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Fluvio-Ecological Modifications and Livelihood options of an Oxbow lake of Kalindri River, Malda District, West Bengal, India

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Abstract

The river Kalindri experienced severe channel change due to lateral shifting associated with bank erosion over course of time. The shifting of the river Kalindri created a good number of oxbow lakes which has direct and indirect impacts on livelihood pattern of the people living in surrounding region. This paper attempt to discuss the consequent phases of oxbow lake genesis and hydro-ecological modification of an oxbow lake of Kalindri River situated near Amrity (8803'11" E and 25^{0}1'44") and Balupur (88^{0}3'4" and 25^{0}2'26") region. It is found that oxbow lake has direct impact on local people. Process of oxbow lake formation generated fertile soil for agricultural production. The oxbow lake is considered as resource pool of water, floral and faunal diversity, fishing ground, source of irrigation water, seasonal agricultural field and many other visible and invisible resources storage. So, if one assembled all goods and services provided by this wetland and converted them to monetary term, the monetary value of the wetland produced by those goods, services and other resources would be greater in comparison to any other productive agricultural land. Still oxbow lake is rapidly transforming into agricultural land. Livelihood opportunities where material opportunities is more common than services provided by oxbows which is in fact immeasurable in monetary terms.

Keywords: Hydrological characters, Ox bow lake, Hydro-ecological evolution, Kalindri River and Change of livelihood options.

Introduction

Oxbow lakes are extensive and unique landforms within the lowland floodplain environment[1]. Oxbow lakes are mainly created by meandering river[2]. Occurrences meander cutoff Oxbow lakes and sedimentary deposits influence rates of meander migration[1,3], the width of the meander belt[4], the hydro-geological characteristics of alluvial reservoirs[5] and floodplain habitat diversity[6]. On the basis of source of water availability and link with the river Oxbow are categorized as semi-closed or closed water bodies made by dead limbs of rivers[7] due to horizontal migration of bed occurring predominantly during floods[2]. Davis[8] and Tower[9] were the first who documented and described in details the oxbow lake genesis. Oxbow lakes develop mostly through either a neck cut-off, normally when a new channel created across the neck of an over extended bend[10,11]. Oxbow lakes are created when river meanders are cutoff from the main course due to erosion of the river banks[12]. If a meander neck becomes narrow enough, instead of following the whole perimeter of the meander loop stream flow is directed along the shortest route of greatest slope (neck cutoff). Oxbow lake sometimes also develops through longer chute cutoff that develops along the depression of a point bar complex[10-13]. Lateral shifting of river channel, gully and chute erosion etc of the floodplain surface are some processes which most often contributing to cut offs[14,15]. A significant number of cutoffs induced by artificial trenching of meander necks have been exists along some river e.g., Mississippi River[13,15]. The possibility of the formation of larger lakes are greater in highly sinuous rive as it contains larger meanders[16]. In low sinuous river fewer cut offs and shorter oxbow lakes are seen due short distance of their meanders[16,17]. After meander bends cutoff, oxbow lakes cycle takes place through four evolutionary stages of geomorphic adjustment[18,19], Each stage has a distinctive hydro-geomorphic environments. There are many studies which deals with those four stages[19]. Some comprehensive analysis found in the work of Gagliano and Howard[18], Shields and Abt[20], Rowland et al. [21]. Stage-1 of the ''oxbow lake cycle'' represents the initial cutoff and open connection with the channel[19]. Increasing rate of sedimentary infilling of the lake basin are found in the intermediate stage of two and three[18-20]. Stage - 4 (the final stage) is linked with nearly complete sedimentary infilling of the oxbow lake basin[18-20]. Oxbow lakes are sometimes responsible for enhancing the topographic, hydrological and habitat diversity of the floodplain[22] and the rate of transition from lentic to terrestrial habitat is determined by how quickly they are filled by sediment[23]. Oxbow lakes are traditionally considered as wetland and provides different types of significant ecosystem services, such as offers habitat for freshwater aquatic plants and animals[24], flood waters storage and flood wave attenuation[7,25] and are increasingly known for their valuable role in nutrient and biogeochemical cycles[26,27]. Floodplain oxbow lakes play important role for fisheries[28,29] depending on the type of link with the river channel[30]. Some

oxbow lakes are replenished from groundwater and precipitation. Revitalization and restoration of wetlands under anthropogenic influence became a burning topic of ecological investigations during the past decades[30]. Many species can complete their in oxbows which able to maintain a connection with the channel even during low discharge many and contribute to maintaining a profitable fishery in the channel and the entire river system[29,30]. Oxbow lake wetlands sometimes also provides good livelihood opportunities of fishing, shelling, crabbing, hydrophytic vegetable production, wetland based irrigation non monsoon agriculture practices etc.[16]. This paper tries to explore the genesis of oxbow lake and also to examine the hydro-ecological modifications happened thereon and livelihood opportunities lost and newly generated due to such modifications.

