58	7
11.	Limiting fishing effort is one way of reverting declining fish catch	11	10	3	32	10.67	0.56	8
12.	Overall well being of your household improving	2	23	-	27	9.00	0.47	9
13.	Oxbow lake ecosystem includes only seasonally inundated water	-	15	10	15	5.00	0.26	10
14.	Household income increasing	1	12	12	14	4.67	0.25	11
15.	The community should manage biodiversity	-	10	15	10	3.33	0.18	12
16.	People grow Boro rice in oxbow lake areas as other crop is not suitable there	2	-	23	4	1.33	0.07	13
17.	Information on the Chhariganga oxbow lake not Known	-	-	25	-	-	-	14
18.	Knowledge of fishery limited	-	-	25	-	-	-	14
19.	Rabi crop diversification can contribute to protection and maintenance of oxbow lake fish stock	-	-	25	-	-	-	14
	Total	207	124	143	538	179.33	9.44	

Table-6 details survey of fishers about the knowledge base of degree of danger in different management practices in Oxbow lake ecosystem through PI. Statements like massive use of mosquito nets in flooded oxbow lake, jute retting in the oxbow lake, Irrigate all crops with the oxbow lake water in the dry season, fishing by complete dewatering of oxbow lake in the dry season, converting oxbow lake in to crop lands (raising the low lands) were surveyed to be dangerous while statements like starting intensive fish culture practices in oxbow lake, allowing indiscriminate fishing efforts (over fishing), Fertilizers/pesticides getting in to oxbow lake water, making dykes around oxbow lake got mixed responses from dangerous to not danger to beneficial for the lake ecosystem.

Table-6: Knowledge about the degree of danger of different management practices in Oxbow lake ecosystem through PI

	Management Practices	Dangerous	Not danger	Beneficial	Individual score	Mean score	Average Mean score	Danger Ranking
1.	Massive use of mosquito nets in flooded oxbow lake	25	-	-	50	16.67	1.85	1
2.	Jute retting in the oxbow lake	25	-	-	50	16.67	1.85	1
3.	Irrigate all crops with the oxbow lake water in the dry season	25	-	-	50	16.67	1.85	1
4.	Fishing by complete dewatering of oxbow lake in the dry season	25	-	-	50	16.67	1.85	1
5.	Convert oxbow lake in to crop lands (raising the low lands)	25	-	-	50	16.67	1.85	1
6.	Start intensive fish culture practices in oxbow lake	21	-	4	42	14.00	1.56	2
7.	Allow indiscriminate fishing efforts (over fishing)	15	8	2	38	12.67	1.41	3
8.	Fertilizers/pesticides get in to oxbow lake water	9	9	7	27	9.00	1.00	4
9.	Make dykes around oxbow lake	2	-	23	4	1.33	0.15	5
	Total	172	17	36	361	120.33	13.37	

Knowledge of management benefits from oxbow lake ecosystem were tested through PI and we observed that fishers considered rehabilitation of locally extinct fish species, taking measure for integration of crop and fish culture management, awareness raising, training on conservation of fish and other aquatic resources, adopting conservation measures, restriction in use of different harmful gears to catch fish, establishing fish sanctuary and build deep pool in the oxbow lake, making water regulatory structures (Sluice gates, weir nets bunds etc) at the lake, communication and linkages with other institutions, observing closed season when fish are spawning and alternate crop cultivation (dry season) as beneficial to less beneficial to problematic for the oxbow lake management (**Table-7**).

Table-7 Knowledge of Management Benefits from oxbow lake ecosystem through PI

	Options	Beneficial	Less beneficial	Problematic	Individual score	Mean score	Average Mean score	Benefits Ranking
1.	Rehabilitation of locally extinct fish species	25	-	-	50	16.67	1.85	1
2.	Taking measure for integration of crop and fish culture management	24	-	1	48	16.00	1.78	2
3.	Awareness raising, training on conservation of fish and other aquatic resources, adopt conservation measures	22	3	-	47	15.67	1.74	3
4.	Restricting use of different harmful gears to catch fish	17	-	8	34	11.33	1.26	4
5.	Establish fish sanctuary and build	16	-	9	32	10.67	1.19	5

	deep pool in the oxbow lake							
6.	Water regulatory structures (Sluice gates, weir nets bunds etc)	15	-	10	30	10.00	1.11	6
7.	Communication and linkages with other institutions	2	23	-	27	9.00	1.00	7
8.	Closed season when fish are spawning	9	7	8	25	8.33	0.93	8
9.	Alternate crop cultivation (dry season)		2	23	2	0.67	0.07	9
	Total	130	35	59	295	98.33	10.93	

