FISH DIVERSITY, HABITAT PARAMETERS AND FISH HEALTH IN WETLANDS AND RIVERS OF NORTH-EAST INDIA

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Introduction

Although the name is `standing water', actually, the water in such bodies is in motion in different ways. Hence, `standing water' does not necessarily mean `static'. It simply means that water does not flow (Kar, 1998).

Until recently, many naturalists including biologists, thought the lakes to be much the same wherever they occur because similarities are often found among different lakes with regard to water colour, taste, hardness and aquatic biota. Although a partial survival of this idea is still prevalent among many laymen, with the advent of limnology, it has been established that, lakes as a class, manifest a most amazing physical, chemical and biological diversity (Kar, 1990). Further, as a partial indication of lake diversity, it could well be stated that lakes are large, medium or small; deep or shallow; protected or unprotected; with or without tributaries; and, outlets; fresh, brackish or salt; acidic, neutral or alkaline; hard, medium or soft; turbid or clear; surrounded by bogs, swamps, forest or open shore; high or low in dissolved content; with or without stagnant zones; with marl, muck, sand or clay bottoms; with or without vegetation beds; with high, medium or low biological productivity; young, mature or senescent; and, so on. However, there could exist many imaginable intergrades within the various groups of characters mentioned above. The remarkable lake diversity is the effect of multitudinous combinations of many of these characteristics mentioned above (Kar, 2007).

Sometimes, the fishes are attacked by diseases like Epizootic Ulcerative Syndrome (EUS) (Kar and Dey, 1990 a, b; Kar et al, 1995).

`Wetlands', are, thus, basically `wet- lands' where the soil is saturated with water for sometime during the year. According to IUCN (1970), wetlands are areas of marsh, fen, etc., temporary of permanent; natural or artificial mass of water, the depth of which generally does not exceed 6 m. Wetlands are areas which contain substantial amount of standing water and little flow.
Classification of wetlands in Assam

Wetlands occur throughout the world in all climatic zones and are estimated to cover c. 6 % of the earth’s surface. The simplest classification of wetlands has been provided by IUCN’s Ramsar Convention, which is briefly listed below:

a) Freshwater lakes/wetlands  
b) Oxbow lakes/wetlands  
c) FW ponds  
d) Marshes, swamps, bogs  
e) Reservoirs

In the tropics, notably in India, particularly in Assam and adjoining places, like Bangladesh, etc., wetlands are generally shallow depressions which could normally be in the form of a basin at the centre of hillocks on all sides; or, could be abandoned segment of a river (oxbow wetland); or, a shallow portion of a river course which is detached from the main river course during the dry season. Sometimes, wetlands in NE India, are formed due to tectonic activities (Kar et al. 1996).

In Assam, and in adjoining Tripura and Bangladesh, 3 kinds of wetlands are generally found. They are locally called as follows (Kar, 2007):

(a) ‘Beel’  
Perennial wetlands which contain water throughout the year.

(b) ‘Haor’  
Seasonal wetlands which contain water for some period of the year only, particularly, during the rainy season. As such, they are also called ‘floodplain wetlands’.

(c) ‘Anua’  
These are peculiar river-formed perennial oxbow-type wetlands which are generally formed due to change in river course and which may or may not retain connection with the original river.

Wetlands in North-East India
The North-Eastern (NE) region of India (Fig 1), a typically difficult topography with undulating terrains, however, provides enough potential for fish production which can supplement food requirement for the region and could provide answer to diminishing protein supply.

Situated between 89-97° N Longitude and 20-30° E Latitude, the region encompasses a vast area of 2,55,083 sq km out of total Indian area of 3.3 million sq km. Comprising of eight provinces, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim; and, bordered by Tibet, Bhutan and China on the North; Myanmar in the East and Bangladesh on the West, the region occupies a strategic position both nationally and globally. The lofty Himalayas proudly stand as sentinels to guard the northern and eastern frontiers. The Chittagong Hill tracts form a crescent on the south. The region’s western mountains suddenly rise from the valleys in Bangladesh, leaving only a narrow strip which opens out to the Indian mainland (Kar, 2007).

**Wetlands in Assam**

Besides lotic territories, the lentic water bodies having $0.72 \times 10^6$ ha lake coverage in India, constitute great potential of fishery resources. NE region in general and Assam in particular, is blessed with a number of lentic systems, locally called 'Beel, Haor, Anua, Hola, Doloni, Jalah, etc., which alone constitute c 81% of the total lentic area ($0.12 \times 10^6$ ha) in Assam. These lentic systems are generally shallow and open, ranging in size from 35 to 3458.12 ha and with depth ranging from 0.25 to 3.0 m (in some, however, the maximum depth may exceed 6.0 m) at LSL. Further, in Assam, there are $c\ 1392$ number of wetlands having a total of $c\ 22,896$ number of fisheries of different categories; out of which, the number of registered wetlands is only 394 (30.38 %) covering an area of $c\ 70,000$ ha; of which, $c\ 19,000$ ha is in good condition; $c\ 15,000$ ha is in semi-derelict condition and $c\ 35,000$ ha is in derelict condition (Govt. of Assam, 2006)

A brief account of the present status of the lentic (and also lotic) systems, as potential fishery beds, in Assam is tabulated below:

<table>
<thead>
<tr>
<th>Assam</th>
<th>Beels</th>
<th>1,00,000 ha</th>
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<tbody>
<tr>
<td>Reservoirs</td>
<td>10,730 ha</td>
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<tr>
<td>Swamps</td>
<td>10,000 ha</td>
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<tr>
<td>Ponds and Tanks</td>
<td>19,860 ha</td>
<td></td>
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<tr>
<td>Lotic system</td>
<td>5,000 km</td>
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Some of the significant Lentic systems (Wetlands) in the Barak valley region of Assam (Fig.2) are given below:

Geology

This region is unique geologically because the processes of morphogeny, lithogeny and tectonics are said to be active simultaneously. The catchment of the River Barak is formed by two major geotectonic features, viz., (a) the Nagaland-Haflong-Diyung thrust to the North and (b) the ophiolite belt of Nagaland and Manipur to the East (across the Manipur valley). This strongly-folded mobile belt is separated, by the northern thrust boundary, from the relatively stable platform of Assam, which is said to carry sedimentary cover of the same age. In fact, the ophiolite belt separates the zone from the Myanmarese platform. It is, however, believed that the ophiolite represents the margin of the Indian plate. It continues southward into the Andaman and Nicobar Islands through the Arakan Yoma (around Myanmar) and then into the Indonesian chain of Islands. However, in the folded belt, this stage was passed long ago and the prevalent model of evolution envisages the formation of folded mountain of the subduction margin. As the rising mountains pushed back the sea, the next zone to the west was similarly folded and uplifted. Thus, a progressive migration of orogeny, morphogeny and sedimentation were seen. The area is totally land now, remains dynamically active and the direction of evolution is the same (Kar, 2007).

Hydrography, morphology, morphometry and hydrodynamics of the wetlands in Barak drainage in Assam (Kar, 2007)

Information on the hydrobiological conditions of any water body is of prime necessity before endeavouring to utilize it as a productive fishery. It is an established fact that proper planning depends on the availability of reliable data. But, unfortunately, in the limnological and fisheries sector, there is an acute shortage of such data in the North-Eastern region of India (Kar, 1990).

In Barak drainage

Contrary to such background, the naturally-formed lakes and rivers constitute great potential of fishery resource in India. Many wetlands are still unregistered and under the control of both government and
private sectors. In this context, it is interesting to note that the district of Cachar includes the highest number of unregistered wetlands in Assam (Kar and Bar.bhuiya, 2000, 2001, 2002, 2004).

An account of some of the prominent lentic bodies in Barak drainage of Assam is given below:

**Lentic bodies**

Some of the significant lentic bodies in this region are given below:

(i) Beel (Perennial wetland): Sone Beel, Sat Beel, etc.
(ii) Haor (Seasonal floodplain wetland): Chatla Haor, Puneer Haor, etc.
(iii) Anua (River-formed oxbow wetland): Baskandi Anua, Satkarakandi Anua, etc.

