



WETLANDS, RIVERS, FISH, PLANKTON RESOURCES AND AQUACULTURE IN NORTH- EAST INDIA: AN OVERVIEW

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Abstract– India is blessed with myriads of water resources in the form of numerous rivers, streams, wetlands, lakes, etc. India has c 67,429 number of wetlands covering an area of c 4.1 million ha. Besides lotic territories, the lentic water bodies having 0.72×10^6 ha lake coverage in India, constitute great potential of fishery resources. The NE region 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 (0.12×10^6 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 FSL. Further, in Assam, there are c1392 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. Out of this, 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). Incidentally, on the basis of the research findings of the present author, Sone Beel was declared as a 'Wetland of National Importance' by the Ministry of Environment and Forests, Government of India on 16 October, 2008 (*vide* Resolution No. 11 dt. 16.10.2008, of MOEF Expert Group Meeting; and, also, Letter No. FRM 41/2008/63-A dt. 8.9.2008 from Commissioner and Secretary to the Govt. of Assam, Department of Forests).

The meandering rivers, which criss-cross the NE Provinces, have, through the ages, played a dominant role in shaping its history. 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. Both these mighty rivers have a number of tributaries forming an intricate network of Brahmaputra and Barak drainages. The former includes the rivers like Subansiri, Dhansiri, Kopili, Puthimari, Beki, Manas, Aai, etc.; while the latter includes tributaries like Jiri, Chiri, Madhura, Jatinga, Ghagra, Dhaleswari, etc.

Extensive ichthyological field survey conducted from 1996 to 2006 in the major rivers of Mizoram, Tripura and Barak

drainage (in Assam and partly in Manipur) revealed the occurrence of bewildering diversity of fishes. Of these, the rivers in Mizoram revealed 42 species in river Tuirial, 42 species in river Kolodyne, 31 species in river Karnafuli, 25 species in river Mat, 36 species in river Tlawng, nine species in river Tuirini, 14 species in river Serlui and 23 species in river Tuivai. The rivers in Tripura reflected 28 species in Manu, 22 species in Khowai, 53 species in Gomati, and 22 species in Feni. In Barak drainage, river

Barak portrayed 65 species (including collections from the proximity of its origin in Karong, Manipur), river Jatinga 61 species, river Sonai 54 species and river Dhaleswari 32 species. Declaration of 'aquatic sanctuaries' for the conservation of rare and endangered fishes like the mahseers have been strongly suggested in the paper. Further, the dreadful fish disease, called Epizootic Ulcerative Syndrome (EUS) has been causing large-scale mortality among the freshwater fishes since 1988 initially affecting four species of fishes very widely. Our study (Kar, 1988, 1989, 1990, 1993, 1995a, b, 2000, 2003, 2004, 2006, 2007a, b, 2010, 2012, 2013, 2014, 2015) revealed fluctuations in the intensity of disease in relation to species affected. Our further studies related to aspects like Limnology, chemistry, physics, bacteriology, mycology, and virology along with tissue culture and electron microscopy, revealed interesting findings including isolation of a virus. Details of the EUS in wetland fishes have been discussed in the communication. Our study had portrayed 25 species of fishes in Dolu lake, 34 species in Chatla Haor, 40 species in Karbhala lake, 31 species each in Awangsoi lake and Oinam lake, 33 species in Loktak lake and 32 species in Utra lake have been recorded during the study period. Study revealed that 22.72% of the fishes of Dolu lake, 5.76 % of Chatla Haor, 19.16 % of Karbhala lake, 23.83 % of Awangsoi lake, 33.86 % of Oinam lake, 49.75 % of Loktak lake and 48.8 % of Utra lake were found to be parasitized.

The present level of Annual Fish Production (AFP) is 1.81 lac metric tonnes (mt) against estimated demand of 2.81 lac mt. annually. At present, the deficit is met partially by



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importing fishes from other provinces. This is highly undesirable; because, it is not only rendering our resources uncared for; but also, at the same time, draining out a huge sum of capital from our province everyday; which, otherwise, could have been used for our own developmental purposes.

Hence, Integrated Fish Farming (IFF) Practice could be a promising method for reverting the situation. It is because the integration of Fish Culture with Livestock rearing holds great promise and potential for augmenting production of animal protein, betterment of economy and generation of employment in rural India.

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Keywords— Wetlands, Sone Beel, Rivers, Fishes, EUS, North-East India

INTRODUCTION

Principal wetlands in Barak valley region of Assam: Sone Beel (Biggest) (3458.12 ha), Rata Beel, Sagar Beel, Rani-Meghna Beel, Angang Beel, Medha Beel, Tapang, Duberi Beel, Bishali Beel, Dholi Beel, Gudi Beel, Lora Beel, Narapati Beel, Jabhda Beel, Karkari Beel, Jonamara Beel, Sushka Beel, Charua Beel, Auti Bauti Beel, Raua Beel, Petua Beel, Atoa Beel, Sundarkuri, Mahishatal, Deochhara Beel, Asinia Beel, Dhalchhara Beel, Hatichhara Beel, Doloo Beel, Chatla Haor, Bakri Haor, Puneer Haor, Baskandi Anua, Rupairbala Anua, Dunglepar-Kaptanpur Anua, Satkarakandi Anua, Ram Nagar Anua, Baraknadi-Salchakra Anua, Fulbari Anua, Sibnarayanpur Anua (Kar, 2007, 2013).

A detailed account of the biggest wetland in Assam, viz., the Sone is given below as a typical example of a wetland in this region.

Sone Beel: Sone Beel, situated at 23 m MSL, between 92° 24' 50" – 92° 28' 25" E and 24° 36' 40" – 24° 44' 30" N within Karimganj district of Assam, is the biggest wetland in Assam and falls in a valley geologically called syncline.

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 the Badarpur line of folding; while, there is the Chargola anticline towards the west. A typical geomorphological feature is the tight folded-ness of the anticlines represented by hillocks having very high dips of the sedimentary beds. 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 wetland 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.

The principal feeder of Sone Beel is the major inflow, the river Singla which drains a total catchment area of c 46,105 ha. The wetland also 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.

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

The area of Sone Beel at FSL 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



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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 $101.54 \times 10^6 \text{ m}^3$.

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 $87.03 \text{ m}^3 \text{ sec}^{-1}$ in Aug 2008; while, the maximum inflow was recorded to be $33.91 \text{ m}^3 \text{ sec}^{-1}$ in July 2008. Concomitantly, the minimum inflow and outflow of the wetland were recorded as $0.0027 \text{ m}^3 \text{ sec}^{-1}$ and $0.087 \text{ m}^3 \text{ sec}^{-1}$ (both in Feb 2008).

Aquatic Macrophytes (AM): AM was found to exhibit a heterogeneous assemblage of 23 species in Sone Beel. Association of different species of AM, forming phyto-social units, are generally encountered in Sone Beel. the wetlands. In Sone Beel, among the floating varieties, *S.cucullata* and *A.pinnata*; and, *N.cristatum* and *N.indicum* were found to form distinct phyto-social units. Among the emergent varieties, *E.acutangula* and *S.trifolia*; and, *S.eriophorum* and *E.stagnina* were found to be associated together. Among the submerged types, *H.verticillata*, *V.spiralis* and *N. alternifolia* were found to make an association. Interestingly, *T. bispinosa*, the floating form, also, exhibited association with this group. Further, *E.crassipes* and *E.ferox* were found to remain solitary and thus formed mono-specific unit.

PLANKTON COMMUNITIES: Plankton, the living fraction of material, found in water and move passively by wind or current, is composed of bewildering varieties of microscopic organisms. The 'phytoplankton', are predominantly autotrophic, are the primary producers of organic matters in the aquatic habitats. The nutritionally dependent animal component constitutes the 'zooplankton'.

Phytoplankton: The phytoplankton, though stands on the baseline of many food webs, in the aquatic

environment, is, in turn, dependent on the activities of other microbial organisms, notably bacteria, which convert organic material into inorganic nutrients required by the plants. The phytoplankton, found in this region, could, broadly, be classified into the following groups:

- i. Cyanophyta
- ii. Euglenophyta
- iii. Chlorophyta
- iv. Chrysophyta (which includes the Diatoms)
- v. Pyrrophyta

Zooplankton: The zooplankton, which are the primary consumers in the ecosystem, include many varieties. While some spend only a part of their lives drifting at the surface, others are found to extend to the deeper waters than the phytoplankton do. Many of them make daily sojourns between layers.

The zooplankton, which occur in this region, could broadly be classified into the following groups:

- i. Protozoa
- ii. Rotifera
- iii. Cladocera
- iv. Copepoda
- v. Ostracoda

The NE-region in general and Assam in particular, is gifted with a bewildering diversity of limnoplankton distributed spatially and vertically in enormous number of lentic and lotic systems, spread across the length and breadth of the region. The limnoplankton serve as potential food and nutritional supplement for the fishes of the region.

Studies conducted extensively and intensively in the region covering approx. 270 wetlands and 58 rivers, covering the provinces of Assam, Meghalaya, Mizoram, Tripura, Manipur, Nagaland, Arunachal Pradesh and Sikkim (Kar, 2007, 2013) revealed general abundance of *Brachionus* sp., *Lecane* sp., *Trichocerca* sp., *Filinia* sp., among the Rotifers; *Bosmina* sp., *Bosminopsis* sp., *Moina* sp., *Alona* sp., *Chydorus* sp., *Dadaya* sp., *Pleuroxus* sp., *Ceriodaphnia* sp. among the Cladocerans; *Cyclops* sp., *Diaptomus* sp., among the Copepods. However, plankton in few wetlands have been discussed in the present communication with the aim of brevity.



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Limnoplankton of Sone Beel: 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. 19 different forms of zooplankton, belonging to five groups, have been recorded 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. (Dey and Kar, 1994).

There is a bewildering diversity of fishes in the lentic systems of this region. The data for annual fish yield were extrapolated from daily catch statistics recorded at all the landing stations of the Beel (FAO, 1974) while the trend and cyclic variations were constructed by applying 12 month's moving average method (Coxton and Cowden, 1950).

An account of Zooplankton of Chatla Haor Wetland (Kar and Barbhuiya, 2004): Studies conducted in *c* 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 *c* 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 zooplankton count was found to be 68 ± 45 units/litre (Kar and Barbhuiya, 2004).

