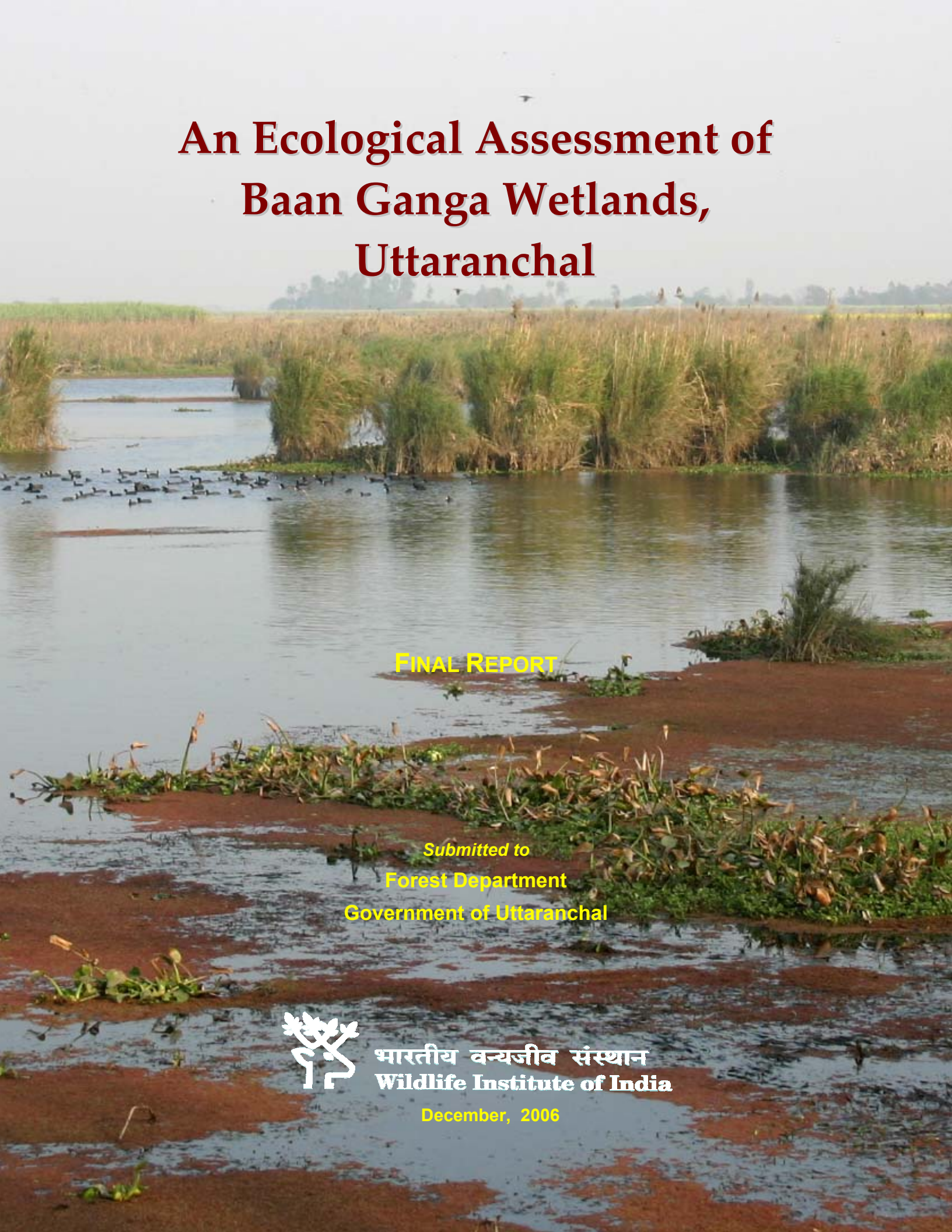
An Ecological Assessment of Baan Ganga Wetlands, Uttaranchal



FINAL REPORT

Submitted to

Forest Department

Government of Uttaranchal

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

December, 2006

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Acknowledgements

An Ecological Survey of Baan Ganga Wetlands in Uttaranchal was conducted by a team of fauclty mebers, students and technical staff of Wildlife Institute of India (WII) Dehra Dun, during January – November 2006. The study was funded by the Forest Department, Government of Uttaranchal. Baan Ganga wetland provides an excellent opportunity to analyse the conservation issues prevalent in the terai habitats dominated by human habitation.

We, the members of study team, are thankful to Shri S. Chandola, Chief Wildlife Warden, Uttaranchal and Shri S. Subudhhi, Divisional Forest Officer, Haridwar Division for providing an excellent opportunity to conduct the ecological survey in the Baan Ganga wetlands and for valuable suggestions from time to time. We place on record our sincere thanks to Shri P.R. Sinha, Director, WII and Shri B.C. Choudhury for encouragements and valuable suggestions. We thank Mr. Dhanajai Prasad, the then Range Officer, Laxar Range and present Range Officer and their team for providing all the logistic support needed during the field work. We acknowledge the assistance provided by the current (10^{th}) batch of M. Sc. (Wildlife Science) students at WII viz., Ishan Agarwal, Pranav Chanchani, Mousami Ghosh, Aparna Lal, Deep Contractor, Navendu Page, Varun Thosrekar and Garga Mohan Das during initial reconnaissance of the area. We thank Shri Ajay Sharma, Shri Rakesh Sundriyal and Shri Chitrapal staff of WII Laboratory for field data collection and analysis of the samples, Shri M.M. Shaklani of WII Herbarium for his help in identifying plant samples, and Shri Virendra Sharma of Computer cell for DTP work.

- **Project Coordinators**

Executive Summary

1. An Ecological Survey of Baan Ganga Wetlands in Haridwar Forest Division, Uttaranchal was conducted during January to November 2006 by a team of faculty and researchers from the Wildlife Institute of India (WII) Dehra Dun. The study components include rapid assessment of the flora, fauna (mammals, birds and fishes), water and soil quality of the area, mapping of the conservation reserve and designing of interpretive facility for the wetland.

2. Baan Ganga wetland represents a remnant Terai habitat in Uttranchal. Occurrence of endangered swamp deer and a variety of floral and faunal communities typical of Terai habitat amidst human dominated landscape warrants careful co-management approach. A total of 178 plant species were recorded from the Baan Ganga wetlands. Of these, 40 species were hydrophytic, 122 species semi-aquatic and 117 mesophytic. Detailed list of the flora along with their habitat and photographic records have been provided.

3. The survey area faces heavy anthropogenic pressures including heavy livestock grazing, fishing, pollution from the untreated sugar mill effluents, cutting and burning of natural vegetation and agricultural encroachment. Despite several pressures the area continues to attract a variety of wetland birds and has tremendous opportunity for developing a popular eco-tourist destination and thereby creating new opportunities in education, recreation, eco-tourism and research in the area.

4. Based on the rapid ecological surveys on various aspects, following major recommendations are given for the conservation and management of the Baan Ganga area: (i) Maintenance of stream flow all through the year (ii) Traditional fishing as in practice at preset may be continued (iii) Initiate a project to promote aquaculture (iv) Initiate conservation awareness programme for the local people especially about the adverse impact of pesticide use in the agriculture fields around the Baan Ganga. There should be a check on the release of effluents from the industries which are located on the upstream areas. Effluents must be treated before releasing into the natural system (v) Maintain heterogeneity in vegetation types. Aquatic weeds are required to be managed properly in year-wise plan. There should not be any construction along the banks of river which will change the hydrological system hence there will be change in the vegetation types. Cattle grazing needs to be regulated and a proper rotational grazing system needs to be implemented in consultation with the local communities (vi) Control of water hyacinth by utilizing this species as a compost / green manure (vii) Regulate exploitation of *Phragmites* and *Typha* and (viii) Develop an interpretation centre highlighting the biological and conservation significance of this area for development of eco-tourism.

1.0 General Introduction

- S.A. Hussain, G.S. Rawat & Bivash Pandav

The Upper Gangetic Plains forms a part of distinct biogeographic zone in India (Rodgers and Panwar 1988). This area, popularly known as *Terai,* characterized by fine alluvium with high water table dominated by a mosaic of hygrophilous grasslands and sal (*Shorea robusta*) dominated Tropical Moist Deciduous forests (Champion & Seth 1968). Terai lies south of *Bhabar* tract that forms a bouldery area of low water table along Himalayan foot-hills. The charismatic faunal species of *Terai* landscape include Great one-horned rhinoceros (*Rhinoceros unicornis*), swamp deer (*Cervus duvauceli duvauceli*), hog deer (*Axis porcinus*), tiger (*Panthera tigris*), Asian elephant (*Elephus maximus*), hispid hare (*Caprolagus hispidus*) and Bengal florican (*Houbaropsis bengalensis*). Reptiles are represented by marsh crocodile (*Crocodilus palustris*), gharial (*Gavialus gangeticus*), monitor lizard (*Varanus flavescens*) and several species of snakes like cobra (*Naja naja*) and common krait (*Bungarus caoruleus*). The Terai landscape has suffered highest degree of habitat loss (Johnsingh et al., 2004).

The wet alluvial nature of Gangetic plains is largely due to a large number of Himalayan rivers and their tributaries that flow across this landscape. These flood plains are drained by three categories of drainages viz., mountain fed, foot-hills fed and plain-fed river systems and differ significantly in morphological, hydrological and sediment transport properties. The mountain fed rivers are generally multi-channel, braided systems characterized by much higher sediment load in comparison to single channel, sinuous foot-hills fed and plains fed river systems. The high water table means that the area is ideal for agriculture and various industries. That is why this region supports over 250 million people in India. Over the years much of the Terai landscape has changed due to encroachment for agriculture, habitation and industries. The natural vegetation has been completely eliminated except in few Protected Areas. The intervening wetlands within the Gangetic plains, which

have immense ecological and social values have been modified and coverted into agricultural fields. With human invasion the values of this ecosystem in terms of ecosystem services and biodiversity have been completely lost. The remnant wetlands are still regarded as major habitat for wintering waterfowls. Some of these wetlands are also important wildlife corridors which facilitate the movement of large mammals such as rhinoceros, swamp deer and often elephants. The remnant wetlands in most cases are surrounded by extensive agricultural fields and settlements. Conserving these wetlands by bringing them under protected area status is a difficult proposition. However, maintaining the *status quo* of these areas by involving the local communities in day to day protection and following the approach of participatory resource management and declaring Community Conservation Reserves (CCR) appears to be much better strategies in this human dominated landscape.

The Government of Uttaranchal has set an example in this regard by notifying India's first two conservation reserves: the Asan and the Jhilmil Jheel wetlands. Baan Ganga wetland near Idrispur village in Haridwar district lies diagonally opposite to Jhilmil Jheel Conservation Reserve. The characteristic feature of the river is its shallow nature, high nutrient deposition rate and rich aquatic and semi aquatic vegetation. Baan Ganga wetland is located between Hastinapur Wildlife Sanctuary in Uttar Pradesh and Jhilmil Jheel Conservation Reserve in Uttaranchal. This area provides swamp deer with suitable terrain, cover and also some of the plants which are apart of their diet. Besides swamp deer the Baan Ganga wetlands support a small population of hog deer (*Axis porcinus*), a typical grassland species that has suffered massive decline from most part of its distribution range.

Despite a heavy anthropogenic pressure and intensive land use, Baan Ganga wetland still harbors rich aquatic vegetation. The aquatic vegetation and the mudflats adjoining the river attract large number of migratory water birds every winter. Dense strands of *Phragmites karka, Ipomoea carnea* and *Typha elephantina* provide ideal breeding habitats for resident water birds. Portions of this wetland supports commercial fishery. However, the biological wealth of this wetland has been subjected to little documentation. Considering the

importance of this area and at the request of Uttaranchal Forest Department, the Wildlife Institute of India initiated a pilot study to document the biological resources of the area. As part of this pilot study an inventory of plants, animals, birds and lower vertebrates were prepared, water quality of the area was analyzed, socio economic status of the local communities were investigated and a concept plan for nature interpretation and conservation education was prepared. The following chapters of the report deal with all these details.

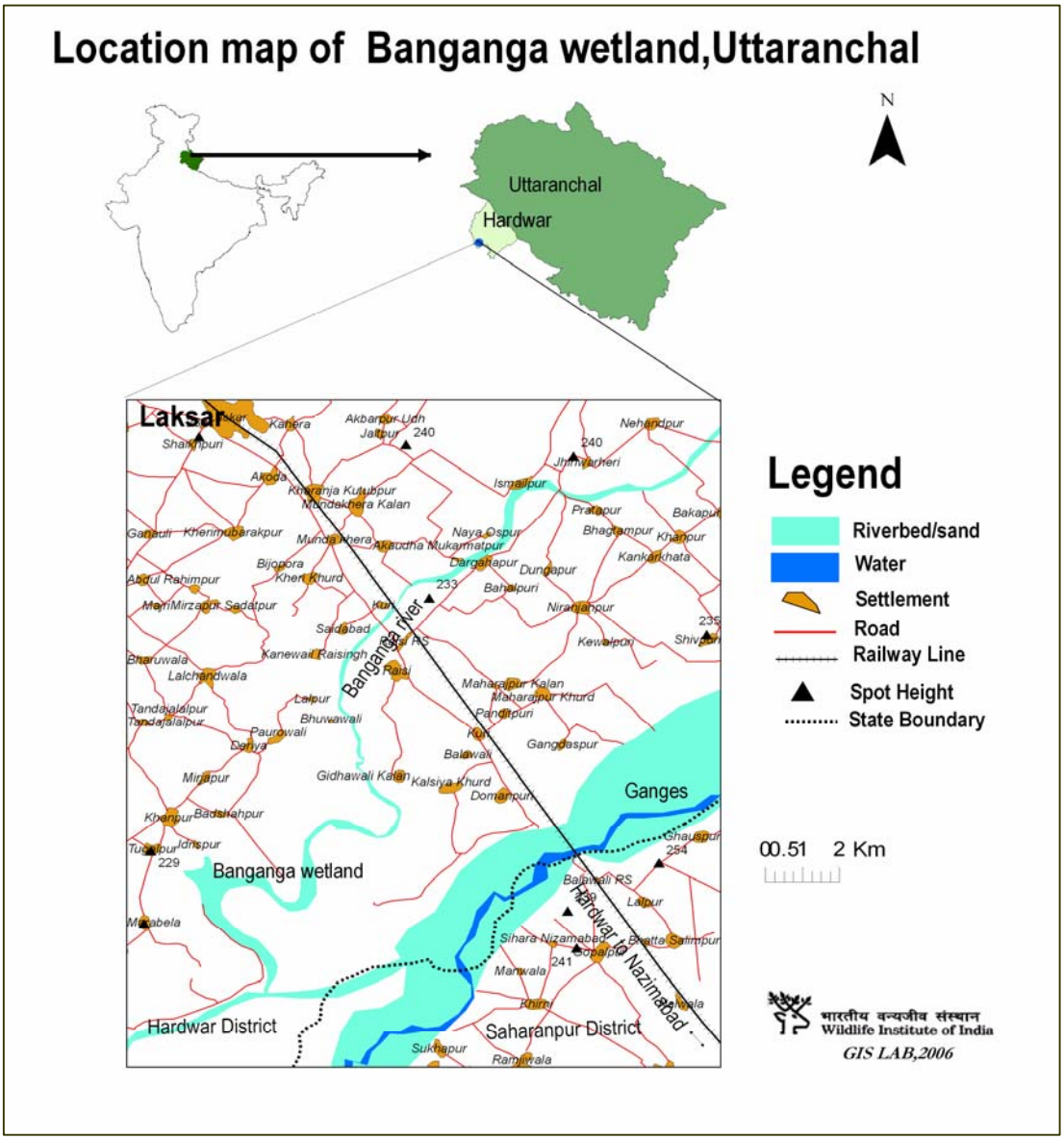
2.0 Biophysical Setting of Baan Ganga Wetland

- S. A. Hussain

The Banganga and its associated water bodies (hence forth referred to as wetlands) occur in the upper Indo Gangetic plains bordering southern Lakshar Range of Hardwar Forest Division. The southern boundary is contiguous with Muzzafarnagar and Sharanpur Forest Divisions of Uttar Pradesh. These wetlands have been formed due to anabranching and subsequent braiding of Ganges River at the exit point below Haridwar. Anabranching is described as multiple channel formation of a river which is separated by vegetated, semi-permanent, alluvial islands usually excised from existing flood plain but also sometimes developed by within-channel accretion. Upon entering into the plains the first branching of Ganges occurs at an altitude of 265 m, forming a Secondary River, approximately 40 km in length, called Baan Ganga. This river rejoins the main branch of Ganges near Idrishpur at an altitude of 228 m. The coordinates where the branching and rejoining take place are 29^0 36'10.92"N and 78^0 03' 51.33" E and 29^0 26 54.22" N and 77^0.59'54.42" E, respectively.

Apart from anabranching, Ganges, at the point of entrance into plains and subsequently downstream has braided channels with large islands. Based on substrate characters a river stretch could be classified into four zones: Zone 1: gravelly-sandy braided, Zone 2: sandy braided, Zone 3: fine sand/mud straight and Zone 4: fine sand/mud meandering. Formation of these zones depends on the stream power, sediment characteristics and sediment load. The Ganges including the Baan Ganga River falls into Zone 2 *i.e* sandy braided. Thus the land around the wetland has little water holding capacity but because of lower water table and over bank flooding the surrounding landscape remains flooded from July to October.