Community needs (**Table-8**) in household survey through PRA and PI revealed that highest (13.7%) of the fisher families felt proper implementation of fishery law to be top most need among many and ranked it as 1st, while 12.59% demanded good roads facility ranking 2nd, 10.37% needed electricity as 3rd most need while banning harmful gears in the oxbow lake and Control use of pesticides in the immediate agriculture as 4th most need. About 9.26% fishers needed alternative income generating activities like fish processing industries, crafts and gear making units, ornamental fishery unit for women etc and Educational institutions as 5th need. Health care facility was needed as 6th most by 7.04% fishers. Water regulatory structures (Sluice gates, weir nets bunds etc) on the lake and Conservation of wild fish are demanded by 4.44% fishers members and ranked 7th. The fishers also demanded special task group formation within the cooperative society, awareness building, stoppage of catching brood fish, sanctuary establishment and building up deep pool in the oxbow lake and rehabilitating extinct/rare species including fish on their needs.

Table-8: Community needs in household survey through PRA and PI

	Needs	Fishers family numbers	Fishers family %	Needs Ranking
1.	Proper implementation of fishery law	37	13.70	1
2.	Road	34	12.59	2
3.	Electricity	28	10.37	3
4.	Ban harmful gears	27	10.00	4
5.	Control use of pesticides in the immediate agriculture	27	10.00	4
6.	Alternative income generating activities like fish processing industries, crafts and gear making units, ornamental fishery unit for women etc	25	9.26	5
7.	Educational institutions	25	9.26	5
8.	Health care facility	19	7.04	6
9.	Water regulatory structures (Sluice gates, weir nets bunds etc)	12	4.44	7
10.	Conservation of wild fish	12	4.44	7
11.	Special task group formation within the cooperative society	10	3.70	8
12.	Awareness building	7	2.59	9
13.	Stop catching brood fish	3	1.11	10
14.	Sanctuary establishment and build deep pool in the oxbow lake	2	0.74	11
15.	Rehabilitate extinct/rare species including fish	2	0.74	11
	Total	270	100.00	

DISCUSSIONS

Baruah *et al*. (2000) reported Illiterate fishers (49%), Lower primary (18%), secondary level (22%), and higher secondary level (11%). Peixer and Petrere (2009) reported most of fishers (66.6%) of only incomplete primary and junior

education which quite similarity with our study. Biswasroy *et al*. (2011) reported higher percentage (29%) of surveyed as illiterate and lower level of 31% as literate in an oxbow lake in the same district when compared to our findings (17.42% and 82.58% respectively). Kostori (2012) found fishers of 54% as illiterate as they could sign only. Abdullah-Bin-Farid *et al.* (2013) found Education status of majority fishermen was could sign only (37%) followed by fishermen up to primary level (31%). Siddiq *et al.* (2013) and Zahan (2013) reported about 22.5% of the fishermen as illiterate (ours is 17.42%) and the rest 40% and 17% had primary or higher education (ours is 67.90%, of which primary 50.16%, secondary 16.61%, rest higher education 1.13%) and also observed that 32.5% and 46.5% of the fishermen could sign their name (ours is 14.68%).