Ichthyospecies of Sone Beel: Of the 70 ichthyospecies, 84.2 % belong to the Primary FW group while the rest are of peripheral class. The annual fish yield from the Beel was determined as 358.21 mt during 1979-80 and 312.16 mt during 1980-81 having an annual average yield of 355.18 mt. Per hectare fish yield was determined as 103.5 and

90.26 kg respectively during the investigating years (Kar, 1990). The present data show a declining trend revealing an annual average yield of *c* 315.0 mt (Kar, 2003 a). Inconsistent trend of natural recruitment in such water bodies (Dey, 1981) coupled with higher catches in the turbid water might be the causative factor for higher yield during the first year. The forage fish containing mainly the cyprinids and chandids which constitute the bulk landing, could have gained ascendance over the predatory catfish to add further reasons to such propositions. The fish yield from Sone Beel appeared to be low as compared to 250 kg/ha obtained by Vaas and Schurman (1949) in some tropical FWs of Java. Further, Jhingran and Tripathi (1969) had recorded the range of fish yield from the Indian reservoirs to be as low as 6-7 kg/ha/year.

The constant deposition of silt reduces the living space of fish and fishes in the shallower areas become vulnerable (Welcomme, 1979). This has impacts on the production through an eventual diminution of the water spread area (Kar, 1990). Moreover, the lake soil with pH 5.0 to 5.9, organic carbon 0.25 to 1.74%, available phosphorus 0.15 to 1.93 %; and, water with pH 6.0 to 7.9 and dissolved oxygen 2.4 to 5.9 mg/lit were not very suitable for fish production (Banerjee, 1967; Michael, 1969). Also, dense strands of aquatic macrophytes, often known to bind up nutrient materials, thus, could result in reduction of natural food availability for the fish and lead to poor fish yield (Bennet, 1962). Further, as an attempt to increase fish yield (Fernando and Furtado, 1975) by introduction of *Cyprinus carpio* into the Beel, there have been adverse effect on the autochthonous ichthyofauna of the Beel which could well account for overall poor yield from Sone Beel (Dey and Kar, 1990). On the basis of the earlier research findings, Sone Beel (Kar, 2007, 2013) was declared as a 'Wetland of National Importance' by the Ministry of Environment and Forests, Government of India on 16 October, 2008 (*vide* Resolution No. 11 dt. 16.10.2008, of MOEF Expert Group Meeting; and, also, Letter No. FRM 41/2008/63-A dt. 8.9.2008 from Commissioner and Secretary to the Govt. of Assam, Department of Forests).

Potentials of Sone Beel: i). Very big size; ii). Continuous inlet and outlet; iii). High fish yield, IMC naturally growing, also could be cultured;



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iv). Occurrence of Hilsa; v. Ideal site for rehabilitation of fishermen.

Major Problems of Sone Beel in Assam: (a) Inlet(s) diversification; (b) Outlet(s) diversification; (c) Outlet(s) blockade(s) (d) Siltation; (e) Mahajal (enormous encircling gear) operation; (f) Paddy cultivation; (g) Big size carnivorous fishes; (h) Availability of exotic fishes; (i) Day-in and day-out fishing operations; (j) Fish disease, particularly Epizootic Ulcerative Syndrome (EUS).

(a) Problems with regard to siltation and shrinkage: As a typical example, study, using GIS Geomatica Version 10, showed that 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 of Sone Beel (Kar, 2012). This is the fate of other wetlands as well. Extensive deforestation coupled with soil erosion had been leading to large scale siltation of the 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 (Kar, 2007).

Deepor Beel: This is a perennial FW wetland, located between 26° 05' - 26° 09' N and 91° 36' - 91° 45' E, about 10 km SW of Guwahati city, in Kamrup district of Assam, India. It is situated at a surface elevation of 53 m MSL and has a total area (waterspread + others) of 4014 ha (40.1 km²) at FSL and 10.1 km² at DSL. However, an area of 414 ha has been declared as "Deepor Beel Sanctuary" by the Government of Assam. It has a maximum depth of 4 m at FSL about 1 m at DSL. It has been declared as a Ramsar wetland in November 2002. It is categorised as representative of the wetland type under the Burma Monsoon Forest biogeographic region. About 1200 families in 14 villages live around Deepor Beel.

The Beel is bounded by steep highlands on the north and south. The Beel, and its adjoining areas were, perhaps, abandoned channels of the Brahmaputra river system. The Beel soil represents recent alluvium consisting of clay, silt, and sand while the highlands around the Beel are made up of gneisses and schists of the Archaean age.

The Rivers of South Assam, Mizoram and Tripura in North-East India: The meandering rivers, which criss-cross the NE Provinces, have, through the ages, played a dominant role in shaping its history. 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. Originating in a Himalayan glacier, and after traversing c 1600 km in Tibet, the Tsangpo, as the Tibetans call the river, cuts the Himalayas and enter Arunachal Pradesh as Siang. Two other rivers, viz., Dibong and Lohit, join the river Brahmaputra; and, the main river, thus replenished, flows down the Assam plains as the River Brahmaputra.

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 Baleswar 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



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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.

In Assam

River Sonai: It is a 4th order stream which originates from Mizo Hills as river Tuirial. The study sites lied between geographical limits of 24° 34' 36.4" N and 92° 53' 47" E at altitude ranging from 25-39 m MSL. The rate of flow of the river varied from 15-37 rev/10 sec. However, the surface water depicted maximum flow of 47 rev/10 sec by the flow meter. The valley segment is of alluvial type while the reach is of regime type. As such, the river is generally highly turbid during the rainy season and fishes are sometimes found gulping due to little asphyxiation (Kar, 2003a, 2005a; Kar, *et al.*, 2002 a).

The river Sonai is seasonally flooded due to intermittent rains. The river sometimes shows roots of plants along the bank. A peculiar feature portrays undercut banks on the outside of the curves and sand bars on the inner side. Patches of overhanging vegetation provides shelter for fishes. Reaches were selected both in the plainwater downstream region as well as in the rheophilic little upstream region.

More recent studies (Kar, 2005a) revealed small rivulets, viz., Jorkhal and Nagakhal, joining the main river Sonai from the surrounding catchment. Gravels and cobbles formed the principal component of the substratum of these rivulets; which, along with higher transparency (as compared to the main river Sonai) and faster flow of water, probably, paved the way for some fishes to migrate locally from the main river to these rivulets.

The river Sonai joins the **river Rukni** (flowing down from Mizo Hills as River Serlui) around the village Palonghat and the combined flow, as river Sonai, joins the river Barak around the village Kaptanpur in Sonai Revenue Circle in Cachar.

River Jatinga: It is a 2nd order stream which originates from the North Cachar (NC or Dima Hasao) Hills in Assam and flows down the side of Jatinga village. It is one of the North bank tributaries of river Barak. The reach type is mainly pool-riffle to braided-type; while, the valley segment of the river is colluvial to alluvial type. Bedrocks, boulders, cobbles, gravels and fine sand form the main components of the river substratum. The study spots (selected reaches) of the river were situated within the geographical limits of 24° 57' 49.4" N and 92° 45' 41.3" E having an altitude of 19 m MSL on the average. The river is less entrenched (E/R : 3.06) possibly because the valley segment is V-shaped. Turbulence is the principal fish cover; while, small woody debris, overhanging vegetation and depth was also found to serve as fish cover. River Jatinga is of hydriparian type having riparian vegetation consisting mainly of herbs, shrubs and trees. There is an abundant population of *Polygonum* spp., *Sesbania* spp., and *Bambusa* spp. Dominant land use pattern includes human habitation, some amount of agriculture (mostly 'Jhum' or shifting cultivation) and some tea gardens, many of which are abandoned today mainly due to transportation problems. It is remarkable to note here that, not much soil erosion has been observed, which could be because of deforestation to a little lesser extent. However, recent earth-cuttings going-on in the gauge-conversion of the Indian Railways, from MG to BG is causing a lot of soil being deposited into the river bed sliding down from the surrounding hills leading to changes in the riverine habitat. Also, undercut banks are sometimes seen. Dominant riparian texture includes boulders and gravels. Flow rate of the river was found to be 56 rev/10 sec at the surface level and 23 rev/10 sec at a little deeper level; while, it was found to be 5 rev/10 sec at the deepest point (Kar, 2003a, 2005a; Kar, *et al.*, 2002 a).

In river Jatinga, vegetation, depth and bottom types vary according to gradient. The river is braided-type at some spots mainly because of accumulation of sand bars and boulders by the water current. The river has many logs and fallen trees which provide excellent shelter for fishes. Also, there are spots where the banks are deeply undercut and soil has eroded from the bank.

River Dhaleswari: This river is a 4th order river,



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which originates, as river Tlawng, from the Mizo Hills, around Lunglei. After flowing through a tortuous course through the Mizo Hills, this river enters the Barak valley region of Assam around a place called Ramnathpur (Gharmura), situated at a distance of *c* 30 km down from Bhairabi in Mizoram. The river is called Dhaleswari from the point it enters Barak Valley region of Assam. After flowing for about 25 km in Barak valley of Assam, the river had been blocked by a blind dam and the main flow of the river had been diverted at a village called Karichhara (near Katlichhara) as river Katakhal which joins the River Barak, on its south bank, after passing through villages Matijuri, Mohanpur, etc. The original river Dhaleswari, as a dead river from village Karichhara, also joins the river Barak, on its south bank, around the place called Panchgram where the Cachar Paper Mill (of the Hindustan Paper Corporation) is situated. Incidentally, the Hailakandi town is situated on the bank of (now) dead river Dhaleswari. The study sites in these rivers were situated between the geographical limits of 24° 57' 48.9" N and 92° 45' 41.1" E having an altitude of 16 m MSL on the average. The reach type is regime while the valley segment type is alluvial. 'Run' and 'mid-channel type' pools were the dominant micro-habitat types. The E/R is generally 2.27. The river is of riparian type with riparian vegetation type varying from herbs, shrubs and trees including grasses and quite a dense population of bamboos. The riparian soil texture is largely silt and clay on both the banks while the riparian land use pattern is mainly human habitation, agriculture and tea gardens. The river substratum consists mostly of silt and fine sand with a large amount of clay. Signs of erosion are seen quite frequently. The water current was measured as 5.0 rev/10 sec on the average. There is not much natural fish cover and consisted mainly of turbulence, undercut banks and depth; but, not much overhanging vegetation. The total cover was estimated to be *c* 10 % (Kar, 2003a, 2005a; Kar, *et al.*, 2002 a).