Figure 2.1


Location map of Banganga wetland,Uttaranchal
N
Uttaranchal
Hardwar
Laksar
Banganga river
Ganges
Banganga wetland
Hardwar District
Saharanpur District
Hardwar to Nazimabad
Legend
Riverbed/sand
Water
Settlement
Road
Railway Line
Spot Height
State Boundary
00.51 2 Km
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Wildlife Institute of India
GIS LAB,2006

On the left bank of Ganges below Haridwar is Chandi Reserved Forest with mean altitude of 584 m followed by Sablgarh and Amsot Reserved Forests (269-253 m). Between these two Reserved Forests, Rawason River joins the Ganga. The confluence area gets inundated during floods and forms extensive marshes known as Jhilmil tal – Dasuwala Khatta and Naalki Khatta, with *Phragmites, Typha, Arundo donax* thickets. The landscape downstream of Amsot Reserved Forest between Ganges and Malin River is extensively cultivated and lies in the Bijnor and Muzaffarnagar districts.

On the right bank of Ganges where anabranching of Baan Ganga has taken place, there is an island of about 12 km in length. The island itself has several water bodies, prominent of which are near Rampur Raighati and Panditpuri villages. The landscape at right bank of Ganges near the confluence of Baan Ganga extending up to Ganga East Canal has extensive lowland areas with around 20 scattered water bodies and marshes, prominent of which are Jogawali and Kalawala marshes with extensive *Phragmites* and *Typha* stands. These marshes have been formed because of over flooding of Ganges at Sitapuri Majra and Hajipur - Jahangirpur Reserved Forest areas. The Solani River and Ratmau Nala also drain into this marsh. The Solani River subsequently joins the Ganges near Hajipur-Jahangirpur Reserved Forest.

The Baan Ganga wetland lies between the confluence of Baan Ganga River with Ganges and Solani River confluence at Hajipur – Jahangirpur. The Ganges River at this point is around 5 km wide braided with several minor anabranches. The islands are predominantly vegetated with *Phragmites* and *Typha* and scattered *Acacia nilotica* trees. Thus, any conservation measure for Banganga wetlands should take into surrounding water bodies in conservation plan.

Of the four major types of wetlands occurring in Gangetic plains, the Baan Ganga group of wetlands can be classified as “Tropical seasonal marshes” where flooding occurs largely during July to October. The wetlands dry up during May – June except water in depressions.

3.0 Land use/Land cover mapping of Baan Ganga Wetland

- Hitendra Padalia and V.B. Mathur

Wetland ecosystem constitute an integral part of the cultural and biological landscape of Indo-Gangetic plains. Many micro wetlands or satellite wetlands along river Ganges in Haridwar district act as a constellation of habitat mosaic for resident and migratory waterfowl and relict population of swamp deer. Spatial information on wetlands resources is critical and urgently needed for planning effective conservation of these important eco-systems. The digital nature of remote sensing data allows the analysis and manipulation of the observations to identify and measure changes in wetlands due to encroachment, pollution, and urbanization. Technological advancements in viewing digital imagery on desktop computers have further enhanced wetland analysts' ability to view digital imagery as well as map data and collate it with other layers of information. Visual evidence of hydrologic conditions such as saturation, flooding or ponding combined with collateral data sources, including GPS surveys, topographic maps and management maps, are critically important for understanding the dynamics of wetland ecosystem.

This chapter describes the application of remote sensing imagery and GIS for wetland identification, delineation, and mapping of land cover and land use types in the Banganga area. In addition to this, the study has specifically tried to explore the potential of recently available relatively high resolution satellite data (LISS IV) in characterizing the wetland resources and surrounding infrastructure.

3.1 METHODOLOGY

The methodology for wetland characterization included a reconnaissance survey of the study site during the month of December 2005 for collection of ground truth data. The methodology is described below.

3.1.1 Satellite Data Procurement

One scene of LISS IV (Linear Self Imaging Sensor; Swath: 23 km × 23 km) data of Resourcesat satellite of February 2005 was procured from National Data Centre, National Remote Sensing Agency, Balanagar, Hyderabad. This satellite data has spatial resolution of 5.8 meter and comprises four spectral bands (Figure 3.1). The February season data was preferred to obtain high spectral contrast in the data both within the natural growth types and in associated agriculture land use types. The Banganga wetland area corresponds to the Survey of India toposheet reference No 53 K/2. For showing flood plain dynamics of the area, IRS LISS III data of October, 1999 was used.

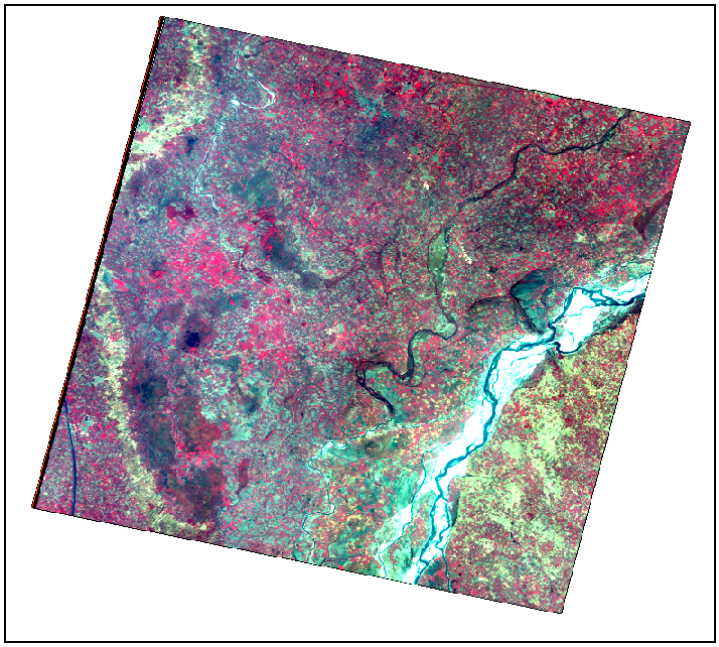


Figure 3.1 False Color Composite, LISS IV image of the study area

3.1.2 Rectification of Satellite Image

The satellite data was rectified for geometric corrections using five GCPs given in the volume file with the CD-ROM by NDC, Hyderabad. This was done because of the non-availability of SOI toposheets at 1:25,000 scale. The geometric accuracy of the rectified image was kept within the limit of less than two pixels.

3.1.3 Classification

The classification of satellite data was attempted to delineate different categories of land cover and land use types in the area. The classification was done following an unsupervised ISODATA classification techniques using

ERDAS IMAGINE 8.7 software. The study site was surveyed and ground truth data was collected using a hand held GARMIN 7.2 Global Positioning System (GPS).

3.1.4 Extraction of Infrastructural Details

Taking advantage of high resolution of LISS IV data, almost all the settlement congregations in the area were picked up in polygon vector format using ARC GIS software and were attributed with name of the settlement. Road and railway tracks have also been directly extracted in line mode from LISS IV data.

3.2 RESULTS

3.2.1 Land use/ Land cover (LULC) types

The classes delineated in the study area are: plantation, aquatic vegetation, agriculture (mostly sugarcane), fallow land/ open land, riverbed/sand/settlement, and water (Figure 3.2).

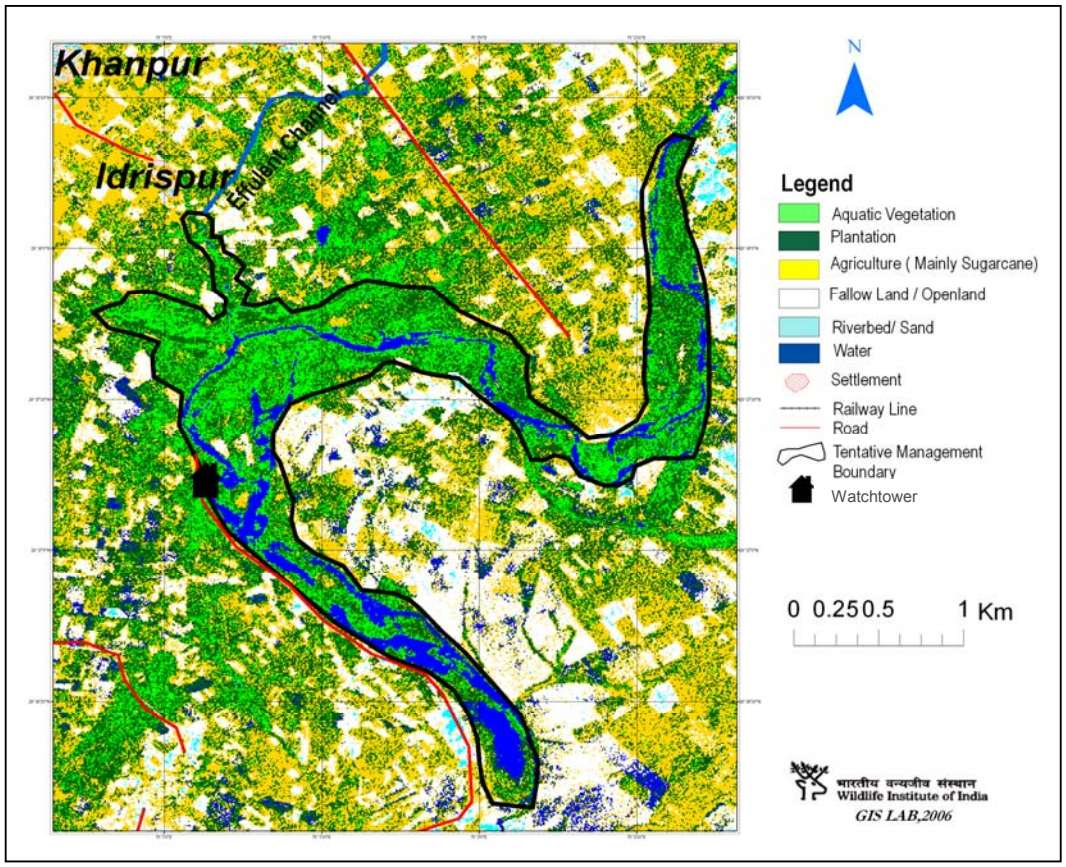


Figure 3.2: Land cover/ Land use type map of Banganga wetland and surrounds

The accuracy of classified output was checked at certain points on the image using ground collected GPS points and the classification was found acceptable. The boundary of the wetland has been arbitrarily delineated and demarcated in consultation with Uttaranchal Forest Department. The area under each class within proposed management extent has been provided in Table 3.1.

Table 3.1 Area under different LULC types in the tentative management area.

S. No.	LULC	Area (km^2)
1	Plantations	24.5
2	Aquatic vegetation	22.8
3	Agriculture (mainly sugarcane)	4.0
4	Fallow land/ open land	1.6
5	Riverbed/Sand/Settlement	0.1
6	Water	11.2
	Total Area	**64.4**

3.2.2 Infrastructure

The settlement layer has been provided for 85 villages located on both sites of river Ganges in Banganga area. The road network connecting all these villages has also been provided.

3.2.3 Flood Plain Dynamics

Comparison of satellite data of different dates of the same area provides unique information on the direction, extent and types of changes in the land cover and land use system in the wetland and the adjoining area. A comparison of satellite imagery of year 1997 (LISS III image) and 2005 (LISS IV image) was performed (Figure 3). Although the magnitude of change could not be precisely assessed due to differences in spatial resolution of two datasets used, even then at many of the localities in this region changes such shift in course of river Ganges, shrinkage and expansion of sizes of wetlands and vegetation patches were observed. Figure 3.3 pinpoints the localities of

landscape change. At point number 1, depicted on the map for comparison between two maps below show considerable shift in water channel from the middle of river in year 1997 to left bank in year 2005. Similarly, at point number 2, the water channel flowing close to left bank of Ganges has shifted it route close to the right bank. The wetland existing at point number 3 in year 1997 was drained by raising plantations. It can also be observed that the sandy areas on the northern west part of Banganga wetland in year 1997 were converted into agriculture fields and plantations. There has been significant upsurge in area under the plantation of poplar and eucalyptus species in the past one decade.

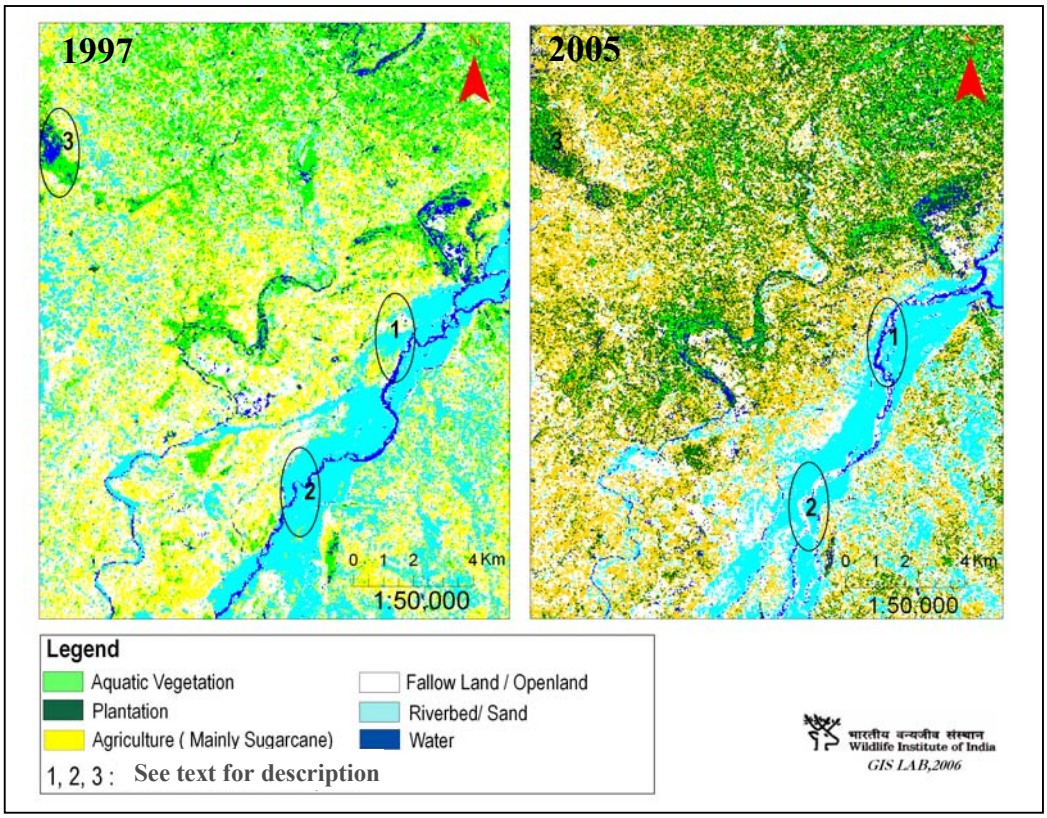


Figure 3.3: Flood plain dynamics in Banganga Area between year 1997 and 2005

3.3 Discussion

Remote sensing with supporting ground truth data, can be regularly used for identification of wetland areas and monitoring their general health and extent of wetland vegetation. Use of Remote sensing and GIS techniques in the Banganga wetland complex has been very useful in characterization of wetland resources and socio-economic developments in the surrounds. The study also highlights the hydrologic environment and interconnectivity of wetland sites of river Ganges which indicates the availability of the water resources supporting wetlands. Since most threats to wetlands in this region originates from outside of the wetland, monitoring for wise use includes observation of the surrounding watershed and the socio-economic factors that may affect it. Hence, a spatial database of sufficiently large area around Banganga wetland has been developed comprising the most critical information on expanse of road, railway, settlements network in the region. The database developed would act as baseline for tracking the environmental and development changes taking place in the area. Remotely sensed data used in the present study has not provided much information for discrimination of resource pool of wetland interior for which a spectrally more sound remote sensing will be needed.

4.0 Hydrochemistry and water quality

- K. Sankar & R. K. Chaturvedi

The Baan Ganga landscape receives water directly from main Ganges River and its anabranch Banganga all through the year. It also receives water from Pathri Rau, Hadwaha and Badshapur Nallahs. During normal monsoon years it receives water from Solani River through Jogiwala and Kallawala wetlands. The area between Ganges and Baan Ganga and the associated water bodies remains inundated during July to October. In the Baan Ganga and the surrounding wetlands the water level goes up to 3 m during peak flooding and the water level reduces to 2 m at the end of monsoon. By January the water level in the Baan Ganga wetlands usually remains at 1-1.5 m and by the month of May most part of the wetland dries up leaving water in the mainstream only.

The water from Baan Ganga is used for irrigating a strip of land on the bank of the river and also for fishing by the local community. No previous work has been carried out on the physico-chemical studies of this wetland. It is envisaged that this study will elucidate the prevailing physicochemical conditions in this wetland and compare them with established water quality criteria. The main goal of this study was to establish a base line study of water and sediment quality of the Baan Ganga wetland. A secondary objective was to identify the extent to which the relevant water and sediment quality parameters vary seasonally.