An account of some of these is briefly given below:

(a) Sone Beel (Kar, 1990, 2007)

It is situated between 92° 24’ 50” – 92° 28’ 25 “ E and 24° 36’ 40” – 24° 44’ 30” N within Karimganj district of Assam and falls in a valley geologically called syncline (Fig 3).

The physiography of the district consists of small hillocks intervened by wide low valleys. The hillocks have NE-SW and NE-SSW trend near the Barail range and N-S trend towards south away from the Barail range. Notably, Sone Beel, the biggest 'Beel' (wetland) in Assam is situated in between two hill ranges, viz., the Badarpur-Saraspur range and the Chowkirmukh-Dohalia range. In the East, the neighbouring structure is the Badarpur line of folding; while, there is the Chargola anticline towards the west. A typical geomorphological feature is the tightfoldedness of the anticlines represented by hillocks having very high dips of the sedimentary beds (Kar et al., 1999).

Information obtained from ONGC and GSI (Personal communication) reveal that, Cachar represents a type area of Surma sediments exhibiting only Tertiary deposits (70 million years old) Investigations into the rock samples of this wetland revealed that the hillocks around the weland, were, probably, formed after Tipam sedimentation. Most of the wetlands in this region, including the mighty Sone Beel, might have been originated after the Dupitila sedimentation during the Mio-Pliocene period (Kar et al., 2003).

Around Sone Beel, the soil in the catchment of the plains is generally loamy, but occasionally sandy or gravelly admixed with quartz. Conversely, hilly portion of the catchment consists generally of fine grain sand stones bearing many angiosperms and thus forming the evergreen forest.
The principal feeder of the wetland is the major inflow, the river Singla, which drains a total catchment area of c 46,105 ha. The wetland receives water from 12 minor inlets and many other canals flowing from both hills and plains, all of which together drain a total of c 18,941.9 ha of the catchment area of the wetland. Out of this, c 11,003.9 ha lies in the plains; while, c 7,938.0 ha falls in the hilly portion of the wetland. These, otherwise, form respectively 58.09 % and 41.91 % of the total catchment area of the wetland (Kar and Dey, 1986, 1987, 1988).

Further, the catchment of the wetland also includes the reserve forests (RF) of the State, notably, the Singla RF. During monsoon, the wetland receives some humic as well as inorganic and organic nutrients from the hillocks and cultivable areas, particularly around the swollen tail end of the wetland.

The maximum length (L) and breadth (B) of the wetland at Live Storage Level (LSL) were measured as 12.5 km and 3.9 km respectively. Interestingly, these values reduce to 4.07 km and 2.22 km respectively at its Dead Storage Level (DSL).

The area of Sone Beel at LSL was measured as 3458.12 ha; while, at DSL, the area diminished to only 409.37 ha. The length of the shoreline was measured as 35.4 km while the shore and volume developments were recorded as 1.69 and 0.15 respectively with mean depth of 0.29 m. The gross volume of the wetland was found to be 101.54 x 10⁶ m³.

Silt Islands (SI) were recorded on the northern and southern parts of the lake. Of these, the Gopikanagar SI (area 3.74 ha and 25 MSL) and Khagdi tila SI (area 3.31 ha and 21 MSL) were noteworthy. Interestingly, the wetland surface itself is situated 23 m above the sea level (MSL).

The wetland basin tended to become deeper from south to north. The contours in the west were found to be almost parallel and closer than their counterparts in the east.

Although the wetland did exhibit variable water level ranging from 0.07 to 5.69 m at FSL (Jun-Sep) and 0.02 to 2.08 m at DSL (Nov-Apr), the average depth of the wetland was found to vary from 0.18 m (Feb 1980) to 3.34 m (Sep 1979) in 1979-80 and 0.16 m (Jan 1981) to 3.38 m (Jun 1980) during 1980-81.

Although 12 minor inlets were found to exist in different parts of the wetland, the wetland is mainly fed with the major inlet, the river Singla. It originates as `Thing Tlawng Lui' at a height of c 365.21 m MSL in Mizo Hills, from where, after traversing a meander course of c 62.75 km, it enters Sone Beel.

The major outflow (there being no minor outflow) of the wetland, the river Kachua originates from the
northern-most end of the wetland. It drains out the wetland water into the mighty river Kushiara after covering a length of c 19.30 km. Although the river Kachua was blocked by a blind dam constructed by the Government of Assam in 1950-51, the dam was replaced by a lock gate in 1964 after experiencing navigational and fishery problems. The maximum outflow of the wetland was found to be 87.03 m$^3$ sec$^{-1}$ in Aug 1980; while, the maximum inflow was recorded to be 33.91 m$^3$ sec$^{-1}$ in July 1980 during the entire period of investigations. Concomitantly, the minimum inflow and outflow of the wetland were recorded as 0.0027 m$^3$ sec$^{-1}$ and 0.087 m$^3$ sec$^{-1}$ (both in Feb 1980) during the period of study.

Physico-chemical characteristics of water of Sone Beel in Assam (Kar, 1990)

In Sone Beel wetland, the water was found to exhibit interesting trend in its physico-chemical features (Table 1). Turbidity, temperature, hydrogen-ion-concentration, dissolved oxygen (DO), free carbon dioxide (FCO$_2$), total alkalinity (TA) and specific conductivity were the parameters investigated (Table 1). The silt load of the inlet water measured at the Beel mouth was found to vary from 27-350 mg/lit. Concomitantly, the values of the outlet water was found to fluctuate from 9.0-88.1 mg/lit. The overall result indicated that more amount of silt is retained and deposited in the Beel and lesser amount is expelled through the outlet; thereby, resulting in overall siltation of the Beel (Dey and Kar, 1987).

Physico-chemical characteristics of soil of Sone Beel in Assam (Kar, 1990)

The values of various physico-chemical characteristics of soil of Sone Beel in Assam are given below:

- Temperature (C) : 19.9 – 32.3
- pH : 5.09 – 5.99
- Conductivity (µhmhos/cm at 25 C) : 47.42 – 322.08
- Organic Carbon (%) : 0.25 – 1.74
- Available Phosphorus (mg/100 g) : 0.15 – 1.93
- Available Potassium (mg/100 g) : 1.6 – 24.8

Plankton Communities

An account of Limnoplankton of Sone Beel (Kar, 1990)

47 different forms of phytoplankton belonging to five groups, as indicated above, have been recorded, till date, in Sone Beel. Of these, the Chrysophyta included the maximum number and Pyrrophyta, the least. The phytoplankton density in the Beel varied from 48-5308 (average 1027) units/lit. (Dey and Kar, 1994).

19 different forms of zooplankton, belonging to five groups, as indicated above, have been recorded, till date, in Sone Beel. The zooplankton density varied from 6-380 (average 49) units/lit. Low density is
generally recorded during February-March and high density during November-December (Kar, 2007).

An account of Aquatic Macrophytes of Sone Beel (depicting species composition, phyto-sociology, standing crop and seasonal succession) (Dey and Kar, 1989 a)

AM was found to exhibit a heterogeneous assemblage of 23 species in Sone Beel. The list of important AM species is given below:


AM biomass was found to vary from 0.58 – 21.90 kg/m$^2$ (average 2.48 ± 0.82) having the maximum in December and the minimum in May. In addition to water level (WL) and amplitude of flooding (Welcomme, 1979), the growth and distribution of the AM was found to be influenced by water quality of the wetland.

E.crassipes was the sole perennial species in the wetland, followed by H.verticillata and T.bispinosa, occurring during most of the months of the year. During dry season, the emergent varieties (like E.stagnina, E.acutangula, S.eriophorum, O.sativa, S.trifolia and P.flaccidum) and the submerged types (like H.verticillata, T.bispinosa, V.spiralis) generally succeed, flourish and show abundance at less WL when the wetland exhibits a decreasing trend in its depth. It indicates an indirect relation of AM biomass with WL ($r = -0.130 \pm 0.442, P>0.05$) during this period. Higher ranges of conductivity at this time was found to sustain (Pearshall, 1938) a rich biomass of T.bispinosa.