Mizoram: The province of Mizoram (area 21,081 km²) is a beautiful terrain (maximum height *c* 2,743.90 m MSL) situated in the southern part of NE India bordering Bangladesh in the SW and Myanmar in the East having the Tropic of Cancer passing through it. Inhabited by a population of *c* 8,91,058 (2001 census), growth rate was found to be *c* 21.18 % (1991-2001); while, density/ km² was found to be

c 42. *c* 85 % of the rural mass are engaged in various kinds of agricultural practices including fisheries. The province has *c* 24,000 ha of cultural fishery resources and *c* 6000 ha of riverine water spread area which is spread over *c* 1100 km² of riverine stretches. *Per capita* availability of fish per annum is only *c* 3.01 kg. The major rivers of Mizoram are the Tuirial, Tlawng, Tuirini, Tuivai, Mat, Kolodyne (Chhimtuipui), Tuichong, Karnafuli and Serlui. Of these, the rivers Tuirial, Tlawng, Tuivai and Serlui join the Barak drainage at different points of their course. A small river, called, Tuirini, also joins the river Tuirial. The river Chhimtuipui originates in Myanmar, flows northward along the Indo-Myanmar border for some distance, then, takes turn towards south to flow back to Myanmar again. This river, further, as river Kaladan, is said to have joined the the river Karnafuli in Chittogong district of Bangladesh after flowing through Indo-Myanmar-Bangladesh border The river Mat joins the river Chhimtuipui in Mizoram. The river Karnafuli, after originating from around Marpara region in the Mizoram-Tripura border, flows along the Mizoram-Bangladesh border; and, ultimately, joins the Bay of Bengal in Bangladesh. In addition to the lotic systems, there are few lentic bodies in Mizoram. The prominent among those are the following:

Lentic bodies

(a) Tum Dil Lake near Saitual; (b) Rih Dil Lake near Champhai along Indo-Myanmar border; (c) Palak Dil Lake near Tuipang along Indo-Myanmar border; (d) Rengtlang Dil Lake near Parva along Indo-Bangladesh border

An account of Tumdil Lake is briefly given below:

Tum Dil: It is one of the very few perennial wetlands in Mizoram situated at a distance of *c* 40 km away from Aizawl city. It lies between the geographical limits of 92-93° N and 22-24° E. It has a maximum length, breadth and depth of 0.73 km, 0.10 km and 6.5 m respectively. It has a water spread area of *c* 12.0 ha at FSL. It receives water mainly during the monsoon months from the surrounding catchment. There is no major inlet or outlet of the lake except few drains. This lake is under the joint management of departments of Fisheries and Tourism of the Govt.



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of Mizoram. In Tum Dil, the land use pattern involves mainly pisciculture and horticulture. Among the practices in Animal Husbandry, it is mainly poultry farming with little amount of cattle farming. There is much amount of naturally-occurring farm forestry as well as much amount of support area of forests around these wetlands. However, there is not enough of grazing in view of not a big population of cattle being available. Concomitantly, the amount of pasture land is also limited. The source of pollutants in these wetlands is mainly horticultural wastes and refuges as well as domestic sewage and effluents from the surrounding human habitations (Kar, 1998).

Lotic systems: Among the many rivers, an account of river Tuirial is given below:

River Tuirial: It is a 3rd order stream which originates from around Serchip region of Mizo Hills and is formed by the union of two 2nd order streams, viz., Chite and Zelhui. After following a tortuous course in Mizo Hills, it enters the Barak valley region of Assam as river Sonai and merges with another river called Rukni (river Serlui in Mizoram) around village Palonghat. The combined flow joins the river Barak in its south bank near the village Sonaimukh (Kar, 2003a, 2005a; Kar, *et al.*, 2002 a).

The study spots in this typical hill stream are situated in Mizoram between the geographical limits of 22° 23' 45.5" N and 92° 57' 59.9" E and at altitude ranging from 500 m to 920 m MSL. The reach type is cascade to pool-riffle type. The valley segment is mostly of colluvial type. Falls, cascades, riffles, eddy pools and mid-channel pools constitute the diversity of micro-habitat types in this river. The E/R of the river is, generally, 8.35. Tuirial is a mesoriparian type of river with riparian vegetation consisting of herbs, shrubs and trees. Herbs include different types of grasses and a rich population of bamboos; while, teak (*Tectona grandis*) forms a rich component of bank vegetation. There is also a very big abundance of *Saccharum* spp. almost all along the river bank. The riparian soil texture is generally dominated by gravels and cobbles with some amount of boulders and few bedrocks. The riparian land use pattern consists mainly of human habitation, agriculture ('Jhum') and plantations. The water current is generally 28 rev/10 sec on the average. Fish covers

include mostly turbulence and undercut bank; while, depth and vegetations also serve as fish covers in some spots. The total cover in some area could be c 30 %. The river substratum was found to consist mostly of gravels and cobbles and also some boulders and few bedrocks. Signs of soil erosion was seen to be quite significant in some portions with accumulation of heaps of silt and sand on the river bank (Kar, 2007).

Tripura: The province of Tripura is flanked by both hills and plains having four principal rivers flowing through its terrains, viz., (a) River Monu, (b) River Khowai, (c) River Gomati, (d) River Feni. In addition to above, there are other little smaller rivers, viz., (e) River Howrah, (f) River Deo, (g) River Muhuri. Of these, the rivers Monu and Gomati originate from the Longtarai Hills while the river Khowai originates from the Atharamura Hill ranges. The river Feni is said to also originate from the escarp of the Chittagong Hill tracts and flows down beside the village Shilachhari along the Indo-Bangladesh border. The river Howrah originates from the Baramura Hill ranges.

Notwithstanding the lotic systems mentioned above, there are a number of lentic bodies in Tripura. Some of these lentic bodies are called by the word 'Sagar', meaning 'tank', which are said to have been constructed by the Monarchs who had ruled Tripura (Tiperrah) once upon a time. Some of the lentic bodies are cited below:

Kurti Beel: This wetland is situated within the geographic boundary of 92° 15' E to 24° 45' N in the Kadamtala Block of North Tripura near Churaibari on the Inter-state border of Assam and Tripura. It could be regarded as a classic example of a wetland which has reached almost the climax of siltation and eutrophication. It is situated c 30 km away from Dharmanagar town and c 110 km away from Silchar city along NH 44. The Beel has a maximum length, breadth and depth of 0.6 m, 0.3 m and 2.8 m respectively; and, a waterspread area of c 93.67 ha at FSL. Kurtichhara is the main inlet of the of the Beel while Kalanadi drains into the Thal river as the major outlet. The Beel also receives water from the surrounding catchment and domestic sewage through a number of small drains (Kar, 1998).



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Lotic bodies: An account of river Gomati, as one of the principal rivers of Tripura, is given below:

River Gomati: It is a 3rd order river which originates from Tirthamukh-Mandirghat Hills of South Tripura district and is one of the biggest rivers in Tripura. After flowing a tortuous course through Jatanbari, Natun Bazar, Amarpur Udaipur and Melagarh, it enters Bangladesh. Our study sites in this river are located between the geographical limits of 23° 30' 32" N and 91° 28' 38" E at an altitude of 41 m MSL on the average. The reach type is regime while the valley segment is mostly alluvial. The micro-habitat types include riffles, runs, eddy pools and debris pools. Nevertheless, cascades are seen in a small stretch of the upstream portion. There is quite a rich amount of overhanging vegetation. The total cover is generally c 20 % of the area of the habitat. Signs of erosion is significant at some spots with accumulation of silt and sand (Kar, 2003a, 2005a; Kar, *et al.*, 2002 a).

Awangsoi lake (24° 39'48"N and 93°46'90"E) is situated south of Keinou village in Bishnupur District, Manipur, about 22 km. away from Imphal city. It contains about 31 species of fishes belonging to 20 genera, 5 orders and 14 families.

An account of Disease and Health status of fishes with particular reference to EUS

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 reveal focal areas of increased fibrosis and chronic inflammatory cell infiltration in muscles; and focal areas of fatty degeneration of hepatocytes surrounding the portal triads in the liver. Preliminary Histochemical (HC) studies with regard to interruption in glycogen synthesis and blockade of respiratory pathways are being conducted. Similarly, preliminary enzymological studies are being conducted with regard to amount of Alkaline Phosphatase, SGOT, SGPT, LDH. Inoculation of 10 % tissue homogenate of EUS-affected *Clarias batrachus* into 80 % confluent monolayer form BF2 fish cell line in Leibowitz L-15 medium, revealed progressive CPE which was passable in subsequent cultures; thus, indicating the 'isolation' of virus (Kar, 2007, 2015).

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.

The present level of Annual Fish Production (AFP) is 1.81 lac metric tonnes (mt) against estimated demand of 2.81 lac mt. annually. At present, the deficit is met partially by importing fishes from other provinces. This is highly undesirable; because, it is not only rendering our resources uncared for; but also, at the same time, draining out a huge sum of capital from our province everyday; which, otherwise, could have been used for our own developmental purposes.

Hence, Integrated Fish Farming (IFF) Practice could be a promising method to revert the situation. It is because the integration of Fish Culture with Livestock rearing holds great promise and potential for augmenting production of animal protein, betterment of economy and generation of employment in rural India. Vincke (1976) reported combined production of 8000 kg of Fish and 6000-9000 kg of pigs / ha / year in ponds stocked with



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Tilapia niloticus @ 20000 fingerlings / ha in some African Countries. Chen and Li (1980) reported 3.5mt / ha / year of fish by raising 1500 ducks / ha in Taiwan. Ahmed *et al.* (1995) reported that several projects have been undertaken to assist farmers in fish culture in small water bodies in and around Bangladesh. Banerjee *et al.* (1979) reported a fish yield of 670 kg / ha / 90days from Poultry-cum-fish farming in India. Anon (1977) reported an average fish yield of 3,543 kg / ha / year from Integrated farms with intensive feeding and fertilization in Eastern India. Jhingran and Sharma (1980) reported a yield of 4,323 kg of fish / ha / year, 250 kg of ducks and 1,835 eggs from Integrated farms in India. The input consisted of 6,340 fingerlings/ ha of IMC and 100 ducks / ha in India. Edwards *et al.* (1983) reported that the highest production obtained so far in Integrated fish farming are with pigs, ducks and chicken, a very wide spread technique in India. Kar (2007) worked on various water bodies in North-East India with regard to their fish diversity and Fish yield. In Barpeta District of Assam, a common system among local tribals and fisherfolk for collecting fish and other aquatic resources from the paddies is in vogue. The yield of fish from such indigenous practice ranges from 25-280 Kg / ha / season, as reported by Das *et al.* (1996). Most of the rice farmers of Assam are small holders and have small ponds in their rice fields (measuring about 25-30 sq. m) locally called 'Pukhuri', as reported by Baruah (1999). According to the National Sample Survey Organisation, at present, only about 40 % of Indian population eat fish and the fish eating population is increasing slowly but steadily. About 8.5 million tonnes of fish are needed to meet the present demand but the production at present is 4.37 million tonnes from the marine and fresh water resources together. The domestic demand of fish, by the turn of this century, is projected to be 12.5 million tonnes, a half of which has to come from Inland Sector. However, the expected production of fish is only 6 million tonnes. To achieve this national goal, scientific understanding of all the water bodies supporting fisheries is imperative to back up their optimum exploitation. Integrated Fish Farming could also be a promising method to achieve this goal.

