Land Use Land Cover Changes: Its impact on the Wetland Ecosystem of Maguri Beel, Assam India

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ABSTRACT

Maguri *Beel* or wetland is one of the largest Floodplain Lakes in the upper Brahmaputra Basin with an area of 167.40 ha at FSL. This is an 'open' *beel* (FPL) connected with the R. Dibru and is affected by frequent channel change and sedimentation. The villages surrounding this beel are solely dependent on it for their domestic and agricultural use. About 80 species of fish species contributes to the fishery resources of that area. Similarly this beel harbors more than 160 species of local and migratory birds which is a major tourist attraction. Average net and gross primary productivity of phytoplankton was 937.5 and 1707.71 mgCm3day-1 respectively. About 35 macrophytes species have been identified whose average net and gross primary productivity was 3075.83 and 4429.82 mgCm3day-1 respectively. This weed-infested beel has a dense population of macro-benthos, the species diversity of which ranges between 1.81 and 3.63. The soil is acidic (pH 4.9 to 6.8) and prone to pollution from agricultural runoff. The pesticides from adjacent tea gardens sometimes cause havoc to the beel fishery. Remote Sensing data through time series have also been used to analyze the past and present status of the riparian area and to quantify land-cover changes due to natural and anthropogenic impacts. Assessment of socio-economics was also done as a part of formulation of conservation strategies and also for alternative livelihood option for the people depending on the bioresources of Maguri Beel.

INTRODUCTION

Wetland ecosystems, including rivers, lakes, marshes, rice fields, and coastal areas, provide many services that contribute to human well-being and poverty alleviation. Some groups of people, particularly those living near wetlands, are highly dependent on these services and are directly harmed by their degradation. Two of the most important wetland ecosystem services affecting human well-being involves fish supply and water availability. Inland fisheries are of particular importance in developing countries, and sometimes are the primary source of animal protein to which rural communities have access. Wetland-related fisheries also make important contributions to local and national economies. The degradation and loss of inland wetlands and species has been driven by infrastructure development (such as dams, dikes, and levees), land conversion, water withdrawals, pollution, overharvesting, and the introduction of invasive alien species. Global climate change and nutrient loading are projected to become increasingly important drivers in the next 50 years. Increased human use of fresh water has reduced the amount available to maintain the ecological character of many inland water systems (Anon, 2005). Humans are the major force of change around the globe, transforming land to provide food, shelter, and products for use. Land transformation affects many of the planet's physical, chemical, and biological systems and directly impacts the ability of the Earth to continue providing the goods and services upon which humans depend (Anon, 2002). According to Andrew (1990), settlement pressure, wetland reclamation and destruction of forests combined with high rates of population growth and rapidly dwindling reserves of land for development of new agricultural areas, are all typical problems are faced by many developing countries. The modifications and changes made by man on wetlands to cater to increasing agricultural and housing and developmental needs may not seem to be as prominent in the initial years. But the effects of these losses and modifications are cumulative and subtle. According to Williams (1991) and Ehrenfeld & Schneider (1991), drainage and other disturbances associated with agriculture are the main contributors to wetland loss and modification. Fog & Lampio (1982) emphasized that few of the world's major habitat type have suffered as drastically from man's abuses of the environment as wetlands.

Another paradoxical view is that "Nature destroys nature more than humans". If we base our present study on this, probably this could be validated well in the Maguri wetland complex. Natural changes have impacted much on the landuse-landcover, habitat alterations-both faunal and human, and livelihood pattern of the local residents. One particular effect of natural events which occur regularly on the Brahmaputra basin is the frequent change in river course, avulsion and excessive erosion and aggradations. This study is an effort to quantify the various changes happening on a particular wetland system of the upper Brahmaputra basin and the cumulative impact on the bioresources and humans and the changing trend of dependency on the wetland.

MATERIALS & METHODS

The present work accounts the hydrobiological investigation and socio-economic analysis carried out in Maguri wetland system.