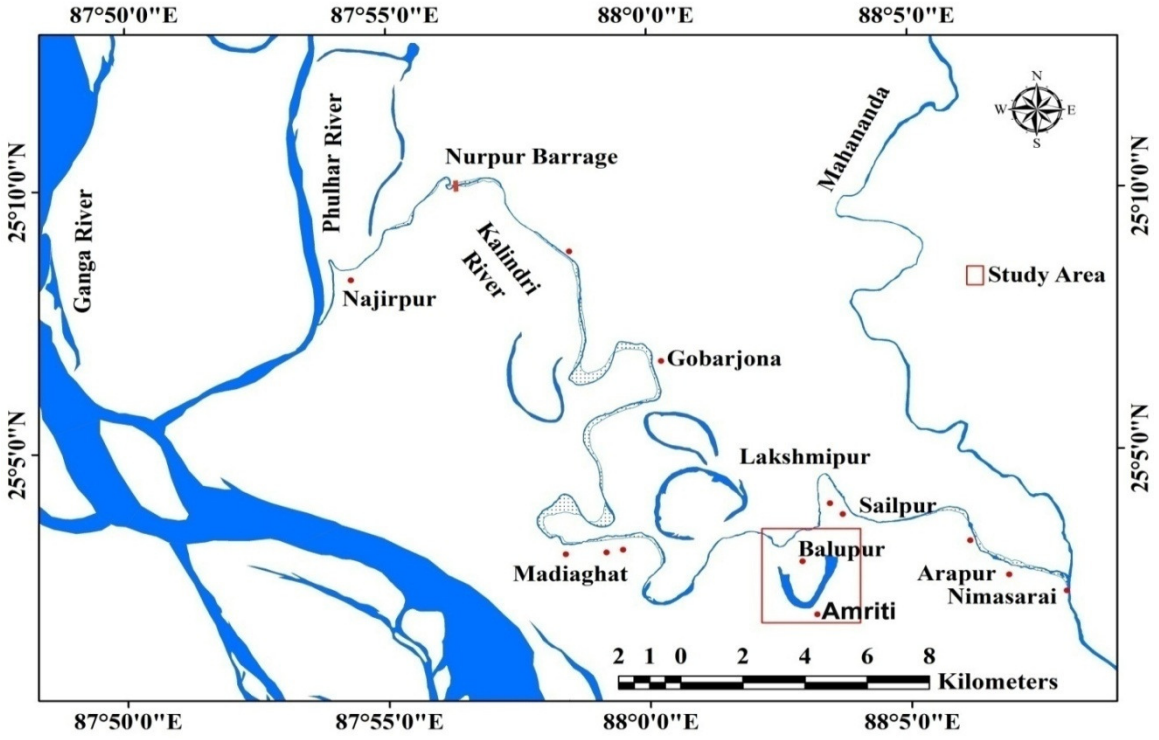
About Study Area: An oxbow lake of Kalindri River situated near Amrity has been selected as a study area for the present research work. The Amrity wet land situated near Amrity Bus stand. According to field study and human perception and previous maps the lake formed by the lateral shifting of the River Klindri. According to Sengupta[34], Kalindri River is known as a distributary of the eastern branch of the river Ganga[34]. According to Sengupta and Lambron, Phular was a branch of river Mahananda and lower part of this river was considered as Kalindri[34,35]. According to filed visit October 2014, May 2015 and January 2016 the river Kalindri a branch of River Phulher which is bifurcated from Phulher at Najirpur ($87^0 53' 48''$E and $25^0 08' 13''$) in Malda district (Figure-1). It is flowing mainly south east and join Mahananda River at Nimasari Ghat ($88^0 8' 07''$ E and $25^0 02' 42''$ N). The northern portion of this river has been known as 'Tal' land and the southern portion called 'Diara'. Diara region is the most fertile and the most populous area of the district and the Oxbow situated near Amrity which offers various livelihood opportunities situated within Diara region. Total geographical area of the lake is 125.76 hectares (Table–1 for other information related to wet land at a glance). According to the GSI report the maximum portion of study area composed by Entisoil (This is a very diverse group of soils with one thing in common, little profile development) which was formed during Holocene period[36]. One of the important features of this area is dominance of mango trees than other species of vegetation and the entire region is well known for its mango production.

Materials and Methods

The present study has been based on both primary as well as secondary data. To measure the depth, area, bank material etc. a detailed empirical survey has been conducted. 3 Cross profile have been prepared through the help of dumpy level and cross staff at different portion of the lake. To measure economic and ecological value of the wetland a detailed perception survey has been conducted with the help of structured questionnaire in the Survey of India Topo sheets, Google earth image, U.S Army maps (Table-2) has been consulted to prepare map of different period.Land use land cover maps have been prepared with the help topo sheet, Bhumi sanskar Department's land use map and mouza map analysis method. Various cross profiles and long profiles also prepared with the help of SRTM data (Source-USGS) after collection of various data all the data processed and represented through the help of various statistical tools and tables.

Table-1
Wetland at a glance

Location	Balupur, English Bazar Malda,West Bengal, India
Total area	125.76 hectares
Mouza within which it is situated (with no.)	Niamatpur(23),Lakshmighat(26),Balupur(27),Kanaipur(28),Sonatala(29) And Pichli(40)
Wetted portion 1968 (Source: Survey of India topo-sheet)	45.31 hectares
Wetted portion 2013,September (Source: Survey of India topo-sheet)	29.35 hectares(29.75 % of total Area)
Maximum depth in 1968(according to perception of people)	Almost 6-7 metre
Present Maximum depth (according to field study)	3.87m
Shape	U
Height above sea mean level	19m
Linkage with River	The Amrity wetland is an Oxbow lake of Kalindri in present there does not exist any direct link between the lake and the river, but according to human perception few decades ago there was directly connection with the river with a narrow link.
Source of water	Rain water



Source: Google Earth Image

Figure-1
The Course of River Kalindri, 2015

Table-2
Data types and Sources

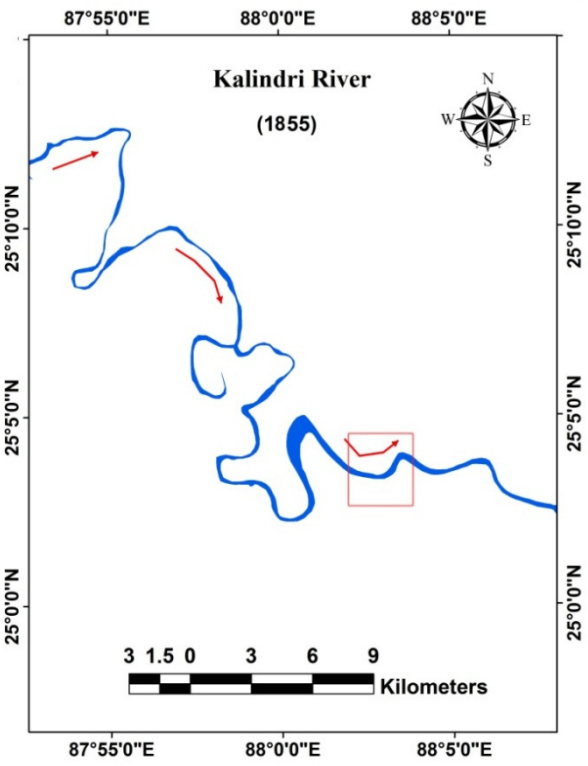
Data Type	Sources
Drainage Map,1968	Survey of India toposheets (78 $\frac{C}{4}$,1972 and 72 $\frac{0}{16}$ 1974) and Google Earth Image
Drainage Map of J.Rennel (1767)	Rennell, J. (1781)
Drainage Map of 1855 based on revenue survey map	Revenue Survey Map(1855)
Drainage Map,1924	Survey of India Toposheet
Drainage Map,1955	U.S.Army
Drainage Map,1961	U.S Army map(sheet no NG 45-11)
Drainage Map Map-1988	Landsat image
Drainage Map Map-2014	Landsat image, Path/Row-139,43,2005
Drainage Map,2001,2015 and 2016	Google Earth Image
Landuse Map-1968	Survey of India toposheets
Landuse Map-2001	Land and Land reform Department, Govt. of India
Landuse Map-2016	Google Earth Image, Mouza map analysis

Results and Discussion

Temporal change of wetland connections with Main River: Phase-1(1855-56): The Kalindri River was showing complex scenario of channel shifting and change[36]. There is a long history of channel change of Kalindri river for attain the phase-1(1855-1856). Drainge Map of 1855 (Figure-2) based on Revenue displays curvature within river is relatively low. The Sinuosity of the river is also low as the sinuosity index value is 1.66.