An effluent channel, carrying sewage of Laksar city and effluent of sugar mill are drained into the wetland. It was observed that the effluent channel is not perennial and the water flow is found only in peak season of sugar production i.e. mid February to September. After preliminary investigations, the wetland was divided into two zones to establish possible local variations in physico-chemical parameters. Zone-I was demarked for 3 km upstream from the point of effluent mixing, while zone-II was demarked up to 4 km from this point.

Four sampling stations at 0.5, 1.0, 2.0, 3.0 km from the effluent mixing point and two sampling stations in effluent channel were selected in zone-I for sample collection. The zone-II was divided into 8 stations i.e. mixing point, and every 500 meters from the mixing point for sample collection. The location and details of sampling stations are given below:

S. No.	Location		Code	Distance from Effluent Mixing point (km)
	N	E		
1	293733.3	780158.5	UBG-1	3.0
2	293744.2	780157.1	UBG-2	2.0
3	293744.6	780144.6	UBG-3	1.0
4	293746.2	780124.9	UBG-4	0.5
5	293749.3	780109.8	EBG-1	0.05
6	293745.7	780109.9	EBG-2	0.15
7	293744.2	780110.9	DBG-1	0.0
8	293730.6	780101.9	DBG-2	0.5
9	293723.1	780106.0	DBG-3	1.0
10	293708.3	780108.7	DBG-4	1.5
11	293702.7	780117.7	DBG-5	2.0
12	293646.4	780133.4	DBG-6	2.5
13	293630.4	780204.4	DBG-7	3.0
14	293613.6	780206.8	DBG-8	3.5

UBG-Banganga upstream; EBG- Banganga effluent channel;
DBG- Banganga downstream; 7- Effluent mixing point

4.1 Methodology

Duplicate water samples and one sediment sample were collected in alternate months from each station during the year 2006 from February to June. Water temperature, DO, pH and EC were measured on the site using portable meters. Samples were transported to WII laboratory and analyzed for various parameters following standard methods of APHA (1998) for water analysis and sediments samples were analyzed according to Methods as described by Page (1982).

4.2 Result

4.2.1 Water quality

The measured physico-chemical parameters are shown in figure 4.1 to 4.4.

4.2.2 Temperature

The temperature ranged from 12 to 29^0C. The temperature was minimum in February and increased with weather conditions and reached up to 29^0C in June. Values of temperature were slightly higher in the effluent channel.

4.2.3 pH and Electrical Conductivity (EC)

The pH and EC ranged from 7.3 to 9.1 and 0.29 to 0.59 dS/m respectively. These were maximum in effluent channel and became almost similar to upstream after the distance of 1 km from the effluent mixing point in the downstream. Highest value of EC was obtained in April when sugar mill effluent was drained in to the wetland. However the recorded pH and EC were found with in the permissible limit of Bureau of Indian Standard (BIS 1982).

4.2.4 Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD)

The DO and BOD showed negative correlation. The range of DO and BOD were 1.1 to 9.0 and 1.6 to74.0 mg/l respectively. Lowest DO and highest BOD were recorded in the effluent channel during April and it reflected higher organic load in the effluent discharge. The organic load decreased with distance from effluent mixing point as reflected with decreasing BOD and increasing DO in downstream water.

4.2.5 Nitrate Nitrogen (-NO_3)

Nitrate nitrogen was high, ranging from 0.2 to 0.78 mg/l as shown in figure 2. Maximum values were obtained in April in Effluent Channel and minimum occurred in February in the upstream water. Concentration of nitrate decreased with distance from the effluent mixing point (DBG-1).

4.2.6 Phosphate- Phosphorus (PO_4-P)

Concentrations of phosphate were also high, ranging from 0.38 to 1.85 mg/l and followed similar trend as nitrate.

4.2.7 Carbonate (CO_3) and Bicarbonates (HCO_3)

CO_3 and HCO_3 did not show any definite trend, although their highest values were recorded in the effluent water. The values of these parameters decreased up to distance of 1.5 km downstream and then became irregular. It may be due to physical disturbance in the water body as some construction work was carried on in the wetland.

4.2.8 Sodium (Na), Potassium (K) and Hardness

Concentration of Na, K and Hardness of water was lowest on upstream (14.8, 2.8, 150.1 mg/l) and maximum in the effluent water (35.1, 10.3, 230.2 mg/l) and showed decreasing trend in the downstream.

4.2.9 Elements

The concentration of zinc, iron, copper, manganese, lead and chromium were found below the detection limits. Only Iron was found in the effluent water during April, with concentration of 0.9 mg/l.

4.2.10 Sediment Quality

The measured physicochemical parameters of sediments are shown in figure 5 & 6.

4.2.11 Organic Carbon (OC) and Nitrogen (N)

Organic carbon ranged between 0.58 and 3.84 % and it was found higher in down stream in comparison to upstream. Figure 4.5 shows the trend of OC and N in the sediments of Banganga wetland. The over all trend for OC was higher in February followed by June and April. Nitrogen also followed similar

trend to that of OC and was ranging between 0.03 and 0.67%. The highest values of OC and N were recorded in the effluent channel and downstream.

4.2.12 Phosphorus (P) and Potassium (K)

Concentration of P and K ranged from 348 to 898 and 1404 to 8890 mg/kg respectively. Figure 4.5 shows the trend of P and K. The highest concentration of P and K were recorded in the downstream during April.

4.2.13 Calcium (Ca) and Magnesium (Mg)

Concentration of Ca and Mg ranged from 6571 to 17323 and 5199 to 15627 mg/kg respectively. Figure 4.5 shows the trend of Ca and Mg. The highest concentration of Ca and Mg were recorded in downstream during June.

4.2.14 Iron (Fe) and Manganese (Mn)

Concentration of Fe and Mn ranged from 3618 to 13780 and 273 to 1076 mg/kg respectively. Figure 4.6 shows the trend of Fe and Mn. The highest concentration of Fe and Mn were recorded in the downstream during June.

4.2.15 Copper (Cu) and Zinc (Zn)

Concentration of Cu and Zn ranged from 14.4 to 158.3 and 32.2 to 101.7 mg/kg respectively. Figure 4.6 shows the trend of Cu and Zn. The highest concentration of Cu and Zn were recorded in the downstream during June.

4.2.16 Electrical Conductivity (EC) and Sodium (Na)

The EC of sediment ranged from 0.379 to 1.98 dS/m, and was lowest in upstream and highest in downstream. The EC was found to be the highest in February followed by April and June. Sodium ranged between 477 and 1160 mg/kg and followed similar trend like EC.

4.3 Discussion

The higher water temperature during June may be due to high albedo while lower temperature during February may be due to the influence of cold winds from December through February. Slightly higher temperature observed in the effluent channel may be related to the untreated sugar mill effluent and high organic load, as their subsequent decomposition by micro organism could lead to elevated temperature.

The lower oxygen saturation and high BOD in the waters of effluent channel and downstream was due to high organic load in the untreated sugar mill effluent. Under-saturation of oxygen was associated with high concentration of iron in the sediment, where oxygen is involved in the oxidation of ferrous to ferric ions (Egborge 1971). High water temperature during the June might have contributed to the lowered oxygen concentration in the wetland water.

The observed low conductivity of wetland water places it in class 1 of Talling & Talling (1965) classification (the most dilute waters of EC < 0.6 dS/m). This class of water is said to be poor in chemical nutrients. This is supported by below detection limits of Zn, Fe, Cu and Mn in the wetland water. A observed higher conductivity during the April, may be due to mixing of effluents.

The range of water hardness showed that the water in Baan Ganga is of soft nature. It may be due to adhere of Ca, Mg and other cations to the silt in the sediment and these were carried out by the runoff/water current from the wetland. Similar observations have been made by Kemdirim (2005) and Ufodike & Garba (1992).

Phosphorus content in sediment followed the trend of P in water. The phosphorus in sediment was high in April in effluent and downstream water. The major source of Phosphorus in the area is effluent water and agricultural runoff. As untreated wastewater is directly discharged to the wetland and has high amount of nutrients and micro-organisms, which during summer increase the biodegradation activity, reduce DO and pH and affect the redox process of Fe, Mn and P. Similar observation was recorded by Shomer *et al.* (2005) in

the Wadi Gaza wetland. The decay of water plants in winter may have increased the P in sediment and decreased the P in water. Moreover, the sediment release P to water in summer and adsorb it in winter (Kelderman 1996).

Source of carbon in the wetland include not only natural but also effluent of sugar mill. There was no definite trend for organic carbon, although it was high in downstream water during April. Organic carbon and Nitrogen had positive correlation; therefore amount of nitrogen was recorded high in the sediment. It may be due to higher organic load in the effluent water as well accelerated decomposition, as temperature was optimum during March – April for the bacterial activities. The analysis of Zn in sediment showed almost similar values during the period, although it was slightly higher in downstream during April. Cu was recorded low in April and highest in the June. Fe and Mn represent major metals in the sediment samples of this wetland. The effluent was the source of these metals. Summer season also had many impact on metal concentration by sediment – water exchange. In summer, the sediment released P, whereas in the winter it gets accumulated. Higher temperature could lead to anaerobic conditions in sediment resulting in Fe and P release. In winter the sediment are oxygen rich as DO of water was high, Fe is in the Fe (III) form, which forms an insoluble in water and bond with phosphate. Under anaerobic conditions in summer, the Fe (III) was reduced to Fe (II). Since Fe (II)-phosphate are 100 times more soluble than Fe (III)-phosphates, this give rise to Fe-P bonding (Shomar *et al.* 2005). Conductivity and sodium content of sediment were also high during the summer (June) and it may be due to the presence of shallow water in the June.

The level of physicochemical parameters we measured in Banganga wetland was higher in the downstream in comparison to upstream. Water of upstream and downstream during the February fall within the range of permissible limits recognized for water quality standards (Akeredolu 1982, Chapman 1992, WHO 1993, BIS 1982).Values of Cl, Na, K, BOD, NO3, P and hardness were higher in the effluent channel and downstream during April. The concentration of all the analyzed parameters were influenced by discharge of sugar mill

effluent as it occurred only during mid March to April. Effluent channel and downstream became eutrophic during the April – June due to enrichment of N, P and K. Similar findings were recorded by Shomar *et al.* (2005) in the wetland of Wadi Gaza, Gaza Strip.

4.4 Conclusion

1. This study has established baseline information on the water quality at various sections along Baan Ganga. Continued monitoring of water quality on year to year basis would be valuable in detecting the amount of pollutants added to the river.
2. High BOD, low DO and eutrophication in the effluent channel and downstream, were due to the untreated effluents of the sugar mill.
3. There was no heavy contamination in the water.
4. The water may be categorised as inland surface waters class A, as per the limits of Bureau of Indian Standards (BIS).

