Do floodplain wetlands enhance the potential of fish ponds? Assessing supporting ecosystem service of Chatla wetland of Barak Valley, Assam, India

Wetland ecosystems provide a range of ecological and economic benefits to people and society through provisioning of various goods and services[1,2]. Many studies have highlighted the role of wetlands in provisioning of ecosystem goods, viz. fishery, agriculture, non-timber forest products, etc.[3,4]. Culture- and capture-fishery are important economic activities of people living in the Southeast Asian countries, viz. India and Bangladesh[5,6], which have large areas under floodplain wetlands[7]. Globally, around one billion people rely on fish as the only source of protein, of which 35 million people are engaged in fishing and aquaculture, and 95% of them reside in developing countries like India and Bangladesh[6]. In this region, a large number of people practice commercial culture fishery by constructing earthen ponds in and around the floodplains (http://agritech.tnau.ac.in).

We hypothesize that the ponds located in a wetland should have better habitat conditions for fish growth and productivity compared to those located outside and/adjacent to the wetland. We propose this based on the following observations: (i) floodplain wetlands experience annual flood events that enrich them with nutrients[8,9]; (ii) this nutrient enrichment supports the growth of plankton[10–12] and (iii) the higher planktonic productivity is linked to greater fish production[13,14]. Scientific validation of this hypothesis should help the fishery development in the adoption of necessary management strategies in floodplain areas.

We tested this hypothesis in the Chatla floodplain wetland of Barak river basin, Assam, India (Figure 1). Chatla retains water for approximately six months and remains mostly dry during winter, except the low-lying areas. We selected six fish ponds; three ponds, i.e. ponds 1–3 were located within the wetland and the rest, i.e. ponds 4–6 were located outside the wetland. These ponds were stocked with a mixture of fish species, viz. *Labeo rohita*, *Labeo bata*, *Cirrihinus mrigala*, *Cyprinus carpio*, *Catla catla*, *Punctius sarana*, *Notopterus notopterus*, etc. We would like to mention that *C. carpio*, which is a globally invasive species, is stocked by the farmers due to its good growth response in the culture fishery systems and higher economic returns. However, they ensure that the stocked fish do not escape from the culture fish ponds (pers. commun.). We did a comparative study on the water quality, and phytoplankton and zooplankton population in the fish ponds located within and adjacent to the Chatla wetland. These parameters were selected for the study, as they are important for evaluation of the potential of such systems for fish production[14]. Sampling in the selected fish ponds was done for a period of three months, i.e. January–March 2016 ($n = 18$) during the dry phase of Chatla. Air and water temperatures were recorded using a mercury bulb thermometer (0–100°C).