DESCRIPTION OF STUDY AREA

The Upper Brahmaputra Valley has 15,196.0 ha area of wetland which is 15.01%

of the total 1,01,231.60 ha areas of wetlands in Assam. Out of this, Tinsukia district has 74 contributing 2732.50 ha water spread area. The wetland ecosystem of Maguri is situated between 27°33/795// to 27°34/357// N and 95°22/081// to E 95°22/190//E in the upper Brahmaputra basin within Tinsukia district and adjacent to the Dibru-Saikhowa National Park (Fig 1). It is an 'open' *beel* or wetland which is connected to the river Dibru and in fact, the river actually flows through the wetland. The length and width of Maguri is 1.85-2.8 m and 0.64-0.8 respectively. Maguri also covers an area of c167.40 ha at Full Storage Level (FSL) and c117.18 ha at Dead Storage Level (DSL). The marginal area of Maguri wetland was recorded around 50.22 ha. The depth of Maguri ranged between 0.95 - 4.3 m in different seasons.

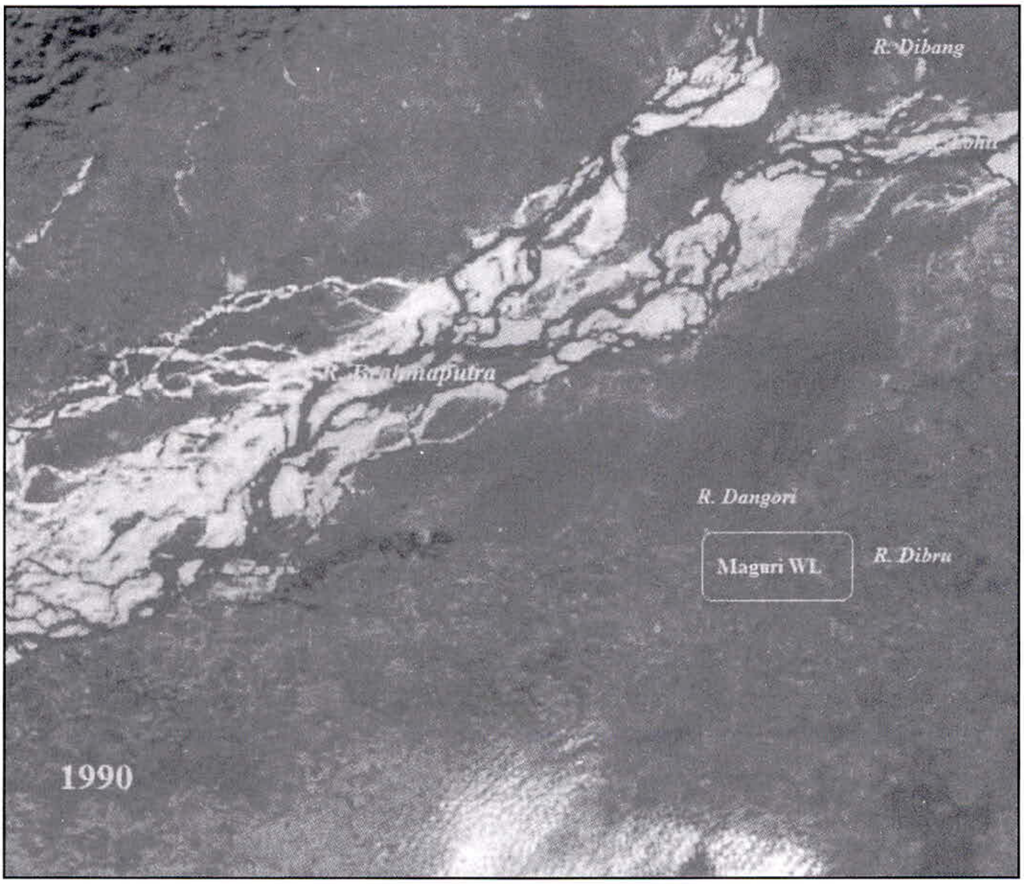

Fig. 1(a) : Satelite image of the maguniwetland complex in 1990

HYDROBIOLOGICAL DATA

The assessment of the physico-chemical parameters of water was carried out by following the methodologies given by Welch (1952) and APHA (1991). The collected flora and fauna including planktons, macrobenthos and fish were identified by following the descriptions of Pennak (1978), Subba Rao (1989), Ward (1992), Jhingran (1991), Menon (1974), Jayaram (1981), Datta Munshi and Srivastava (1988) and Talwar and Jhingran (1991). Productivity values were calculated following Sreenivasan (1967).

SOCIO-ECONOMIC SURVEY

The present socio-economic section of this paper is the outcome of a study conducted on eight villages in and around Maguri wetland between 2004-06. This study is based on primary data supplemented by secondary data from various government and non-government publications.