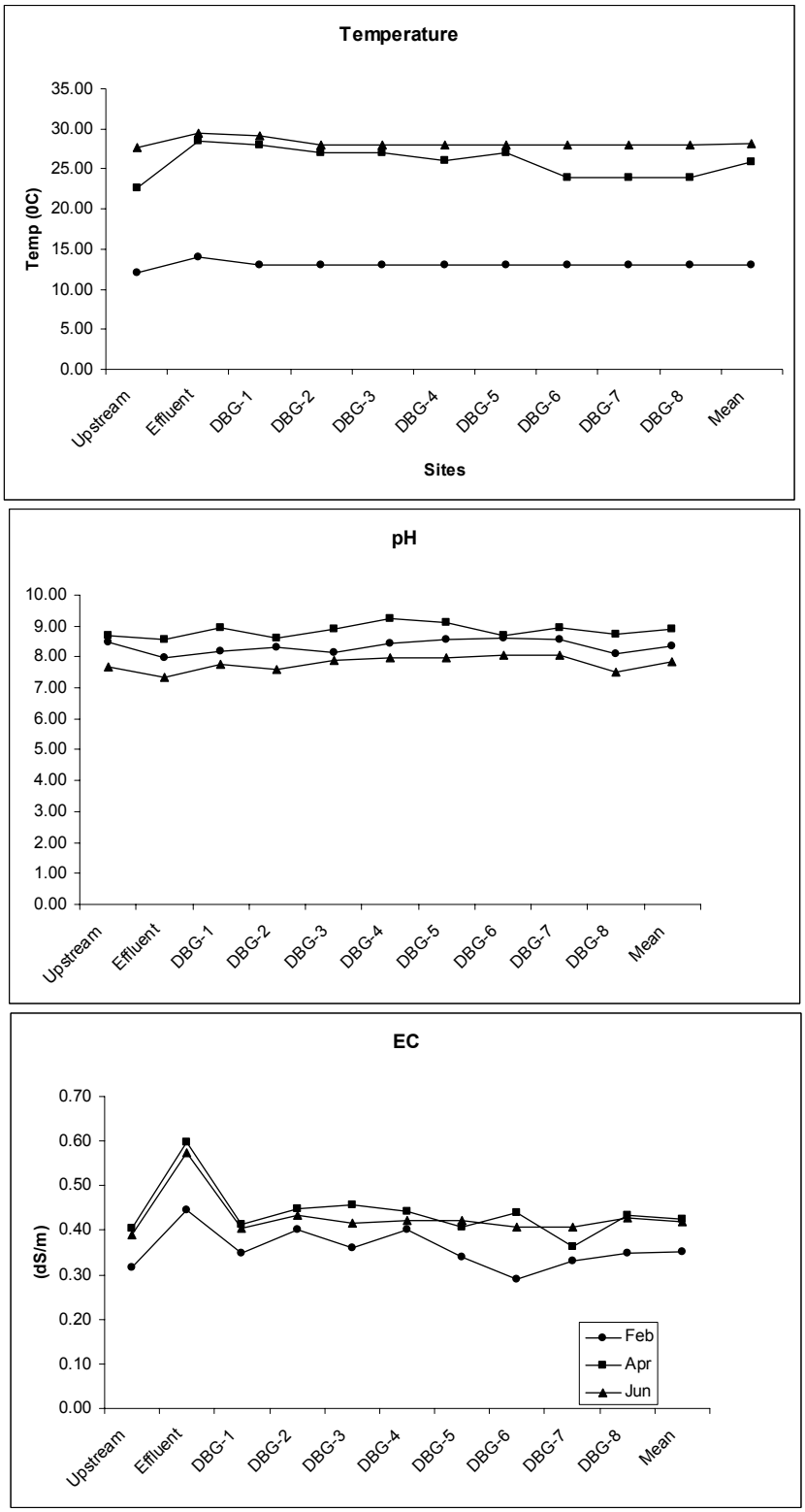


Fig. 4.1 Temperature , pH and EC of water samples of Banganga wetland

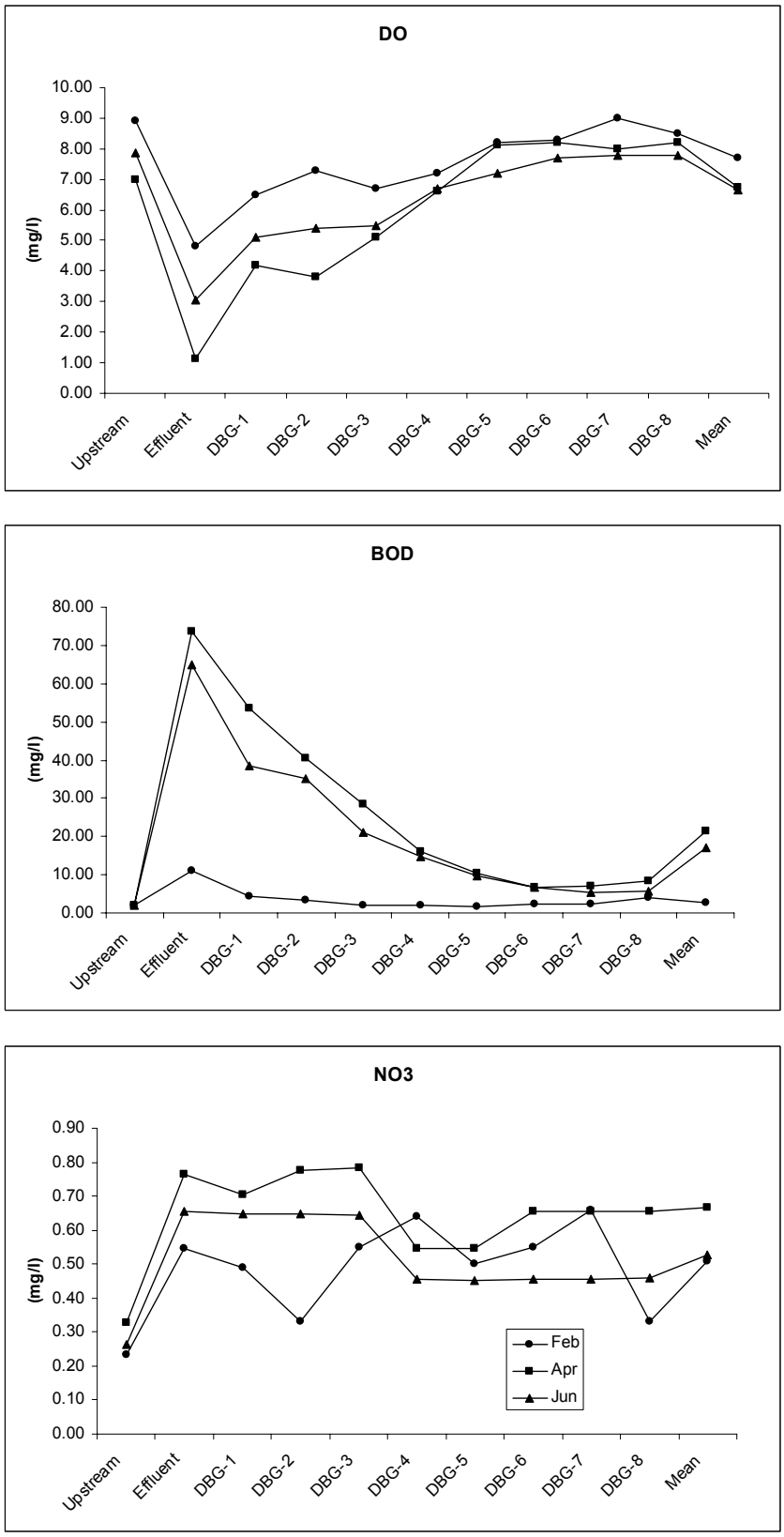


Fig. 4.2 DO, BOD and NO3 in water samples of Banganga wetland

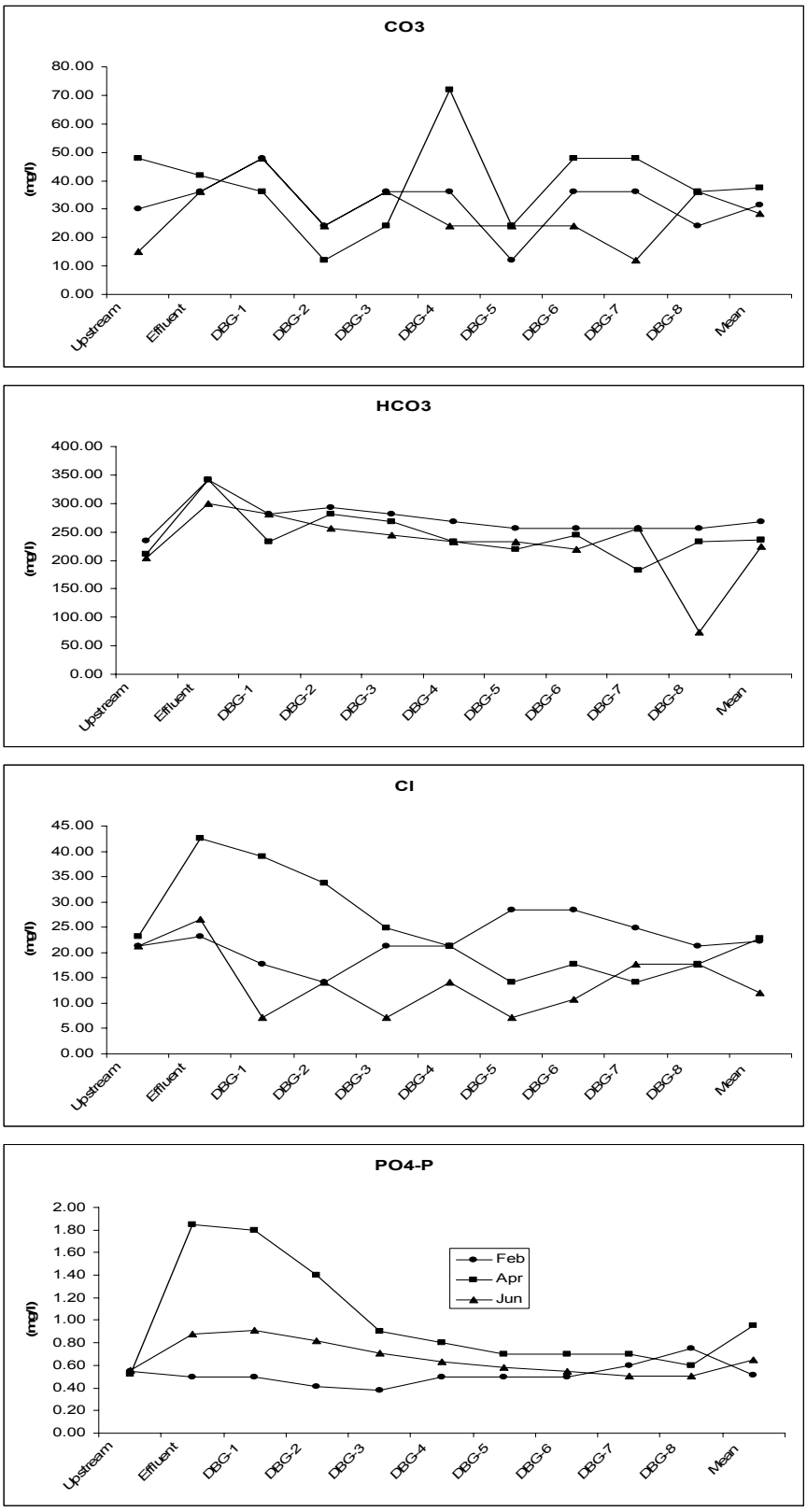


Fig. 4.3 CO3, HCO3, Cl and PO4-P in water samples of Banganga wetland

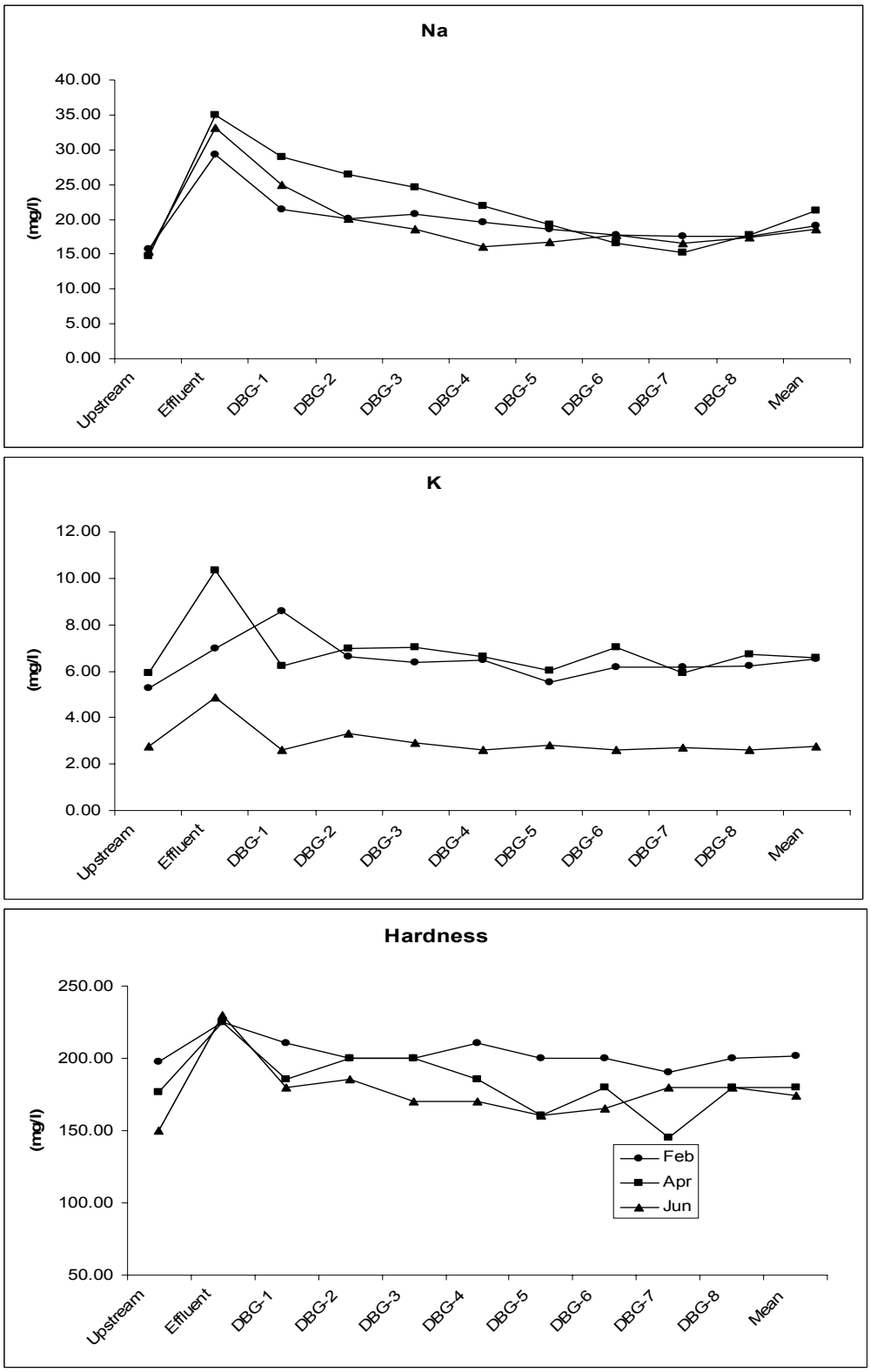


Fig. 4.4 Na, K and Hardness in water samples of Banganga wetland

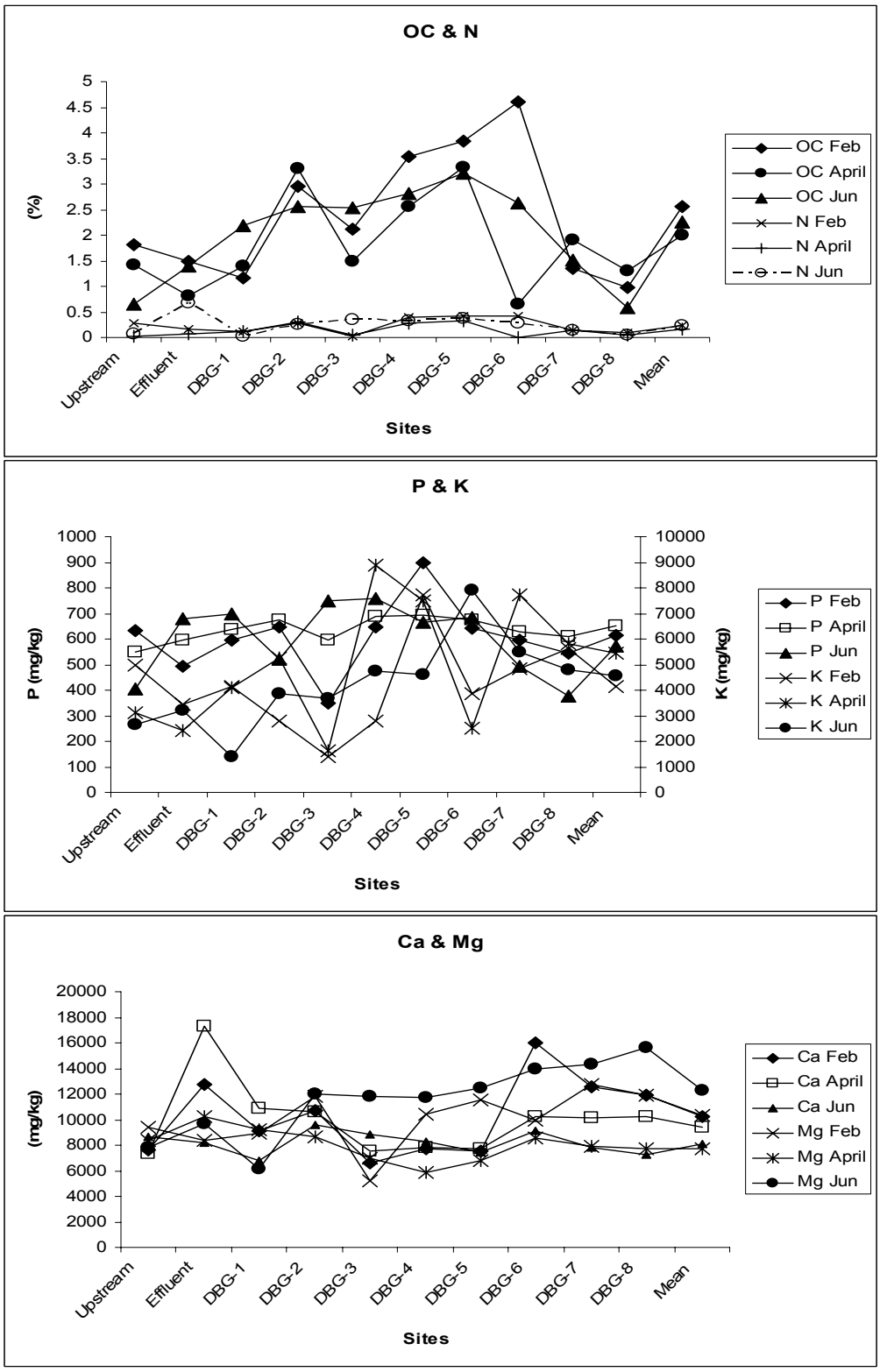
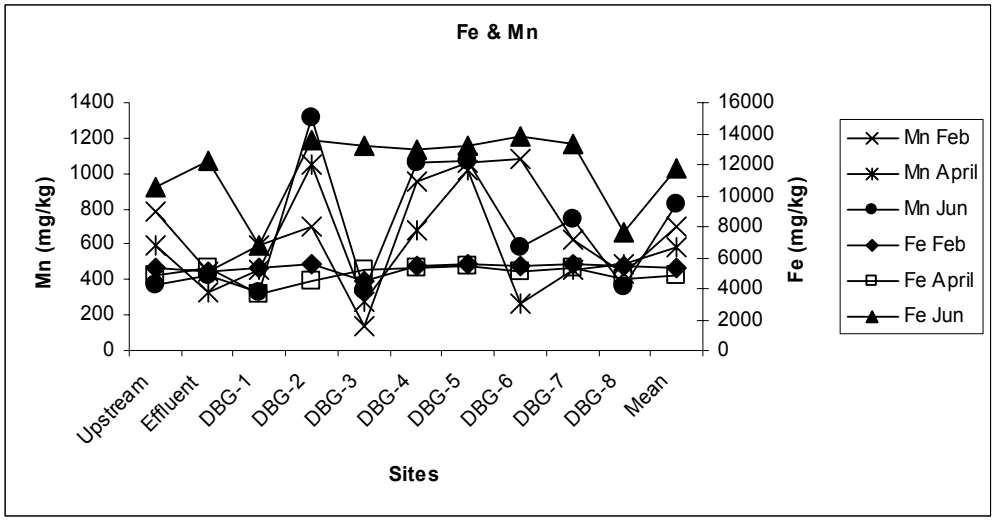
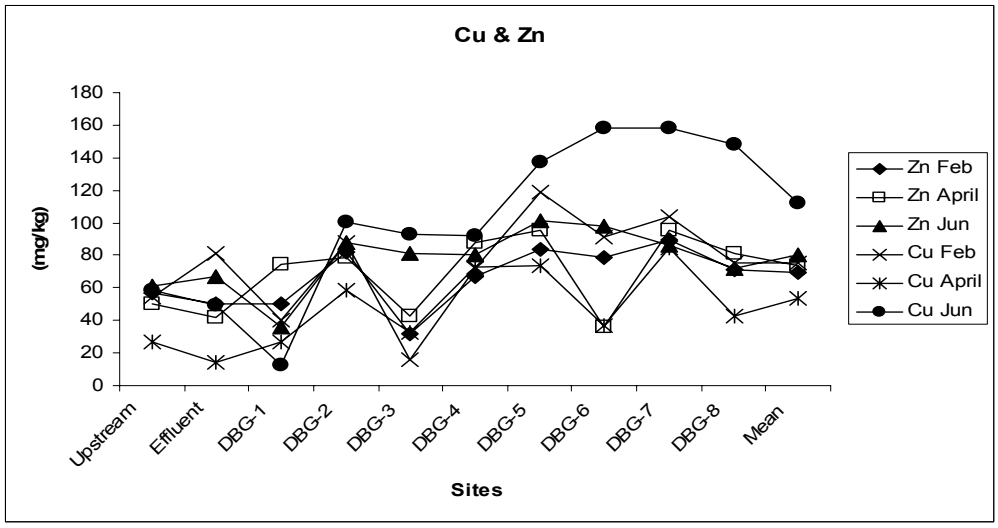


Fig. 4.5 OC,N, P, K, Ca and Mg in the sediment samples of Banganga wetland





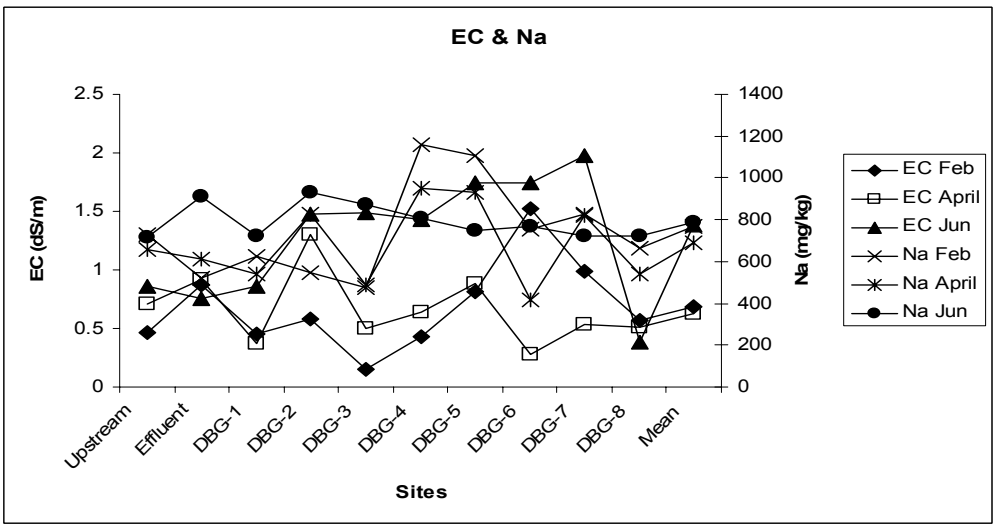


Fig. 4.6 Conductivity, Na, Cu, Zn, Fe and Mn in the sediment samples of Banganga wetland

5.0 Flora and Vegetation

- B.S. Adhikari & M. M. Babu

The tropical wetlands are among the most productive ecosystems. Human activities such as agriculture, livestock grazing and aquaculture greatly modify the aquatic and semi-aquatic systems. The wetland vegetation enrich the water bodies as natural filters and protect the edges from water current and rain flashing, provide food to human beings and used in different ailments as medicine in rural areas. The chapter deals with the status and distribution of wetland vegetation in and around Baan Ganga river.

