

A Wetland and a Lifeline: the Importance of Loktak Lake for Manipur, India

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Abstract: Wetlands are highly productive ecosystems which provide multiple-value ecosystem services. The Loktak Lake wetland is located in the Bishnupur district of the Indian state of Manipur, and is the largest freshwater wetland in Northeast India. The lake is used extensively by local people as a source of water for irrigation and domestic use and is an important wintering and staging area for water birds, particularly ducks. The Loktak Lake has a socioeconomic and cultural relationship with the people of Manipur. However, of late, the impacts of increase in population, urbanisation and the rapid pace of development have started being felt on Loktak Lake. The once over 266 sq. km large Loktak Lake is now showing signs of shrinking and reduction in wetland spread. The lake had a seasonal and pulsating characteristic which kept it clean and healthy. However, changes in its hydrology due to regulation of water flow for development purpose are now showing a detrimental effect on the health of this wetland. The following article is an attempt at putting greater focus on the lifeline of Manipur, the Loktak Lake and a floating island paradise where tourism is wanting.

Keywords: Loktak Lake, wetland, ecosystem services, Manipur.

1. Introduction

Loktak Lake is the largest freshwater wetland in Northeast (NE) India and was declared a wetland of international importance by the Ramsar Convention in the year 1990. Loktak Lake is considered the lifeline of Manipur and is an integral part of the socioeconomic and cultural life of the people in the state. It plays an important role in flood control as well. A characteristic feature of Loktak Lake are *phumdis* or the 'floating islands'. *Phumdis* are floating heterogeneous mass of entangled

vegetation, formed by the accumulation of organic debris and biomass with soil particles, which have been concentrated in solid form. Floating islands are a common phenomenon in lakes and wetlands around the world (Kaul and Zutshi, 1966; Trivedy et al., 1978; Sasser et al., 1995; Mallison et al., 2001) and are also known as tussocks (Hujik, 1994), floatons, floatant (Sasser and Gosselink, 1984) or suds (Alam et al. 1996; Haller, 1996). Floating islands are composed of native or exotic plants growing on a buoyant mat consisting of plant roots and organic matter (detritus). This definition of floating islands includes small (less than 0.01 ha) free-floating islands and extensive, stationary, vegetated mats which may cover hundreds of hectares of water (Mallison et al., 2001). *Phumdis* of Loktak Lake are basically heterogeneous mass of soil, vegetation and organic matter at various stages of decomposition (Trisal and Manihar, 2002). The *phumdis* occur in different sizes and thickness and in the natural state, occupy almost half of the wetland area. The southern part of Loktak Lake wetland forms the Keibul Lamjao National Park, which is the one of the largest 'floating island' wildlife protected areas in the world. It is composed of a continuous mass of floating *phumdis* occupying an area of approx. 40 sq. km (Prasad and Chhabra, 2001).

Loktak Lake was indexed as a Ramsar site (Site No. 463) (Wetland of International Importance) on the 23rd of March, 1990 (Ramsar, 2012). Loktak Lake has also been added to the Montreux Record since 16th June 1993. The Montreux Record is a register of wetland sites on the list of wetlands of international importance where changes in ecological character have occurred, are occurring, or are likely to occur as a result of technological developments, pollution or other human interference (Ramsar, 2012). Loktak Lake wetland was added in the Montreux Record largely because of the ecological problems it faces such as deforestation in the catchment area, infestation of water hyacinth and pollution. According to the Ramsar listing,

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the construction of the Ithai barrage (in 1979) at one end of the Loktak Lake, largely for hydroelectric power generation and irrigation purposes, has caused the local extinction of several native fish species.

The Loktak Lake is an important source of water, fisheries and vegetation providing sustenance to a large population dependent upon lake resources for their sustenance. The lake water is used for irrigation, domestic purposes and power generation. The lake vegetation is harvested for use as food, fodder, fiber, fuel, handicrafts and medicinal purposes. The lake water is also used for power generation by the National Hydro Electric Power Corporation (NHPC) which has installed a hydroelectric power project with a total installed capacity of 105 MW (Trisal and Manihar, 2002).

The increase in population and greater dependency on Loktak Lake in recent years is deteriorating the ecological balance of the lake leading to a reduction in ecosystem services. There is no comprehensive seasonal assessment of the ecosystem services provided by Loktak Lake. The ecological and socio-economic significance of the *phumdis* does not form a part of contemporary management plan for Loktak Lake. At the same time, detailed investigation of human dependency on Loktak Lake is wanting and is required for developing a more inclusive management plan. There are no detailed studies of direct impact of Loktak Lake and its changing conditions on the neighbouring human populations. This article is therefore an attempt to collate the various benefits that are being obtained from the Loktak Lake and a forewarning that apathy and ignorance towards the now increasing pollution of Loktak Lake will only result in greater misery for the people of Manipur and Northeast India.