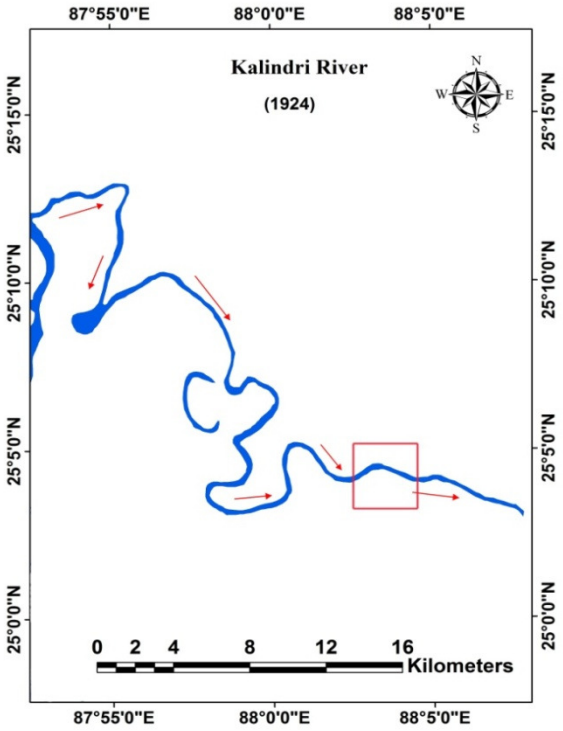
Phase-2(1924-25): In phase-2 near Pirpur Diara an oxbow lake completely detached from main channel. Suddenly the sinuosity of the river has decreased and energy of the active channel flow has risen. During that period the river Kalindri originated from the eastern branch of Ganga, almost 882m North East from Kamalpur (87052'38"E and 25011'33"N) Ratua. From source it was flowing towards South East and join with the river of Mahananda at Nimasarighat. During this time phase the course near Amrity was almost straight (Figure-3).

Phase-3(1955-56): In phase-3 sinuosity of river Kalindri was increasing with respect to its previous successive phases. Sinuosity of the river in this period recorded almost 2.41 which was little higher than previous two phases. So the initial stage of development of the oxbow lake had been started in this phase. There was a small curvature in Kalindri near Amrity (Figure-4).



Source: Revenue Survey Map

Figure-2
Drainage Evolution, Phase-1(1855)



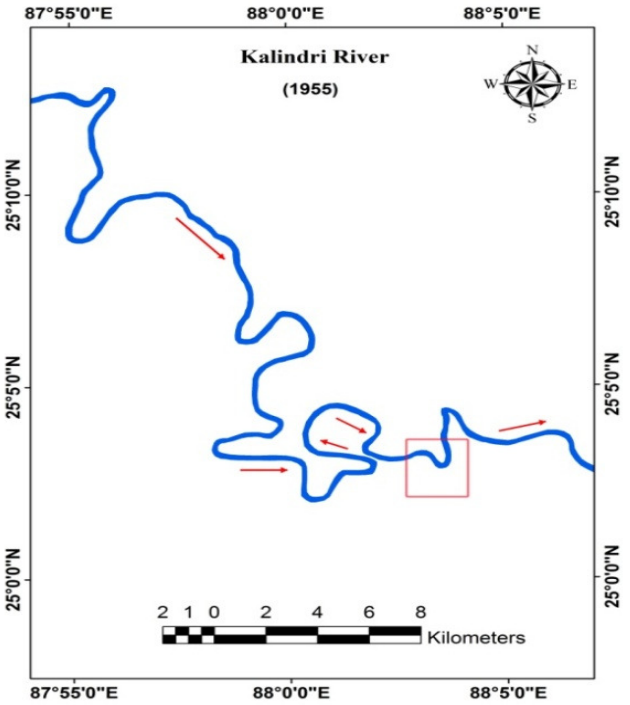
Source: Topo-sheet, Survey of India

Figure-3
Drainage Evolution, Phase-2(1924)

Phase-4(1967-68): Phase-4, within this period the bend of the river has cut separated from the main stream and rejected channel of the river forms an oxbow lake .When the water level of the Kalindri river raises up to entrance level, some amount of river water enter into lake which was basically happened during monsoon. But except monsoon season the lake unable to receive any volume of water from the Kalindri River. Existing monsoonal storage of water from the lake drained through the outlet.

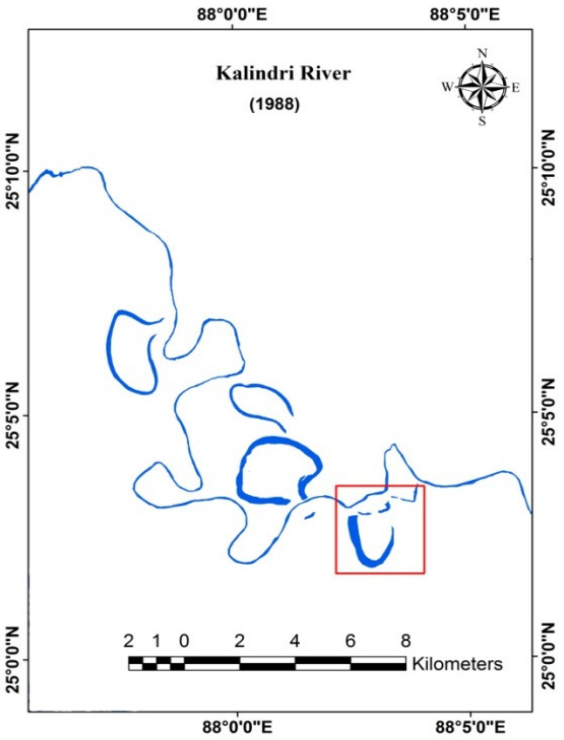
Phase-5(1988-89): Within Phase-5 the flow pattern was almost similar to previous phase. Land building activities has been going on within the interior parts of the lake. Depth and width of the lake decrease. The lake provides good opportunity for cultivation of fishes. After separation from the river the rejected portion of the river recognized oxbow lake and dry portion of the lake proves very fertile to the farmers. The good fertile lands of the lakes cultivated more than one per year in that period.