Remote-sensing data: LULC

To study LULC change, remote-sensing applications were used. IRS satellite data was acquired for 1990, 1997 and 2002. The 1990 data was acquired in four spectral bands (0.45-0.52 μm 0.52-0.59 μm, 0.62-0.68 μm, and 0.77-0.86 μm) and had a ground resolution of 78 metres. The later images were acquired in 4-bands (0.52-0.59, 0.62-0.68, 0.77-0.86, and 1.55-1.70 μm) and had a ground resolution of 23.5 metres. Image analysis took place in ENVI version 4.1. Georeferenced scenes representing the Maguri wetland complex was taken and for convenience an area of 1404 sq. km was taken covering the study area with its adjoining villages to study the LULC. Plotting of GCPs to exact location was a constraint as the river shifted a few points almost every year. However, the IRS images (of the years 1990, 1997, and 2002) of the study area (Fig 1a&b) were georeferenced with reference to available map of the Brahmaputra basin and by plotting GCP's at constant points on the images. Geo-rectification was then undertaken with a RMS value of 1. A fixed ROI (Region of Interest) was plotted on all the three images so that a constant region was available for proper classification. Unsupervised classification of each image into 15 classes was undertaken with these subsequently grouped into river, wetland, vegetation and sandbars for a tier 1 level of analysis (Table 1). Each image was subjected to the same process of ENVI's K-Means unsupervised classification. ENVI's accuracy assessment was then applied to the data.

RESULTS AND DISCUSSION

In the mejuni wetland, the pH of soil was acidic in nature and the value ranged from 4.86 to 6.79. In general, an increasing trend was observed in soil pH from acidic to near neutral from post monsoon to monsoon. The air temperature ranged between 17.7 to 36.4o C, the highest temperature recorded during monsoon was 34.3 to 36.9o