The wetland water, during dry season, in general, portray high DO produced by photosynthesis at rich insolation, in which, FCO$_2$ is consumed and shows a fall. Concomitantly, a direct relationship of AM biomass with DO ($r = 0.500 \pm 0.340, P < 0.05$) and an inverse with FCO$_2$ ($r = -0.780 \pm 0.178, P < 0.05$) was recorded in the study. The pH and TA, which were found to depict rise, portrayed their direct relationship ($r = 0.850 \pm 0.126, P < 0.05$; $r = 0.022 \pm 0.454, P <0.05$) with AM biomass. H.verticillata and V.spiralis, as indicated earlier, were found to be closely ($P < 0.05$) associated during this period ($\chi^2, 34.67$). Also, a close ($P < 0.05$) association between floating T.bispinosa and submerged V.spiralis ($\chi^2, 24.15$) and between submerged H.verticillata and emergent S.eriophorum ($\chi^2, 31.89$) was discernible during the period.
With the onset of monsoon, the floating varieties, viz., $N. nouchali$, $N. cristatum$ and $N. indicum$ generally occur in their flowering stage. Most of the emergent varieties encountered during winter, spring and summer, get submerged and decayed during monsoon. However, the littoral and sub-littoral zones of the Beel, during monsoon, are generally found to be moderately infested with emergent varieties like $C. dactylon$ and $V. zizanoides$. $H. verticillata$, among the submerged varieties, are, sometimes, found to occur. Onset of monsoon, as stated earlier, cause decay of AM, thus, rendering poor AM biomass with corresponding low DO, pH and TA but high FCO$_2$ during the periods. Concomitantly, a direct relation of AM with DO ($r = 0.940 \pm 0.053$, $P < 0.05$), pH ($r = 0.160 \pm 0.443$, $P > 0.05$) and TA ($r = 0.530 \pm 0.320$, $P < 0.05$) were recorded. Significant ($P < 0.05$) phyto-social association between $C. dactylon$ and $E. crassipes$ ($\chi^2$, 12.44), $C. dactylon$ and $N. indicum$ ($\chi^2$, 10.21), $H. aristata$ and $E. crassipes$ ($\chi^2$, 13.87), $H. aristata$ and $N. cristatum$ ($\chi^2$, 18.96) were recorded during this season. However, none of the AM species formed significant phyto-social relation with $E. ferox$, possibly, due to its thorny body; and, the latter, thus, formed a monospecific unit.

High Species diversity among the AM species were evident in this wetland. And, the level was found to be high (biased estimate of $H' = 2.015$; expected value, $E (H') = 2.014$; variance of $H' = 1.431$ E-3) in Sone Beel (Dey and Kar, 1989 a).

(b) Sat Beel (Kar, 1998)

This wetland is situated in the village Rongpur of Silchar Sub-division in Cachar district of Assam. This Beel is an aggregation of seven wetland units closely applied to each other and they become a single sheet of water during monsoon.

The physiography of the locality consists mainly of plain land with a small forest along the right bank of Barak. The seven wetland units, of which Sat Beel is constituted, are, Gajaria, Chepta, Bardoloo, Kachudaram, Mokachakri, Koia and Kejua. The river Barak, which flows c. 1.0 km away from the Beel, diverted its original course by c. 2.0 km during the last 30 years due to erosion of soil in its right bank. Sat Beel is situated at c. 25 m MSL. The geology is mostly Tertiary formation and is mostly fertile clayey loam. Dihing series beds are exposed near the river Madhura which flows also near the Sat Beel.

(c) Chatla Haor (Kar and Barbhuiya, 2000 b)

It is situated between 93°15’ N to 24° 10’ E in the Cachar district of Assam. It was said to be a `Beel’ (perennial wetland) some decades ago having its waterspread area reaching Silchar town. Due to gradual
siltation and eutrophication occurring naturally in the successional process, accelerated by human interference, today it has become a ‘Haor’ (seasonal wetland) and retains water for approximately six months in a year having practically no dead storage level. So, it is almost completely dry during the winter. Having a water spread area of ~1600 ha at the FSL, Chatla is considered as one of the biggest ‘Haor’ in Assam.

Around Chatla, the soil in the catchment is generally sandy-loam, but shore vegetation is thin. The Haor is drained by a number of small inlets (viz., Jalengachhara, Baluchhara, Salganga) and an outlet (viz., river Ghagra) which drains itself into the river Barak. The catchment of the Haor includes a small portion of the Innerline Reserve Forest. During monsoon, the Chatla, like other similar wetlands, receive some humic as well as inorganic and organic nutrients from the hillocks and surrounding cultivable lands.

The maximum length (L), breadth (B), depth (D) and water spread area (A) of the wetland at FSL have been measured to be 10 km, 2.5 km, 5.5 m and 1600 ha respectively. Prominent Silt Islands (SI), viz., Bairagiitila and Harintila have been found to occur towards the eastern shore of the Haor. Other small SIs, viz., Haltia, Diblia and Barshangan occur towards the SW side of the Haor.

Among the inlets, river Salgonga originates from the foot hills of the Mizo Hill range while the Jalengachhara and Baluchhara, which are mostly rheophilic in nature, flow down into the Haor from the Innerline RF. The only major outlet, river Ghagra, drains the water of the Haor directly into the river Barak traversing a tortuous course of ~14 km from the northern boundary of the Haor.

Physico-chemical characteristics of water of Chatla Haor in Assam (Kar and Barbhuiya, 2000 b)

The following water quality parameters were studied.

Temperature, Turbidity, pH, FCO₂, TA, Conductivity.

An account of Zooplankton of Chatla Haor Wetland (Kar and Barbhuiya, 2004)

Studies conducted in ~1600 ha Chatla Haor in Cachar district revealed the occurrence of 18 species of zooplankton consisting of 2 species each of Protozoa and Copepoda, 6 species of Rotifera and 8 species of Cladocera. Occurrence of Arcella sp among the protozoans and Brachionus calyciflorus among the rotifers, indicate eutrophy of the wetland. Two protozoans, viz., Arcella sp and Paramoecium sp, represented ~11.11 % of the total zooplanktonic taxa in the wetland. Verma and Dalela (1975) had reported Arcella sp in eutrophic waters. Six rotifers constituting 33.33 % of the total zooplanktonic taxa were also identified; of which, Filinia sp and Lecane sp were found to be abundant. The identified Copepods included the Cyclops sp and the Diaptomus sp and they represented 11.11 % of the total
zooplanktonic taxa. The total zooplanktonic count was found to be 68± 45 units/litre (Kar and Barbhuiya, 2004).

An account of the AM of Chatla Haor seasonal floodplain wetland (Kar and Barbhuiya, 2001)

23 species of AM could be recorded, till date, in the 1600 ha (at FSL) Chatla Haor situated in the Cachar district of Assam. These could be classified as follows:

5 free floating, 4 rooted floating, 2 submerged and 12 emergent. Of these, 6 AM species could be found throughout the year. These are: Azolla pinnata, Eichhornia crassipes, Salvinia cucullata, Trapa bispinosa, Jussiaea repens and Cynodon dactylon.

J. repens showed flowering during March-May, while Nymphaea nouchali bloomed during June-August followed by Nymphoides cristatum and N. indica which exhibited profuse flowering during September-October. Ipomoea aquatica depicted significant growth of population during July-August. Hydrilla verticillata, Vallisneria spiralis among the submerged varieties and Alternanthera sessilis, Cyperus platystylis, Echinocloa stagnina, Eleocharis acutangula, Enhydra fluctuans, Scirpus eriophorum, Sagittaria trifolia among the emergent varieties succeeded at a lesser water level during the dry season. The floating varieties, viz., A. pinnata, E. crassipes, S. cucullata were recorded throughout the year and found to be associated with each other. Further, among the submerged varieties, H. verticillata and V. spiralis were found to be associated.

(d) Puneer Haor

It is situated c 38 km away from south of Silchar city near the village Dhalai along the Assam-Mizoram border. This Haor has a waterspread area of c 2.5 ha at FSL and c 1.3 ha at DSL. The maximum L, B and D of Puneer Haor at FSL have been found to be 1.5 km, 0.9 km and 2.5 m while its average depth was found to be 0.4 m. The Puneer Khal, flowing along the eastern shoreline of the Haor, originates from Panchhara hill ranges and water from this khal spills over into the Haor at FSL. A drain from the adjoining Bhubandhar TE flows along the western shoreline of the Haor and water containing TE pollutants also spills over into the Haor at FSL.