Bhaumik *et al*. (1991) reported ignorance of fishers about developed aquaculture technology, lack of quality inputs and unavailability of implements. The similar findings were also reported by Choudhary *et al*. (2001) and the findings of Nair *et al.* (2007) were in partial agreement with the present finding. The proper marketing facility for harvested fish within easy reach of the fishermen covering a number of cooperatives or group can provide viable fishing strategies as reported by Datta and Kundu (2007). This was in full agreement of the present study. Annamalai (1996) reported the absence of effective management as the major constraint of cooperative society. Sau *et al.* (2012) reported the social constraints as the highest intensity as perceived by the fishers. They also reported both undue harassment by non-members and poaching of fishes followed by lack of coordination within cooperative structure among the social constraints, lack of effective supervision followed by lack of motivating agency among the general constraints most faced by the fisheries societies. Their findings are partially similar with some of our findings. Bhaumik *et al.* (2006) opined that it might not be possible to achieve equitable and sustainable socioeconomic development for the people of the Gangetic basin in West Bengal without improving the sustainability of the ecosystem through responsible utilization of water resources by the people. Biswasroy *et al*. (2011) suggested of culture based fisheries with the advent of culture based capture fisheries, culture and capture system merged into one integrated whole for capture fisheries and renovation of margins/pockets for culture fisheries, desilting of connecting channels and construction of perimeter dykes as prerequisite for such exercise, intensive aqua culture practices with stress on adoption of integrated fish farming rather than composite fish culture alone, a multi-commodity farming system as more advantageous to the farmer, duck husbandry with fish culture as gaining popularity due to high returns. They also opined finally that the participation of each and every stakeholder needed more, not only for preserving or conserving but also emerging fisher's life style and livelihood and this whole process could be successful through proper training of stakeholders and the biggest benefit of utilizing the water resource would be the opportunity for employment of large number of people those benefiting the economy of the district.

Table-9: Proposed strategies to bridge the gaps in sustainable ecosystem management of oxbow lakes in Nadia district, West Bengal Key Goals, problems and Interventions with SWOT analysis

Goals	Ecological
Constraints	Problems of water bodies and lack of rain water harvesting structure for conservation & utilization of rain water
Strengths	Large nos and areas of fertile oxbow lakes available for fish farming
Weaknesses	Large water bodies especially are under derelict and semi-derelict conditions
Opportunities	Large nos water bodies still un &/ or underutilized, Proper management of water-bodies
Threats	High siltation and weed infestation
Interventions	Expedite conversion, demarcation, renovation and conservation process of multi owner water bodies, Mass awareness campaign exposure visit for Creating awareness on rain water, and promoting ecotourism in the oxbow lake ecosystem

Strategies and Prioritization of Government interventions

1. Development of oxbow lakes through interventions like de-silting, demarcating, biological and manual control measures for macrophytes infestation (potentially through employment guarantee programme), regulating water lifting, jute retting intensity and density, and indiscriminate uses of fishing gears with varying mesh sizes and chemicals and pesticides.
2. Promoting ecotourism at oxbow lake ecosystems of the district.

Chhariganga Oxbow Lake Ecosystem as tourist center

Chhariganga Oxbow Lake ecosystem (COLE) is having unique shape, originated by cut-off of an acute meander of the river Jalangi. Numerous kinds of fishes of the oxbow lake are of great demand in local markets. Migratory wading birds along with sedge-birds and local birds are much more than enough to attract one's tourist's watch especially during winter months. There is no tourist resort in the COLE. Strategies could be developed as successful tourist spots with their heritage resources can be summarized as bellow-