2. A Note on Wetlands

Wetlands are areas subject to permanent or periodic inundation or prolonged soil saturation sufficient for establishment of hydrophytes and/or the development of hydric soils. They are places where a recurrent excess of water imposes controlling influences on all biota (plants, animals and microbes) (Tiner, 1999). Cowardin (1979) defines wetlands as land where an excess of water is the dominant factor determining the nature of soil development and the types of animals and plant communities living at the soil surface and spanning a continuum of environments where terrestrial and aquatic systems integrate. Burton and Tiner (2009) have defined wetlands as lands that are either inundated by shallow water less than 2 m deep during low water events or have soils that are saturated long enough during the growing

season to become anoxic and support specialized wetland plants (hydrophytes). In addition to this, wetlands could be of marine or estuarine nature and even include lake and streams which are greater than 2 m deep. However, the latter is the case only when such wetlands support persistent emergent plant diversity (Burton and Tiner, 2009). Due to the regional differences in hydrologic regimes, climate, soil-forming processes and geomorphologic settings in areas marked by the aforementioned characteristics, a vast diversity of wetlands have evolved worldwide. Consequently, there is no single, indisputable and ecologically sound definition for wetlands, primarily because of the diversity of wetlands (Cowardin, 1979).

One of the most widely accepted definition of wetlands has been given by the Ramsar Convention on Wetlands of the International Union for the Conservation of Nature and Natural Resources (IUCN) (Lehner and Döll, 2004). The Ramsar Convention is an inter-governmental treaty that embodies the commitments of its member countries to maintain the ecological character of pre-defined 'Wetlands of International Importance' and to plan for sustainable use of the wetlands in the member countries' territories. The Convention and its underlying principles came into force in 1971 in the city of Ramsar in Iran. According to the Ramsar Convention, wetlands can be defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Article 1.1). Also, wetlands "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands" (Article 2.1) (Ramsar, 2012). It needs to be mentioned here that wetlands are known to be one of the most important and productive ecosystems in the world (Mitsch and Gosselink, 2000). They occur in all climatic zones, from boreal to tropical, and include bogs, fens, herbaceous marshes, woody swamps, shallow water bodies, riverine floodplains, and coastal beaches (Gopal and Ghosh, 2008).

The existence of the above mentioned large-scale diversity of wetlands necessitates the classification of wetlands into different types. Consequently, wetlands have been classified for various purposes by different authors from time to time. These classifications have been made largely for one or all of the following reasons: 1) to provide common terminology to describe similarities and differences among wetlands, (2) to group them for scientific studies and comparison, (3) to provide the

foundation for conducting wetland inventories that report on the status, trends, functions, and condition of wetlands in specific geographic areas, or (4) for their conservation, use, and management (Tiner, 1999). The underlying objective of all classification systems is to ensure effective and efficient natural resource management and conservation of wetlands. The criteria for wetlands classification systems developed for natural resource management is based on factors such as vegetation, hydrology, water chemistry, soils/substrate, and geomorphology. Some prominent wetlands classification schemes and approaches are the Ramsar multinational classification system, its regional modification for East Africa, wetland classifications from the United States, Canada, and New Zealand: a geomorphic approach to global wetland classification and a hydrogeomorphic approach used in the United States (Tiner, 1999). It needs to be noted here that two sets of environmental factors determine the principal types of wetlands. These are water regime and nutrient supply. The term “water regime” refers to hydrological factors including depth and duration of flooding while “nutrient supply” refers to chemical factors including available nitrogen, phosphorous and calcium (Keddy, 2010).

3. Appraisal of Natural Resources of Loktak Lake

Brühl and Biswas (1926) studied the algae of the Loktak Lake wetland while Biswas (1936) made an inventory of the diatoms of the Loktak Lake wetland. Chaudhuri and Benerjea (1965) have reported on the fisheries of Loktak Lake with special reference to the development of Takmu beel area of Loktak Lake for pisciculture. The fauna of the Loktak Lake has been reported by Annandale and Hora (1921). The 40.5 sq. km Keibul Lamjao National Park, which forms part of the Loktak Lake wetland is the last remaining natural habitat of the Manipuri brow-antlered deer (*Rucervus eldi eldi*) (Gee, 1960).