(e) Baskandi Anua

This oxbow wetland is situated between 24°10’ N (latitude) and 93°15’ E (longitude) in the Lakhipur Sub-division of Cachar district in Assam. It is said to have been formed due to change of course of the River Barak.
The Anua is situated near the Manipur range of hills. Towards the east, lies the Manipur valley while the Silchar sub-division is situated in the west. The North Cachar Hills is situated towards the north and the province of Mizoram lies towards the south. The catchment soil is found to be mainly sandy loam. Rain is the main source of water for the Anua. The wetland also receives water from the surrounding catchment having human habitation. The catchment vegetation includes herbs, shrubs and trees including a lot of bamboos.

The L, B and A of Baskandi Anua have been found to be respectively 2.230 km, 205 m and 39.2 ha at FSL and 2.090 km, 190 m and 36.7 ha at DSL. The wetland basin tends to be deeper towards the southern side as compared to the northern. The Anua exhibits variable water level ranging from 0.25 m to 5.85 m at FSL (Jun-Sep) and from 0.14 m to 4.12 m at DSL (Nov-Apr) (Kar, 2007).

An account of the AM of Baskandi Anua River-formed Wetland (Dhar et al., 2004)

16 species of AM have been recorded in the 39.2 ha (at FSL) Baskandi Anua which belong to 6 free-floating (Azolla pinnata, Echhornia crassipes, Salvinia cucullata, Lemna pausicostata, Pistia stratiotes, Wolffia sp); 2 rooted submerged (Hydrilla verticillata, Vallisneria spiralis); 6 rooted with floating leaves (Nymphaea nouchali, Nymphoides indicum, N.cristatum, Trapa bispinosa, Euryale ferox, Nelumbo nucifera); and 2 rooted emergent (Jussiaea repens, Muradania nudiflora). Of these, 6 AM species were found to occur throughout the year. These are Azolla pinnata, Eichhornia crassipes, Salvinia cucullata, Trapa bispinosa and Jussiaea repens.

Studies conducted during the period 1998-2000 revealed wet AM biomass to be ranging from 4.4 to 11.4 kg/m². Wet biomass was observed to be higher during monsoon and post-monsoon reaching trough value during winter with a concomitant increasing trend during summer. Significant positive correlation of AM biomass with water temperature ($r = 0.1820$) has been recorded during the study period.

(f) Satkarakandi Anua

This Anua lies between 92° 53’ E and 24° 1’ N in the Sonai Revenue Circle in the Cachar district of Assam. The wetland is situated at a distance of c 15.5 km away from Silchar city. River Barak flows towards the northern side of the wetland.

The maximum L and B of the wetland were found to be c 1.75 km and 0.3 km respectively. The Anua was found to have an average depth of c 3.0 m at FSL. During monsoon, the Anua establishes connection
with the river Barak through a channel on the northern side of the wetland which is, however, guarded by a sluice gate as a flood-mitigation measure.

(g) Sibnarayanpur Anua

This oxbow wetland is an abandoned segment of river Barak situated at a distance of c 32 km from Silchar city. It lies within the jurisdiction of Katigora Revenue Circle in Cachar district of Assam. It has a L, B and A of c 1.7 km, 0.7 km and 53 ha respectively. The catchment soil is mostly loamy. At present, it seems to have a connection with river Banaimulla.

Ichthyogeography and Ichthyodiversity of the Wetlands of Assam

Fish constitutes almost half of the total number of vertebrates in the world. They live in almost all conceivable aquatic habitats. c 21,723 living species of fish have been recorded out of 39,900 species of vertebrates (Jayaram, 1999). Of these, 8411 are freshwater species and 11,650 are marine. India is one of the Megabiodiversity countries in the World and occupies 9th position in terms of freshwater Megabiodiversity (Mittermeier and Mittermeier, 1997). In India, there are c 2500 species of fishes; of which, c 930 live in freshwater (FW) and c 1570 are marine (Kar, 2003 a). This bewildering ichthyodiversity of this region has been attracting many ichthyologists both from India and abroad. Concomitantly, North-Eastern region of India has been identified as a ‘Hotspot’ of Biodiversity by the World Conservation Monitoring Centre (WCMC, 1998). This rich diversity of this region could be assigned to certain reasons, notably, the geomorphology and the tectonics of this zone (Kar, 2005 a, b, c). The hills and the undulating valleys of this area gives rise to large number of torrential hill streams, which lead to big rivers; and, finally, become part of the Ganga-Brahmaputra-Barak-Chindwin-Kolodyne-Gomati-Meghna system (Kar, 2000).

An account of the Ichthyospecies

Zoogeographically, FW fish have been classified differently by different workers. Although the classification made by Myers (1949) have been proved to be the most useful, and widely accepted one, the FW fish of marine origin had been further classified as ‘peripheral FW forms’ by Nichols (1928) and Darlington (1957) which has also been accepted by many recent fish geographers. Incidentally, the ichthyofauna of this region, by and large, have been found to belong to the following categories (Kar, 1990):

(A) Primary FW Fish
Genera-wise break-up of the species under this group include, among others, Notopterus, Chitala, Labeo, Cirrhinus, Catla, Cyprinus, Puntius, Rasbora, Aspidoparia, Amblyphtyngodon, Barilius, Danio, Esomus, Salmostoma, Botia, Lepidocephalus, Nemacheilus, Somileptus, Rita, Mystus, Wallago, Ompok, Ailia, Eutropiichthys, Clupisoma, Silonia, Pangasis, Gagata, Glypotothorax, Claras, Heteropneustes, Chaca, Badis, Nandus, Anabas, Colis, Mastacembelus, Macrognathus, Tetraodon (Kar, 2003 a, b).

(B) Peripheral FW Fish

Genera-wise break up under this group include, among others, Gudusia, Hilsa (Tenualosa), Pisodonophis, Chanda, Xenentodon, Aplocheilus, Amphipnous, Sicamugil, Rhinomugil, Glossogobius (Dey and Kar, 1989 b).

In addition to the above, on the basis of Indian and Extra-Indian fish distribution (Motwani, et. al., 1962), the following ichthyospecies of this region could significantly be incorporated under the following two groups:

(a) Widely distributed species

Genera-wise break up under this group include, among others, Esomus, Puntius, Rasbora, Ompok, Wallago, Clarias, Xenentodon, Channa, Glossogobius, Anabas, Macrognathus and Mastacembelus. Incidentally, these ichthyospecies, in addition to this region, also occur in many other parts of India, Pakistan, Bangladesh, Sri Lanka and Malaya (Kar and Dey, 2000).

(b) Species of Northern India

Species under this group include, among others, Rasbora elanga, Botia Dario, Lepidocephalus guntea, Glypotothorax telchitta, Chanda baculis, Rhinomugil corsula, Sicamugil cascasia and Tetraodon cutcutia (Kar and Dey 1991, 1993 a, b, 1996)

In addition to the foregoing analyses, ecomorphologically (Dey, 1973), the fishes of this region could further be categorized into four distinct groups which are as follows:

(a) True Hill-stream or rheophilic forms

Fishes with strong body musculature and adapted to torrential abode, e.g., Garra, Psilorhynchus, Balitora, Glypotothorax, etc. (Dey, 1973)
(b) Semi-torrential forms

Fishes with less body modifications as compared to rheophilic forms, Botia, Lepidocephalus, Nemacheilus, Schistura, Somileptus, Gagata, etc.

(c) Migratory forms

Well-built fish having the power of overcoming adverse ecological conditions, Hilsa (Tenualosa), Barilius, Channa, Badis, etc (Kar, 2002).