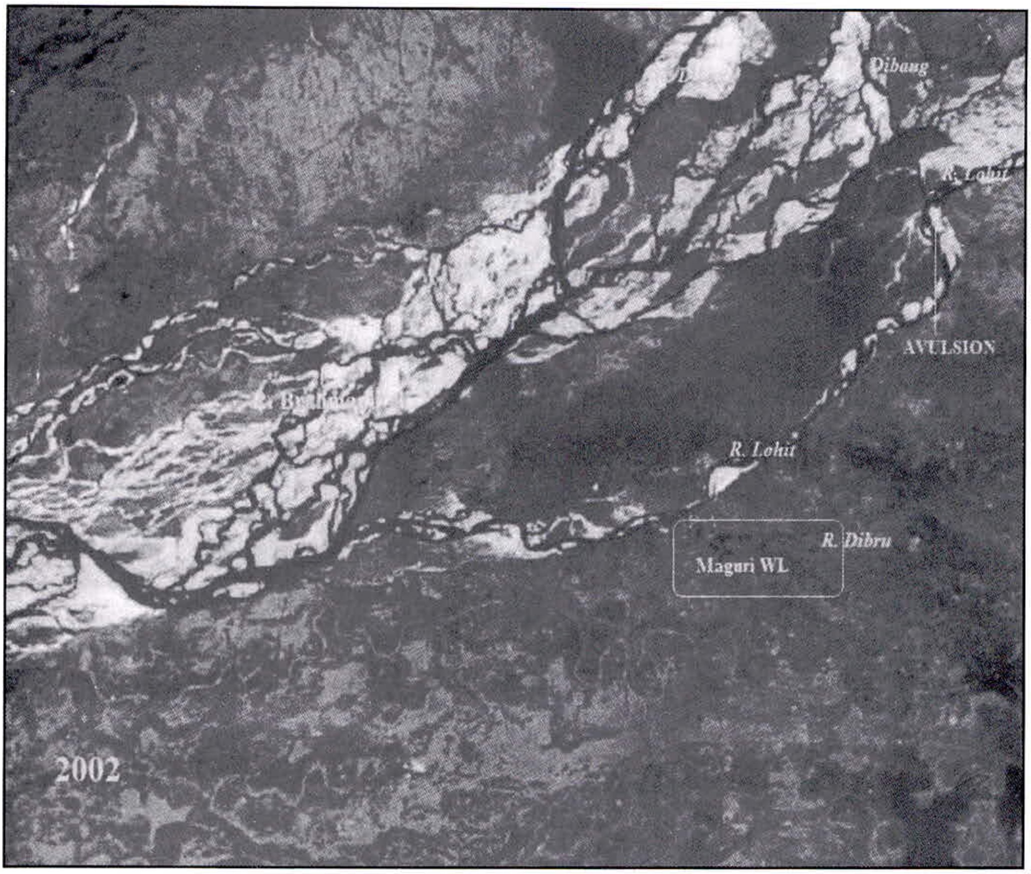

Fig. 1 L (a & b): Satellite images of the Maguri wetland complex in 2002

while the lowest values 19.3o to 22.2o C of water temperature were recorded during winter. pH value ranged from 5.71 to 7.5. In general, lesser values were recorded during monsoon season while high values were recorded during post monsoon months. Considerable variations in dissolved oxygen in the waters of Maguri was noted during the period of study and ranged between 4.58 mg/l and 7.79mg/l respectively. The value fluctuated from 4.75 mg/l to 16.15 mg/l. Spatio-temporal variation of total alkalinity ranged from 31.35 to 98.8 mg/l respectively. Spatio temporal variation of conductivity ranged from 0.04-0.54 ìmhos/cm. In general, winter months showed an increase in electrical conductivity. Spatio-temporal variation indicated higher organic carbon content in Maguri and ranged from 0.65 to 2.91%/. Season wise value of Organic Carbon indicated higher values during post monsoon and winter season. Available nitrogen value ranged from 15.40 to 32.48-mg/100 gm. Further, higher values were noted during winter whereas lesser values were noted during monsoon season. Available phosphorus values ranged from 0.496 to 3.008 mg/l00gm in Maguri. Season-wise mean showed higher values during post monsoon to winter and lower values during monsoon season respectively.

Table 1: LULC classes in the satelite imagery from 1990 through 2002 of Maguri Wetland Complex of Upper Brahmaputra basin.

		1990		1997		2002	
Class	Sub class	Percent	Area (Sq. Km)	Percent	Area (Sq. Km)	Percent	Area (Sq. Km)
River	River:Deep	0.7	9.2	3.2	44.6	2.11	29.6
	River:Medium	2.3	32.3	0.3	3.6	0.95	13.3
	RiverConfluence	0.7	10.1	1.3	18.1	1.54	21.6
	River:Tributary	3.9	54.9	2.8	39.0	4.42	62.1
	River: Residential dolphin site	1.5	20.6	2.3	32.6	0.62	8.7
Wetland	Wetland:Deep	0.3	4.0	0.1	0.9	0.48	6.8
	Wetland: Shallow	0.3	4.9	0.7	10.0	0.59	8.2
	Wetland: Aquatic veg	17.4	243.9	12.0	168.2	1.00	14.0
Vegetation	Vegetation: Dense	18.3	257.4	1.7	24.0	2.74	38.4
	Vegetation: Medium	6.8	95.8	17.2	241.4	26.79	376.3
	Vegetation: Low	2.2	30.9	13.1	183.5	19.39	272.4
	Vegetation: Grassland	25.4	357.3	20.3	285.3	16.34	229.4
	Vegetation: Rough-pasture/soil	7.1	99.8	12.4	174.0	7.74	108.7
Sand bars	Sandbars: Exposed	9.9	138.9	11.0	154.5	12.37	173.8
	Sandbars: Submerged	3.1	43.8	1.8	24.7	2.93	41.2
Total		100	1404	100	1404	100	1405

Wide fluctuations in primary productivity was noticed in Maguri wetland and NPP, GPP and CR due to phytoplankton varied from 235 to 1890 mgCm-3day-1 (mean: 937.50), 825 to 2770 mgCm-3day-1 (mean: 1707.71) and 295 to 1365 mgCm-3day-1 (mean:737.50). NPP and GPP registered a peak, during winter. The NPP, GPP and CR due to macrophytes varied from 1645 to 4608.33 mgCm-3day-1 (mean: 3075.83), 2210.13 to 6522.08 mgCm-3day-1 (mean: 4429.82) and 1155 to 3068.75 mgCm-3day-1 (mean:2146.12) respectively. Spatially NPP, GPP and CR registered peaks during post monsoon. Also, energy fixed by phytoplankton during NPP, GPP and CR ranged from 5941.10 to 18559.80 Cal m-2 day-1 (mean: 9206.25), 8985.30 to 27201.40 Cal m-2 day-1 (mean: 16763.05), 2896.90 to 13404.30 Cal m-2 day-1 (mean: 7328.18) respectively. Energy fixed by macrophytes during NPP, GPP and CR ranged from 16153.90 to 45253.833 (mean: 30204.68), 21704.49 to 64046.860 (mean: 43506.99) and 11342.10 to 30135.125 Cal m-2 day-1 (mean: 20915.52) respectively. Energy fixed during NPP, GPP and CR registered two peaks during post monsoon'04 and winter'05. Spatial variation in the energy fixed during NPP, GPP and CR registered a peak during post monsoon season.