1. Migratory birds come regularly in during winter. Proper protection measure should be taken for those birds to provide them environment suitable for breeding. Bird watching may be a good item of attraction to tourists.
2. Swan and geese along with Campbell ducks reared in floating-cage on commercial basis will positively attract tourists for their beauty. Moreover, meat and eggs in dishes of tourists must raise the mercury.
3. Duck Chase is a game where ducks reared for commercial purpose swimming on open and wide water body are tried to catch. This may be a funny game for tourists.
4. Boat racing (Nouka Baich) is the boats race popular in rural Bengal. Colorful boats may be introduced for Baich and participants will be tourists. Each tourist participant must be well protected by life-jacket etc to do in much water.
5. Angling may be very attractive to tourists as the lake is rich in fish population. Angling can earn a lot along with fish cultivation.
6. House boat may be kept for tourists stay. These may add glamour as tourist spot.
7. Home stay with local community to experience their cultural heritage and agricultural practices are also recommended. This may raise and increase respect and love for farmers, their living and their culture.
8. Local festivals and village culture like famous and unique Boul Sammelani at Agradip Ghat Mela (near Gopinath Dhaam near the COLE during spring), Pous Parvana (January), Jagadhatri puja (October), Rasa (November), Dol utshav (April/May), etc have great importance in the COLE. This lake can take opportunity of thousands of tourists visiting these festivals.
9. Proximity to Historic town Krishnagar, pilgrim town Nabadwip, spiritual capital Mayapur (ISKCON), Bethuadahari Wildlife Sanctuary, Bahadurpur forest, dolls of Ghurni and archaeological treasury Ballal Dhibi must add potency to the COLE. Krishnagar, headquarter of Nadia District is famous for its tourist spots like Royal Palace, Clay Modeling of Ghurni, Cathedral, etc. Ghurni is the birthplace of Yogiraj Sri Shyama Charan Lahiri fountain-head of Kriya yoga. The Jhulan Mela is celebrated around the Rajbari in July–August and Baro Dol (as it is held 12 days after Dol Purnima) in March–April every year. The church is famous for its architectural and sculptural splendor. There are 27 oil paintings describing the life of Lord Jesus Christ. Of special mentions are the wooden sculptures by Italian artists. Others include the College Bhavan (1846), the Public Library (1856), Krishnagar Collegiate School (1846) the former house of barrister Monomohun Ghose, Anandamoyi Tola Kali Bari and the Protestant Church. Company Bagan is a horticultural garden run by the state government. Nabadwip, within 55 km from the COLE, is birth place of Sri Chaitanya, leader of Bhakti movement in 16th century Bengal and great social reformer. He is considered as an incarnation of God. Millions of pilgrims visit this place every year. So, there is high potency of this lake along the like to prosper as a tourists spot. Mayapur, the spiritual capital of the world, is located on the banks of the Ganges River, at the point of its confluence with the Jalangi, near Nabadwip, West Bengal, India. Headquarter of ISKCON is situated in Mayapur and it is considered a holy place by a number of other traditions within Hinduism. Sri Chaitanya is regarded as a special incarnation of Krishna in the mood of Radha played a lot of role here. Mayapur is visited by over a million of pilgrims annually. During the visit one can see the huge headquarters of the International Society of Krishna Consciousness (ISKCON) and 'a long stream of saffron-robed devotees chanting' the Hare Krishna. Mayapur is also within 55 km from the lake giving them more gravity to attract international along with national tourists.. Mayapur is also famous for Ballal Dhibi, a ruined architecture of 12th century by Sena dynasty and named after King Ballal Sen. Bethuadahari Wildlife Sanctuary is situated 10km away from the COLE, in the C. D. Block Nakashipara of Nadia District, West Bengal, India. The sanctuary is located beside National Highway 34. It covers an area of 67 hectares, and was established in 1980 to preserve a portion of the central Gangetic alluvial ecozone. The sanctuary has a large population of spotted deer (chital), jackal, Bengal fox, porcupine, and common langur. Bird species include parakeets, Indian cuckoos, barbets and other smaller birds, while reptiles and

amphibians include pythons, monitor lizards and gharials, a type of small crocodile. The sanctuary is wonderful space for beginner photographers' tourists etc. The amazing rock python is the greatest attraction of the forest. Among the trees found within the sanctuary are shal, teak, arjun, Indian rosewood, and bamboo. Nearness of this sanctuary also multiplies the potency of the lake to be tourist spot.

10. Finally eco-tourism practices forbidding plastic carry bags, wastage, and misuse of natural resources and encouraging nature fresh local foods, recycle, reuse and reduce of wastage are to be practiced.
11. All these are only achievable through local community participation and adequate advertizing by government. Local government must be actively involved within the project.
12. The most potential Chhariganga Oxbow Lake is a Govt property and its development as a tourist center is obvious.