(d) Plainwater forms

Fishes having minimum body modifications and insignificant migratory habit, Pisodonophis, Gudusia, Notopterus, Chitala, Amblypharyngodon, Aspidoparia, Catla, Cirrhinus, Cyprinus, Danio, Esomus, Labeo, Puntius, Rasbora, Salmostoma, Mystus, Aorichthys, Ompok, Wallago, Rita, Clupisoma, Eutropiichthys, Silonia, Pangasius, Claras, Heteropneustes, Chaca, Xenentodon, Aplocheilus, Amphipnous, Chanda, Nandus, Sicamugil, Rhinomugil, Anabas, Colisa, Glossogobi, Macrgnathus, Mastacembelus, and Tetraodon

Fish Biodiversity in the Lentic Systems of Assam

There is a bewildering diversity of fishes in the lentic systems of this region.

An account of the principal lentic bodies of this region, with regard to their ichthyodiversity (Kar et al., 2002) and fish yield trend in briefly given below:

(a) Fish Diversity in Sone Beel of Assam

70 species of fishes belonging to 49 genera under 24 families and 11 orders have been recorded in Sone Beel, the biggest wetland in Assam.

Of the 70 ichthyspecies of Sone Beel, 59 species under 39 genera belong to the Primary FW group while 11 species under 10 genera belong to the category of Peripheral FW group (Nichols, 1928; Darlington, 1957). On the other hand, on the basis of Indian and Extra-Indian Territorial Distribution (Motwani et al., 1962; Kar, 1990), 28 ichthyspecies of Sone could significantly be incorporated under two groups, viz., (a) Widely distributed species and (b) Species of Northern India. Further, among the other species, one species, viz., Glyptothorax telchitta was found to be a true hill stream form; while, five
speices, viz., Botia dario, Lepidocephalus guntea, Acanthocobitis botia, Somileptes gongota and Gagata nangra were recorded as Semi-torrential forms (Dey, 1973). Thirtynine fish species were found to belong to the Plainwater group (Dey and Kar, 1990). The Fishermen fishing in Sone Beel belong to 4 communities (Dey and Kar, 1989 c).

(b) Fish Diversity in Sat Beel of Assam

14 species of fishes belonging to 12 genera, 6 families and 3 orders have been recorded in Sat Beel (Kar, 1998).

(c) Fish Diversity in Chatla Haor of Assam

57 species of fishes, belonging to 28 genera, 17 families and 9 orders, have been recorded in Chatla Haor (Kar and Barbhuiya, 2000 b)

Zoogeographically, the ichthyspecies of Chatla Haor contains 79.62 % of Primary FW fish while the rest (20.38 %) belong to the Peripheral class (Nichols, 1928; Darlington, 1957; Kar, 1990). Further, on the basis of Indian and Extra-Indian territorial fish distributional pattern (Motwani et.al., 1962), ichthyspecies of Chatla Haor did contain fishes belonging to the groups called `widely distributed species (notably, Puntius, Ompok, Channa, Anabas) and species of Northern India (notably, Botia dario, Lepidocephalus guntea, etc.). Ecomorphologically (Dey, 1973), fish species of Chatla Haor contain only the `Semi-torrential` forms and the `Plainwater` forms (notably, A.mola, C.catla, C. carpio, Puntius spp., Mystus spp)( Kar, 1996)

(d) Fish Diversity in Puneer Haor of Assam

The Puneer Haor contains altogether 24 species of fishes belonging to 22 genera, 15 families and 8 orders (Laskar, et.al., 2002).

(e) Fish diversity in the Anuas of Assam

(i) In Rupairbala Anua

24 species of fishes belonging to 21 genera, 15 families and 9 orders have been recorded in this Anua (Kar, et.al.,2000 b).

(ii) In Baskandi Anua
13 species of fishes belonging to 10 genera, 6 families and 4 orders have been recorded in Baskandi Anua (Kar, et.al., 2000; Dhar, 2004).

(iii) In Fulbari Anua

In course of a pilot survey, 7 species of fishes belonging to 6 genera, 6 families and 6 orders have been recorded from Fulbari Anua (Kar et.al.,2000).

(iv) In Sibnarayanpur Anua

22 species of fishes belonging to 21 genera, 10 families and 5 orders have been recorded from Sibnarayanpur Anua (Kar, et.al., 2000).

Management and Conservation of Wetlands: A case study in Sone Beel in Assam

Profitable harnessing of fish resources from these natural ‘Beels’ depend today on systematic management of these waterbodies.

We may consider SONE BEEL as an example

At Dead Storage Level (DSL), Sone Beel has eight deeper Fishing Centres locally called ‘Bundhs’ (Nov – April: 5 ha - 200 ha approx.):
1 m- 1.75 m

Now the ‘Bundhs’ witness only “Capture Fishing”.

Conversely Scientific pisciculture in these’ Bundhs” would increase fish Yield and would generate employment & income.

Concomitantly certain other measures forming part of the management strategies as well as may be applicable to other similar ‘Beels’ are as follows:

1. Regulation of siltation at the upstream region of the inlet(s) coupled with construction of ‘check dams, wherever necessary, along with concomitant allotment of ‘Patta’ to the local inhabitants to prevent further encroachment into the Beel mainly for paddy cultivation.

2. Leasing-out of the Sone Beel to Peoples’Organisation like
Sone Beel Fishermens’ Co-operative Society (SBFCS) instead of to individuals with complete responsibility of its management to SFFCS; as well as imposition and realization of its proper share. Govt. may do developmental works through the earnings.

3. SEFCS may further earn through collection of token tolls from the fishermen as well as the fish traders on the basis of fish caught and purchased respectively.

4. The generation of employment and income through proper management would prevent avaricious exploitation of the Beel, check exodus of fishermen from the Bee to the cities and thus would help conserving fishermen as fishermen.

5. Proper steps to be taken by the Board of Management to control fish disease like the Epizootic Ulcerative Syndrome (EUS) in order to prevent large scale Fish mortality.

6. Similar management strategies could also be thought of the other lentic and lotic systems.

Lotic System

The most striking feature of the Region’s drainage is the magnificent flow of the mighty Brahmaputra and the Barak reckoned amongst the world’s most majestic rivers. Further, North-East region of India sustains nearly full range of microcosms, from tiny bogs followed by marshes, fens, floodplains and very big perennial wetlands, locally called ‘Beels’

The Barak valley is formed mainly by the River Barak and its tributaries.

The river Barak originates from Japvo peak in Nagaland (c3353.65m MSL), and flows through Karang village along the Manipur-Nagaland border and drains almost the entire Manipur valley before entering Assam. It flows through the southern part of Assam (thus, forming the Barak valley); and, after traversing through a stretch of c 532 km from its origin, the River Barak bifurcates into two branches, viz., the Surma and the Kushiara at village Harinagar (Haritikar) at the Indo-Bangladesh border. After flowing a short spell along the Indo-Bangla border, both these rivers flow into Bangladesh to join the Meghna basin before entering the Bay of Bengal. Barak has a number of tributaries joining it on both north and south banks, viz., Jiri, Chiri, Madhura, Jatinga, (north bank tributaries) and Sonai, Rukni, Dhaleswari, Ghagra (south bank tributaries). In addition to these, the River Shingla and the River Longai, both originating from the Mizo Hills, join the River Kushiara in Barak valley, the former flowing via Sone Beel, the biggest wetland in Assam. Also, the River Baleshwar joins River Surma in Barak valley.
The province of Mizoram is drained by eight major rivers belonging to three principal drainage systems as mentioned below:

1. River Tuirial
2. River Tlawng
3. River Serlui  Barak-Meghna drainage system: Indo-Bangladesh
4. River Tuivai
5. River Mat
6. River Kolodyne  Kolodyne drainage system: Indo-Myanmar
7. River Tuichong
8. River Karnafuli  Tuichong-Karnafuli drainage system: Indo-Bangladesh

The province of Tripura is drained by four major rivers forming four independent basins as given below:

1. River Manu: Manu basin
2. River Khowai: Khowai basin
3. River Gomati: Gomati basin
4. River Feni: Feni basin

All these rivers flow into Bangladesh independently (Kar, 2007a).

Fish Disease Problem

Notwithstanding the rich fish biodiversity, the fishes of this region are affected by diseases causing fish health problems and mortality. Understanding the relationship between the fishes, their environment, pathogens and parasites is a pre-requisite in achieving success in pisciculture; and, is also the basis for rational management.