Among the fish fauna, 80 species have been recorded from the Maguri wetland complex of which 38 species were frequently available, 29 were occasional and 13 were rare. Macrobenthos population in the studied wetlands mainly comprised of Gastropoda, Pelecypoda, Oligochaeta and Insecta (Diptera). The standing crop ranged from 146 to 500 Nos.m-2 in Maguri. The population showed a sudden drop in monsoon months and then attained a peak during post monsoon to winter uring the study period. The value of Sanon-Weaver Index (H/) of species diversity for macrobenthos ranged from 1.8066 to 3.6314. During the period of study the indices remained well within 3 and generally monsoon and winter exhibited higher values in all stations.

According to Keddy (2000), Mitsch and Gosselink (1993), the capacity of a particular wetland for performing a specific function is dependent on:- wetland characteristics (e.g. size, morphometry); adjoining environment; watershed characteristics; position of wetland in the watershed; and greater landscape condition. Specifically, the flood control function of wetlands is most directly predicted by hydro-geomorphic class, which reflects geomorphic and hydrologic setting. Bio-geochemical and other wetland functions change along environmental gradients. Shallow riverine wetlands, and to some extent depressional outflow wetlands, do not reduce peak flows to the extent of depressional closed wetlands of the same size, in which the dominant hydrodynamics include the capture and vertical fluctuation of water level. This has been represented well in the Maguri FPL as it is an 'open' beel being connected to the river throughout the year. The fluctuation in depth varies between 0-3mts during the different seasons.

The effect of widening of the Brahmaputra channel has been observed in 1915, 1966 and 1996. The most remarkable change of the river Brahmaputra river channel pattern, which has started since 1996, is the bifurcation of the flow of the Lohit river after taking the river Dibang in the west of Saikhowa Ghat joining the Brahmaputra at the mouth of Dibru river near Balijan. There was a small tributary of the Dibru in Saikhowa reserve forest. It has joined the Dibru River near Guijan. The Dibru met the Brahmaputra at Larukharia Gaon. In the year 1996, a part of the flow of the Lohit overtopped its bank and made its way through the Dangori River to the Dibru River to meet the Brahmaputra near Balijan. As a result the Dibru Saikhowa reserve forest has been converted to a major river island comprising an area of about 322 sq km, surrounded from all sides by the channels of the Brahmaputra and the Lohit rivers. The length of this island is 42 km and its maximum width is 11.25 km. the channel of the Dibru which was only about 25-30 m wide in 1995 had widened to an extent of more than 1.5 km by 2002. Thus the second major river island, similar to the famous Majuli Island, had been formed in the eastern of Assam due to change in river channel. The mouth of the river Dibru was near Dibrugarh town in1925, it had advanced progressively upstream by 19 km to Larukharia till 1965 and then further by 11 km to Balijan till 1996. Danger due to erosion is widening of river channel in the undivided Dibrugarh district. The following inevitable hazards can be foreseen because of erosion and channel change of the rivers of the area. Continuous erosion is happening due to the increase in width of the new channel of the river Dangori and quantity of the water of both Dihang and Lohit. This has resulted in large-scale flooding, bank erosion and destruction of agriculture and forest land due to deposition of sand. There is a serious threat to the Dibru Saikhowa reserve forest famous for many rare species of flora and wild animals including the feral horse, which is unique in India.

Also the probable conversion of the flow of the river Lohit and the river Dibru near Balijan TE into an ancient river channel, presently separated by less than half a kilometer.