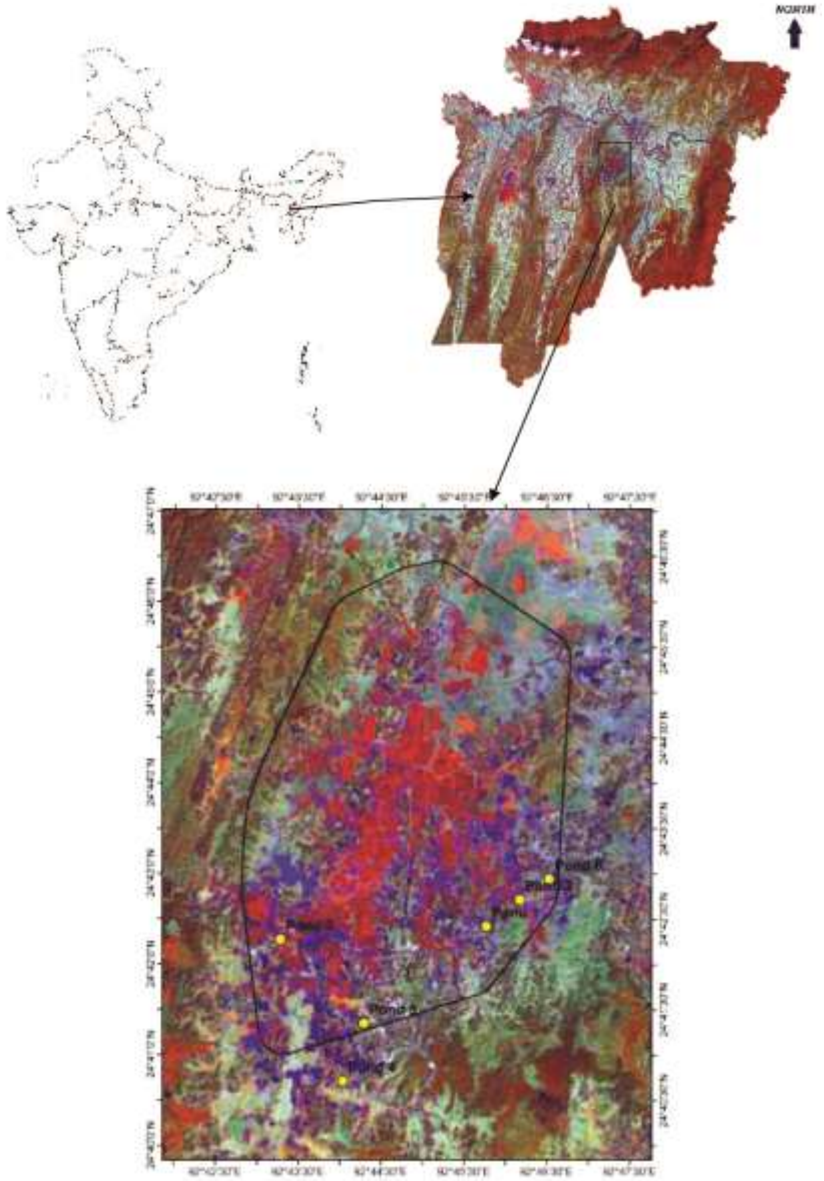

Figure 1. Location of fish ponds in Chatla wetland of Barak Valley, Assam, India.

Air temperature was recorded as it influences water temperature as well as various ecological processes[15]. pH and conductivity of the water samples were recorded using a pH metre (make: Systronics, model 368) and conductivity meter (Make: Systronics, model 308) respectively. Dissolved oxygen (DO), total alkalinity, free carbon dioxide, nitrate-N, phosphate-P and chlorophyll *a* in the water samples were analysed following standard method[16]. For studying planktonic composition and richness, 30 litres of water sample from each pond was passed through a plankton net (mesh screen 45 µm), preserved in 2 ml of 4% formalin, and brought to the laboratory for further analyses. Identification of both phytoplankton and zooplankton was done up to the lowest possible taxonomic level following standard keys[17–26] using a binocular microscope (Olympus, model B-2) at 10× and 40× magnification. Finally, results were expressed as the number of individuals per litre following Lackey's drop method[27]. Univariate statistics, i.e. mean, standard deviation, one-way analysis of variance (ANOVA); and multivariate analysis, viz. cluster analysis (using Gower distance) of the two different groups of fish ponds based on water parameters and density of phytoplankton and zooplankton genera were done using PAST 3.12 (ref. 28).

The two groups of fish ponds displayed significant variation in transparency, pH and conductivity (Supplementary Table 1). The fish ponds located within the wetland had greater transparency, and lower pH and conductivity compared to those located adjacent to the wetland. Greater transparency indicates clearer water that facilitates greater phytoplankton production. The ponds located adjacent to the wetland had a higher pH compared to those located inside the wetland (Supplementary Table 1). The higher pH of ponds located adjacent to the wetland can be attributed to application of lime ($CaCO_3$) by the fish farmers, which is a management intervention to maintain the pH level for better fish growth, though it is known that fish can survive and grow in the pH range 5–9 (ref. 29). Higher conductivity values in fish ponds located adjacent to wetland can be attributed to the reduced water inflow[30]. The other water parameters, viz. DO, CO_2, total alkalinity, nitrate-N and phosphate-P did not vary significantly between the two groups of ponds.

A total of 30 genera of phytoplankton belonging to four classes, viz., Bacillariophyceae (5), Chlorophyceae (18), Cyanophyceae (5), Euglenophyceae (2) were recorded (Supplementary Table 2). Greater generic richness and density of Chlorophyceae in all the fish ponds indicate greater availability of nutrients[31,32], viz. nitrate-N and phosphate-P. On the other hand, a total of 15 genera of zooplankton belonging to 5 groups, viz. Cladocera (6), Copepoda (3), Rotifera (4), Protozoa (1), Ostracoda (1) were recorded in all ponds (Supplementary Table 2). The dominance of Cladocera and Rotifera in the fishponds indicates a nutrient-rich condition[33]. It is important to mention that both rotifers and cladocerans are the most nutritive group of zooplankton which enhance fish growth[33,34]. One-way ANOVA revealed significantly higher phytoplankton (F-ratio: 41.219; $P < 0.01$) and zooplankton (F-ratio 27.997; $P < 0.01$) density in ponds located within the wetland compared to those located adjacent to the wetland. The higher plankton density of ponds located within the wetland (Supplementary Figures 1 and 2) can be attributed to natural rejuvenation by the wetland through supply of oxygenated and nutrient-rich seasonal flood water to those ponds every year, besides washing out of the metabolic waste of stocked fishes from such ponds. All of these plausibly make fish ponds within the wetlands a rich repository of planktonic communities, which act as a source of live food for the fish species stocked in such systems.