Baan Ganga wetland harbors many islands, varying in shape and size. In few localities the river is deep and narrow, while the area between islands is shallow, full of decomposed *Eichhornea* and elevated land away from the river is dominated by *Typha.* The islands are mainly dominated by species like *Phragmites karka*, *Ipomoea* sp., *Polygonum barbatum and Polygonum glabrum*. Among free floating plants (*Azolla, Eichhornia, Spirodela* and *Lemna*), semi-submerged (rooted plants with aerial float; *Enydra, Ludwigia, Potamogeton, Nymphaea, Nymphoides, Marsilea,* and *Trapa*), submerged (*Ceratophyllum, Hydrilla, Najas, Potamogeton* spp. and *Vallisneria*) and moist loving plants (*Ipomoea* sp., *Typha, Monochoria, Phragmites, Polygonum* spp., *Rotala, Rumex* and *Sagitaria*) can be seen.

***Azolla* in foreground, *Eichhornia* in the centre and *Phragmites* in the background**

A continuous strip in the background is *Typha*, *Phragmites* in pockets (centre) *a*nd *Azolla, Lemna* & *Eichhornia* in foreground

***Phragmites* in the background and *Scripus* in the foreground**

Islands are full of *Polygonum* spp., *Ipomoea* and *Ranunculus*

The infestation of weeds (*Eichhornia crassipes, Enydra fluctuans* and *Ipomoea etc.*) and agricultural fields in the Baan Ganga area are major concerns. Heavy weed growth along the water courses raises the bed level due to silt deposition and affects the wetland area and weeds impede the free flow of water. Some management aspects have been made for the mitigation of these problems in the report.

5.1 Methods

Several trips were made during February-June, 2006 to asses the status and distribution of vegetation in Baanganga wetland. The entire study area was divided in to three major habitat types, viz. aquatic (only water), moist shore (river bank to 5-7m depending upon the specific site quality and islands) and upland up to road on the right side of the river and on left side of the river up to the revenue lands. For the sake of convenience the entire area was further divided into segments to carry out the survey. The plants were identified based on the Illustrated flora of Keoladeo National Park, Bharatpur (Prasad et al. 1997), Flora of the Upper Gangetic Plain (Duthie 1903-29) and Herbaceous Flora of Dehradun (Babu 1977).

The hydrophytes (plants growing in water bodies) have been classified in to four categories as follows:

1. **Free floating plants** or parts of plants floating : **f**
2. **Submerged plants** (plants under water) : **s**
3. **Semi-submerged plants** : **ss**
   (rooted plants with aerial float/plant part under water)
4. **Moist loving plants** along the edge of the water body : **ml**

The Status of plants in relation to study area has been categorized as frequent (F), which are frequently occurring, occasional (O), are not very common and rare (R), which are rarely occurring in the area.

5.2 Results

The survey area can be divided in to five different habitat types viz., Water bodies, Marshy area, Islands, Moist shores and Upland, which occupy approximately 55, 4, 15, 8 and 18 % area, respectively. Each category has been further classified based on cover percent (Table5.1).

Table 5.1: Cover percentage of vegetation and water in different land use category.

Category	Cover percentage		
	Water	Vegetation	Open
Water body	70	30	-
Marsh area	15	75	10
Island	10	75	15
Moist shore	-	85	15
Upland	-	70	30

A total of 178 plant species were recorded from the Baan Ganga Wetlands. Aquatic, semiaquatic and mesophytic habitats were represented by 40, 122 and 117 species of vascular plants respectively. Among hydrophytes, 4 are free floating, 8 submerged, and 13 semi-submerged. A list of plant species collected and identified in Baan Ganga area is given in Table 5.2. Most of the plants photographed in the study area are shown in plates (1-10). The site

specific distribution of plants is mentioned below, however, it is not necessarily restricted in these habitats only.

The plants species which are common in all habitats are *Phragmites karka, Polygonum barbatum, Ipomoea carnea* and *Typha elephantina.* Ninteen species were restricted to aquatic habitat, viz. *Alternanthera pheloxeroides, Azolla pinnata, Ceratophyllum dimersum, Eichhornia crassipes*, *Hydrilla verticillata, Lemna perpusilla, Najas graminea, Najas minor, Nymphaea nouchali, Nymphoides cristata, Nymphoides indica, Potamogeton crispus, Potamogeton nodosus, Potamogeton pectinatus, Scirpus* sp., *Spirodela polyrhiza, Trapa natans* var *bispinosa, Utricularia* sp. and *Vallisneria natans.*

Twenty five species were found along seasonally inundated shores. These include *Acacia farnesiana, Ammannia baccifera, Brachiaria ramosa*, *Cyperus compressus, Cyperus pygmaeus, Cyperus rotundus, Cyperus triceps, Fibristylis falcata, Grangea maderaspatana, Hydrocotyle sybthorpioides, Ipomoea sp., Martynia annua, Oxystelma secamone, Phalaris minor, Pithecellobium dulce*, *Pouzolzia pentandra, Pouzolzia zeylanica, Saccharum spontaneum*, *Salvia plebeia, Scirpus tuberosus, Stellaria media, Tamarindus indica, Terminalia arjuna, Trewia nudiflora* and *Vernonia cinerea*.

Thirty seven plants are found in the upland habitats, viz. *Acacia nilotica*, *Albizia procera, Amaranthus spinosus, Blumea membranacea, Blumea mollis, Boerhavia difusa, Campanula wallichii, Cordia dichotoma, Elephantopus scaber, Euphorbia hirta*, *Exacum sp., Ficus palmata, Ficus racemosa, Imperata cylíndrica, Ixeris polycephala*, *Kirganelia reticulata*, *Launea procumbens, Leucas cephalotes, Linum usitatissimum, Malvastrum coromandelianum*, *Oplismenus burmanii, Perilla frutescens*, *Physalis minima*, *Pongamia pinnata*, *Pulicaria crispa, Rungia pectinata, Sida rhombifolia*, *Solanum torvum, Sonchus oleracea, Syzygium cumini*, *Trigonella hamosa, Verbascum chinense, Vicia tetrasperma, Xanthium strumarium, Zeuxine strateumatica, Zizyphus mauritiana* and *Zizyphus nummularia*.

The similarity (%) between habitats is in following order: moist shore and upland (64%) > aquatic and moist shore (26%) > aquatic and upland (5%).

Table 5.2: List of plants growing in and around Baanganga river.

[**Habit**: Tree (T), Shrub (S), Herb (H) and Grass (G); **Hydrophytes**: Free floating plants (f), Submerged plants (s), Semi-submerged plants (ss) and Moist loving plants (ml) and **Status**: Frequent (f), occasional (O)
and Rare ®; Habitat: Aquatic (AqT), Moist Shore (MoS) and Upland (UpL)]

S. No.	Scientific Name	Family	Habit	Habitat type	Status
1	*Acacia catechu* Willd.	Mimosaceae	T	MoS, UpL	R
2	*Acacia farnesiana* Willd.	Mimosaceae	T	MoS	O
3	*Acacia nilotica* (L.) Del.	Mimosaceae	T	UpL	O
4	*Achyranthes aspera* L.	Amaranthaceae	H	MoS, UpL	F
5	*Ageratum conyzoides* L.	Asteraceae	H	MoS, UpL	F
6	*Albizia procera* Benth.	Mimosaceae	T	UpL	O
7	*Alternanthera paronychioides* St. Hill.	Amaranthaceae	H	MoS, UpL	F
8	*Alternanthera pheloxeroides* (Mast.) Griseb.	Amaranthaceae	H (ss, ml)	AqT	O
9	*Alternanthera sessilis* (L.) R. Br.	Amaranthaceae	H	MoS, UpL	F
10	*Amaranthus spinosus* L.	Amaranthaceae	H	UpL	R
11	*Ammannia baccifera* L.	Lythraceae	H	MoS	O
12	*Anagallis arvensis* L.	Primulaceae	H	MoS, UpL	F
13	*Argemone mexicana* L.	Papaveraceae	H	MoS, UpL	O
14	*Avena sativa* L.	Poaceae	H	MoS, UpL	O
15	*Azolla pinnata* R. Br.	Azollaceae	H (f)	AqT	F
16	*Bacopa monnieri* (L.) Penn.	Scrophulariaceae	H (ss, ml)	AqT, MoS	R
17	*Bacopa procumbens* (Mill.) Greenm.	Scrophulariaceae	H	MoS, UpL	O
18	*Bidens bitternata* (Lour.) Merr. & Sheriff	Asteraceae	H	MoS, UpL	F
19	*Blumea laciniata* (Roxb.) DC.	Asteraceae	H	MoS, UpL	O
20	*Blumea membranacea* DC.	Asteraceae	H	UpL	O
21	*Blumea mollis* (D.Don) Merr.	Asteraceae	H	UpL	F
22	Boerhavia diffusa L.	Nyctaginaceae	H	UpL	R
23	*Brachiaria distachya* (L.) Stapf.	Poaceae	G	MoS, UpL	F
24	*Brachiaria ramosa* (L.) Stapf.	Poaceae	G	MoS	F
25	*Brassica junceae* (L.) Czern.	Brassicaceae	H	MoS, UpL	F
26	*Campanula wallichii* Babu	Campanulaceae	H	UpL	R
27	*Cannabis sativa* L.	Cannabinaceae	H	MoS, UpL	F
28	*Carex* sp.	Cyperaceae	H (ss)	AqT, MoS	F
29	*Cassia tora* L.	Caesalpiniaceae	H	MoS, UpL	F
30	*Centella asiatica* (L.) Urb.	Apiaceae	H	MoS, UpL	F
31	*Centepeda minima* (L.) A. Br. & Asch.	Asteraceae	H	MoS, UpL	F
32	*Ceratophyllum dimersum* L.	Ceratophyllaceae	H (s)	AqT	F
33	*Chenopodium album* L.	Chenopodiaceae	H	MoS, UpL	F
34	*Chenopodium ambrosioides* L.	Chenopodiaceae	H	MoS, UpL	O
35	*Cirsium arvense* (L.) Scop.	Asteraceae	H	MoS, UpL	O
36	*Commelina benghalensis* L.	Commelinaceae	H	MoS, UpL	F
37	*Commelina hasskarlii* Clarke	Commelinaceae	H	MoS, UpL	F
38	*Cordia dichotoma* Forst. f.	Ehretiaceae	T	UpL	R
39	*Coronopus didymus* (L.) Sm.	Brassicaceae	H	MoS, UpL	O
40	*Cynodon dactylon* (L.) Pers.	Poaceae	G	MoS, UpL	F
41	*Cynoglossum zeylanicum* (Vahl.) Thunb. ex Lehm.	Boraginaceae	H	MoS, UpL	O

S. No.	Scientific Name	Family	Habit	Habitat type	Status
42	*Cyperus bulbosus* Vahl.	Cyperaceae	H (ss)	AqT, MoS	F
43	*Cyperus compressus* L.	Cyperaceae	H	MoS	F
44	*Cyperus cyperoides* (L.)O. Kuntze	Cyperaceae	H	MoS, UpL	O
45	*Cyperus kyllingia* Endl.	Cyperaceae	H	MoS, UpL	F
46	*Cyperus pygmaeus* Rottb.	Cyperaceae	H	MoS	F
47	*Cyperus rotundus* L.	Cyperaceae	H	MoS	F
48	*Cyperus triceps* (Rottb.)Endl.	Cyperaceae	H	MoS	F
49	*Dalbergia sissoo* Roxb.	Fabaceae	T	MoS, UpL	O
50	*Desmodium triflorum* (L.) DC.	Fabaceae	H	MoS, UpL	F
51	*Dryopteris* sp.	Dryopteridaceae	F	MoS, UpL	F
52	*Eclipta prostrate* L.	Asteraceae	H	MoS, UpL	F
53	*Eichhornia crassipes* (Mart.) Solms.	Pontederiaceae	H (f)	AqT	F
54	*Elaeocharis palustris* R.Br.	Cyperaceae	H (ss)	AqT, MoS	F
55	*Elephantopus scaber* L.	Asteraceae	H	UpL	R
56	*Eleusine indica* (L.) Gaertn.	Poaceae	G	MoS, UpL	F
57	*Enydra fluctuans* Lour.	Asteraceae	H (ss)	AqT, MoS	F
58	*Equisetum ramosissimum* Desf.	Equisetaceae	F	MoS, UpL	R
59	*Erigeron barbadensis* L.	Asteraceae	H	MoS, UpL	O
60	*Euphorbia hirta* L.	Euphorbiaceae	H	UpL	O
61	*Euphorbia prostrata* W. Ait.	Euphorbiaceae	H	MoS, UpL	O
62	*Exacum* sp.	Gentianaceae	H	UpL	R
63	*Fibristylis falcate* (Vahl.) Kunth.	Cyperaceae	H	MoS	F
64	*Ficus palmata* Forsk.	Moraceae	S	UpL	O
65	*Ficus racemosa* L.	Moraceae	T	UpL	O
66	*Gnaphalium pensylvanicum* Willd.	Asteraceae	H	MoS, UpL	F
67	*Gnaphalium polycaulon* Pers.	Asteraceae	H	MoS, UpL	F
68	*Grangea maderaspatana* (L.) Poir.	Asteraceae	H	MoS	F
69	*Hedyotis corymbosa* L.	Rubiaceae	H	MoS, UpL	O
70	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae	H (s)	AqT	F
71	*Hydrocotyle sibthorpioides* Lamk.	Apiaceae	H	MoS	O
72	*Hygrophila polysperma* (Roxb.) T. Anders.	Acanthaceae	H (ml)	AqT, MoS	F
73	*Imperata cylindrica* (L.) P. Beauv.	Poaceae	G	UpL	F
74	*Ipomoea carnea* Jacq.	Convolculaceae	S (ml)	AqT, MoS, UpL	F
75	*Ipomoea* sp.	Convolculaceae	H	MoS	O
76	*Ixeris polycephala* Cass.	Asteraceae	H	UpL	O
77	*Kirganelia reticulata* (Poir.) Baill.	Euphorbiaceae	S	UpL	R
78	*Lathyrus aphaca* L.	Fabaceae	H	MoS, UpL	O
79	*Launea procumbens* (Roxb.) Ram. & Raj.	Asteraceae	H	UpL	O
80	*Lemna perpusilla* Torrey	Lemnaceae	H (f)	AqT	F
81	*Leucas cephalotes* (Roth.) Spreng.	Lamiaceae	H	UpL	R
82	*Lindernia ciliate* (Colsm.) Penn.	Scrophulariaceae	H	MoS, UpL	O
83	*Linum usitatissimum* L.	Linaceae	H	UpL	R
84	*Ludwigia adscendens* (L.) Hara	Onagraceae	H (ml, f)	AqT, MoS	F
85	*Malvastrum coromandelianum* (L.) Garcke	Malvaceae	H	UpL	O
86	*Marselia quadriolia* L.	Marseliaceae	H (ml, ss)	AqT, MoS	O
87	*Martynia annua* L.	Martyniaceae	H	MoS	R
88	*Mazus pumilus* (Burm. f.) Steen.	Scrophulariaceae	H	MoS, UpL	F
89	*Medicago lupulina* L.	Fabaceae	H	MoS, UpL	F