‘Disease, per se, is not an entity of an end in itself. Disease is the end result of an interaction between a noxious stimulus and biological system.
Severe outbreaks of disease may result from the introduction of parasites, pathogens, from malnutrition, from chemical and physical alterations of the water, from the genetic make-up of the fish; and, from the interrelationship of any or all these factors.

The dreadful fish disease called `Epizootic Ulcerative Syndrome (EUS)’ has been causing large-scale mortality among the freshwater fishes of India since 1988

Following the report of Mycotic Granulomatosis (MG) in Japan, sometime around 1972, the earliest report of EUS outbreak goes back to Australia during 1972 and Papua New Guinea during 1974 (Mackenzie and Hall, 1976); from where, EUS has been sweeping almost in a chronological manner through most of the South-East and South Asian countries, like Indonesia (1980), Malaysia (1979-83; Shariff and Law, 1980), Thailand (1985; Tonguthai, 1985), Kampuchea and Lao PDR (1984; Boonyartapalin, 1985); Myanmar (1984-85), Sri Lanka (1987); Bangladesh (March, 1988; Barua, 1990); until, EUS had reached India through the Barak valley region of Assam during July, 1988 (Kar and Dey, 1988; Kar, 2007a); and, has been sweeping the region, even today, causing large-scale mortality among the freshwater fishes.

Review of Literature

Fish Biodiversity


Kar (2003 a) reported the occurrence of 133 species of fishes through a pilot survey conducted in 19 rivers spread in Barak drainage (Assam), Mizoram and Tripura. Kar (2005 a), further, reported the occurrence of 103 species of fishes through an extensive survey conducted in six principal rivers in Barak valley (Assam), Mizoram and Tripura. Kar (2007a) and Kar and Sen (2007) have done detailed study on the biodiversity of fishes in North-East India with particular reference to Barak drainage, Mizoram and Tripura.

Wetlands

Fish disease

Significant works done on EUS Fish Disease include those of Kar (1999, 2005 d); Kar and Dey, S (1988); Kar and Dey, SC(1988 a, b; 1990 a, b, c); Kar and Das (2004 a, b); Kar et al. (1990 a, b; 1993, 1994, 1995 a, b, c; 1996 a, b, c; 1997; 1998 a, b, c, d; 1999 a, b; 2000 a, b, c,d; 2001 a, b; 2002 d, e, f; 2003 a, b, c, d, e, f, g; 2004 a, b, c); Patil et.al. (2003).Outbreaks of EUS in India have been comprehensively reviewed at various levels by The Zoological Society of Assam (1988); Jhingran and Das (1990); National Workshop on Ulcerative Disease Syndrome in Fish (1990); Kumar et al. (1991); ICSF, (1992); Das and Das (1993); Mohan and Shankar (1994); Kar (2007a).

The present communication deals with the Panorama of wetlands, rivers and fish diversity in North-east India with a glimpse on fish health.

2. Materials and methods

General survey of the Fish Biodiversity was done using standard procedures (Armontrout, 1990). Also, NBFGGR Manual (2000) was consulted for studying the habitat parameters. Headwater to downstream studies were based on River Continuum Concept (Vannote, et. al., 1980). Spatial heterogeneity of river channel across small to large spatial scales (Forman and Godran, 1986), longitudinal (upstream vs downstream) and lateral (stream margin/mid-channel) dimensions were studied.

Fish samples were collected through experimental fishing using caste nets (dia.3.7 m and 1.0 m), gill nets (vertical height 1.0 m- 1.5 m; length 100 m -150 m), drag nets (vertical height 2.0 m), triangular scoop nets (vertical height 1.0 m) and a variety of traps. Camouflaging technique was also used to catch the fishes. Fishes have been preserved at first in concentrated formaldehyde in the field itself and then in 40 % formalin. Fishes have been identified after standard literature (Day, 1878, 1889; Shaw and Shebbeare, 1937; Misra, 1959; Menon, 1974, 1999; Talwar and Jhingran, 1991; Jayaram (1981, 1999). Yield statistics were extrapolated (Dey and Kar, 1990; Kar, 1990) from daily catch statistics recorded at the landing stations (FAO, 1974) while the trend and cyclic variations were constructed by applying 12 months moving average method (Coxton and Cowden, 1950; Kar and Dey, 2000).
Physico-chemical characteristics of water were estimated after Standard Methods (APHA, 1995).

In connection with study of EUS fish disease, sick fish samples were collected (FAO, 1974) and processed and preserved following standard procedures for bacteriological, mycological, histopathological, tissue cultural, virological and electron microscopic studies (FAO, 1986). Also, epidemiology of EUS fish disease was studied after Park (1997).

Based on our extensive field works, as a typical example of lotic system, an account of River Barak is briefly given below:

River Barak

It is a 4th order river situated between the geographical ordinates N 24° 47' 12.9" and E 93° 2’ 9.1”. Its altitude was found to vary from 17-43 m MSL in our different study sites within the Barak valley region of Assam. After originating from Japvo peak in Nagaland, the first place it reaches the plains is the village Karong situated in Senapati district of Manipur at the Manipur-Nagaland border. It, then, flows through a tortuous course in Manipur, passes through places like Noney, Tipaimukh (at the junction of Manipur and Mizoram where the proposed Barak Dam is to be constructed), Jiribam, etc.; and, finally, enters the Cachar district of Assam through which it flows along a serpentine course; and, ultimately, bifurcates into Surma and Kushiara at village Harinagar near village Haritikar at the Indo-Bangladesh border (Kar, 2003 a, 2005 a; Kar et al., 2002 a).

Observations in our study sites indicates the following:

The valley segment is mostly alluvial. The flow rate of the river ranged from 12-61 rev./10 sec; which, at the surface, revealed a range of 30-35 rev/10 sec. The Entrenchment Ratio (E/R) varied form 1.15-2.87. The reach type is mostly regime. The river bottom mainly consists of sand and silt as substratum which is also the case with river bank. However, bedrocks are found on the bank in some places. The bankful width and depth, channel width and depth and wetted width and depth are given below:

<table>
<thead>
<tr>
<th>Parameter type</th>
<th>Bankful Width (m)</th>
<th>Bankful Depth (m)</th>
<th>Channel Width (m)</th>
<th>Channel Depth (m)</th>
<th>Wetted Width (m)</th>
<th>Wetted Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>430-490</td>
<td>23-29</td>
<td>340-410</td>
<td>17-19</td>
<td>150-270</td>
<td>3-12</td>
</tr>
</tbody>
</table>
Depth, turbulence and some amount of overhanging vegetations serve as moderate cover and protection of the fishes in Barak. Depending on the contact of soil with water, Barak is of mesoriparian type having grass, shrubs and evergreen trees as riparian vegetation. Bamboos form one of the most dominant types of riparian vegetations.

The dominant texture of the riparian zone is mostly silt and fine grain sand stone with some amount of clay. The riparian land use pattern includes mainly human habitation and agriculture. Signs of erosion are common along the river bank.

Critically, our surveys revealed very turbid river water mainly because of heavy rainfall during monsoon. High turbidity indicates bringing-in of eroded soil by the river. Inspite of its high depth, the river depicted the existence of backwater type pools having dense vegetation cover at some spots. Interestingly, bedrocks are found even at some spots in the mid-stream and downstream regions of the river. There is variation in water temperature and transparency with seasons. Turbid water is less productive although it gives cover to fish. Barak also has undercut bank.