Phase-6(2014-15): Phase 5 shows that a large part of the oxbow lake has dried up and mouth of the inlet elevated due to deposition. As the river Kalindri remain dry throughout the year for deposition of sands at the source, so the river failed to achieve such elevation what needed to supply water to the lake. Wetted portion of the lake is decreasing day by day and the maximum portion of the lake remains dry for scarcity of water except rainy season.



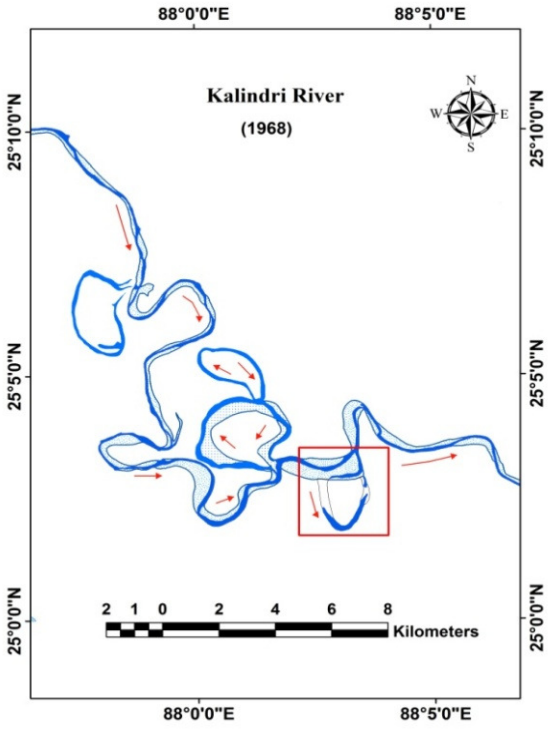
Source: U.S. Army Map

Figure-4
Drainage Evolution, Phase-3(1955)



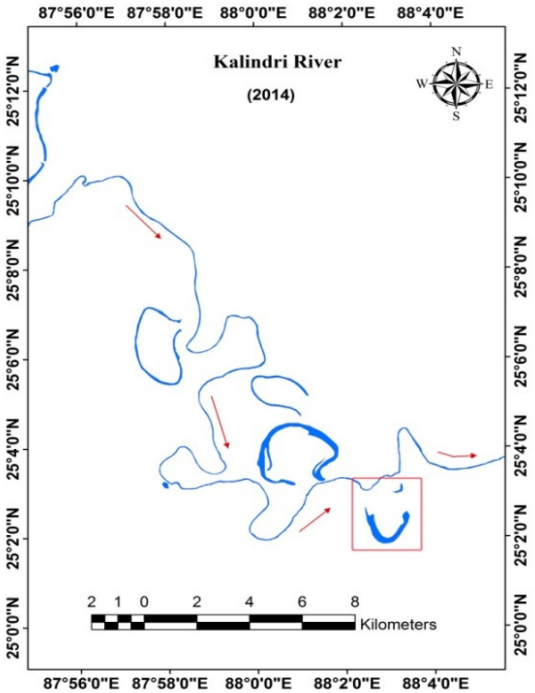
Source: Landsat Image

Figure-6
Drainage Evolution, Phase-5(1988)



Source: Topo-sheet, Survey of India

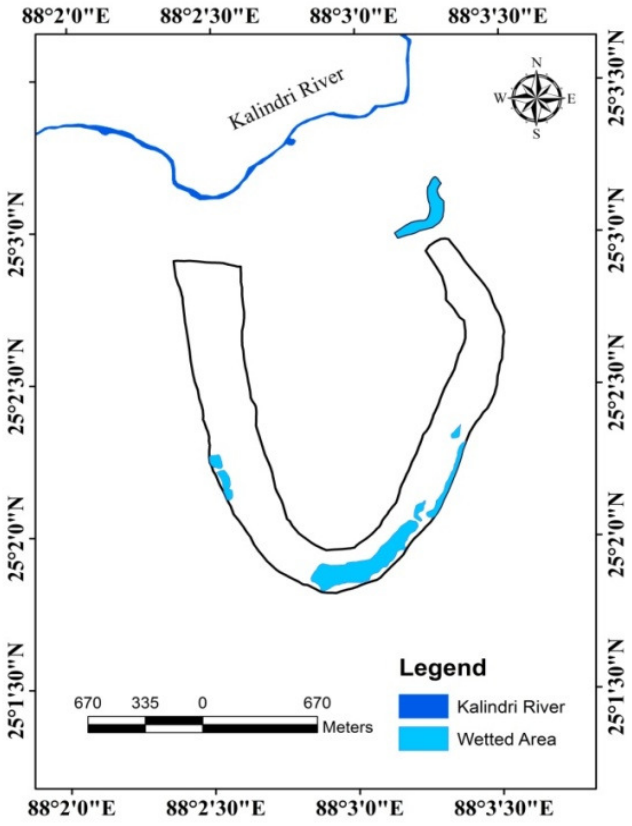
Figure-5
Drainage Evolution, Phase-4(1968)



Source: Landsat Image

Figure-7
Drainage Evolution, Phase-6(2014)

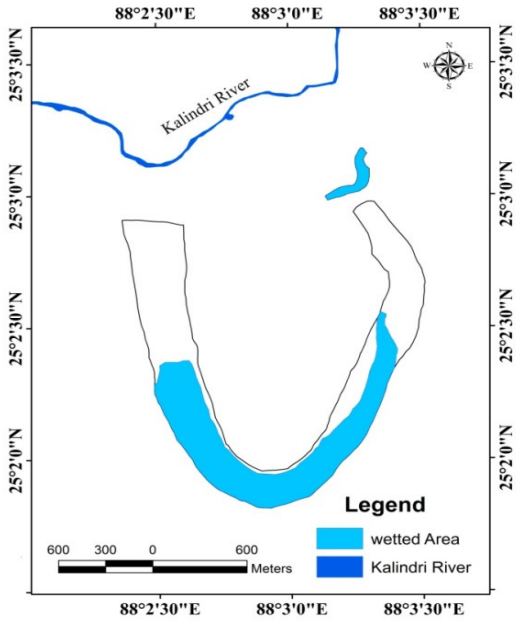
Seasonal hydrological regime: The oxbow lake of Kalindri situated near Amrity now disconnected from the main course of river Kalindri. The mouth of the inlet of the wet land has been blocked by deposition of sediment. So now there are no direct link between river and wet land. Loss of both inlet and out let the oxbow lake has transformed the flowing lake into stagnant wetland. The figure 8- 10 displays the seasonal hydrological characteristics of wetland. The water availability of the lake is decreasing day by day. Areal extent of the lake and depth of water have been reduced with respect to its previous evolutionary phases. Wet land of Kalindri near Amrity is a non perennial wetland placed at 19 meters over M.S.L. which grows to cover 54 hectares when it is flooded during the monsoons and shrinks to about 10.81 ha in the dry season. It encompasses an approximate area of 125.76 hectares. The depth of the lake varies from 1.5 to 2 meters; maximum depth of lake during monsoons is approximately 4 meters. Out of 10.81 hectares, water cover area, during pre-monsoon, 62% area of the wetland possesses less than 1 m. depth. The landscape of wetland is gently sloping towards North East. According to table-3 the potential water holding capacity of wet land is approximately 2030903cubic meter, where in monsoon only 248918.4 Cubic meter water volume of water is available.