Integrated Fish Farming is a diversified and coordinated way of producing fish with non-fish such

as crops, poultry, pigs, ducks etc. The wise integration of these items in a fish farm promotes the full utilization of its land area and recycling of wastes and by-products, minimizes the operation expenses in feeds and fertilizers, improves the living conditions of the workers due to the increase of income and maintains a balanced ecosystem (NACA, 1989). The recent surge of interest in Integrated fish farming is due to the growing concern to maximize productivity through optimum utilization of resources in a most dynamic world undergoing rapid increase in population growth and diminishing per capita availability of resources.

Types of Integrated Fish Farming

i) Aquaculture–Horticulture: Where there is sufficient water, the integration of aquaculture and forestry into agriculture based farms provides an appropriate starting point for the design of regenerative farming systems.

ii) Paddy–cum–Fish Culture: Fish Culture in paddy fields is common in parts of Italy, Japan, Taiwan, Malaysia, etc. and to some extent in India. Over 80 million ha of land produce the world's supply of rice and in favorable situations at the end of the season, paddy–cum–fish culture yields c 3 kg or more of fish per ha for an inundation period of 3 to 8 months.

iii) Fish Culture–cum–Duckery: Fish–cum–duck farming is very common in China, Hungary, East Germany, Poland etc. This type of integration has been found to be quite compatible as the ducks feed on miscellaneous items of biota like insects, tadpoles, mollusks, etc. The duck droppings act as excellent fertilizer and the dabbling of ducks in the pond water in search of feed releases nutrients from the soil which enhance the pond's biological productivity and consequently increases the fish yields.

iv) Fish Culture–cum–Poultry Rearing: Inland fish culture in conjunction with poultry rearing is a compatible business and can provide an aqua-culturist a ready source of manure to fertilize the fish pond. In a larger sense, fish and poultry are mutually complementary, the former providing fish meal, a protein rich poultry feed, and the latter, through its droppings, fertilize the aquaculture ponds on which depends the production of plankton to serve as natural fish food.



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v) **Fish Culture-cum-Pig Farming:** Among the integrated fish culture system, pig-cum-fish culture is one of the most popular and profitable venture in our province. It is a fact that while fish fetches a good market price, there also exists a good pork market in our province. Pigsties are constructed either on the pond embankment or near the pond to facilitate easy drainage of waste directly into the pond, which acts as pond fertilizer and supports dense growth of natural fish food organisms. In case of indirect method of pig-cum-fish farming, there is no direct connection between pigsty and pond. In this case, pig dung are stored in a pit and applied as and when necessary. The size of the pond varies from 0.03 ha to 0.40 ha under integrated fish farming system organized by Assam Agricultural Competitive Project (AACP).

Three Integrated Pig-cum-fish farms of village Silcoorie namely Babul Saha's farm, Sudarson Das's farm and Hiralal Das's farm are not in practice now due to some unavoidable reasons. Recently, six Integrated Fish-cum-pig farms have been introduced in Village Dharamkhal under AACP scheme of Fishery Department in Cachar, Assam.

The Selected Integrated Fish Farms: A brief Profile

The works done were concentrated on Integrated Fish Farming around Silchar City. The area was chosen as least number of surveys had been done here. Eight Integrated Fish Farms were selected, four from village Silcoorie and other four from village Irongmara.

Silcoorie village is situated along the Assam University Road (Silchar) at an altitude of 39.6 m above Mean Sea Level (MSL). The annual rainfall is about 2728.07 mm. Maximum rainfall occurs during the period from May-September. The average maximum and minimum temperature are 30.63 °C and 20.02 °C respectively. Study revealed that more than 90 % of the inhabitants are fishermen belonging to the 'Kaibarta' community. In addition to this, more than 8 % is represented by others, notably the Tea garden workers. Study revealed that the fishery is an important source of livelihood in village Silcoorie.

Fish ponds ranged in size from 1 Bigha to 2.5 Bigha (1 Bigha = 1338.0 m²). The selected Integrated farms of Silcoorie rear poultry with fishery.

Integrated Farms in village Irongmara: Irongmara village is situated in the Cachar District, 23 km away from Silchar City and 10 km away from village Silcoorie. It is located at an altitude of 39.7 m above mean sea level. The annual rainfall is about 2,729.07mm. Maximum rainfall occurs during the period from May-September. The average maximum and minimum temperature are 30.74 °C and 20 °C respectively. Study revealed that more than 80 % of the inhabitants are fishermen belonging to the 'Kaibarta' community. The fishery is an important source of livelihood in this village too. The selected Integrated farms in village Irongmara rear piggery with fishery. The area has a great market demand for pig meat as well as fishes.

The integrated farms of village Silcoorie cited above sell their poultry to Silcoorie market, Silchar market after achieving the marketable size (600-1.5 kg). The integrated farms of village Irongmara cited above sell their piggery to Irongmara market, Dwarband market etc. after reaching the marketable size (45 kg - 1.5 quintal). The information regarding different heads mentioned above of integrated farms of village Silcoorie and Irongmara was compiled basing on interviews with respective farm owners, Associates, fish farmers, local people and respected members of the Fishery Deptt. Cachar, Assam.

ECONOMIC ANALYSIS IN THE FARMS

The integration of fish culture with pig farming and poultry farming from the economic point of view is much more viable. The combined cultures are mutually beneficial and hence the profitability will also significantly increase to a large extent. In this project work, greater emphasis was given on potentialities and prospects of different selected Integrated Farms of village Irongmara and Silcoorie.

Expenditure under different heads in different selected farms

The capital investment of different integrated farms differ from place to place. The land as well as the construction expenses are the two most



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important capital investments in the establishment of an Integrated fish farm. These costs are rapidly increasing and also other costs, such as, those for fish seeds, lime, piglets, chicks, pig-mash, poultry-feed etc. are also rising. But costs of production in Integrated Fish farming is less than simple fish farming as artificial fish feeds, fertilizers are not much required here.

The capital investment for selected Integrated farms in village Silcoorie consists of buying of fish seeds, lime, chicks, poultry feeds, medicine, labour cost, fish harvest cost, constructions cost, etc. The capital investment for selected Integrated farms in village Irongmara consists of buying of fish seeds, lime, piglets, pig-mash, medicine, labour cost, constructions cost, fish harvest cost, etc.

Annual fish and non-fish yield in different studied Integrated Farms

The mutual benefit of combined fish culture and non-fish (piggery, poultry etc.) raising is very difficult to assess with accuracy due to complex interaction in the pond ecosystem but the result has shown that this integration increases the production of both fish and non-fish and at the same time decreases the input cost of fish culture operations considerably. The selected integrated fish farms of Silcoorie rear poultry with fishery.

Each batch of chicks requires roughly 45 days for maturing. Thus, 8 batches of chicken can be reared along with one crop of fish during culture period of one year. The selected integrated fish farms of Irongmara rear piggery with fishery. The pigs attain slaughter maturity in about 6 months time. So, the system envisages harvest of two crops of pigs and one crop of fish during culture period of one year.

Expenditure and Income in different analysed Integrated Farms

Integrated Fish Farming is one of most popular and profitable ventures in Assam. It has become an important money-earning area where piscicultural and non-piscicultural works are done in a profitable

manner minimizing cost of their production. Thus, it also helps to improve rural development and rural economy.

Expenditure and Profit of Different selected Integrated Farms.

Study revealed that Integrated Fish Farming is more profitable, being an efficient technology than that of Simple Fish Farming and its cost of production is also less. Profit of any farm is measured by deducting expenditure from total income.

Experiments on Integrated Livestock fish farming have opened up a new horizon of high animal protein production at very low cost. In addition to providing cheap protein-rich food, integrated farming has proven to be an efficient means of waste disposal and has allowed savings on the use of inorganic fertilizer and supplementary feeds in fish production.

Indian Fisheries Sector is of immense economic importance in view of its extensive resources potential, employment opportunities to improve the Socio-economic condition of fishermen, promising export growth and providing animal protein for growing population.

On Global level, 85 % of world fish production comes from marine resources and 15 % from freshwater, while in India, the contribution of FW fish production was 29.33 % in 1950–51 which increased to 40.99 % in the year 1992–93.

In India, efforts are made to develop low-cost farming systems for Indian condition based on the principles of productive utilization of farm wastes and full utilization of available resources and manpower. In some pockets in the Districts of Kamrup, Nagaon, Morigaon, Cachar, Karimganj, Darrang and Barpeta, fish farming projects have been taken up on commercial basis. The present study conducted in 8 Integrated Farms (IFs) in Silcoorie and Irongmara villages, indicated the total Fish yield (FY) to be 10, 10, 10 and 2 Qtls respectively in the four Farms in Silcoorie while those in the four farms in Irongmara were 5.7, 8.3, 10.4 and 9.3 Qtls respectively. The IFs in Silcoorie integrate only poultry with fish while those in



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Irongmara integrate Fish with Piggery. As such, the poultry yields in the Silcoorie IFs were 137, 274, 48, 82 Qtls respectively while the yields of pigs in the Irongmara IFs were 4, 4.2, 5 and 4.2 Qtls respectively. The total annual recurring and non-recurring expenditure (in Rs/year) were 3,70,000; 7,95,000; 2,87,000 and 3,62,000 respectively in IFs in Silcoorie; while those in the Irongmara IFs were 47,966; 84,663.50, 84,529.50 and 67,238 respectively. The study further revealed that the total annual profit (in Rs/year) were 2,40,000; 3,85,000; 37,000 and 1,40,000 in Silcoorie IFs while those in the Irongmara IFs were 53,084; 36,486.50; 63,070.50 and 58,812 respectively.