Public private Partnership (PPP) Ventures

1. The Activities proposed from the local community and professional collaboration given below:
2. Construction of Artisan, cottage hub: Local masons and craftsmen with Architect / architecture students for Matir putul, handloom garments etc
3. Marketing: Local youth with marketing enterprise / consultant
4. Hospitality, lighting, horticulture park: local enterprise/cooperative with hotel management enterprise/consultant
5. Fishing, parking , boating and racing, sky roping (rope way), Aquatic sporting, games, Eco van (electronic van) plying etc
6. Food court, drinking water supply: Youth from the fisher folk community is to be identified to run the fish/food court.
7. Fishery information centre: Local youth involved in outbound activities, etc
8. The fishers' community should also be the resource base for all the fish product items that are required by this facility. In addition to this they should demonstrate their skills in the craft of fishing, boat making and net making to the tourists.

Guiding principles of the proposed Ecotourism

1. Protecting and rejuvenate the oxbow lake environment and ecology-the proposed tourist spot shall not in any disturb the existing natural features of the area and forestation activity shall be taken up in the site where the indigenous species of plants shall be grown to mitigate the effects of cyclones and other natural calamities.
2. Creating a unique tourism destination-it shall be the first to offer the tourists a unique opportunity to experience the adventures and the moods of the lake through their daily activities and also give them an insight into their cultural and social life. Nadia is the resource for a variety of fish but it does not have an eating facility that can provide this cuisine to the fish lovers. In the tourist spot, the fishermen, who are a ready resource for fresh fish, shall provide the people with exclusive taste of their cuisine and also other foods.
3. Generating awareness amongst the people about the importance of environmental protection-Concepts of appropriate technology shall be adopted in this spot by the use of sustainable methods of waste disposal and recycling and renewable energy resources. They aim to make this spot as a place that shall sensitize the people about the need to protect their environment and also disseminate information about eco friendly methods.
4. Establishing a prototype for future tourism initiatives in the district-The main objective of this is to develop a working prototype that shall be used as a case study and for sustainable tourism development and also as a project that can prove the efficacy of eco tourism concepts in development.
5. Staying within the framework of fisheries regulation-it will follow all the rules and challenge the popular belief that these rules are a hindrance to tourism development. All the structures in this spot will be of temporary nature. The principle of reduce and recycle of water shall be used.
6. Sustaining and enhancing the tourism potential of the district.
7. Sustaining and uplifting the indigenous fishers community-The local fishing community of villages which forms an integral part of the district history and culture is slowly being decimated due to the pressures of urbanization and the unplanned development that has come along with it. The poverty alleviation programmes and the numerous NGOs working in this sector have made negligible progress in improving their lot. About 50% of the population in the villages has abandoned their traditional profession of fishing and has moved to the cities to work as

construction labour or so. However this has not improved the life in the village. And they are only a shade better than their counterparts who continue the profession of fishing. The literacy levels are also low. Tourism being hospitality it is largely dependent on the hospitality shown to the tourists by the locals. It is therefore impossible promote tourism projects at the expense of the local fishing community. They have to be made a part of the tourism development process so as to be able to make Nadia a sought after tourism destination. This is a project that shall be set up run by the fisher folk. This project shall therefore give the fishermen an opportunity to reap the benefits tourism development and at the same time enhance the tourism potential of the place.

Impacts and Benefits-costs (SWOT) analysis of ecotourism and Environmental impacts

1. Direct benefits & Direct costs- provides incentive to protect environment, both formally (protected areas) and informally, provides incentive for restoration and conversion of modified habitats. Ecotourists actively assisting in habitat enhancement (donations, policing, maintenance, etc.) danger those environmental carrying capacities will be unintentionally exceeded, due to rapid growth rates, difficulties in identifying, measuring and monitoring impacts over a long period.
2. Indirect benefits & indirect costs- Exposure to ecotourism fosters broader commitment to environmental well-being, space protected because of ecotourism provide various environmental benefits, fragile areas may be exposed to less benign forms of tourism (pioneer function), may foster tendencies to put financial value on nature, depending upon attractiveness

CONCLUSION

We are of the opinion of development of oxbow lakes through the immediate interventions like de-silting; demarcation; biological and manual control measures for macrophytes infestation; strict prevention and regulation of water lifting, jute retting, indiscriminate uses of fishing gears with varying mesh sizes and chemicals and pesticides; and promotion of organic aquaculture and ecotourism at the oxbow lake ecosystem.

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