Further, in the present study, the percentage contribution of cyprinids in some of the rivers were found to be as follows: Barak (42.58%), Jatinga (62.91%), Sonai (75.82%), Dhaleswari (6.82%), Tuirial (92.41%) and Gomati (69.03%). Order-wise, the relative abundance of fishes in the said rivers revealed the occurrence of Siluriformes to be highest in river Dhaleswari (21.98%), followed by Barak (17.15%), Sonai (13.27%), Gomati (11.29%), Jatinga (10.32%) and Tuirial (1.42%). Similarly, occurrence of Perciformes was the highest in Barak (33.89%), followed by Jatinga (22.06%), Gomati (16.77%), Sonai (7.1%), Dhaleswari (4.96%) and Tuirial (2.84%). The study, further revealed that, almost all the cyprinid fishes are generally distributed in pools, pool edges, backwater pools, riffles and riffle edges. Runs and cascades have been found to be the least preferred habitats for the cyprinids. The edges of the run habitats have been found to be inhabited mainly by ChandaNama, Puntius conchonius and Esomus danricus in river Barak while the cascade habitats are generally colonized by Labeo pangusia and Garra sp. in river Jatinga. Dammed pools, backwater pools and deep pool edges with bedrock substratum are generally the highly preferred habitats for Botia dario, Danio dangila, Devario naganensis, Badis badis, Puntius conchonius, Tor mosal, Salmostoma bacaila and Cirrhinus ariza as found in rivers Sonai and Jatinga. Barilius bendelisis, B. dogarsinghi, Schistura sp., Nemachellus spp., are generally abundant in the riffle-type of microhabitats in river Tuirial where the substrata have been found to be mainly dominated by cobbles. Among the cyprinids, Tor progenius and Neolissochilus
hexagonolopis are generally confined to large deep pools in river Jatinga. Nevertheless, species like Crossocheilus latius, Psilorhynchus balitora and Balitora brucei have been recorded generally from the cascade to riffle regions in the upper gradient zones of rheophilic streams.

With regard to lentic system, a detailed study was conducted in Sone Beel, the biggest wetland in Assam, as a typical example.

Results the hitherto unknown dreadful fish disease, called Epizootic Ulcerative Syndrome (EUS) is briefly discussed below:

EUS Fish Disease

EUS has been causing large-scale mortality among the freshwater fishes since 1988, initially affecting four species of fishes very widely. Our study revealed fluctuation in the intensity of the disease in relation to species affected. Large haemorrhagic cutaneous ulcers, epidermal degeneration and necrosis followed by sloughing of scales are the principal symptoms of EUS. Low total alkalinity (TA) could be pre-disposing ‘Stress factor’. Sick fishes show low haemoglobin and polymorphs, but high ESR and lymphocytes. Communicative nature of EUS revealed variation in time gap between fish and infection in different species. Inoculation of microbes in the test animals did not reveal of any sign of ulcerations for two years. Bacterial culture revealed occurrence of haemolytic E. coli, Aeromonas hydrophila, Pseudomonas aeruginosa, Klebsiella sp, Staphylococcus epidermitis in the surface lesions as well as in the gut, liver, gills, heart, kidney and gonads of sick fishes, all of which have been found to be sensitive to Chloramphenicol, Septran, Gentamycin, etc. Fungal isolation revealed the occurrence of Aphanomyces sp with concomitant occurrence of the same fungal genus in histological sections of EUS-affected fishes. Histopathological (HP) studies revealed focal areas of increased fibrosis and chronic inflammatory cell infiltration in muscles; focal areas of fatty degeneration of hepatocytes surrounding the portal triads in the liver. Preliminary Histochemical (HC) studies portrayed interruption in glycogen synthesis and blockade of respiratory pathways. Similarly, preliminary enzymological studies portrayed interruption in Alkaline Phosphase, SGOT, SGPT, LDH. Inoculation of 10 % tissue homogenate of EUS-affected Clarias batrachus into 80 % confluent monolayer from BF2 fish cell line in Leibotiz L-15 medium, revealed progressive CPE which was passable in subsequent cultures; thus, indicating the ‘isolation’ of virus.

Electron Microscopic studies with the ultra-thin sections of still-occurring EUS-affected fish, tissues, revealed the presence of virus-like particles (inclusion bodies); and, preliminarily, the picobirna virus has
been electron microscopically identified as the primary aetiological agent of EUS. Further studies in this regard are being conducted (Plates 1, 2, 3)

Concluding Remarks

(Inference)

An attempt has been made in the present study to reflect the Change detection of boundary contour of Sone Beel wetland in Assam on a GIS Platform using PCI Geomatica version 10.1 by comparing the ground map (prepared through standard survey, Kar, 1990) with Georeferenced Survey of India Topomap and superimposing the LISS IV Satellite imageries data of 2006 over a period spanning from 1880, 1980 to 2006 (Fig 4). Orange coloured region depicts the area for the year 1880 which is 6,774 ha (approx). Blue colour depicts the area for the year 1980 which is 3,234.4 ha (approx) and Red coloured region depicts the area for the year 2006 which is 392.4 ha (approx) prepared in winter season while other two contours are during rainy season. So, within a span of 100 years (approx) from 1880 to 1980, there is shrinkage of c 3,539.6 ha of the water spread area. Extensive deforestation coupled with soil erosion had been leading to large scale siltation of water bodies; thus, causing shrinkage in the water spread area. One can expect further diminution in the water spread area due to the siltation process, if it continues (Fig.4).

In addition to the above, present status of the Wetlands in this region with regard to their potentialities and problems have been summarized in a Table. The wetlands in this region could function very well with regard to Pisciculture and flood management in this severely flood-prone area. They could also serve significantly in the rehabilitation of the innumerable immigrated fishermen.

The potentialities of Beels, Haors and Anuas are reflected in the following aspects: Vast waterspread area, presence of continuous inlets and outlets, maximum depth sometimes upto 6m, occurrence of rich fish biodiversity to the extent of 70 species in a single Beel (Sone Beel), presence of migratory Hilsa in some of the Beels, etc. Likewise, some of the Haors (though do not have any Dead Storage Level) have rich diversity of phyto and zooplankton and occurrence of juveniles of IMCs and Hilsa
indicating possibilities of their natural breeding grounds. The Anuas, being detached from original course of the rivers, could serve as ideal sites for culture fishery.

Significant problems faced by these wetlands are mostly man-induced, e.g., diversification of the course of the inlets and blocking of the outlets resulting in siltation of the Beels and the channels due to less expulsion of silt from the Beel leading to diminution and depth and water-spread area rendering loss of breeding ground for the LGF; exposure of the land, their subsequent encroachments and paddy cultivation often using chemical fertilizers and pesticides. Day-in and day-out fishing operations by thousands of unrehabilitated fishermen using approx. 30 different types of fishing gears (some of which are fine-meshed) and methods is a problem of grave concern. Acute weed problems in some of the ‘Anuas’ is another problem of serious concern.

Some of the important suggestions include removal/modification of man-made blockades in order to revive the migration of fishes, to help boost fish trade through navigation and to enable some amount of natural desiltation. Further, some amount of man-made desiltation could revive the breeding ground of the LGF, discourage paddy cultivation due to re-submergence of the exposed wetland beds; rehabilitation of the innumerable immigrated fishermen, minimum education and monitoring of the wetland users by the NGOs for less input towards eutrophication; culture of IMCs in the deep fishing centres at the DSL to boost locao earnings; and, initiation /re-vamping of the Fishermen Co-operative Societies; could go a long way in maintaing the health of the Wetlands and Wetland-users and in the emancipation of the poor fishermen. Some of the local case studies regarding the modus operandi of the Beel Management has been discussed in the present communication which could help in the socio-economic upliftement of the poor fisherfolk.

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Table 1: Physico-chemical characteristics of water of the Wetlands in Assam:

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Water body</th>
<th>Temp. (°C)</th>
<th>Water Air</th>
<th>Turbidity (NTU)</th>
<th>pH</th>
<th>DO (mg/l)</th>
<th>Free-CO₂ (mg/l)</th>
<th>TA (mg/l)</th>
<th>Conductivity (µ mhos/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sone Beel</td>
<td>25.5</td>
<td>26.8</td>
<td>104.87 TU</td>
<td>7.28</td>
<td>4.28</td>
<td>6.77</td>
<td>51.4</td>
<td>70.5</td>
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<tr>
<td>2</td>
<td>Sagar Beel</td>
<td>25</td>
<td>26</td>
<td>0.5</td>
<td>5.62</td>
<td>4.9</td>
<td>47</td>
<td>80</td>
<td>22</td>
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<tr>
<td>3</td>
<td>Rani Meghna Beel</td>
<td>27.5</td>
<td>24</td>
<td>17</td>
<td>5.3</td>
<td>5</td>
<td>39</td>
<td>49</td>
<td>23</td>
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<tr>
<td>4</td>
<td>Angang Beel</td>
<td>28</td>
<td>29</td>
<td>1</td>
<td>5.15</td>
<td>3.95</td>
<td>52</td>
<td>41</td>
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<tr>
<td>5</td>
<td>Deochhara Beel</td>
<td>27</td>
<td>24</td>
<td>2</td>
<td>5.7</td>
<td>5.2</td>
<td>42</td>
<td>81</td>
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<tr>
<td>6</td>
<td>Dubria Beel</td>
<td>27</td>
<td>25</td>
<td>9</td>
<td>5.1</td>
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<td>59</td>
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<td>5</td>
<td>Srikona Beel</td>
<td>27.5</td>
<td>27</td>
<td>70 TU</td>
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<td>12</td>
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<td>6</td>
<td>Karkari Beel</td>
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Table 2: Fish Biodiversity in Assam Wetlands (‘+’ Present, ‘-’ Absent):