Source: Google Earth Image and Field study, 2015

Figure- 8

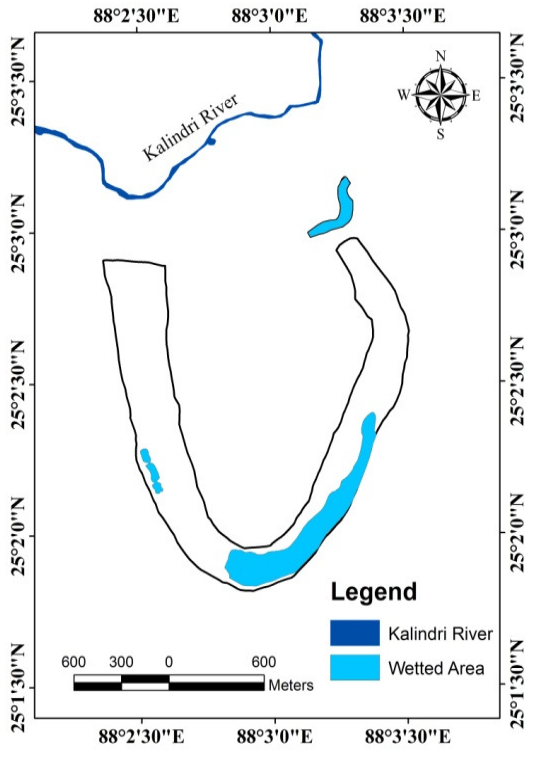
Water Covered Area, Pre –Monsoon, 2015



Source: Google Earth Image and Field study, 2015

Figure-9

Water Covered Area, Monsoon, 2015



Source: Google Earth Image and Field study, 2015

Figure-10

Water Covered Area, Post –Monsoon, 2015

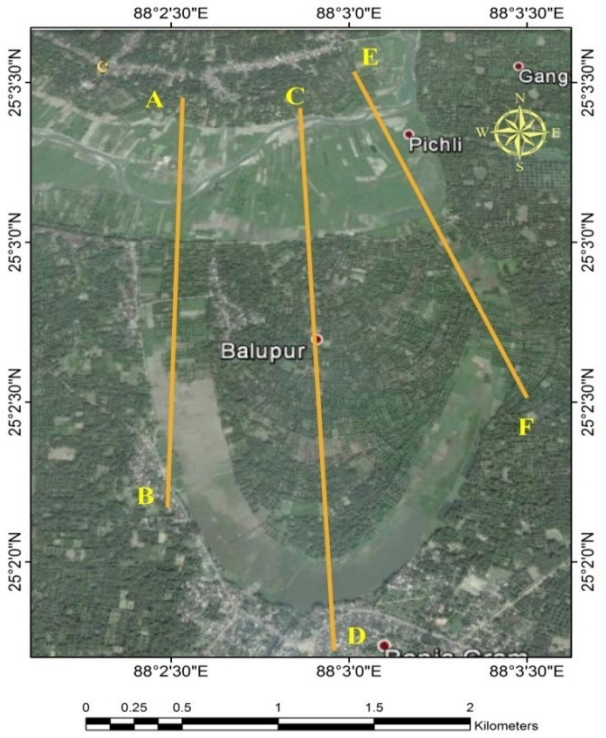
Table-3
Hydrological characters of the ox bow lake

Cross sectional area (Sq. m.) & depth	Water holding capacity	Hydrological regime	Actual water availability		Actual water availability	
			Monsoon		Pre monsoon	
Length=3100m	2030903 cubic meter	Permanent 0.60 m.	Cross sectional area (Sq. m.) & depth	248918.4 cubic meter	Length=731m	55292.84 cubic meter
Width=343m			Length=960 m		Width=122m	
Depth=1.91m			Width=201m		Depth=0.62m	
			Depth=1.29m			

Source: Field study, 2015 and 2016

Reason behind isolation: At present the Amrity wetland converted into a closed wetland as there is not any direct link between the river and lake. The only source of water is rain water. Carter[37] in his settlement report described the course of river Kalindri in the District of Malda as it is existed in 1935: "The Kalindri has always been connected with the Ganges by navigable Channel, down which the flood water of Ganges passes[37]. According to field study survey of India topo-sheet that Kalindri is a branch of river Phulhar. Lambroun[34] and Sengupta[35] also mentioned in their West Benga District Gazetteers, Malda in 1819 and 1969 that lower portion of river Phulhar was called as Kalindri. So it is clear that before 1969 the river Phulhar sends huge volume of water through the channel of Kalindri during rainy season. Shifting of Kalindri was a horrible problem to people living both banks of river. But at present four tributaries of Phulhar Kalkos, Kankor,