IRS datasets of 1990, 1997 and 2002 have been analyzed through remote-sensing applications to study the changes taken place in and around the Maguri wetland complex and the results are depicted in Table 1. The study reveals that there has been a progressive increase in deeper waters (about 2.2% or 30 sq. km of area) in the river from 1990 to 2002. Also there has been an increase in medium and low vegetation upto 2.9 % and 7.8% respectively making it a combined 550 sq km increase. This suggests that erosion and deposition must have contributed to the change in land cover as shown by the satellite images and thereby converted forested land to lower vegetation areas (Fig. 2). Since the last few years, a continuous changing trend in agricultural practices by the human settlements has been also been observed near the Maguri wetland. These changes in land use pattern have been validated by primary study of the villages in and around Maguri wetland complex.

SOCIO-ECONOMICS OF THE SURVEYED VILLAGES

There are in total 23 districts in Assam according to 2001 census. The Maguri Wetland Complex is in the district of Tinsukia. The district consists of 7 blocks, 3 subdivisions, 88 gaon panchayats and 1146 inhabited villages. Data on socio economic characteristics and the demographic pattern of the eight villages surrounding the beel has been given in Table 2 a&b.

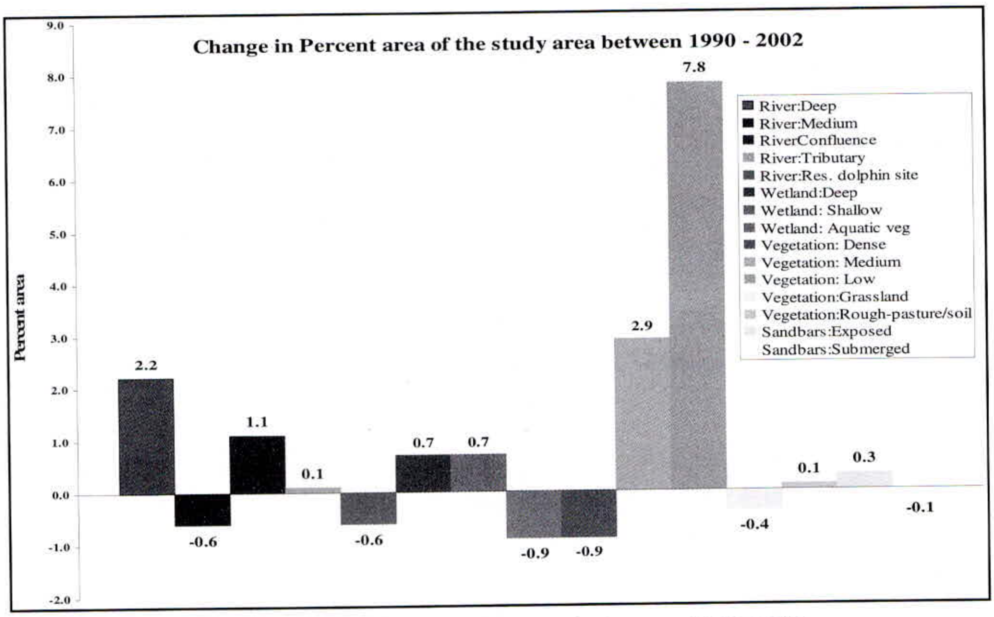

Fig. 2: Percent change in area between 1990-2002

The surrounding villages are inhabited mostly by people belonging to the Assamese community (84.64%) while the rest are people belonging to tea tribe community (15.36%). Assamese is spoken by majority of the people (84.64%), while the rest of the population (13.3 number per family) is about 6 and the sex ratio (M:F) is close to 1:1 except in Baghjan and Kaisa where males were outnumbered by their female counterparts. The data represented in Table 2 & 3 is an averaged figure taken during the study.

It is noteworthy that due to erosion and flood the villagers and the location of their villages often change. The vulnerability of these villages has been intensified by the frequently changing river course which is affecting their livelihood and property. Flooding and subsequent erosion is a regular event in the Brahmaputra basin which impacts on agriculture, live-stocks, land, and property and brings untold miseries to the people at

Table 2: Distribution of Village population and sex-ratio

Village/Sex	Baghjan	Hatipathi	Kaisa	Borguri	Motapung	Dhelakhat	Natungoan	Milanpur
Male	421	197	403	433	361	237	256	333
Female	476	186	509	410	356	228	255	309
Total	897	383	912	843	617	642	511	642