The phytosociology, primary production and nutrient status of the macrophytes of Loktak Lake have been investigated in great detail by Devi (1993). Santosh and Bidan (2002) studied the distribution of aquatic vegetation of Loktak Lake. The characteristics and classification of soils in the Loktak Catchment Area was carried out by Sarkar et al. (2002). The soils in this area were found to be deep, moderate to slightly acidic (pH 4.6–5.4) in the surface, rich in organic carbon, low to medium in exchange capacities with higher clay and low base status in the subsurface horizon. Soils were high in available nitrogen, medium to high in available potassium and low in available phosphorus. Available iron and manganese were high, Cu and Zn were low particularly in subsurface horizon (Sarkar et al., 2002). The habitat

heterogeneity of the Loktak Lake wetland has been reported by Sanjit et al. (2005) with a special focus on avifauna.

The actinomycetes in the Loktak Lake wetland were isolated and screened for antimicrobial activities by Singh et al. (2006). A total of 37 actinomycetes with distinct characteristics were isolated from the soil samples collected from the *phumdis* in the Loktak Lake. 12 of these isolates (which belonged to genus *Streptomyces*) were found to have broad spectrum of activity against the tested microorganisms which underlines the potential of the *phumdis* of the Loktak Lake as a source of novel antibiotics (Singh et al., 2006). Ningombam and Bordoloi (2008) conducted a survey of the amphibian diversity of Loktak Lake wetland and checked the inventory with the conservation status of individual species. They have reported a total of 25 different species of amphibians belonging to 7 families. Some rare frogs belonging to the Megophryidae family have also been reported in the Loktak Lake (Ningombam and Bordoloi, 2007). The rotifers of Loktak Lake wetland were extensively studied by Sharma (2009).

4. Anthropogenic Dependency on Loktak Lake

Leima et al. (2008) studied the dependency of lakeshore communities for livelihood (especially aquatic vegetation) on the floating islands of Keibul Lamjao National Park. The socioeconomic conditions of residents of six villages located in close proximity to the National Park were analyzed using appropriate survey methodology. The villages selected are Thanga Salam, Sagram, Keibul Mayai Leikei, Wapokpi, Nongmaikhong and Khordak. They found that aquatic vegetation collection from the Park alone contributes as high as 89.70% of the average annual household income in Keibul Mayai Leikei village (with 111 number of households) while fishing in and around the Park contributes 67.2% of the average annual income in Thanga Salam village (with 116 number of households) (Leima et al., 2008).

They have also documented the collection pattern of non-wood forest products for livelihood generation by the lakeshore communities residing around the Keibul Lamjao National Park. Sunanda et al. (2014) carried out an assessment of the Sustainable Livelihoods of Loktak Lake Islanders in Bishnupur District of Manipur. They found that majority of the Islanders had medium level of livelihood on different aspects of sustainability factors. Indeed further, and more comprehensive studies are required to establish the resource dependency of the people living around the Loktak Lake on its resources.

5. Sustainable Management Challenges

The Loktak Development Authority (A Government of India undertaking) has analysed the ecological and socio-economic features of the Loktak Lake wetland. The analysis was based on a holistic study of the integrated catchment as well as institutional arrangement to deduce the following key issues in the conservation and management of Loktak Lake wetland (LDA, 2011):

- Enhanced soil erosion leading to wetland sedimentation due to shifting cultivation and loss of vegetal cover in the catchment area
- Reduction in water holding capacity of wetlands as a consequence of siltation, encroachments, and prolific growth of aquatic vegetation
- Flooding in peripheral areas leading to inundation of agricultural areas and damage to life and property
- Deterioration of water quality due to inflow of sewage from urbanized and peripheral areas
- Decline in fish resources thereby affecting the livelihoods of the fisher communities
- Degradation of *phumdis* in KLNP affecting the biodiversity of the national park particularly the flagship species, *Rucervus eldi eldi*
- Poverty due to resource degradation and limited opportunities of livelihood diversification.

The impacts of climate change upon river discharge within three sub-catchments of Loktak Lake wetland was carried out by Singh et al. (2010). Two groups of climate change scenarios are investigated by them. Group 1 uses results from seven different Global Climate Models (GCMs) for an increase in global mean temperature of 2°C, the purported threshold of “dangerous” climate change. Group 2 is based on results for increases in global mean temperature between 1°C and 6°C. Results from the Group 1 scenarios show varying responses between the three sub-catchments. The majority of scenario-sub-catchment combinations indicate increases in discharge will vary from <1% to 42%. Six of the GCMs suggest overall increases in river flow to Loktak Lake (2–27%) whilst the other results in a modest (6%) decline. In contrast, Group 2 scenarios lead to an almost linear increase in total river flow to Loktak Lake with increasing temperature (up to 27% for 6°C), although two sub-catchments are modeled to experience reductions in mean discharge for the smallest temperature increases.

Further, they have noted that although elevated water levels may permit enhanced abstraction for irrigation and domestic uses, future increases in hydropower generation are limited by existing infrastructure (Singh et al, 2010).