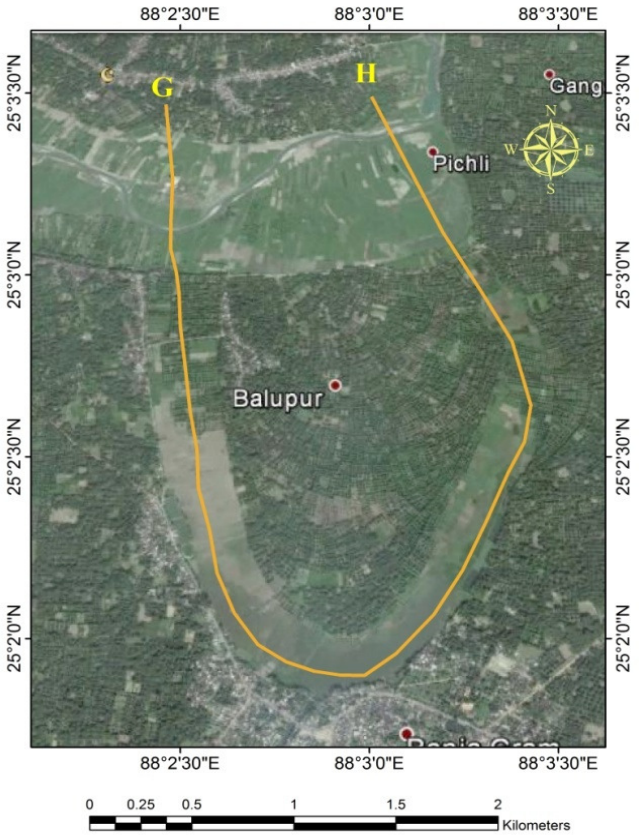
Kos and Baromaisa remain almost dry throughout the year and their contribution on discharge of Phulhar reduced highly as the level of water drops. During 1969 there are two link between River Kalindri and Phulhar, first one is situated at Debipur and second is located at Najirpur but at present the Kalindr river reject its upper portion from Debipur to Kalindri and prepare a new link to Phulhar some Kilometres downstream from its previous source. Figure-8 to 10 displays that the width of the oxbow lake is much greater than the actual river at present. But situation was quite different in 1968(Figure-5) as the width of the river and ox bow lake was almost same. So the greater width of the lake comparison to the width of Kalindri River indicates that the hydrological power of the present river is reduced. Now the mouth of Kalindri River blocked by sand deposit as a result supply of water from Phulhar to Kalindri reduced and the river remain dry except rainy season. Even rainy season after construction of Nurpur barrage over Kalindri the flow of water downstream of the barrage also reduced as the flow of water controlled by regulator at Nurpur barrage. So, it is clear that discharge of Kalindri reduced as a result Kalindri failed to provide over spilled water to the lake.



Source: Google Earth Image, 2016

Figure-11
Section lines for various cross profiles

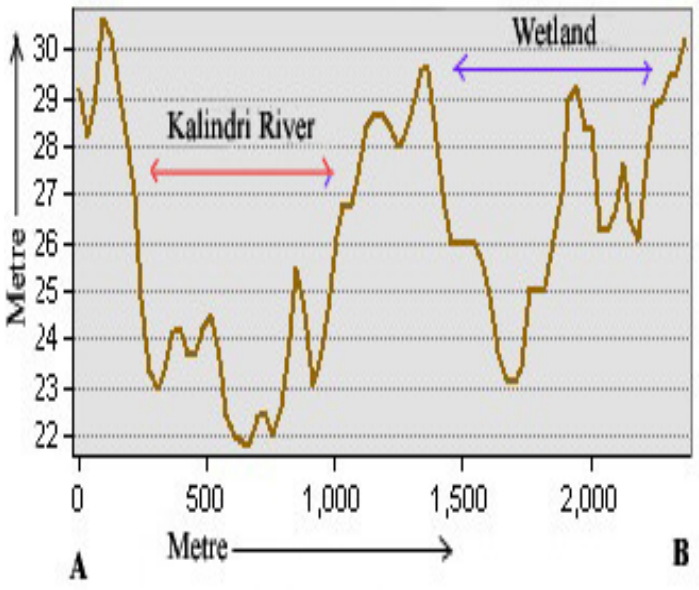
After rejection of the lake from the main river the mouth of the lake blocked by sediment, and at present the region between main channel and mouth of lake (almost 500m.) converted into mango orchards so the lake is isolate. Figure 11-15 displays various cross sections drawn along the various lines. According to Fig- 13 at the mouth of the lake (inlet) the height of the lake is quite high and acted as ridge between lake and river. Gradual deposition of the outlet of the ox bow lake is getting raised up and it is caused for resisting free water movement from lake to river (Figure-15).