The difference in fish yield in different Integrated Farms of village Irongmara and Silcoorie have been found to be largely dependent upon the physico-chemical characteristics of water. As fish growth depends greatly on the quality of the water used in the pond. And the quality of water depends upon factors like temperature, oxygen content, pH, turbidity, alkalinity etc. Study revealed that pond water having pH values from 6.5 to 8 is very suitable for fish culture. Study further revealed that ponds having depth range of 2-2.5 m, a temperature range of 20-30 °C and a DO value of 4.0 mg/lit are considered to be optimum for maximum productivity. In the present studies in the IFs in the two villages, turbidity of the pond water has been found to be a major problem. The farm owners take suitable steps to combat this problem

Differences in fish yield in different farms of Silcoorie and Irongmara was due to a variety of reasons, however, liming and fertilization with non-fish excreta should be perfect for better fish yield. Further, variation in piggery yield of different farms of village Irongmara could be due to various factors such as selection of variety of pigs to be reared, Feed quality, Rate of feeding etc. Hybrid variety (Hampshire, Yorkshire) of pigs having high growth rate are generally selected. They must be fed in the sty itself with balanced feed called pig-mash at the rate of 1-1.5 kg / pig / day.

Variation in poultry yield of different farms of village Silcoorie was due to different factors such as Improper housing, Feed quality, rate of feeding, lack

of proper knowledge regarding various diseases etc. Success in broiler production depends mainly on the efficiency of the farmer, his experience, aptitude and ability in the management of flock. The difference in expenditure and in profit of different Integrated Farms of village Silcoorie and Irongmara were because of management techniques followed by owners of respective farms, their knowledge regarding physico-chemical characteristic of water etc.

The Integrated fish farming is a very useful technology for the backward areas of the country and is the most effective possible way to help economically, the small and marginal farmers and poor fishermen who has a small holdings for crop production and few heads of livestock but surplus family labour to diversify their farm production to increase cash income, improve quality and quantity of food produced and exploit unutilized resources particularly labour and wastes. Study revealed that out of four farms of village Silcoorie Gourhari Das's Farm has showed less profit where as in the case of IFs of village Irongmara, Arun Bhuiya's Farm had showed less profit; while, the other studied farms had depicted profits. The annual profit of farms of Silcoorie was less because most of the farms were affected by Bird flue disease during 2007. The success in Integrated farming depends upon proper liming, fertilization of ponds, selections of fish and non fish, proper feeding etc. The water quality of ponds of IFs should be maintained by controlling non-fish dung discharge.

Problems in Integrated System: Most of the current integrated farm in south East Asia are operated in the traditional way without proper planning, modern technology or modern farm management techniques and rely on personal experience. Marketing is therefore a recurrent problem in years where demand is sufficient. Fish disease, non-fish disease constitute a further major problem with the farmers cannot solve by themselves since they have inadequate experience and knowledge and such knowledge is not as readily accessible as with other farm animals integrated. A further problem for farmer is the shortage of credit and working capital, which forces them to contact the middlemen for selling their products usually at losses. The selected integrated farms of village Silcoorie and



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Irongmara, explained to operate their farming on small or large scale without proper knowledge regarding modern technology, diseases etc. which had resulted in the variation of their annual profits.

Future Trends: Fish is relatively cheaper than other animal protein sources. Increase of food supply is essential to feed the growing population. But land is a limited resource and if more land is used for agriculture, the forestry will soon be reduced to a degree which will be harmful to the environment. Also, the cost of production could rise. Therefore, a method is needed to produce more food from existing agricultural land, and integrated farming offers a possible solution. Integrated farming will probably play a very important role in natural development, as well as in the national economy.

Research Needs: Although integrated farming has now been proved to be highly profitable, its practice remains very limited in scale. This is because the relevant scientific and technological information on diversification of methods is unavailable to farmers. To fill-in this gap, there must be a bridge between information sources and the farmers, perhaps through extension services. A multidisciplinary approach is needed, including technological, economic, social and political aspects, which are, interrelated. Any approach must, however, be relevant to national economic, social and environmental conditions and to the farmers' need.

Thus, investigations are required in rural areas of Assam where integrated fish farming is going on in a quite small scale without much knowledge of modern technology, etc. The selected areas around Silchar city need attention from people of modern civilization. To fight with world's 'Protein Hunger', Integrated Fish farming should be encouraged and managed on larger scale in a quite effective and profitable manner. The conclusions derived from the present study are briefly summarized below:

The current study revealed that the total annual recurring and non-recurring expenditures of different IFs of village Silcoorie were Rs 3,70, 000.00, 7,95,000.00, 2,87,000.00 and 3,62,000.00 respectively; while those in the Irongmara IFs were

Rs. 47,966.00, 84,663.50, 84,529.50 and 67,238.00 respectively.

The study indicated the total annual fish yield in the four farms in village Silcoorie were 10,10,10 and 2 Qtls respectively while those in the farms in village Irongmara were 5.7, 8.3, 10.4 and 9.3 Qtls respectively.

The study further revealed that the total annual non-fish (poultry) yield in four farms in village Silcoorie were 137, 274, 48 and 82 Qtls respectively while the non-fish (piggery) yield in four IFs in village Irongmara were 4, 4.2, 5, and 4.2 Qtls respectively.

The study displayed that the total annual profit in four IFs in village Silcoorie were Rs, 2, 40, 000.00; 3, 85, 000.00; 37,000.00 and 1, 40, 000.00 respectively while those in 4 IFs in village Irongmara were Rs 53,084.00; 36, 486.50; 63,070.50; and 58,812.00 respectively.

Notwithstanding the above, the NE India is very rich in diverse types of water bodies. And, the water bodies, both natural and man-made, could serve as potential habitats for aquaculture.

Select References

- Darlington, P.J. (Jr.) (1957). Zoogeography: The Geographical Distribution of Animals, pp. 675, John Wiley and Sons (New York).
- Das, B and Kar, D. (2011). Essentials of Limnology and Fishery Science, pp. 190, Mangalam Publishers (New Delhi).
- Dey, S.C. (1973). Studies on the Distribution and Taxonomy of the Ichthyofauna of the hill streams of Kamrup-Khasi-Garo Regions of Assam with special reference to the Functional morphology of some rheophilic Fishes, D.Sc. Thesis, xi + 299, University of Calcutta (India).
- Dey, S.C. and Kar, D. (1987). Physico-chemical Complexes of Water and Soil in Sone, an Ichthyologically potential tectonic lake of Assam. J. Assam Sci. Soc., 30 (1): 1-11.
- Dey, S.C. and Kar, D. (1989 a). Aquatic Macrophytes of Lake Sone in Assam. Environment



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and Ecology, 7 (1) : 253-254.

Dey, S.C. and Kar, D. (1989 b). An account of *Hilsa ilisha* (Hamilton) of Lake Sone in the Karimganj district of Assam. Bangladesh J. Zoology, 17 (1): 69-73.

Dey, S.C. and Kar, D. (1989 c). Fishermen of Lake Sone in Assam: Their socio-economic status. Science and Culture, 55 : 395-398.

Dey, S.C. and Kar, D. (1990). Fish yield trend in Sone, a tectonic lake of Assam. Matsya, 15-16: 39-43.

Dey, S.C. and Kar, D. (1994). Phytoplankton dynamics of Lake Sone in Assam. Bull. Life Sciences, IV : 49-54.

Dhar, N. (2004). Certain aspects of Limnology and Fishery of Baskandi Lake in the Cachar district of Assam, pp. 165, PhD Thesis, University of Gauhati (Assam).

Dhar, N.; Goswami, M.M.; and Kar, D. (2004 a). Aquatic Macrophytes in Baskandi Lake, an Oxbow Lake of Barak Basin, Assam. Environment and Ecology, 22 (Spl.4):606-608.

Dhar, N.; Goswami, M.M.; and Kar, D. (2004 b). Cooperative Movement: Need for the hour in Capture Fishery sector: pp. 113-116. In: Cooperative Movement in Assam: Problems and Prospects (Eds.) Goswami, P.J. and Acharjee, P.R., pp. xiv + 124, G.C. College Employees' Credit and Thrift Cooperative Society Ltd. (Silchar).

Govt. of Assam (2006). Statistical Handbook of Assam. Directorate of Economics and Statistics, pp. xv + 308, Govt. of Assam (Guwahati).

Jayaram, K.C. (1999). The Freshwater Fishes of the Indian Region, xvii + 551, Narendra Publishing House (Delhi).

Kar, D (2013) Wetlands and Lakes of the World, pp. xxx + 687, Springer (London), Print ISBN 978-81-322-1022-1; e-Book ISBN: 978-81-322-1923-8

Kar, D. (2015). Epizootic Ulcerative Fish Disease Syndrome. (Elsevier, USA) ISBN: 9780128025048.

Kar, D. (1990). Limnology and Fisheries of Lake Sone in the Cachar district of Assam (India), Matsya, 15-16: 209-213.

Kar, D. (1996). Biodiversity Conservation Prioritisation Project (BCPP) in India. Proc. International Project Formulation Workshop of BCPP, World Wide Fund (WWF) for Nature-India, 1 (New Delhi).

Kar, D. (1998). Biodiversity Conservation Prioritisation Project (BCPP) in India. Proc. International Project Finalisation Symposium of BCPP, World Wide Fund (WWF) for Nature-India, 1: New Delhi.

Kar, D. (2000). Present status of Fish Biodiversity in South Assam and Tripura: pp.80-82. In: Fish Biodiversity of North-East India (Eds.) Ponniah, A.G. and Sarkar, U.K., NBFGR-NATP Publication No. 2: pp.228 (Lucknow).

Kar, D. (2002). Present status of Biodiversity of Fishes of Barak valley region of Assam with a note on their Management and Conservation, pp. 3-10. Proc. UGC-Sponsored State-level Seminar on Biodiversity of Assam, Session Chairman's Lecture, 30 Jan 2000 (Eds.) Bhattacharjee, M.K.; Dattachoudhury, M.; and Mazumder, P.B., Karimganj College, Assam University (Assam).

Kar, D. (2005 a). Fish Genetic Resources and Habitat Diversity of the Barak drainage: pp. 68-76. In: Aquatic Ecosystems, Conservation, Restoration and Management (Eds.) Ramachandra, T.V.; Ahalya, N.; and Rajsekara Murthy, C., xiii + 396, Capital Publishing Company (Bangalore).