Cluster analysis based on different water parameters and density of phytoplankton and zooplankton genera clearly differentiated the two groups of ponds (Figure 2). It indicates that fish ponds located within the wetland are influenced in a similar manner because of seasonal flooding effects of the wetland. Because of such natural phenomenon in the wetland every year, fish farmers do not have to invest much of their energy and money for the management of their fishery ponds (personal interactions with the fish farmers). Thus, supporting ecosystem services of wetlands may enhance fish production through greater abundance of live food organisms in the culture fishery systems within the wetlands.

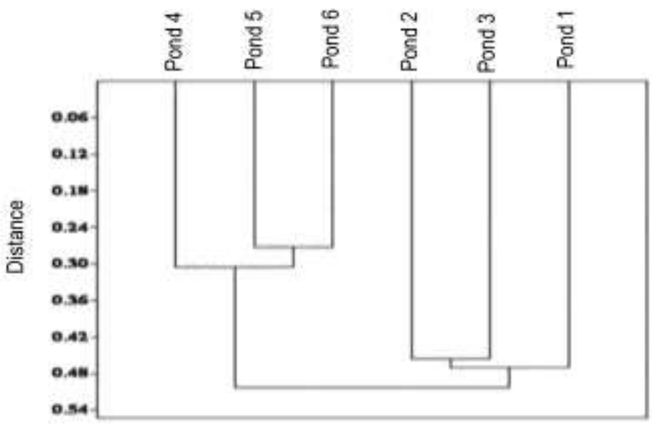

Figure 2. Cluster analysis (using Gower distance) of different fish ponds located within (ponds 1–3) and adjacent (ponds 4–6) to the Chatla wetland based on water parameters, and density of phytoplankton and zooplankton genera.

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SULTANA PARVEN
PRIYANKA SARKAR
TAPATI DAS*

Department of Ecology and Environmental Science,
Assam University,
Silchar 788 011, India
**For correspondence.*
e-mail: das.tapati@gmail.com

Largest freshwater lake 'Loktak' in Manipur needs urgent conservation

Wetlands are one of the most productive ecosystems that support diverse and unique habitats[1]. Loktak Lake in Manipur, India is the largest freshwater lake (area of 287 km^2) which has been included under the Ramsar Convention and also listed under the Montreux record. The Ramsar Convention is an international treaty for the conservation and sustainable use of wetlands[2]. The most unique feature of the Loktak Lake is the presence of floating 'phoomdis', which are the massive heterogenous masses of soil, vegetation and organic matter in different stages of decay and present in various sizes. People of Manipur are dependent on Loktak Lake and phoomdis for different economic activities like fishing, agriculture, fish farming, trading of lake products, traditional handicraft made of lake products such as mats, baskets and other woven goods, etc.[3]. In Manipur agriculture is not limited to land; people use the phoomdis for agriculture and even build houses on them[4]. It is a rich ecosystem harbouring 81 species of birds; 25 species of reptiles; 6 species of amphibians and 22 species of mammals, migratory fish from Chindwin–Irrawaddy basin of Myanmar, migratory waterfowl and an endangered species of Eld's deer, i.e. the sangai[5]. The only floating National Park in the world is Keibul Lamjao (40 km^2), is situated on the largest phoomdi of Loktak Lake. Important vegetation of the phoomdis includes *Zizania latifolia*, *Eichornia crassipes*, *Lersia hexandra*, *Cynodon* spp., *Phragmites karka*, *Oryza sativa*, *Limnophila* spp., *Sagitlaria* spp., *Saccharum latifolium*, *Erianthus pucerus*, *Erianthus ravennae*, *Carex* spp., etc. The most dominant species is *P. karka* which has nutritional, medicinal and cultural significance[2] and is also used as