Source: Google Earth Image, 2016

Figure-12

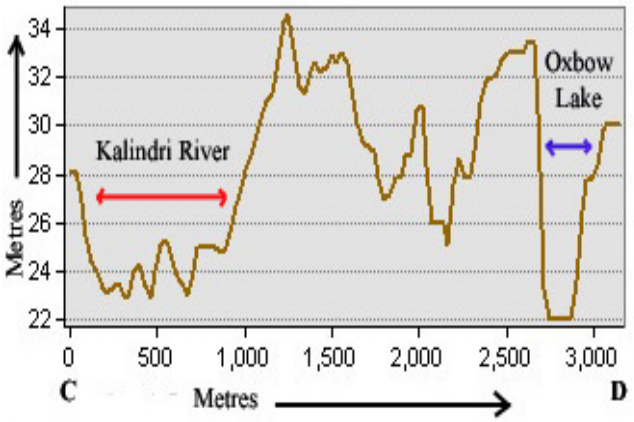
Section line for long profile



Source: SRTM, USGS

Figure 13

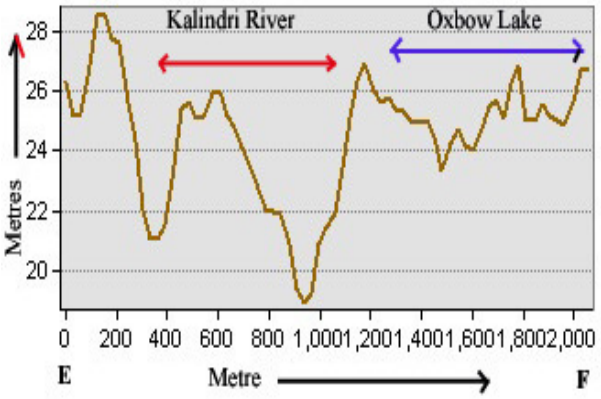
Cross Section along the line A-B



Source: SRTM, USGS

Figure-14

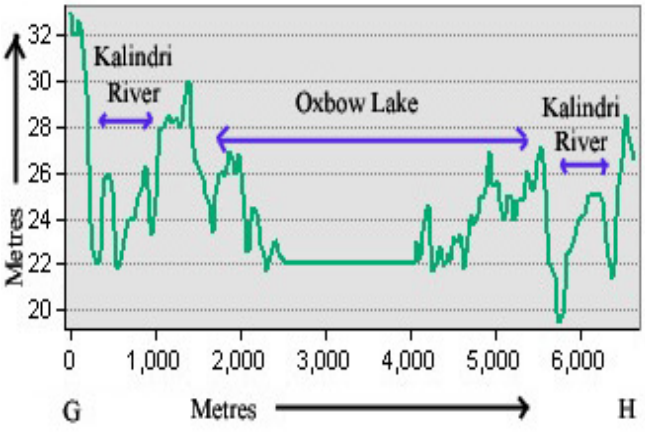
Cross Section along the line C-D



Source: SRTM, USGS

Figure-15

Cross Section along the line E-F



Source: SRTM, USGS

Figure-16

Long profile along the line G-H

Land use & land cover change after and before isolation of oxbow lake: The figure-17 to 19 displays the landuse land cover maps of various periods. With the journey of shifting of river course of Kalindri and evolution of oxbow of Kalindri some significant changes has introduced in the land use pattern to its surroundings. The land built by sediment deposition of Kalindri was very fertile and productive capacity of soil is also high but now most of the fertile portion of the lake have been gradually converting into mango orchards. During 1968-69 the maximum portion of the agricultural land of the lake was cultivated more than one (double/multi cropped) throughout year. Maximum portion of the lake was used for cultivation as almost 53.88% of the lake was under water during 1968-69. But during 2001 the maximum portion of the lake and it's surrounding region have been converted into mango orchards. Almost half of the double cropped/multi cropped lands transformed into single cropped land due to lack of flood water. Wetted portion of the lake has been reduced with respected to its previous phase. Conversion of the land into mango orchards does not bring any negative impact on economy because per hectare monetary return is excessively high in case of mango orchards.Table-4 represents the land use and land cover of Amrity oxbow lake and its surroundings.

Changing ecological characteristics: Wetland is logically called 'biological supermarket','biodiversity pool', 'kidney of biospheric system', 'granary of resources' form the interface between terrestrial and aquatic systems and perform a number of important functions of ecological importance and socio-economic relevance. The flora of the lake consists mainly of Water hyacinth (Eichhornia crassipes), which has spread over a large area of the lake. Plants inhabitating open water is both free floating, submerged and rooted in mud with floating leaves. Hincha (Enhydra fluctuans), Kalmi (Ipomoe aquatica), and Kachu (Colocasia esculenta) etc are observed at the water edges.

Fauna consists mainly of avifauna and the lake fauna consisting of several fish species reptiles and amphibians. The prominent avifauna that visit this lake are Dicrurus macrocercus, Alcedines, Little Acridotheres tristis etc. The water body consisted insects like Ranatra filiformis, Geris sphaerodema,; Crustacea consisting of Macrobradium dayamum, M. lamari lamari; and Fishes like Puntius sophore Chandanama etc. On the banks Reptilia Naja Naja and mammals such as Bandicota indica and Felis viverrina (Fishing cat) are commonly observed.

Livelihood options: Agriculture: The study area offered good quality fertile soil which is so suitable for grow of various types of crops. The 23.35% area of entire wetland had been used for mango orchad during 2015.Paddy is main product of oxbow and boro paddy is the major crop cultivated in the water spread area of the beel, where the process of cultivation starts at the end of November in every year. During summer season when wetland bed dries up, wetland cultivation is a common practice carried out by the farmers having land in wetland bed and/or in the low lying area. From the beginning of historical journey of the wetland to present agricultural yield had been decreased gradually. Paddy and jute are the major crops cultivated in the wetland bed. About 54% of our sample households cultivate wetland paddy and another 11% of our sample households cultivate jute in the wetland during monsoon. In post-monsoon main species for agriculture are pulses, paddy and vegetables. Monsoon has been mainly dominated by paddy cultivation. The lake provides irrigation water for agriculture; people extract water through man-made canal and electrical pump machine (paying money or crops for water to the lease owner). In present time shows multi crop practices. Farmers are farming various pulses; vegetables and paddy seedling for boro cultivation (Table-6). In present biological and chemical fertilizer is used for cultivation. It should also be mentioned that per hectare productivity has increased significantly at present. In general, expenditure for cultivation has increased disproportionately with profit. But, as this land itself possesses good level of fertility, water availability come from river or oxbow lakes, level of expenditure is to some extent less in this study area. Off record extension of agricultural land in the mango orchard area is a positive sign of agricultural development. Pulses cultivation has intensified and this cultivation intruded in most parts of mango orchards.

Table-4
Landuse land cover account of Amrity oxbow lake and its surroundings

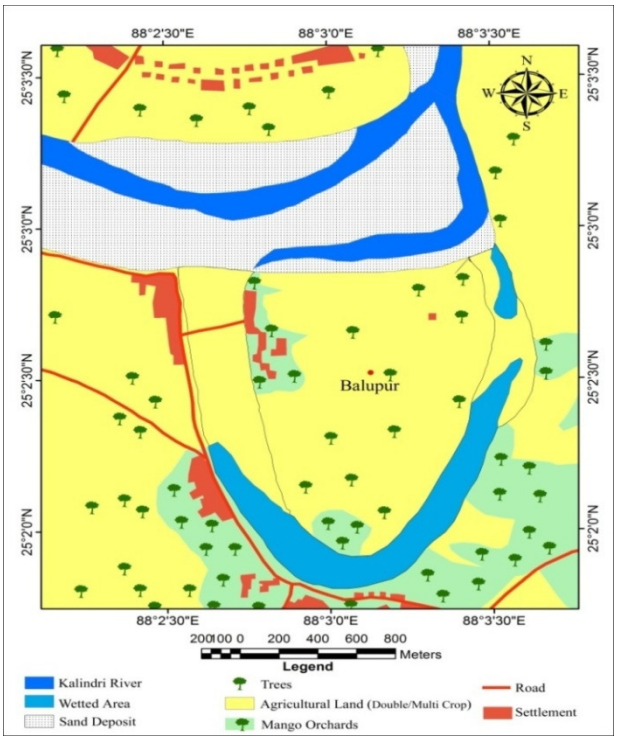
Land use pattern	1968		2001		2016	
	Area in hectares	% to total area	Area in hectares	% to total area	Area in hectares	% to total area
Water body	67.76	53.88	25.126	19.98	18.66	14.84
Agricultural land (Double/Multi crop)	52.78	41.97	45.02	35.80	34.5	27.43
Agricultural land(Single crop)	5.22	4.15	39.58	31.47	42.69	33.95
mango orchard			16.03	12.75	29.36	23.35
Settlement					0.55	0.44
Total	125.76	100.00	125.76	100.00	125.76	100.00

Table-5
Floral and Faunal Diversity

Floral Diversity		**Faunal Diversity**	
Common Name	Scientific Name	Name	Scientific Name
Bhringaraj	Wedelia Chinense	Black Drongos	Dicrurus macrocercus
Halencha	Alternanthera Philoxeroydes	Kingfisher	Alcedines
Kalmi	Ipomoea Aquatica	Mynah	Acridotheres tristis
Kuchuri Pana	Eichhornia Crassiper	Common Kingfisher	Alcedo atthis
Susni Sak	Marsilea Minuta	Little Cormorant	Phalacrocorax niger
Thankuni	Centella Asiatic	Black Kite	Milvus migrans
Kachu	Colocasia esculenta	Indian crow	Corvus splendens
Kulekhara	Hygrophilla	Woodpecker	Melanerpesm superciliaris
Hingcha	Enydra Fluctuans	Spotted dove	Spilopelia chinensis
Water Fern	Salvinia Cucullata	Red-vented bulbul	Pycnonotus cafer