Kar, D. (2005 b). Fish Diversity in the Major Rivers in Southern Assam, Mizoram and Tripura: pp.679-691. Proc. 2nd International Symposium on GIS and Spatial Analyses in Fisheries and Aquatic Sciences, 2-6 Sep 2002, University of Sussex, Brighton (UK), (Eds.), Vol.2, Nishida, T.; Kailola, P.J.; and Hollingworth, C.E. Fisheries and Aquatic GIS Research Group, Kawagoe, Saitama (Japan).

Kar, D (2007). Fundamentals of Limnology and Aquaculture Biotchnology, xiv + 609, Daya Publishing House (New Delhi).



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- Kar, D (2010). Biodiversity Conservation Prioritisation, pp. xi + 167, Swastik Publications (New Delhi).
- Kar, D. (2012 a). Essentials of Fish Biology, pp.vii + 244, Dominant Publishers, (New Delhi).
- Barbhuiya, A.H. and Kar, D. (2012). Treatise on Mahseer Fishes, , pp. vii + 293, Dominant Publishers, (New Delhi).
- Kar, D. (2012 b). Taxonomy, BSc, MSc, NET, SLET, pp. 102, APH Publications (New Delhi)
- Kar, D. (2013). Wetlands and Lakes of the World. Pp xxxv+687, Springer, (London).
- Kar, D. and Dey, S.C. (2002). On the occurrence of Advanced fry of *Hilsa (Tenualosa) ilisha* (Hamilton-Buchanan) in Chatla Haor Seasonal wetland of Assam. Proc. Zool. Soc. Calcutta, 55 (2) : 15-19.
- Kar, D. and Barbhuiya, M.H. (2000). Ichthyodiversity of Chatla Haor: A Floodplain wetland in Barak valley Region of Assam: pp.3-6. In: Advances in Zoology and Environmental Degradation and Biodiversity, pp. 279 (Ed.) Pandey, B.N. and Singh, B.K., Daya Publishing House (New Delhi).
- Kar, D. and Barbhuiya, M.H. (2001). Ecology of Aquatic Macrophytes of Chatla Haor, a floodplain wetland in Cachar district of Assam. Environment and Ecology, 19 (1): 231-233.
- Kar, D. and Barbhuiya, M.H. (2002). Macrophytic diversity in certain Wetlands of Barak valley region of Assam: pp. 86-89. In: Restoration of Lakes and Wetlands (Eds.) Ramachandra, T.V.; Rajasekara Murthy, N.; and, Ahalya, N., pp. xxii + 400, Allied Publishers (P) Ltd. (Bangalore).
- Kar, D. and Barbhuiya, M.H. (2004). Abundance and Diversity of Zooplankton in Chatla Haor, a floodplain wetland in Cachar district of Assam. Environment and Ecology, 22 (1): 247-248.
- Kar, D.; Roy, A.; Dey, S.C.; Menon, A.G.K.; and, Kar, S. (1995). Epizootic Ulcerative Syndrome in Fishes of India. World Congress of In Vitro Biology, *In Vitro*, 31 (3) : 7 pp.
- Kar, D.; Dey, S.C.; Kar, S.; Michael, R.G.; and, Gadgil, M. (1996). Ichthyoecology, Management and Conservation Fish Resources of Lake Sone in Assam (India). Tiger Paper (FAO, UN), XXIII (3): 27-32
- Kar, D.; Dey, S.C.; Kar, S.; and, Ramachandra, T.V. (1999). Trawls of Lake Sone in Assam. J. Applied Zool. Res., 10 (2): 170-172.
- Kar, D.; Mandal, M.; Laskar, B.A.; Dhar, N.; and , Barbhuiya, M.H. (2000). Ichthyofauna of some of the oxbow lake in Barak valley region of Assam. Proceedings of the National Symposium on Wetlands and Fisheries Research in the New Millennium, 1: 16 pp.
- Kar, D.; Laskar, B.A.; Mandal, M.; Lalsiamliana; and, Nath, D. (2002). Fish Genetic Diversity and Habitat parameters in Barak drainage, Mizoram and Tripura. Indian J. Environment and Ecoplanning, 6 (3) : 473-480.
- Kar, D.; Dey, S.C.; and, Datta, N.C. (2003). Welfare Biology in the New Millennium, xx + 97, Allied Publishers Pvt. Ltd. (Bangalore).
- Kar, D. and Dey, S.C. (1986). An account of ichthyospecies of Lake Sone in Barak valley of Assam. Proc. All-India Sem. Ichthyology, 2 : 3 p.
- Kar, D. and Dey, S.C. (1987). An account of the Fish and Fisheries of Lake Sone in the Barak valley of Assam (India). Proc. Workshop Development of Beel Fisheries in Assam, 1 : 13 pp.
- Kar, D. and Dey, S.C. (1988). An account of Fish yield from Lake Sone in the Barak valley of Assam. Proc. Indian Sci. Congr., 75: 49 pp.
- Kar, D. and Dey, S.C. (1991). Gill nets in Lake Sone of Assam with their Economics and Impact on Fishery. J. Applied Zool. Res., 2 (2): 76-79.
- Kar, D. and Dey, S.C. (1993a). Variegated Encircling gears in Lake Sone of Assam. J. Appl. Zool. Res., 4 (2) :171-175.
- Kar, D. and Dey, S.C. (1993 b). Interrelationship and Dynamics of Fish Population of Lake Sone in Assam. Environment and Ecology, 11 (3): 718-719.



Lake 2016: Conference on Conservation and Sustainable Management of Ecologically Sensitive Regions in Western Ghats [THE 10TH BIENNIAL LAKE CONFERENCE]

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- Kar, D. and Dey, S.C. (1996). Scooping Gears of Lake Sone in Assam. *J. Applied Zool. Res.*, 7(1): 65-68.
- Kar, D. and Dey, S.C. (2000). Yield and Conservation of Indian major carps of Lake Sone in Assam. *Environment and Ecology*, 18 (4): 1036-1038.
- Kar, D. (1999 b). Microbiological and Environmental Studies in relation to Fish Disease in India. Gordon Research Conference, Connecticut, USA.
- Kar, D. (2000 b). Socio-economic Development of the Fisherwomen through Aquaculture with emphasis on Integrated Farming in the villages around Chatla Haor Wetland in Silchar, Assam. Seminar presented on DBT-sponsored Awareness Workshop on Biotechnology-based Programmes for Women and Rural Development, NEHU, Shillong, 1 : pp. 13-14.
- Kar, D. (2001). Species composition and distribution of Fishes in the rivers in Barak valley region of Assam and the Principal rivers in Mizoram and Tripura in relation to their Habitat parameters. Proc. National Workshop, NATP-ICAR Project Mid-term Review, 1 : Central Marine Fisheries Research Institute, Cochin, 25 p.
- Kar, D. (2002). Present status of Biodiversity of Fishes of Barak valley region of Assam with a note on their Management and Conservation, pp. 3-10. Proc. UGC-Sponsored State-level Seminar on Biodiversity of Assam, Session Chairman's Lecture, 30 Jan 2000 (Eds.) Bhattacharjee, M.K.; Dattachoudhury, M.; and, Mazumder, P.B., Karimganj College, Assam University (Assam).
- Kar, D. (2003 a). Fishes of Barak drainage, Mizoram and Tripura: pp. 203-211. In: *Environment, Pollution and Management* (Eds.) Kumar, A.; Bohra, C.; and, Singh, L.K., pp. xii + 604, APH Publishing Corporation (New Delhi).
- Kar, D. (2003 b). An account of the Fish Biodiversity in South Assam, Mizoram and Tripura along with a brief account of Epizootic Ulcerative Fish Disease Syndrome in freshwater fishes. UGC-sponsored Invited Lecture in Dept. of Environmental Engg., Guru Jambheshwar University, Hissar (Haryana).
- Kar, D. (2003 c). Peoples' Perspective on Fish Conservation in the Water bodies of South Assam, Mizoram and Tripura : pp. 325-328. In: *Participatory Approach for Fish Biodiversity Conservation in North-East India* (Eds.) Mahanta, P.C. and Tyagi, L.K., v + 412, National Bureau of Fish Genetic Resources (ICAR) (Lucknow).
- Kar, D. (2004). A Glimpse into the Fish Bioresources of North-East India with a note on their Management, Conservation and Biotechnological Potential. Proc. (Invited Lecture) DBT-sponsored National Symposium on Biodiversity Conservation and Sustainable Utilisation of Environmental Resources: Tripura University, 10-11 Jan., 2004: 9 p.
- Kar, D. (2004 a). Inventorying of Fish Biodiversity in North-East India with a note on their Conservation. Proc. National Conference on Fish and their Environment, 9-11 Feb 2004, B.A. Marathwada University, Aurangabad, 1.
- Kar, D. (2004 b). Conservation and Ichthyodiversity in the River Systems of Barak drainage, Mizoram and Tripura. Proc. National Symp. Management of Aquatic Resources for Biodiversity Maintenance and Conservation, 2-4 Feb 2004, J.N. Vyas University, Jodhpur, 1.
- Kar, D. (2005 a). Fish Genetic Resources and Habitat Diversity of the Barak drainage: pp. 68-76. In: *Aquatic Ecosystems, Conservation, Restoration and Management* (Eds.) Ramachandra, T.V.; Ahalya, N.; and, Rajsekara Murthy, C., xiii + 396, Capital Publishing Company (Bangalore).
- Kar, D. (2005 b). Fish Fauna of River Barak, of Mizoram and of Tripura with a note on Conservation. *J. Freshwater Biol.*, 16
- Kar, D (2007 a). *Fundamentals of Limnology and Aquaculture Biotechnology*, pp. xiv + 609, Daya Publishing House (New Delhi).
- Kar, D. (2007 b). Sustainability issues of Inland Fish Biodiversity and Fisheries in Barak drainage (Assam), in Mizoram and Tripura: pp.555-560. In: *Sustain Fish* (Eds) Kurup, Madhusoodana, B and