S. No.	Scientific Name	Family	Habit	Habitat type	Status
90	*Melilotus alba* Medik.	Fabaceae	H	MoS, UpL	F
91	*Melilotus indica* All.	Fabaceae	H	MoS, UpL	F
92	*Momordica dioica* Roxb. ex Willd.	Cucurbitaceae	H	MoS, UpL	F
93	*Monochoria vaginalis* (Burm. f.) Presl.	Pontederiaceae	H (ss)	AqT, MoS	O
94	*Najas graminea* Del.	Najadaceae	H (s)	AqT	F
95	*Najas minor* All.	Najadaceae	H (s)	AqT	F
96	*Nepeta hindostana* (Roxb.) Haires	Lamiaceae	H	MoS, UpL	O
97	*Nicotiana plumbaginifolia* Viv.	Solanaceae	H	MoS, UpL	F
98	*Nymphaea nouchali* Burm. f.	Nymphaeceae	H (ss, f)	AqT	O
99	*Nymphoides cristata* (Roxb.) Kuntze	Nymphaeceae	H (ss, f)	AqT	F
100	*Nymphoides indica* (L.) Kuntze	Nymphaeceae	H (ss, f)	AqT	F
101	*Oplismenus burmanii* (Retz.) P. Beauv	Poaceae	H	UpL	F
102	*Oxalis corniculata* L.	Oxalidaceae	H	MoS, UpL	F
103	*Oxystelma secamone* (L.) Karst.	Asclepiadaceae	H	MoS	O
104	*Parkinsonia aculeate* L.	Caesalpiniaceae	T	MoS, UpL	R
105	*Parthenium hysterophorus* L.	Asteraceae	H	MoS, UpL	O
106	*Perilla frutescens* (L.) Britt.	Lamiaceae	H	UpL	F
107	*Phalaris minor* Retz.	Poaceae	G	MoS	O
108	*Phragmites karka* (Retz.) Trin. ex Steud.	Poaceae	G (ml, ss)	AqT, MoS, UpL	F
109	*Phyla nodiflora* (L.) Greene	Verbenaceae	H	MoS, UpL	F
110	*Physalis minima* L.	Solanaceae	H	UpL	O
111	*Pithecellobium dulce* (Roxb.) Benth.	Mimosaceae	T	MoS	R
112	*Polygonum barbatum* L.	Polygonaceae	H (ml)	AqT, MoS, UpL	F
113	*Polygonum glabrum* Willd.	Polygonaceae	H (ml)	AqT, MoS	F
114	*Polygonum hydropiper* L.	Polygonaceae	H (ml, ss)	AqT, MoS	F
115	*Polygonum lapathifolium* L.	Polygonaceae	H (ml)	AqT, MoS	F
116	*Polygonum plebeium* R. Br.	Polygonaceae	H	MoS, UpL	F
117	*Polypogon fugax* Nees. ex Steud.	Poaceae	G	MoS, UpL	F
118	*Pongamia pinnata* (L.) Pierre	Fabaceae	T	UpL	O
119	*Potamogeton crispus* L.	Potamogetonaceae	H (s)	AqT	F
120	*Potamogeton nodosus* Poir.	Potamogetonaceae	H (ss, f)	AqT	O
121	*Potamogeton pectinatus* L.	Potamogetonaceae	H (s)	AqT	F
122	*Potentilla supina* L.	Rosaceae	H	MoS, UpL	F
123	*Pouzolzia pentandra* (Roxb.) Benn.	Urticaceae	H	MoS	O
124	*Pouzolzia zeylanica* (L.) Benn.	Urticaceae	H	MoS	O
125	*Primula umbellata* (Lour.) Bentv.	Primulaceae	H	MoS, UpL	O
126	*Psamogeton canescens* (DC) Vatke.	Apiaceae	H	MoS, UpL	F
127	*Pulicaria crispa* Sch.-Bip.	Asteraceae	H	UpL	O
128	*Ranunculus muricatus* L.	Ranunculaceae	H	MoS, UpL	F
129	*Ranunculus sceleratus* L.	Ranunculaceae	H (ml, ss)	AqT, MoS	F
130	*Rorippa nasturtium-aquaticum* (L.) Hayek	Brassicaceae	H (ss, ml)	AqT, MoS	F
131	*Rotala densisflora* Koehne	Lythraceae	H (ml)	AqT, MoS	O
132	*Rumex dentatus* L.	Polygonaceae	H	MoS, UpL	F
133	*Rumex nepalensis* Spreng.	Polygonaceae	H	MoS, UpL	F

S. No.	Scientific Name	Family	Habit	Habitat type	Status
134	*Rungia parviflora* (Retz.) Nees	Acanthaceae	H	MoS, UpL	O
135	*Rungia pectinata* (L.) Nees	Acanthaceae	H	UpL	O
136	*Saccharum bengalensis* Retz.	Poaceae	G	MoS, UpL	O
137	*Saccharum spontaneum* L.	Poaceae	G	MoS	O
138	*Sagitaria sagitifolia* L.	Alismataceae	H (ss)	AqT, MoS	F
139	*Salvia plebeia* R. Br.	Lamiaceae	H	MoS	O
140	*Scirpus* sp.	Cyperaceae	H (ss)	AqT	F
141	*Scirpus tuberosus* Des. f.	Cyperaceae	H	MoS	F
142	*Seseli diffusum* (Roxb. ex Sm.) Sant. & Wagh.	Apiaceae	H	MoS, UpL	O
143	*Seteria verticillata* (L.) P. Beauv.	Poaceae	G	MoS, UpL	F
144	*Sida rhombifolia* L.	Malvaceae	H	UpL	F
145	*Solanum nigrum* L.	Solanaceae	H	MoS, UpL	F
146	*Solanum torvum* Sw.	Solanaceae	H	UpL	R
147	*Solanum viarum* Dunal	Solanaceae	H	MoS, UpL	O
148	*Sonchus asper* (L.)Hill.	Asteraceae	H	MoS, UpL	F
149	*Sonchus oleracea* L.	Asteraceae	H	UpL	O
150	*Spirodela polyrhiza* (L.)Schl.	Lemnaceae	H (f)	AqT	F
151	*Stellaria media* (L.) Vill.	Caryophyllaceae	H	MoS	F
152	*Suaeda fruticosa* (L.) Forsk.	Chenopodiaceae	H	MoS, UpL	O
153	*Syzygium cumini* (L.)Skeels	Myrtaceae	T	UpL	O
154	*Tamarindus indica* L.	Caesalpiniaceae	T	MoS	R
155	*Tamarix dioica* Roxb.	Tamaricaceae	S	MoS, UpL	O
156	*Terminalia arjuna* (Roxb.) Wt. & Arn.	Combretaceae	T	MoS	R
157	*Trapa natans* var *bispinosa* (Roxb.) Makino	Trapaceae	H (ss, f)	AqT	O
158	*Trewia nudiflora* L.	Euphorbiaceae	T	MoS	O
159	*Tridax procumbens* L.	Asteraceae	H	MoS, UpL	O
160	*Trifolium tomentosum* L.	Fabaceae	H	MoS, UpL	F
161	*Trigonella foenum-graecum* L.	Fabaceae	H	MoS, UpL	O
162	*Trigonella hamosa* L.	Fabaceae	H	UpL	O
163	*Triticum vulgare* Vill.	Poaceae	G	MoS, UpL	F
164	*Typha elephantina* Roxb.	Typhaceae	H (ml, ss)	AqT, MoS, UpL	F
165	*Urena lobata* L.	Malvaceae	S	MoS, UpL	F
166	*Utricularia* sp.	Utriculariaceae	H (s)	AqT	F
167	*Vallisneria natans* (Lour) Hara	Hydrocharitaceae	H (s)	AqT	F
168	*Verbascum chinense* (L.) Santap.	Scrophulariaceae	H	UpL	O
169	*Vernonia cinerea* (L.) Less.	Asteraceae	H	MoS	O
170	*Veronica anagallis-aquatica* L.	Scrophulariaceae	H (ml, ss)	AqT, MoS	F
171	*Vicia hirsuta* (L.) SF.Gray	Fabaceae	H	MoS, UpL	F
172	*Vicia sativa* L.	Fabaceae	H	MoS, UpL	F
173	*Vicia tetrasperma* (L.) Moench.	Fabaceae	H	UpL	O
174	*Wendlandia excerta* DC.	Rubiaceae	T	MoS, UpL	R
175	*Xanthium strumarium* L.	Asteraceae	H	UpL	F
176	*Zeuxine strateumatica* (L.) Schl.	Orchidaceae	H	UpL	F
177	*Zizyphus mauritiana* Lamk.	Rhamnaceae	T	UpL	O
178	*Zizyphus nummularia* (Burm.f.) Wt. & Arn.	Rhamnaceae	S	UpL	R

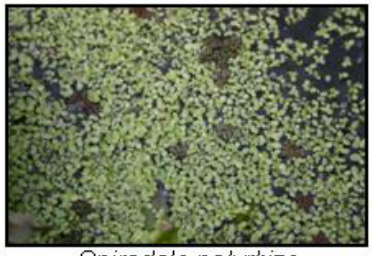
Management implications:

i. *Typha* and *Phragmites* patches in the study area need to be monitored regularly. They provide important habitat for swamp deer and birds.

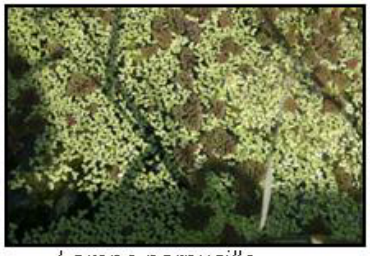
ii. *Eichhornia* and *Azolla* are closely associated with each other. As they clogg the area especially in the upper section of the river, such areas need to be treated on priority basis with the help of local people. Use of Eichhornia as a compost or green manure seems to be a viable option.

iii. Livestock grazing in the area needs to be regulated and executed in a rotational manner in consultation with the local people. Islands amidst water channels need to be protected from heavy grazing as the islands are ideal habitats for the breeding birds.

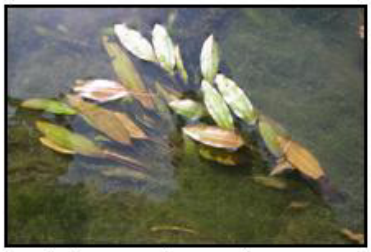
Azolla pinnata



Spirodela polyrhiza

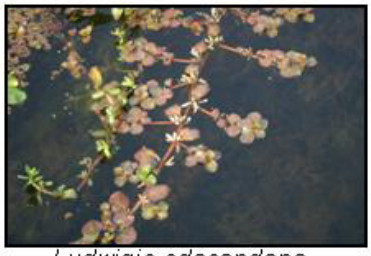


Lemna perpusilla



Potamogeton nodosus

Potamogeton crispus



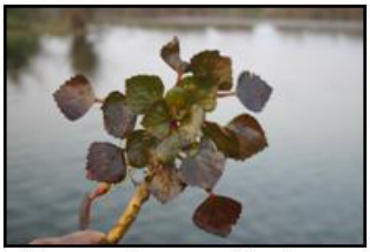
Ludwigia adscendens

Potamogeton pectinatus

Vallisneria natans

Polygonum hydropiper

Carex sp.



Trapa natans var. bispinosa

Ceratophyllum dimersum

Najas minor

Nymphoides cristata

Nymphoides indica

PLATE 1

Vicia sativa

Trifolium tomentosum

Sonchus arvensis

Elephantopus scaber

Phragmites karka

Ranunculus sceleratus patch

Ranunculus sceleratus
Individual plant

Ranunculus sceleratus Flower

Vicia hirsuta

Mazus pumilus

Momordica dioica

Grangea maderaspatana

Fimbistylis falcata

Trigonella foenum-graceum

Hygrophylla polysperma

PLATE 2

Cyperus triceps

Hygrophila polysperma

Psamogeton canescens

Primula umbellata

Ammannia baccifera

Dryopteris sp.

Phalaris minor

Equisetum ramosissimum

Xanthium strumarium

Cyperus sp.

Psamogeton canescens

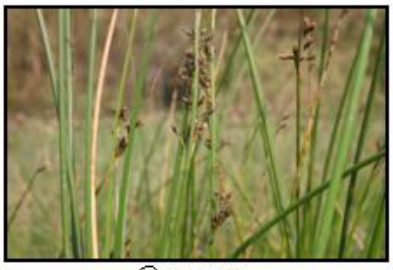
Trigonella polycerata

Kirganelia reticulata

Dalbergia sissoo

Ficus racemosa

PLATE 3



Carex sp.

Polygonum glabrum

Enhydra flactuans

Marselia quadrifida

Eichhornia crassipes

Ipomoea sp.

Ceratophyllum dimersum

Hydrilla verticillata

Oxystelma secamone

Potamogeton pectinatus

Najas graminea

Uticularia sp.

Elephantopus scaber

Rorippa nasturtium-aquaticum

Cyperus pygmaeus

PLATE 4

Chenopodium album

Psamogeton canescens

Lathyrus aphaca

Phalaris minor

Circium arvensis

Zeuxine strateumatica

Gnaphalium pensylvanicum

Rumex dentatus

Veronica anagalis -aquatica

Amaranthus paronychioides

Seseli diffusum

Gnaphalium polycaulon

Brachiaria distachya

Amaranthus paronychioides

Sagitaria sagitifolia

Sagitaria sagitifolia

PLATE 5

Ammania baccifera

Polygonum plebeium

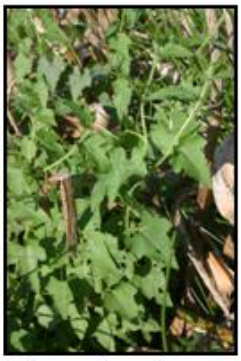
Gnaphalium polycaulon

Solanum nigrum

Trifolium tomentosum

Scirpus tuberosus

Sagitaria sagitifolia

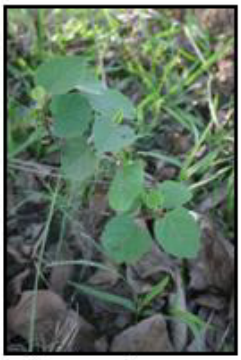


Mormodica dioica

Polypogon fugax

Scirpus tuberosus

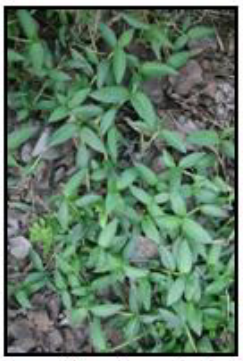
Melilotus alba



Ficus palmata

Equistum ramosissimum

Kirganelia reticulata



Commelina benghalenis

Potentilla supina

PLATE 6

Trigonella foenum-graceum

Pulicaria crispa

Melilotus indica

Solanum viarum

Exacum sp.

Sonchus oleracea

Solanum torvum

Vernonia cinerea

Alternanthera pheloxeroides

Polygonum lapathifolium

Nicotiana plumbaginifolia

Bacopa moneri

Ixeris polycephala

Chenopodium album

Nepeta hindostana

Bacopa procumbens

PLATE 7

Setaria verticillata

Pulicaria crispa

Eregeron barbadensis

Chenopodium album

Urena lobata

Sida rhomboidea

Nicotiana plumbaginifolia

Pithecellobium dulce

Grangea maderaspatana

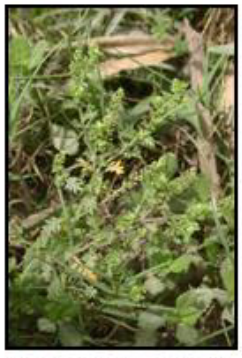
Cyperus bulbosus

Gnaphalium polycaulon

Pouzolzia pentandra

Physalis minima

Polypogon fugax



Coronopus didymus

Nicotiana plumbaginifoli

PLATE 8

Ixeris polycephala

Melilotus alba

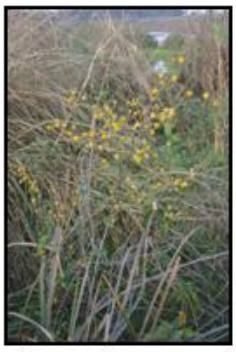
Acacia nilotica

Verbascum chinense

Solanum nigrum

Campanula wallichii

Polygonum plebeium



Acacia farnesiana

Perilla frutescens

Gnaphalium polycaulon

Oxystelma secamone

Tamarix dioica

Acacia farnesiana

Pongamia pinnata

PLATE 9

Parkinsonia aculeata

Ficus racemosa

Acacia nilotica

During early summer season, 2006

During rainy season, 2006

PLATE 10

6.0 Mammals, Avifauna and Other Vertebrates

- S.A. Hussain & Bivash Pandav

6.1 Mammals

The present day Baan Ganga and associated wetlands represent the remnant Terai habitats and faunal assemblage. Small herds of swamp deer and hog deer have been regularly seen in Baan Ganga, Jogawali and Kalawala marshes. However, the population of swamp deer is nonresident moving between Hastinapur Wildlife Sanctuary in Uttar Pradesh and Jhilmil Jheel Conservation Reserve in Uttaranchal. As many as 25 individual swamp deer have have been seen in Baan Ganga area. Use of these wetlands by swamp deer and hog deer implies that these wetlands have retained significant conservation values in spite of growing human pressure. It is unlikely that the swamp deer are resident in Baan Ganga area but there is every possibility of their being resident at Jogawali and Kalawala marshes which appear to be rutting grounds. This needs to be confirmed through regular monitoring of these wetlands after each monsoon. Reestablishing the population in the area between Hastinapur WLS and Jhilmil Taal should be the prime objectives of the conservation efforts and would serve as second home for the species apart from Dudhwa-Kishanpur-Katerniaghat complex.