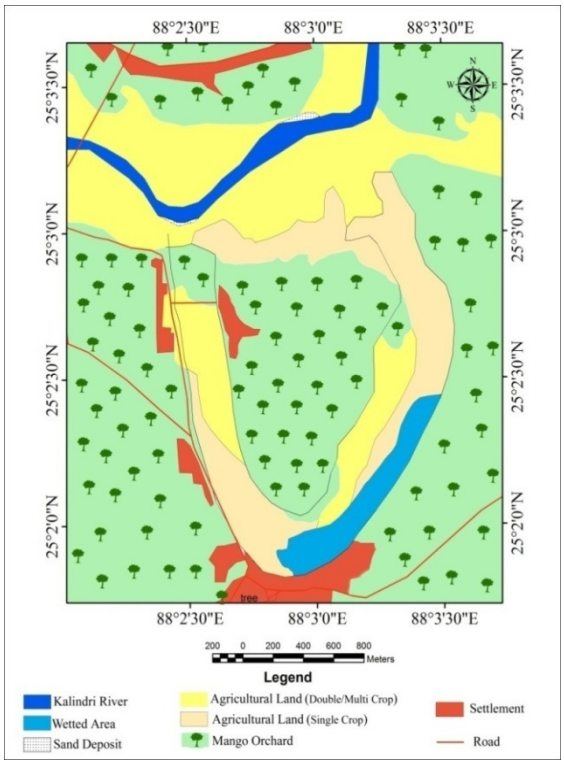
Table-6
Agricultural Diversification

Premonsoon, 2015			**Monsoon, 2015**		
Crop	Area in Hectares	% to total agricultural land	Crop	Area in hectares	% to total agricultural land
Paddy seed plot	5.4	7.00	Paddy	32.27	41.81
Mustard	20.06	25.99	Pulses	8.2	10.62
Pulses	5.4	7.00	Jute	9.56	12.39
cauliflower	17.06	22.10	Vegetables	15.16	19.64
Cabbage	5.4	7.00	Fallow	12	15.55
Cabbage	6.94	8.99			
Other vegetables	10.8	13.99			
Fallow	6.13	7.94			
Total	77.19	100.00		77.19	100.00



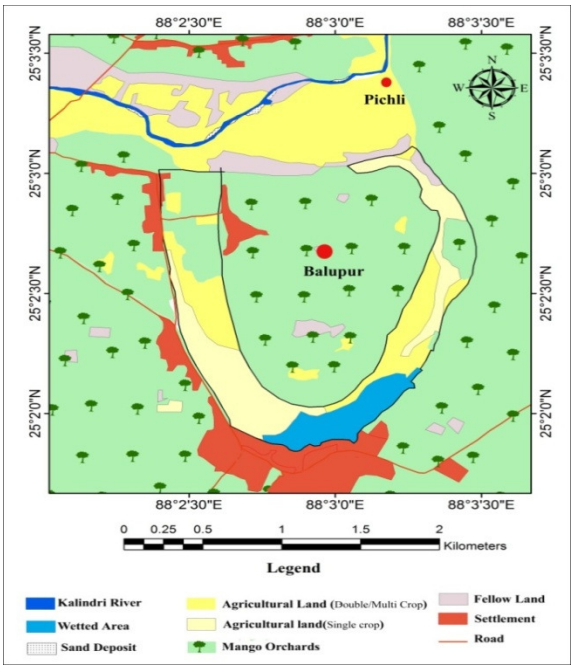
Source: Survey of India topo-sheet, 1968

Figure-17
Land use Map, 1969



Source: Land and land reform Dept., Govt of WB

Figure-18
Land use Map, 2001



Source: Google Earth Image, Mouza map analysis

Figure-19
Land use Map, 2016

Figure-20
Floral Diversity

Figure-21
Faunal Diversity

Table–7
Fish Diversity

Local name	Scientific name	Average Size (weight)	Status
Aeer	Mystus seenghala		Rare
Bata		150-200gm.	Available
Boal	Wallagonia attu	2-3 Kg.	Rare
Catfish	Clarius batrachus	100-250 gm.	Rare
Catla	Catla Catla	3-4 Kg.	Available
Chingri	Fenneropenaeus indicus		Available
Grass cup	Ctenopharyngodon idella	1- 2Kg.	Available
Lata	Ophicephalus stewartii	150-200 gm.	Available
Puti	Burbus phutunio	5-15 gm.	Available
Rui	Lebio Rohita	3-4 Kg.	Available
Shole	Ophicephalus striatus	1.5-3 Kg.	Rare
Silver Carp	Hypophthalmichthys molitrix	1.5-2.5 Kg.	Available
Tengra	Mystus cavasius	25-50 gm.	Rare

Fisheries: Previously owners used to lease out the wetland for fisheries operation for the period - June-July to October-November. Economic value of fisheries operation in the wetland is evaluated by considering management pattern - lease holders operated - when wetland owners lease out the wetland to private operators for an amount decided by open bidding process. The total area under wetland fisheries is 18 hectares. A large number of people surrounding the wetland collect small fishes and shellfishes from the wetland. The fishes cultivated in the wet land are Aeer, Bata, Boal etc. (Table-7).

Before -1970 a large number of fishes were coming with the over spilled flood water to the oxbow lake. But after loss of direct connection to the river now people have been used fish seeds purchased at market price. Before 1970 there was not any restriction for fish catching so many people benefitted by catching fishes but now the entire wetted area of ox bow was under the ownership of local government. Persons take lease of the wetted portion of the wet land for fish cultivation paying high amount of money for each and every year, so only one or two family directly benefitted from the wet land fish cultivation. During 1970 the total production of fishes was low according to human perception as the only source of fish was incoming fishes with flood water but now various kinds of manures, foods provided outside from the wetland (artificial by lease owners) helps production increase the production of fishes though the expenditure has been also increased.

Conclusion

Evolution of ox Bow Lake is very natural. But catastrophic transformation of it due to human interventions can curtail the volume of resources supply to the people. Of course, transformed form of ox bow lake has created some new livelihood opportunities where material opportunities is more common than services provided by them which is in fact immeasurable in monetary terms. Moreover, fast rate change of aquatic environment constricted the opportunities of surviving biodiversity. So, for greater interest apart from material return, process of transformation should be either stopped or slowed down.

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