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- Ravindran, K., pp xii + 863, School of Industrial Fisheries, Cochin University of Science & Technology (CUSAT): Proceedings of International Symposium on 'Improved sustainability of Fish Production Systems and Appropriate Technologies for Utilisation', 16-18 March, 2005 (Cochin).
- Kar, D. (2007c). Lentic Fishery: Fishery of a Tropical Wetland (Beel) in Assam. *Science & Society* : 5(1): 53-72
- Kar, D. and Dey, S.C. (1982 a). *Hilsa ilisha* (Hamilton) from Lake Sone in Cachar, Assam. *Proc. Indian Sci. Congr.*, 69: 77 pp.
- Kar, D. and Dey, S.C. (1982 b). An account of *Hilsa ilisha* (Hamilton) of Sone Beel (Cachar district, Assam, India). *Proc. All-India Sem. Ichthyol.*, 2 : 3 pp.
- Kar, D. and Dey, S.C. (1986). An account of ichthyspecies of Lake Sone in Barak valley of Assam. *Proc. All-India Sem. Ichthyology*, 2 : 3 p.
- Kar, D. and Dey, S.C. (1987). An account of the Fish and Fisheries of Lake Sone in the Barak valley of Assam (India). *Proc. Workshop Development of Beel Fisheries in Assam*, 1 : 13 pp.
- Kar, D. and Dey, S.C. (1988). An account of Fish yield from Lake Sone in the Barak valley of Assam. *Proc. Indian Sci. Congr.*, 75: 49 pp.
- Kar, D. and Dey, S. (1988). Preliminary Electron Microscopic studies on Diseased fish tissues from Barak valley of Assam. *Proc. Annual Conference of Electron Microscopic Society of India*, 18 : 88 pp.
- Kar, D. and Dey, S.C. (1988 a). A critical account of the Recent Fish Disease in the Barak valley of Assam. *Proc. Regional Symp. On Recent outbreak of Fish Diseases in North-East India*, 1 : 8 pp.
- Kar, D. and Dey, S.C. (1988 b). Impact of Recent Fish Epidemics on the Fishing Communities of Cachar district of Assam. *Proc. Regional Symp. On Recent outbreak of Fish Diseases in North-East India*, 1 : 8 pp.
- Kar, D. and Dey, S.C. (1990 a). Fish Disease Syndrome: A Preliminary Study from Assam. *Bangladesh J. Zoology*, 18 : 115-118.
- Kar, D. and Dey, S.C. (1990 b). A Preliminary study of Diseased Fishes from Cachar district of Assam. *Matsya*, 15-16: 155-161.
- Kar, D. and Dey, S.C. (1990 c). Epizootic Ulcerative Syndrome in Fishes of Assam. *J. Assam Sci. Soc.*, 32 (2): 29-31.
- Kar, D. and Barbhuiya, M.H. (2005). Length-weight Relationship and Relative Condition Factor in *Hilsa ilisha* (Hamilton) of Barak drainage in Assam. *Indian J. Environment and Ecoplanning*, 10 (1).
- Kar, D. and Mazumdar, J. (2004). Biodiversity, Disease and Conservation of Fish Bioresources: A perspective. *Proc. National Workshop on Sci. and Tech. for Regional Development : Case for North-East India*, 3-6 Feb 2004, Tezpur University and I.I.T. Guwahati : 34 pp.
- Kar, D. and Das, M. (2004 a). Preliminary Histochemical studies with diseased fishes suffering from Epizootic Ulcerative Syndrome in Assam. *Proc. National Symposium for Management of Aquatic Resources for Biodiversity Maintenance and Conservation*, 1 : 27 pp.
- Kar, D. and Das, M. (2004 b). Preliminary Enzymological studies with diseased fishes suffering from Epizootic Ulcerative Syndrome in Fishes. *Proc. National Conference on Fish and their Environment*, 1 : 25 pp.
- Kar, D. and Sen, N. (2007). Systematic List and Distribution of Fish Biodiversity in Mizoram, Tripura and Barak drainage in North-East India. *ZOOs' Print Journal*, 22 (3): 2599-2607.
- Kar, D.; Dey, S.C.; Michael, R.G.; Kar, S.; and, Changkija, S. (1990 a). Studies on Fish Epidemics from Assam, India. *J. Indian Fisheries Association*, 20 : 73-75.
- Kar, D.; Bhattacharjee, S.; Kar, S.; and, Dey, S.C. (1990 b). An account of 'EUS' in Fishes of Cachar district of Assam with special emphasis on Microbiological studies. *Souv. Annual Conference of Indian Association of Pathologists and Microbiologists of India (NE Chapter)*, 8: 9-11.



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- Kar, D.; Dey, S.C.; Kar, S.; Bhattacharjee, N.; and Roy, A. (1993). Virus-like particles in Epizootic Ulcerative Syndrome of Fish. Proc. International Symp. On Virus-Cell Interaction: Cellular and Molecular Responses, 1 : 34 pp.
- Kar, D.; Dey, S.C.; Kar, S.; Roy, A.; Michael, R.G.; Bhattacharjee, S.; and Changkija, S. (1994). A Candidate virus in Epizootic Ulcerative Syndrome of Fish. Proc. National Symp. Of the Indian Virological Society, 1 : 27 pp.
- Kar, D.; Kar, S.; Roy, A.; and Dey, S.C. (1995 b). Viral Disease Syndrome in Fishes of North-East India. Proc. International Symp. Of International Centre for Genetic Engg. And Biotechnology (ICGEB) and the Univ. of California at Irvine, 1: 14 pp.
- Kar, D.; Dey, S.C.; and Kar, S. (1995 c). A Viral Disease among the Fishes of North-East India. Annual Congress on Man and Environment, National Environment Sci. Acad. And National Institute of Oceanography, 10 : 62 pp.
- Kar, D.; Dey, S.C.; Purkayastha, M.; and Kar, S. (1996 a). An overview of the Impediments in Conservation of Biodiversity of Lake Sone in Assam. Proc. Seminar on Conservation of Biodiversity in Indian Aquatic Ecosystems, JawaharLal Nehru University, New Delhi, 1.
- Kar, D.; Dey, S.C.; Roy, A.; and Kar, S. (1996 b). Viral Disease Syndrome in Fishes of India. Proc. International Congress of Virology, 10.
- Kar, D.; Purkayastha, M.; and Kar, S. (1996 c). Biodiversity Conservation Prioritisation Project: A case study from Sone Beel in Assam. Proc. National Workshop on Biodiversity Conservation Prioritisation Project (BCPP), World Wide Fund (WWF) for Nature-India and Centre for Ecological Sciences, Indian Institute of Science (Bangalore).
- Kar, D.; Saha, D.; Laskar, R.; and Barbhuiya, M.H. (1997). Biodiversity Conservation Prioritisation Project (BCPP) in Barak valley region of Assam. Proc. National Project Evaluation Workshop on BCPP, Betla Tiger Reserve and National Park, 1 (Palamu).
- Kar, D.; Saha, D.; and Dey, S.C. (1998 a). Epizootic Ulcerative Syndrome in Barak valley of Assam: 2-4. In: Project Report submitted and presented at the National Symposium of Biodiversity Conservation Prioritisation Project (BCPP) held at WWF-India, 18-19 Jan 1998 (New Delhi).
- Kar, D.; Dey, S.C.; and Roy, A. (1998 b). Present status of Epizootic Ulcerative Syndrome (EUS) in Southern Assam. Proc. Regional Project Initiation Workshop for NATP-ICAR-NBFGR Project, 1 : 9 pp.
- Kar, D.; Dey, S.C.; Kar, S.; and Roy, A. (1998 c). An account of Epizootic Ulcerative Syndrome in Assam: pp.1-3. In: Final Project Report of Biodiversity Conservation Prioritisation Project (BCPP). Submitted and presented at the International Project Finalisation Workshop of BCPP, 1, 22-28 April 1998 (New Delhi).
- Kar, D.; Dey, S.C.; and Roy, A. (1998 d). Fish Disease Diagnosis and Fish Quarantine problems in India and South-East Asia with particular emphasis on Epizootic Ulcerative Syndrome (EUS) fish disease problems. Proc. International Workshop on Fish Disease Diagnosis and Quarantine, Indian Council of Agricultural Research (ICAR)-Ministry of Agriculture (MoA), Govt. of India (GoI)-Network of Aquaculture Centres in Asia (NACA)-Food and Agricultural Organisation (FAO) of the United Nations (UN)-OIE, France: Held at the Central Institute of Freshwater Aquaculture (CIFA), 1.
- Kar, D. and Upadhyaya, T. (1998). Histopathological Studies of Fish tissues affected by Epizootic Ulcerative Syndrome in Assam. Technical Bulletin, XIII Convention and National Symposium of Indian Association of Veterinary Anatomists (IAAM), 11-13 Dec 1998, College of Veterinary Sciences, Assam Agricultural University (Guwahati).
- Kar, D.; Rahaman, H.; Barnman, N.N.; Kar, S.; Dey, S.C.; and Ramachandra, T.V. (1999 a). Bacterial Pathogens associated with Epizootic Ulcerative Syndrome in Freshwater Fishes of India. Environment and Ecology, 17 (4): 1025-1027.
- Kar, D.; Mandal, M.; and Bhattacharjee, S. (1999 b). Fungal Pathogens associated with Epizootic Ulcerative Syndrome in Fishes of Barak valley region