The other mammals of the area are nilgai (*Boselaphus tragocamelus*) and wild pig (*Sus scrofa*). Carnivores such as common leopard (*Panthera pardus*), jackal (*Canis aureus*), small Indian mongoose (*Herpestes javanicus*), grey mongoose (*Herpestes edwardsii*), and small Indian civets (*Viverricula indica)* also occur in the surrounding landscape.

6.2 Birds

The rich submerged aquatic vegetation and the mudflats adjoining the river attract large number of migratory water birds every winter. Deep water areas of the wetland attract large flocks of diving ducks such as pochards and grebes. Coot, pintail, gadwall and wigeon are the commonest among the migratory species that visit Baan Ganga wetland. Dense strands of *Phragmites karka, Ipomoea carnea* and *Typha elephantina* provide ideal breeding habitats for resident water birds. Although Sarus crane was not recorded from the Survey area, four of them were seen foraging in a marsh adjoining Khanpura village during our visit to Baan Ganga. A detailed check list of the birds identified during the study area is given in Table 6.1.

Table 6.1. Checklist of birds of Baan Ganga wetland (recorded during January-February 206)

	Common Name	**Scientific Name**
Phasianidae: Francolins, Quails, Partridges and Pheasants		
1.	Black Francolin	*Francolinus francolinus*
2.	Grey Francolin	*Francolinus pondicerianus*
3.	Indian Peafowl	*Pavo cristatus*
Anatidae: Geese and Ducks		
4.	Ruddy Shelduck	*Tadorna ferruginea*
5.	Gadwall	*Anas strepera*
6.	Eurasian Wigeon	*Anas penelope*
7.	Mallard	*Anas platyrhynchos*
8.	Spot-billed Duck	*Anas poecilorhyncha*
9.	Northern Shoveler	*Anas clypeata*
10.	Northern Pintail	*Anas acuta*
11.	Garganey	*Anas querquedula*
12.	Red-crested Pochard	*Rhodonessa rufina*
13.	Common Teal	*Anas crecca*
Alcedinidae: Small Kingfishers		
14.	Common Kingfisher	*Alcedo atthis*
Halcyonidae: Large Kingfishers		
15.	White throated Kingfisher	*Halcyon smyrnensis*
Cerylidae: Pied Kingfishers		
16.	Pied Kingfisher	*Ceryle rudis*
Centropodidae: Coucals		
17.	Greater Coucal	*Centropus sinensis*
Columbidae: Pigeons and Doves		
18.	Oriental Turtle Dove	*Streptopelia orientalis*
Gruidae: Cranes		
19.	Sarus Crane	*Grus antigone*
Rallidae: Rails		
20.	White-breasted Waterhen	*Amaurornis phoenicurus*
21.	Purple Swamphen	*Porphyrio porphyrio*
22.	Common Moorhen	*Gallinula chloropus*

Common Name		Scientific Name
23.	Common Coot	*Fulica atra*
Scolopacidae: Snipe and Sandpipers		
24.	Common Sandpiper	*Actitis hypoleucos*
25.	Common Snipe	*Gallinago gallinago*
26.	Black-tailed Godwit	*Limosa limosa*
27.	Common Redshank	*Tringa totanus*
28.	Marsh Sandpiper	*Tringa stagnatilis*
29.	Common Greenshank	*Tringa nebularia*
Jacanidae: Jacanas		
30.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*
31.	Bronze-winged Jacana	*Metopidius indicus*
Charadriidae: Plovers and stilts		
32.	Black-winged Stilt	*Himantopus himantopus*
33.	Little Ringed Plover	*Charadrius dubius*
34.	Northern Lapwing	*Vanellus vanellus*
35.	Red-wattled Lapwing	*Vanellus indicus*
36.	White-tailed Lapwing	*Vanellus leucurus*
Laridae: Gulls and Terns		
37.	Pallas's Gull	*Larus ichthyaetus*
38.	River Tern	*Sterna aurantia*
39.	Black-bellied Tern	*Sterna aurantia*
Accipitridae: Hawks and Eagles		
40.	Osprey	*Pandion haliaetus*
41.	Black-winged Kite	*Elanus caeruleus*
42.	Black Kite	*Milvus migrans*
43.	Eurasian Marsh Harrier	*Circus aeruginosus*
44.	Lesser Spotted Eagle	*Aquila pomarina*
Anhingidae: Anhinga		
45.	Oriental darter	*Anhinga melanogaster*
Phalacrocoracidae: Cormorants		
46.	Little Cormorant	*Phalacrocorax niger*
47.	Indian Cormorant	*Phalacrocorax fuscicollis*
48.	Great Cormorant	*Phalacrocorax carbo*
Ardeidae: Herons and Bitterns		
49.	Little Egret	*Egretta garzetta*
50.	Grey Heron	*Ardea cinerea*
51.	Purple Heron	*Ardea purpurea*
52.	Great Egret	*Casmerodius albus*
53.	Intermediate Egret	*Mesophoyx intermedia*
54.	Indian Pond Heron	*Ardeola grayii*
Ciconiidae: Storks		
55.	Asian Openbill	*Anastomus oscitans*
Corvidae: Crows and allies		
56.	Rufous Treepie	*Dendrocitta vagabunda*
57.	House Crow	*Corvus splendens*
58.	Large-billed Crow	*Corvus macrorhynchos*
59.	Black Drongo	*Dicrurus macrocercus*
Muscicapidae: Thrushes and Flycatchers		
60.	Indian Robin	Saxicoloides fulicata
61.	White-tailed Stonechat	Saxicola leucura
62.	Pied Bushchat	Saxicola caprata
Sturnidae: Starlings		
63.	Asian Pied Starling	Sturnus contra
Hirundinidae: Swallows		

Common Name		Scientific Name
64.	Wire-tailed Swallow	Hirundo smithii
Cisticolidae: Cisticolas and Prinias		
65.	Yellow-bellied Prinia	Prinia flaviventris
66.	Striated Prinia	Prinia criniger
Sylviidae: Warblers and Babblers		
67.	Yellow-eyed Babbler	Chrysomma sinense
Passeridae: Sparrows, Pipits, Wagtails and allies		
68.	Citrine Wagtail	Motacilla flava
69.	Yellow Wagtail	Motacilla citreola
70.	White Wagtail	Motacilla alba
71.	Olive-backed Pipit	Anthus hodgsoni

6.3 Other vertebrates

The Baan Ganga wetland harbours a small population of Marsh crocodile (*Crocodylus palustris*). Although widely distributed all in many parts of India, Marsh crocodile's distribution in Uttaranchal is restricted only to Corbett Tiger Reserve and Baan Ganga wetland. Although three species of turtles: Indian flapshell turtle (*Lissemys punctata*), Spotted pond turtle (*Geoclemys hamiltonii*) and Red-crowned roofed turtle (*Kachuga kachuga*) were recorded during the study the area has the potential to harbour a much higher diversity of testudine fauna. During the study the team came across an uncommon snake Siebold's Water Snake (*Enhydris sieboldii)*, perhaps only the second report of this species from Uttaranchal.

Siebold's Water Snake (*Enhydris sieboldii)*

7.0 Inventory of Fishes and Prospects for Fisheries Development

- K. Sivakumar

The Indian fish fauna comprises about 2500 species. Of these, 930 species belonging to 326 genera inhabit the inland waters (Talwar & Jhingran 1991). There are 12 major rivers and 48 lesser rivers with a total catchment area of 277.6 million hectares in India. The river Ganges being one of the largest rivers of India, supports a significantly large proportion of fish fauna. Ganges and other rivers of India are covered under 'River conservation program', most important of the programme being the `Ganga Action Plan'. These projects target improvement of water quality but habitat improvement for fish is not taken into account. Lack of concern for fish habitat is reflected in the planning of Farakka barrage on the river Ganga. As a result `Hilsa' and several other fishes are under severe threat. A few studies on fish community structure in the major rivers and their tributaries have proved several differences in the diversity and structure. Major reasons for such differences include temporal variation in the physical environment of streams, fluctuating water flow, and fish habitat.

Baan Ganga wetland forms an important site for the conservation of water birds and swamp deer. At the same time the area harbours a dense population of farmers and fishermen who depend heavily on the resources of the area. This component of the study deals with the following objectives:

1. Inventory of Ichthyofauna in the Baan Ganga river.
2. Development of fisheries in this region.

7.1 Methods

Extensive surveys of fish fauna were carried out during the months of February and June 2006. Since the February is the peak period of fishing, majority of the sample collection was done during this period to prepare a checklist of fish species which occur in the Baanganga. Fishermen were interviewed to know the status of catch throughout a year, fishing pattern and their socio-economic condition. People from near by villages were also interviewed to know their dependency on this ecosystem with respect to fish resources and also to know the scope for the development of fisheries in this region. Collected samples were identified using Talwar & Jhingaran (1991) that was aided by an expert from the Zoological Society of India, Dehradun.

7.2 Observations

1. **River ecology:** Approximately 8.5 km long river stretch of river Baanganga near Chandpuri and Madabila villages was surveyed for fish diversity and fish habitat. Compared to the main course of Ganges, the water velocity was low during winter and summer seasons which makes Baan Ganga suitable for both lotic as well as lentic fishes. Since the water velocity is low and with a moderate sedimentation largely comprises of vegetative material and minerals allow several aquatic plants to grow better here.

2. **Fish Diversity:** A total of 40 species of fishes were recorded during the survey period (Table 1). Most of them were commercially important. *Labeo* spp, *Cirrhinus* spp *Notopterus* spp. and *Channa* spp dominated in the catch. Several species of fishes are believed to be breeding here during monsoon. Heterogeneity in the aquatic habitats such as submerged vegetation, open water and patches of reed (*Phragmites karka*) provide ideal breeding habitat for fish. Based on limited field survey, a tentative checklist to fishes in the area has been prepared (Table 7.1).

Table 7.1 Fishes of Bangana with their conservation status (CAMP, 1998)

Sl. No	Species	Status	Common name	Local name
1	*Badis badis*	Not evalutaetd	Dwarf chameleonfish	*Sumha*
2	*Barilius dimorphicus*	CR	Baril	
3	*Catla catla*	VU	Catla	*Catla*
4	*Chagunius chagunio*	Not evalutaetd	Chaguni	*Utta, Galehri*
5	*Channa marulius*	LRnt	Giant snakehead	*pumurl, bhor*
6	*Channa orientalis*	VU	Asiatic snakehead	*Chainga, dheridhok*
7	*Channa punctatus*	LRnt	Spotted snakehead	*Phool-dhok*
8	*Channa striatus*	LRlc	Striped sankehead	*Morrul, Morl*
9	*Cirrhinus mirgala*	LRnt	Mrigal	*Mrigal, Mirki*
10	*Cirrhinus reba*	VU	Repa carp	*Rewah*
11	*Colisa lalia*	Not evalutaetd	Dwarf Gourami	*Khosti*
12	*Danio devario*	LRnt	Devario danio	*Patukari*
13	*Glyptothorax telchitta*	LRnt	Glyotithorax	
14	*Heteropneustes fossilis*	VU	Stinging catfish	*Singee*
15	*Labeo bata*	LRnt		*bata*
16	*Labeo calbasu*	LRnt	Kalbasu, Black rohu	*Karnaunehar, Kalabenise*
17	*Labeo dero*	VU	Kalabans	*Mohaylee*
18	*Labeo dyocheilus*	LRnt	Labeo	*Boalla*
19	*Labeo gonius*	LRnt	Kurio labeo	*Kursi*
20	*Labeo rohita*	LRnt	Rohu	*Rohu*
21	*Lepidocephalichthys guntea*	Not evalutaetd	loach	
22	*Macrognathus pancalus*	LRnt	Striped Spinyeel	*Gaincha, bami, malya*
23	*Mastacembelus armatus*	Not evalutaetd	Tire-track spinyeel	*Bami, Baam*
24	*Monopterus chuchia*	LRnt	Gangetic mudeel	*Anayabaam*
25	*Mystus bleekeri*	VU	Day's mystus	*Tengra, Palwa*
26	*Mystus*	LRnt	Gangetic	*Tengra, tenguah*

Sl. No	Species	Status	Common name	Local name
	cavassius		mystus	
27	*Mystus vittatus*	VU	Striped dwarf catfish	*Tengra, tenguah*
28	*Nandus nandus*	LRnt	Mottled nandus	*vaadhul, dhebari*
29	*Nemacheilus botia*	LRnt	Loach	
30	*Notopterus chitala*	EN	Humped featherback	*Mohi, moya*
31	*Notopterus notopterus*	LRnt	Grey featherback	*Moh, pholi, golhi*
32	*Ompok bimaculatus*	EN	Indian butter cat-fish	*Chechera, papta, gugli, jalkapoor*
33	*Ompok pabda*	EN	Pabdah catfish	*Tambulivapapta*
34	*Puntius chola*	VU	Chola barb	*Katcha-karawa, siddhari*
35	*Puntius chonchonius*	VU	Red barb	*Pothi*
36	*Puntius sarana*	VU	Olive barb	*Giddi-kaoli, durhie, potah*
37	*Puntius sophore*	LRnt	Spotfin swamp barb	*pottiah*
38	*Puntius ticto*	LRnt	Ticto barb	*Kotree, Pothia*
39	*Wallago attu*	LRnt	Boal	*Barwari, Paran*
40	*Xenentodon cancila*	LRnt	Freshwater garfish	*kankle, Kakhya, Thona*

CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LRnt – Lower risk but near threatened, LRlc – Lower risk and leaset concerned

3. **Conservation status of fishes:** Of the 40 species recorded, conservation status of the 35 species have been assessed based on IUCN-CAMP (1998) and of five species could not been evaluated. Of the identified species, 50% of species assessed as in lower risk but they are near threatened (Figure 6.1).

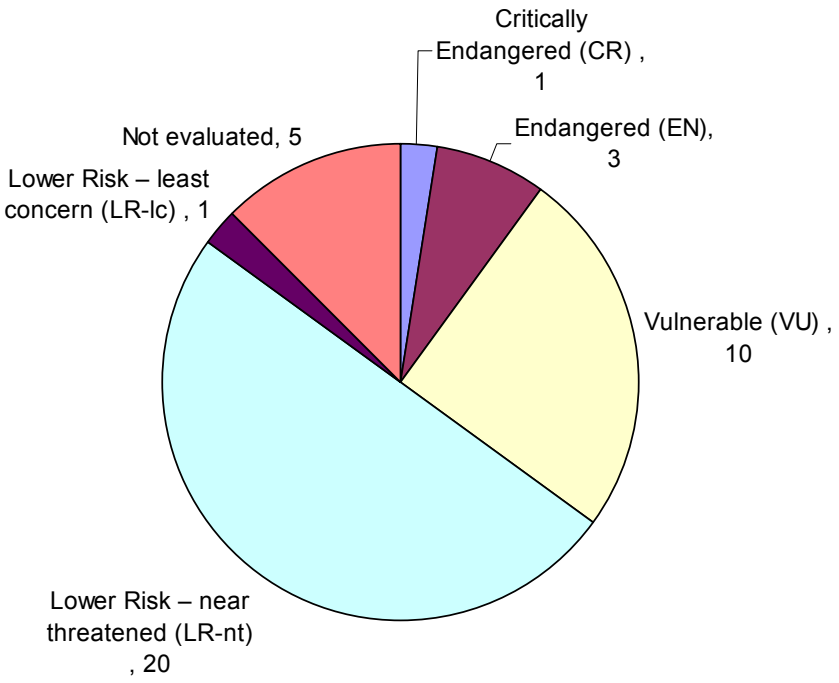


Figure 6.1 Conservation status of the fishes of Bangana.

a. **Critically Endangered** (CR): Fishes which are facing an extremely high risk of extinction in the immediate future. *Barilius dimorphicus* was the only fish species recorded in this category and this species was also found rarely in the catch during survey.
b. **Endangered** (EN): Fishes which are not critically endangered but facing an extremely high risk of extinction in the wild in the near future. *Notopterus chitala, Ompok bimaculatus* and *O. pabda* are found in this region are belonging to this category.
c. **Vulnerable** (VU): Fishes which are likely to move into the endangered category if causal factors continue operating. A total of 10 species were found in this category (Table 6.1).
d. **Lower Risk** (LRnt): Fishes which are not included in any other categories i.e. critically endangered, endangered or vulnerable but they are near threatened. Almost 50% of fishes which occur in the Baanganga river falls in this category.

4. **Fisheries:** Fishing activities usually starts around Diwali festival (November) and ends in (May). There is no fishing during monsoon which is believed to be the breeding season. Fishing has been allowed here on the lease basis. The local district administration lease the area to fishing contractors and the major portion of the lease amount goes to the Village Panchayats. Fishermen from Bihar have been called for fishing and they have been paid 50% of total cost of the fish by the contractor.

Plate 6.1 A fish catch from the Banganga.