Table 3: Village wise distribution of households

Village	Baghjan	Hatipathi	Kaisa	Borguri	Motapung	Dholaghat	Natungoan	Milanpur
Household	115	76	152	166	89	107	81	107
Population	897	383	912	843	617	642	511	642
Family size	7.8	5.04	6.0	5.08	6.93	6.0	6.31	6.0

large. The major flood events that had occurred in the state were in 1954, 1962, 1966, 1972, 1977, 1984, 1988, 2002 and 2004. Floods of less magnitude occur almost every year. Maguri Wetland Complex is important in this context that regular flooding changes the area and demographic pattern of the surrounding villages. The villages are therefore time and again in the process of submergence and re-emergence, either wholly or partially. During the recent field visit (2008), nine villages were found where a part of old Motapung village had re-emerged into Na Motapung ('Na' meaning 'new').

It is significant that since year 2004 there has been no high flood event in and around Maguri wetland Complex. The annual flood event that had occurred during 2007-

08 rather made the soil fertile with moderate level of silt deposition. As such, the land which was abandoned earlier by the inhabitants due to heavy sand depositions caused by the high floods of earlier years, especially 2002 and 2004, was again reclaimed to a certain extent. This is evidenced by the moderate growth of vegetables in Na Motapung village adjacent to Maguri Beel.

Table 4: Occupation pattern of three villages

Name of villages	Natungaon	Milanpur	Motapung
a. Fishing	47.6	39	49.5
b. Daily labour	23.8	26.7	5.4
c. Agriculture	17.9	13	23.5
d. Business	7.2	10.1	12.2
e. Others	3.5	11.2	9.4

The primary occupation of the villagers was found to be fishing (Table 4) followed by daily labour in case of Natungaon and Milanpur; and agriculture in the case of Motapung village. A destructive consequence of land use changes brought about by flood and erosion is the change in occupation pattern of the villages as stated in Table 4. Since the cultivable land had been converted to fallow land, the inhabitants have shifted to alternative sources of livelihood mostly in the form of fishing in the wetland, poaching, felling of trees, logging and other illegal activities thereby increasing pressure on the wetland and nearby forest. The villagers being mostly illiterate, has no other option but to look for their livelihood in an around the wetland complex. Table 4 revealed that fishing has become a major alternative source of livelihood of the villagers. Increase in population also has resulted in over fishing which is very harmful for the wetland ecosystem. Also the inhabitants are primarily dependent on fishing which has led to competition and over-exploitation of fish resources. Also most of the fishing methods used by the people are improper. This is largely because they are not aware of most of the fishing laws and modern fishing methods. Some of the nets used have very small mesh size like mosquito nets. This net is very harmful to fish fauna as due to its small-mesh sie, young fishes as well as fish eggs and larvae also get entangled in it. It was also found during the study period that fishes are also caught in this area by poisoning. This type of fishing methods can, not only destroy the fishes but also the entire ecosystem. The Maguri beel is also surrounded by a tea garden on one side (Dholaghat Tea Estate). The tea gardens extensively use pesticides and other chemicals, which drain into the beel during rains. These types of chemicals which are being added to the beel are not only dangerous to the icthyofauna but also to the whole food chain and ultimately to human beings.

The study revealed that 10.1% of the villagers especially young has opted for culture based fishery and 30.5% of the sample respondents desired for government assistance/intervention for changing their plight. The sample villagers suggested that prevention of poisoning, small meshed net and adoption of culture based fishery can save the ichthyofauna of the wetland complex. An interview with 139 fishermen of the three villages confirmed the fact that depletion in the number/quantity of fishes in the Maguri wetland can be attributed to vigorous and indiscriminate fishing, siltation along with other related factors. With the decrease in catch, their livelihood is now endangered which has compelled them to look for secondary sources to supplement their income. Most of the people from poor class work as daily laborers in timber trade and in nearby Guijan and Tinsukia towns. Also a small section of the society is engaged in poultry farming while most of the people keep poultry for their own utilization.

At present the wetland is in such a state that native fishes alone cannot withstand the fishing pressure due to collapse in native fish stock. Integrity of aquatic communities and ecosystems should be conserved by appropriate management techniques. In particular, efforts should be made to minimize the harmful effects of over-fishing in these waters. In this regard, the carrying capacity of aquatic environments should be well studied in order to eliminate the adverse effect on native fish fauna. The problem needs to be addressed with a view to find a long term solution in terms of sustainable income generation and conservation of the ecosystem symbiotically.

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