They also warn that higher water levels in the Loktak Lake wetland in the near future are likely to exacerbate existing ecological deterioration as well as enhance problems of flooding of lakeside communities.

Since the construction of the Ithai barrage in 1979, the water levels in the Loktak Lake have been constantly regulated to maintain the generation of hydropower. High water levels in the Loktak Lake have impacted the ecological conditions of the wetland, and the floating vegetated islands (*phumdis*) are the worst affected (Singh et al., 2011). Singh et al. (2011) have put forward an integrated solution to this problem by recommending the balancing of hydropower and agricultural abstractions of water with respect to optimizing wetland water-level requirements. The effects on the fluvial system of Loktak Lake sub-basin due to the bi-directional inter-exchange of flows between the Loktak Lake wetland and the Manipur River have been studied by Singh et al. (2008). The flow in two inter-linking channels, viz. Khordak and Ungamel, is examined with a modeling approach. They report that silt transport dominates the fluvial entity of Loktak Lake by more than 80% (relative to clay and sand) in exchange of flows with the main drainage river in the basin.

The pollution status and aquatic bio-resources of the Moirang River near its mouth in the Loktak Lake was evaluated by Kosygin et al. (2007). The river water was found to be polluted noting high concentration of free CO₂ (14.8 mg/l), nitrite-nitrogen (0.040 mg/l), inorganic phosphorus (0.107 mg/l) and faecal coliform bacteria (162 /100 ml). Aquatic bio-resources of the river included 24 species of fish representing 20 genera of 13 families and 16 species of macrophytes representing 14 genera of 9 families (Kosygin et al., 2007).

Banerjee et al. (1983) carried out a comparison of seasonal and diurnal patterns of some physico-chemical parameters of the open and closed parts of Loktak Lake to investigate the impact of human activities on these variations. The study was carried out from 1976 to 1978. They found that the closed part of the lake, used for controlled fishing, was well protected while the open part was subject to considerable human activities. Simultaneously, they found that the variation in the physico-chemical parameters in the open lake were different from those of the closed lake in that (a) there was distinct seasonal variation in dissolved oxygen which was not evident in the closed lake and (b) there was direct relationship between diurnal variation of CO₂ and pH instead of an indirect relationship in the closed lake. A similar pattern was found in the case of pH, electrical conductivity, bicarbonate, free carbon dioxide and

chloride thus indicating significant impact of human activity on the Loktak Lake wetland (Banerjee et al., 1983).

Singh and Khundrakpam (2009) carried out a case study of the phumdi proliferation in the Loktak Lake wetland. The study was based on remotely sensed data of 1989 and 2002 and field surveys covering eight villages and 377 households. Their results showed that the phumdi area has increased from 1989 to 2002 and the main causes for phumdi proliferation are the construction of the Ithai Barrage Dam, increase in athaphum fishing, pollution and growth of settlements on phumdis. Thus, the growth of phumdis is largely a result of the demographic pressure on the Loktak Lake wetland (Singh and Khundrakpam, 2009). The impacts of high water level in the Loktak Lake wetland throughout the year due to the Ithai barrage and the need to regulate such a high intensity of man-made intervention has been discussed by Singh (2010).

The major and trace elements in the water samples of Loktak lake and Nambul River, the most polluted river draining into the Loktak Lake were determined by using Energy Dispersive X-ray Fluorescence (EDXRF) technique by Singh et al. (2013). They found that despite the polluted Nambul River drains into the Loktak Lake, the concentration of some toxic elements are within the permissible level in the Lake (Singh et al., 2013). The Loktak Lake thus has been able to buffer against the increasing pollution and large-scale degradation taking place around it. However, this may not be the case for long and concerted steps and urgent measures need to be taken today for protecting and preserving the Loktak Lake and its natural resources.

6. Conclusion

The Loktak Lake is an important wetland for the people of Manipur and as is the case with other natural resources, Loktak Lake is also witnessing the increasing pressure of rising population and unplanned developmental activities. Indiscriminate removal of *phumdis* is being done in the Loktak Lake without understanding the ecological or social relevance of these masses of vegetation. A sustainable amount of *phumdis* should always be left to sustain the needs of the local communities and ensure the ecological functioning of the Lake. Studies have shown that *phumdis* can be utilized for conversion to fuel and compost (Devi et.al, 2002; Meitei and Prasad, 2012; Singh and Kalamdhad, 2014). This can be explored to maximise the utilisation of the unique phumdis. A natural resource management solution has to be promoted which will improve the sustainability of the Loktak Lake and which would enhance the sustainable livelihood of the

local communities. This can be possible only when all stakeholders are involved in the management process. A viable combination of the traditional knowledge of the local communities and the scientific knowledge of the Manipur administration is the only way forward for sustainable management and development of Loktak Lake.

7. References

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