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- of Assam. Proc. 1st National Conference on Fisheries Biotechnology, CIFE, 1 : 34 pp.
- Kar, D.; Dey, S.C.; and Roy, A. (2000 a). Fish Genetic Resources in the Principal rivers and wetlands in North-East India with special emphasis on Barak valley (Assam), in Mizoram and in Tripura, with a note on Epizootic Ulcerative Syndrome fish disease. Proc. National Project Initiation Workshop of the NATP-ICAR World Bank- aided Project on 'Germplasm Inventory, Evaluation and Gene Banking of Freshwater Fishes', National Bureau of Fish Genetic Resources (NBFGR), Lucknow, 1 : 12 pp.
- Kar, D.; Mandal, M.; Laskar, B.A.; Dhar, N.; and , Barbhuiya, M.H. (2000 b). Ichthyofauna of some of the oxbow lake in Barak valley region of Assam. Proceedings of the National Symposium on Wetlands and Fisheries Research in the New Millennium, 1: 16 pp.
- Kar, D.; Dey, S.C.; Roy, A.; and, Mandal, M. (2000 c) Epizootic Ulcerative Syndrome Fish Disease in Barak valley region of Assam, India. Proc. Nat. Symp. Current Trends in Wetlands and Fisheries Research in the New Millennium, 1 : 2 pp
- Kar, D.; Dey, S.C.; Mandal, M.; and, Lalsiamliana (2000 d). Epizootic Ulcerative Syndrome among the fishes of Assam. In: Proc. National Workshop of NATP-ICAR-NEC North-East Programme, Shillong, 1 : 24 pp.
- Kar, D.; Mandal, M.; and Lalsiamliana (2001 a). Species composition and distribution of Fishes in the rivers in Barak valley region of Assam and in the Principal rivers of Mizoram and Tripura in relation to their habitat parameters. Proc. National Workshop, NATP-ICAR Project, Mid-term Review, 1: Central Marine Fisheries Research Institute, Cochin, 25 pp.
- Kar, D.; Laskar, B.A.; and, Lalsiamliana (2001 b). Further studies on the Ichthyospecies composition and distribution of Freshwater Fishes in Barak drainage and in the Principal rivers in Mizoram and in Tripura with a note on their Feeding and Breeding biology. Proc. National Project Monitoring Workshop of NATP-ICAR Project, National Bureau of Fish Genetic Resources, Lucknow, 1 : 22 pp.
- Kar, D.; Laskar, B.A.; Nath, D.; Mandal, M.; and, Lalsiamliana (2002 b). *Tor progenius* (McClelland) under threat in River Jatinga, Assam. Science and Culture, 68 (7-8): 211.
- Kar, D.; Laskar, B.A.; and, Nath, D. (2002 c). *Tor* sp. (Mahseer fish) in river Mat in Mizoram. Aquacult, 3 (2): 229-234.
- Kar, D.; Dey, S.C.; and, Roy, A. (2002 d). Prevalence of Epizootic Ulcerative Syndrome among fishes of Assam. In: Proc. Regional Symp. On Biodiversity, S.S. College, Assam (Central) University, Hailakandi (Assam).
- Kar, D.; Dey, S.C.; and, Roy, A. (2002 e). On the diseased fishes suffering from hitherto unknown Epizootic Ulcerative Syndrome in Fishes in India. Proc. All-India Congress of Zoology, Dec., 2002 (Bangalore).
- Kar, D.; Dey, S.C.; and, Roy, A. (2002 f). Prevalence of Epizootic Ulcerative Syndrome (EUS) among fishes of Mizoram. In: Proc. Regional Symp. On Aquaculture, 1.
- Kar, D.; Laskar, B.A.; and Lalsiamliana (2002 g). Germplasm Inventory, Evaluation and Gene Banking of Freshwater Fishes. 3rd Annual Technical Report: pp.57. National Project Evaluation Workshop, 3: NATP-ICAR World Bank-aided Project: National Bureau of Fish Genetic Resources (Lucknow).
- Kar, D.; Dey, S.C.; Mandal, M.; Laskar, B.A.; and, Lalsiamliana (2002 h). Preliminary Survey of the Fish Genetic Resources of the Rivers in Barak Drainage, Mizoram and Tripura, pp. 73-81. In: Restoration of Lakes and Wetlands (Eds.) Ramachandra, T.V.; Rajasekhara, Murthy, C.; and, Ahalya, N., pp. xxii + 400, Allied Publishers (P) Ltd. (Bangalore).
- Kar, D.; Dey, S.C.; and, Datta, N.C. (2003 a). Welfare Biology in the New Millennium, xx + 97, Allied Publishers Pvt. Ltd. (Bangalore).
- Kar, D.; Dey, S.C.; and, Roy, A (2003 b). Capture Fishery in Lentic Systems with some light on Sone Beel in Assam with special reference to prevalence to EUS in the Barak valley region of Assam. Proc. Lecture Series in UGC-sponsored Vocational Course



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- in Industrial Fish and Fisheries, Cachar College, Assam University, Silchar, Abstracts, 1.
- Kar, D.; Roy, A.; and Dey, S.C. (2003 c). Epizootic Ulcerative Disease Syndrome in Freshwater Fishes with a note on its Management for Sustainable Fisheries. Proc. International Conference on Disease Management for Sustainable Fisheries, 26-29 May, 2003, Department of Aquatic Biology and Fisheries, University of Kerala, Trivandrum.
- Kar, D.; Lohar, M.; Ngassepam, Z.; Sinom, S.; Tiwary, B.; and Bawari, M. (2003 d). Fish Bioresources in certain rivers of Assam and Manipur with a note on their assessment, management and conservation. Proc. Nat. Symp. Assessment and Management of Bioresources, North Bengal University and The Zoological Society, Calcutta, 28-30 May, 2003: 56 pp.
- Kar, D.; Dey, S.C.; and Roy, A. (2003 e). Epizootic Ulcerative Syndrome: A virulent disease among the freshwater fishes of India. In : Proc. Guest Lecture delivered at the Dept. of Zoology, Arunachal University, Arunachal Pradesh, 1.
- Kar, D.; Dey, S.C.; and Roy, A. (2003 f). Biodiversity of freshwater fishes of North-East India with a note on their health status. In : Proc. DBT-sponsored Guest Lecture Series delivered at the Dept. of Molecular Biology and Biotechnology, Tezpur (Central) University, Tezpur, 1.
- Kar, D.; Dey, S.C.; and Roy, A. (2003 g). Epidemiology of Epizootic Ulcerative Syndrome disease among the freshwater fishes of India. In: Proc. Regional Symp. On World Bank-aided programme entitled, 'Assam Rural Infrastructure and Agricultura Services Project (ARIASP), Silchar, 1.
- Kar, D.; Dey, S.C. and Roy, A. (2003 h). Review of Epizootic Ulcerative Syndrome disease among the freshwater fishes of India. In: Proc. UGC-sponsored lecture series delivered at the Department of Environmental Engineering and Biotechnology, Guru Jambhwar University, Hisar (Haryana).
- Kar, D.; Laskar, B.A.; and Nath, D. (2003 i). Length-weight relationship of *Salmostoma phulo phulo* (Hamilton Buchanan) collected from River Karnafuli along Indo-Bangladesh border (in Mizoram). J. Applied Zoological Researches, 14 (2): 188-190
- Kar, D.; Roy, A.; and Dey, S.C. (2004 a). An overview of Fish Genetic Diversity of North-East India. In: Proc. National Workshop on Rational use of Water Resources for Aquaculture (Eds.) Garg., S.K. and Jain, K.L., 18-19 March 2004, CCS Haryana Agricultural University, 1 : 164-171.
- Kar, D.; Roy, A.; Mazumder, J.; and Patil, P (2004 b) Biotechnological approach for defining Epizootic Ulcerative Syndrome Disease in Freshwater Fishes. In: Proc. Mid-term Review: DBT-sponsored Project, New Delhi, 1.
- Kar, D.; Dey, S.C.; Roy, A.; Mazumder, J.; Patil, P.; and Kohlapure, R.M. (2004 c). Fish Disease Prevalence in Assam with particular reference to Epizootic Ulcerative Syndrome and its pathogens. Proc. International Conference 'Bioconvergence', 18-20 Nov 2004, Thapar Institute of Engineering and Technology, Patiala, 1 : 220 pp.
- Kar, D.; Mazumdar, J.; Halder, I.; and Dey, M. (2007). Dynamics of initiation of disease in fishes through interaction of microbes and the environment. Current Science (Bangalore) 92 (2): 177-179(25 January, 2007).
- Kar, D.; Mazumdar, J.; and Barbhuiya, M.A. (2007). Isolation of Mycotic flora from fishes affected by Epizootic Ulcerative Syndrome in Assam, India. Asian J. Microbiology and Biotechnology 9 (1): 37-39.
- Kar, D.; Laskar, B.A.; and Nath, D. (2006). An account of Fecundity of *Eutropiichthys vacha* (Hamilton-Buchanan): a commercially important fish in Assam. Environment and Ecology , 24 S (3): 726-727
- Kar, D.; Nagarathna, A.V.; Ramachandra, T.V.; and Dey, S.C. (2005 e). Fish Diversity and Conservation aspects in an aquatic ecosystem in North-East India. ZOOS' Print Journal 21 (7): 2308-2315.
- Kar, D. (2005 e). Fish Biodiversity and Habitat Parameters of rivers in Barak drainage (Assam), in Mizoram and in Tripura. Himalayan Journal of Environmental Zoology, 19 (1): 41-45.



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Kar, D (2006 i). Study of Fish Diversity in a Wetland. Activity Guide 'Biodiversity', pp. 37-38. National Childrens Science Congress, NCSTC Network and Dept. of Science & Technology, Govt. of India.

Kar, D; Laskar, BA; and Nath, D (2006). Length-weight relationship of *Neolissochilus hexagonolepis* (McClelland) and *Garra lissorhynchus* (McClelland) from River Jatinga in Cachar district of Assam. Indian J. Fish , 52.(4): 495-496.

Kar,D.; Mazumdar, J.; Devi, P.; Devi, B.R.; and, Devi, V. (2006). Isolation of *Aeromonas hydrophila* from fishes affected by Epizootic Ulcerative Syndrome as well as from corresponding healthy fish species and from their habitat. Journal of Current Sciences, 9 (1) : 323-327.

Laskar, B.A.; Nath, D.; Mandal, M.; Das, S.; and, Kar, D. (2002). Ecological Studies in Punir Haor wetland in Cachar district of Assam with special emphasis on aquatic macrophytes, ichthyofauna and wetland birds. Conservation Forum Journal, 1 (1): 15-18.

Mittermeier, R.A. and Mittermeier, C.G. (1997). Megadiversity: Earth's Biologically Wealthiest Nation. In: Global Freshwater Biodiversity (Ed.) McAllister, D.E; Hamilton, A.L.; and, Harvery, B; Sea Wind, Cemex, Mexico City, 11 : 1-140.

Myers, G.S. (1949). Salt tolerance of freshwater Fish Groups in relation to geographical problems. *Bijdr tot de Dierk*, 28 : 315-322.

Motwani, M.P.; Jayaram, K.C.; and, Sehgal, K.L. (1962). Fish and Fisheries of Brahmaputra River System, Assam, I. Fish Fauna with observation on their zoogeographical significance. *Trop. Ecol.*, 3 : 17-43.

Myers, G.S. (1949). Salt tolerance of freshwater Fish Groups in relation to geographical problems. *Bijdr tot de Dierk*, 28 : 315-322.

Nichols, J.T. (1928). Fishes of the White Nile (with Table of World's Freshwater Fish Faunae). American Mus. Novitates No. 319.

Pearsall, W.H. (1938). The Soil complex in relation to Plant communities. I. Oxidation-reduction potentials in soils. *J. Ecol.*, 26 : 180-193.