<table>
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<tr>
<th>Fish Species</th>
<th>Sone Beel</th>
<th>Sat Beel</th>
<th>Chatla Haor</th>
<th>Puneer Haor</th>
<th>Rupairbala Anua</th>
<th>Baskandi Anua</th>
<th>Fulbari Anua</th>
<th>Sib Narayanpur Anua</th>
</tr>
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<tbody>
<tr>
<td>Pisodonophis boro (Hamilton)</td>
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<td>Gudusia chapra (Hamilton)</td>
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<td>Tenualosa ilisha (Hamilton)</td>
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<td>Chitala chitala (Hamilton)</td>
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<td>Ctenopharyngodon idellus (Valenciennes)</td>
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<td>Hypophthalmichthys molitrix (Valenciennes)</td>
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<td>Devario devario (Hamilton)</td>
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<td><em>Eutropiichthys vacha</em></td>
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<td><em>(Hamilton)</em></td>
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<td><em>Channa marulius</em> (Hamilton)</td>
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<td><em>Channa punctatus</em> (Bloch)</td>
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<td><em>Channa striata</em> (Bloch)</td>
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<td><em>Amphipnous cuchia</em> (Hamilton)</td>
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<td>Species</td>
<td>baculis (Hamilton)</td>
<td>Parambassis ranga (Hamilton)</td>
<td>Chanda nama Hamilton</td>
<td>Badis badis (Hamilton)</td>
<td>Nandus nandus (Hamilton)</td>
<td>Oreochromis mossambica (Peters)</td>
<td>Rhinomugil corsula (Hamilton)</td>
<td>Sicamugil cascasia (Hamilton)</td>
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### Table 3: Potentialities and problems of the wetlands in Assam

<table>
<thead>
<tr>
<th>Wetlands</th>
<th>Potentialities</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sone Beel</td>
<td>Biggest wetland in Assam, Continuous inlet, outlet, Big size IMCs naturally growing, Hilsa, Ideal site for rehabilitation of displaced fishermen</td>
<td>Inlet diversifications, Outlet diversification, Outlet blockade, Siltation, Mahajal operation, Paddy cultivation, Big size carnivorous fishes and exotic carps, day-in, day-out fishing operations, Fish disease (EUS)</td>
</tr>
<tr>
<td>2. Sat Beel</td>
<td>Near Rivers Barak and Madhura, Ideal site for culture fishery</td>
<td>Siltation, Weeds</td>
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<td>3. Malini Beel</td>
<td>Near River Barak, Ideal site for culture fishery and tourism</td>
<td>Siltation, urbanization</td>
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<td>4. Tapang Beel</td>
<td>Big natural Beel, good site for capture fishing</td>
<td>Siltation, encroachment of the Beel</td>
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<tr>
<td>5. Srikona Beel</td>
<td>Near River Barak, ideal site for culture fishery</td>
<td>Weeds</td>
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<tr>
<td>6. Dubria Beel</td>
<td>Ideal site for culture fishery</td>
<td>Siltation</td>
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<tr>
<td>7. Hatichhara Beel</td>
<td>Big size, ideal site for fish stocking</td>
<td>Turbidity, Tea garden effluents</td>
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<tr>
<td>8. Doloo Beel</td>
<td>Big size, ideal site for fish stocking</td>
<td>Tea garden effluents</td>
</tr>
<tr>
<td>9. Hotoir Beel</td>
<td>Potential site for culture fishery</td>
<td>Siltation, weeds</td>
</tr>
<tr>
<td>10. Karkari Beel</td>
<td>Potential site for culture fishery</td>
<td>Siltation</td>
</tr>
<tr>
<td>11. Sagar Beel</td>
<td>Potential site for culture fishery</td>
<td>Bad transport</td>
</tr>
<tr>
<td>12. Rani Meghna Beel</td>
<td>Potential site for culture fishery</td>
<td>Bad transport</td>
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<tr>
<td>13. Angang Beel</td>
<td>Potential site for culture fishery</td>
<td>Weeds</td>
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<tr>
<td>14. Deochhara Beel</td>
<td>Potential site for fish stocking</td>
<td>Weeds</td>
</tr>
<tr>
<td>15. Baua Beel</td>
<td>Potential site for culture fishery</td>
<td>Siltation, paddy cultivation</td>
</tr>
<tr>
<td>16. Chatla Haor</td>
<td>A very big Haor in Assam, Potential site for fish culture if water be retained, IMC and Hilsa juveniles</td>
<td>Siltation, Mahajal operation, Tea garden effluents</td>
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<tr>
<td>No.</td>
<td>Location</td>
<td>Description</td>
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<tr>
<td>17</td>
<td>Puneer Haor</td>
<td>Potential site for culture fishery</td>
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<tr>
<td>18</td>
<td>Bakri Haor</td>
<td>Near River Dhaleswari, Ideal site for capture fishery</td>
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<tr>
<td>19</td>
<td>Baskandi Anua</td>
<td>Potential site for IMC culture</td>
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<td>20</td>
<td>Algapur Anua</td>
<td>Potential site for IMC culture</td>
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<td>21</td>
<td>Silghat Anua</td>
<td>Potential site for IMC culture</td>
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<td>22</td>
<td>Rupairbala Anua</td>
<td>Potential site for IMC culture</td>
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<td>23</td>
<td>Dungripar Anua</td>
<td>Potential site for IMC culture</td>
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<td>24</td>
<td>Satkarakandi Anua</td>
<td>Potential site for IMC culture</td>
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<td>25</td>
<td>Ram Nagar Anua</td>
<td>Potential site for IMC culture</td>
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<td>26</td>
<td>Salchapra Anua</td>
<td>Potential site for IMC culture</td>
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<td>27</td>
<td>Fulbari Anua</td>
<td>Potential site for IMC culture</td>
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<td>28</td>
<td>Sibnarayanpur Anua</td>
<td>Potential site for IMC culture</td>
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<td>29</td>
<td>Ashiali Beel</td>
<td>Good site for capture fishery</td>
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<td>30</td>
<td>Ashiana Beel</td>
<td>Good site for capture fishery</td>
</tr>
</tbody>
</table>
Fig.2: Map of Barak valley region of Assam showing distribution of Wetlands
(1= Chatla Haor, 2= Baskandi Anua, 3= Salchapra Anua, 4= Hathichhara Beel, 5= Dolu Beel, 6= Puneer Haor, 7= Rupairbala Anua, 8= Fulbari Anua, 9= Sib Narayanpur Anua, 10= Bakri Haor, 11 Sone Beel, 12= Rata Beel, 13= Sagar Beel, 14= Angang Beel, 15= Tapang Beel, 16= Dubria Beel)
Figure 3 Boundary contour Map of Sone Beel showing FSL and DSL
Fig. 4: Riverine Network of North-East India
Plate 1: Some of the Fish Species affected by Epizootic Ulcerative Syndrome Fish Disease
Plate 2. Microbiological and Tissue Cultural Isolation of EUS Fish Virus
Plate 3: An Electron Micrograph of Picobirna Virus considered to be
The primary aetiology of EUS Fish Disease
Fig4: Georeferenced Map of Sone Beel

Showing Change Detection of the Wetland from 1880, 1980 to 2006
Plate I: Sone Beel at FSL and DSL
Plate II. Chatia Haor at FSL
Plate III: Baskandi Anua
Plate IV: Satkarakandi A tua