5. **Fish catch:** Around 15 fishermen with five small towing boats, 6 gill nets, bamboo traps and spears, catch approximately 500 quintals of fishes in a year. On an average, 25 to 35 kilograms of fish are caught in a day. The catch varies from 0 to 80 kilograms.
6. **Fisheries use:** The Sub Divisional Magistrate (SDM) issues permit to Fish contractor(s) through open tender system. The SDM distributes the 75% of amount to two villages such as Chandpuri and Madabila Panchayats for the development activities. Of the 75%, the Chandpuri village gets 60% of share and remaining 40% given to Madabila village this is based on the area of the river falls in their respective judiciary.

In the year 2005-06, the Chandpuri village had received Rs. 1.55 lakhs which is lesser than what they have received in the year 2004-05 i.e. Rs.2.75 lakhs. It was estimated that around Rs. 4 to5 lakhs income generated from this fish resources and more than 15 families directly gets employment benefits and more than 10 villages gets fish protein from this region.

7. **Ecological value:** Unique hydrological system and heterogeneity in the vegetation types are reasons for the breeding of several fishes in the Baan Ganga area. More than 80 species of waterfowls visit this area during winter which includes several species of piscivores. Resident birds such as cormorant and egrets breeds here and they live mainly on fishes.

Recommendations

Biodiversity in inland waters is highly threatened as compared to other ecosystem (. Allan and Flecker 1993; Kay 1995; Master *et al*. 1998; McAllister *et al*. 1997, and; Ricciardi and Rasmussen 1999). In this context, inclusion of Baan Ganga in the Jhilmil Jheel – Baanganga Conservation Reserve and appropriate mechanism to sustainable harvest of fish in a self regulated manner would help the fishery resources and its users including water birds and human. Following points are suggested for the conservation and development of fishes in the Baan Ganga wetlands:

1. **Maintenance stream flow**: It is increasingly recognized that the distribution and abundance of riverine species are limited by the effects of flow regulation (Bain et al. 1988, Marchetti and Moyle 2001). A strong correlation exists between stream flow and a river's physicochemical characteristics such as water temperature and habitat diversity (Poff et al. 1997). Research in the distributional ecology of fishes suggests that fish assemblages form in response to the physicochemical factors of the environment (Matthews 1987). Change

in the assemblage structure of stream fishes or species composition is imposed by temporal variation in stream flow (Schlosser 1985). Studies show that flow variability affects use of spatial resources or patterns of microhabitat use (Grossman et al. 1998). Therefore, evidence from elsewhere indicates a strong fish response to flow variability, there should not be any intervention on the water flow in future in the Baan Ganga river by constructing any barriers across river.

2. **Capture fisheries**: Current method of traditional fishing may be continued with following conditions:
    a. Not more than 15 fishermen will be allowed for fishing at any given time.
    b. Traditional boats, less than 6 gill nets, less than 50 bamboo traps and less than 10 spears will be allowed at any given time.
    c. Mesh sizes of the gill nets should not be less than 3 X 3 cm.
    d. Fishing should be allowed after the setting of winter i.e. First week of December to 15 May of every year which allows winter visiting water birds settle here before starting of fishing.
    e. Fishermen should not be allowed to camp in the mounds/islands of the Baan Ganga but they may be allowed to camp on the bank of the southern part of the river. This will help the birds and swamp deer to wander without disturbances.
    f. Fishermen should not be allowed to use any destructive fishing methods such as dynamiting, electrifying, poisoning etc.
    g. A proper guideline for fishing is needs to be developed with the consensus of Gram Panjayat, State Forest Department and Fisheries Department.

3. **Culture fisheries**: In Baan Ganga, more than 35% of fishes have assessed as highly threatened and 50% of fishes are in lower risk but near threatened. Hence, it is proposed to go for small scale culture fisheries in near by village ponds. Discussions on this regard had been organized with village Pradhans of this region. Villagers have agreed for culturing native fish species such as rohu, murrel, catla etc in their

village ponds provided the State Government helps them in this regard. It is recommended that the State Forest Department along with the State Fisheries Department can take up a project to promote aquaculture in this region using existing water bodies with native fish species. This will significantly reduce pressure on the Conservation Reserve and its biodiversity.

4. **Control Contamination of Water:** The management authorities need to make sincere efforts to generate awareness among the local people about the adverse impact of pesticides on the aquatic habitat of Baan Ganga. It was observed that the farmers around the Baan Ganga were not using pesticide and fertilizers in a large amount which need to encouraged further. There should be a check on the release of effluents from the industries which are located on the upstream areas. Effluents must be treated before releasing into the natural system. Clear water is essential for breeding fishes.

Maintaining heterogeneity in vegetation types: Since the heterogeneity in the aquatic habitats which occur in the Baan Ganga helps several fishes to breed, this should be maintained as such. Aquatic weeds are required to be managed properly in year-wise plan. There should not be any construction along the banks of river which will change the hydrology and fish habitat. Livestock grazing needs to be controlled along the stream banks as this results in proliferation of weeds.

8.0 Socio -Economic Status of the Local Communities in the Baan Ganga Wetland Area

- Ruchi Badola

The Indo-Gangetic Plains is the most important zone in terms of human concentration in India. It stretches from Kashmir in the north to the Himalayan foothills in the east and the Deccan Plateau in the south and from the Punjab region of Pakistan and Aravalli Range, Rajasthan in the west to delta of the Ganga in Bangladesh in the east. Average annual rainfall increases moving west to east from approximately 600 millimeters in the Punjab Plain to 1,500 millimeters around the lower Ganga and Brahmaputra.

The region is a vast enclosed basin of numerous small and large rivers, separated by alluvial divides. The western section, comprising Punjab, Haryana, Chandigarh, Delhi and western Uttar Pradesh, is slightly higher in elevation, over 150 metres (m) than the eastern section of the plain. Geologically, the whole region is made up of alluvium brought down by the Himalayan Rivers. It also contains some of the largest reserves of underground water in the world.

In social and economic terms, the Indo-Gangetic Plain is the most important region of India and supports one of the highest densities of human population in the world. Nearly 300 million people, accounting for over 30 per cent of India's population live in this zone. The region is dotted with innumerable jheels and marshes, but in over nearly 90 per cent of the Gangetic Plain the natural vegetation has been converted into cropland. Infact this is one region in the sub-continent that has seen the most deforestation bothe during the pre and post independence era. Excessive irrigation, over-use of fertilizers and pesticides have resulted in depleted soils which now require more and more poisonous chemicals to stay 'productive'. Due to this incredible concentration of population, pollution and the destruction of habitats is a matter of serious concern Only in the narrow northern belt, flanking the Himalayan massif in the Shivaliks and bhabar, can one still see bits of natural forests and grasslands.

Farming on the Indo-Gangetic Plain primarily consists of rice and wheat grown in rotation. Other crops include maize, sugarcane, and cotton. The main source of rainfall is the southwest monsoon, which is normally sufficient for agriculture except for occasional droughts. The many rivers flowing out of the Himalayas provide water for major irrigation works.

8.1 Administrative boundary

The area falls in the Laksar tehsil of Hardwar district. Hardwar district (29.58^{o} degree north and 78.13 ^{o} east), covering an area of about 2360 km², is situated in the western part of Uttaranchal state of India. It is located in the north western part of the Indoa Gangetic plain. The height from the sea level is 249.7 meters. The district came into existence on 28th Dec. 1988. The district is surrounded by Saharanpur in the west, Dehradun in the north and east, Pauri Garhwal in the east, Muzaffarnagar and Bijnor in the south. The district headquarters is situated in the Roshnabad, at a distance of about 12 km from railway station. The district is administratively subdivided into three tehsils i.e. Hardwar, Roorkee and Laksar and six development blocks i.e. Bhagwanpur, Roorkee, Narsan, Bahadrabad, Laksar and Khanpur. Hardwar is one of the first town where Ganga emerges from the mountains to touch the planes. As per the 2001 census, the population of the district is 14,44,213 out of which only 30.8% is urban (census of India, 2001). Sex ratio is 865 females per thousand males. Literacy rate is 63.7% (male 74% and female 52%). Due to Hardwar's location on the bank of river Ganga, it has plenty of water resources and almost all kind of food grains are produced here in abundance.

Laksar tehsil is located at the southernmost tip of the Hardwar district. The population as per 2001 census was 1,89,275, of which 90.4% is rural population. Literacy rate is 59.2, with male literacy rate of 73 and 44 % for females. Of the total population 43.7% is the cultivator and 24.9% work as agricultural labourers. Main crops are sugarcane, tilhan and potato (District Statistical Handbook, 2003).

The Baan Ganga wetland is situated in the Lanksar Block of Hardwar district. An 8 sq. km. stretch of the Baan Ganga near Idrispur-Chakheri forest block has been taken up for Wetland Conservation by the Uttranchal Forest Department. It is a true representative of the riverine wetland ecosystem (UFD, 2005). It is a Khadar area which gets submerged during the monsoon. The Bann Ganga is a perennial river fed by the Pathari rao, Idrishpur, Hadwaha and Badshahpur Nallhs and the water from the Ganga. A socio economic survey of four villages (Mandavela, Idrishpur, Sherpur Bela and Chandrapuri Bangar) falling along the 8 km stretch of the Baan Ganga was carried out. Following an initial reece, a combination of structured and unstructured interview schedule was developed. Data were collected through participant observation and the interview schedules respectively. The interview schedule was developed to capture various aspects of the day-to-day life of people, their socio-economic structure and income and occupational patterns. It also looked at their relationship (and dependence if any) with the Baan Ganga river and their awareness and attitudes towards the river. The background information was gathered from the offices of the Forest Department, governmental, census records and District Statistical Handbook.

8.2 Socio-economic condition of the villages

The area along this 8 km stretch of the Baan Ganga is dominated by sugarcane, wheat and paddy cultivation. The area is not well connected and gets almost cut off during monsoon. Almost a year back, it was difficult to reach these villages as the road was a mud road. Six months back the road was made into a mortar road through the MLA funds and now it is an all weather road. The people are poor and work mainly as farmers and laborers. Not many industries or opportunities for income generation exist in the area. Less than 1 % of the people are employed in the government sector. The islands in the river Ganga are used by the villagers for cultivation during summer and winters. Sand mining is also prevalent in this stretch of the river. Parts of the Baan Ganga River are auctioned off by the village Panchayats for fishing. Reeds are collected from these areas for thatching and weaving mats.

Since the people have few alternatives, removal of vegetation along the river, poaching of birds and wild animals is rampant. Encroachment of sugarcane fields into the forest area is another problem.

Table 8.1: General information of the surveyed villages

	Chandrapuri Bangar	Idrishpur	Sherpur Bela	Mandavela
Distance from Bann Ganga (Km)	2.5	1.5	3.5	1.3
Primary school	Present	Present	N	Present
Middle school	Present	N	N	Present
Distance from the nearest High school (Km)	5	7	4	6
Distance from the nearest hospital (Km)	30	28	27	29
Distance from the nearest inter college (Km)	30	28	27	29
Distance from the nearest market (Km)	30	28	27	29
Distance from the nearest bank (Km)	30	28	27	29
Distance from the motor able pucca road (Km)	0.5	0.4	0	0

Most of the villages are located at a distance of 1.5 to 3.5 km from the Baan Ganga. The villages have poor infrastructural facilities and for higher education, medical treatment and even for market the people have to travel to a distance of 25 to 30 km (Table 8.1). Infact Laksar forms the nearest larger township for these villagers. The number of households varies from 68 to 231, Idrishpur being the smallest in terms of population while Chandrapuri being the largest. However the number of families dependent on the Baan Ganga directly is very small and that too exists only in two villages Chandrapuri and Mandavela (Table 8.2).

Table 8.2: Demographic information of the surveyed villages

	Chandrapuri Bangar	Idrishpur	Sherpur Bela	Mandavela
Number of Families	231	68	205	219
Total Population	1130	231	850	989
Families dependent on Bann Ganga	4	0	0	2
Dependent on Bann Ganga for	Fish	Nil	Nil	Fish

The main use of the wetland by the local people is as a route to go to their lands on the other side

Photo: Dhgananjaya Prasad

The number of illiterate people is highest in village Sherpur Bela, while it is lowest in Idrishpur. In all the villages the females are more illiterate as compared to males, except for village Sherpur Bela. Very few people are educated beyond high school as they have to go far for higher education. The number of females going for higher education is much less as compared to males in all the villages (Table 8.3). However the proportion of males and females going for education beyond High school is higher in Chandrapuri Bangar and Idrishpur as compared to Sherpur Bela and Mandavela. There is also a sharper decline in the level of female education the later two villages as compared to the former two (Table 8.3).

Table 8.3: Literacy levels in the surveyed villages

Education Level		Chandrapuri Bangar	Idrishpur	Sherpur Bela	Mandavela
Illiterate	**Male**	165 (14.6)	22 (9.5)	361 (42.5)	130 (13.1)
	Female	270 (23.9)	34 (14.7)	267 (31.4)	180 (18.2)
Primary	**Male**	405 (35.8)	80 (34.6)	130 (15.3)	400 (40.4)
	Female	195 (17.2)	40 (17.3)	80 (8.5)	181 (18.3)
High School	**Male**	28 (2.5)	17 (7.4)	4 (0.5)	36 (3.6)
	Female	12 (1.1)	8 (3.4)	2 (0.2)	14 (1.4)
Inter	**Male**	22 (1.9)	11 (4.8)	3 (0.3)	29 (2.9)
	Female	8 (0.7))	3 (1.1)	0	11 (1.1)
Graduate	**Male**	20 (1.7)	13 (5.6)	2 (0.2)	5 (0.5)
	Female	5 (0.4)	3 (1.1)	1 (0.1)	3 (0.3)

Figures in parenthesis are in percent

The main sources of income for the people of these villages is agriculture, agricultural labour and small business, some people are employed on daily wages basis with the forest department or other line agencies. In village Sherpur Bela none of the people have even small businesses or earn regular wages. Very few people have government jobs. Majority (85% to 97%) of the families in all the four villages own cattle. The maximum proportion of cattle owning families is in Chandrapuri Bangar, while the minimum is in Sherpur Bela (Table 8.4). The cattle are largely for agricultural purposes and for meeting their own needs of milk and milk products. Some families are able to earn nominal incomes from their cattle through sale of milk and their use as drought animals. The highest proportion of families earning income form cattle is in Chandrapuri Bangar (6.5%) while the lowest is in Mandavela (3.2%).

Table 8.4: Livestock holdings in the surveyed villages

	Chandrapuri Bangar	Idrishpur	Sherpur Bela	Mandavela
Income Source	Employment, Agriculture, Labour, Business	Employment, Agriculture, Labour, Business	Agriculture, Labour	Employment, Agriculture, Labour, Business
% families getting income from livestock	6.5	5.9	4.9	3.2
Livestock number	600	250	500	550
Families owning livestock	224 (96.9)	65 (95.6%)	175 (85.4)	204 (93.2)

Figures in parenthesis are in percent

The highest proportion of landless families is in Sherpur Bela (15.2%) while the lowest are in Idrishpur (1.5%) (Table 7.5). The proportion of families having larger size holdings is also the lowest in Sherpur Bela, 51. 7% have less than 1 acre land, 31.7% have 1-5 acre land, only 1.5% families own more than 5 acres land (Table 8.5). Idrishpur and Mandavela have higher proportion of families having larger landholdings i.e. more than 1 acre. In Idrishpur 67.6 % of the families have land holdings ranging from 1-5 acres, while 2.9% have holdings larger than 5 acres. In Mandavela 61.2 % families have land holdings ranging from 1-5 acres, while 9.1% have holdings larger than 5 acres (Table 8.5).

Table 8.5: Land ownership pattern in the surveyed villages

	Chandrapuri Bangar	**Idrishpur**	**Sherpur Bela**	**Mandavela**
Landless families	5 (2.2)	1 (1.5)	31 (15.1)	5 (2.3)
< 1 acre	81 (35)	19 (27.9)	106 (51.7)	60 (27.4)
1-2 acre	95 (41.1)	26 (38.2)	45 (21.9)	79 (36.1)
2-5 acre	32 (13.9)	20 (29.4)	20 (9.8)	55 (25.1)
> 5 acre	18 (7.8)	2 (2.9)	3 (1.5)	20 (9.1)

Figures in parenthesis are in percent

The direct dependence of people on the Baan Ganga wetland is negligible. Only a few families are involved in fishing from the wetland. The wetland is infact used by the people to navigate to their landholdings on the other side. Another benefit that they derive is as daily wage earners when the management activities are taken up by the forest department. The small patches of forest along the wetland provide some subsistence products to the villagers. Therefore when the villagers were questioned regarding the availability of alternatives to resources form this wetland they were not much concerned (Table 8.6). In fact majority of the villagers from all the villagers supported the idea of developing this as tourism spot. They perceive that they would be able to find some income generation opportunities in that case. The interest of the villagers is all the more because they feel that if this area gains attention as a tourist area then there will be more development activities in the area. In Idrishpur and Sherpur Bela people have no objection if

restriction is imposed on extraction of resources (fish) from Bann Ganga. However in Chandrapuri Bangar and Mandavela, a large number of people oppose any kind of restrictions on fishing (Table 8.6), even though very few of them are actually fishing in this wetland (see Table 8.2). The reason is that fishing tenders in this wetland have been taken up by a few powerful people who are supported by the majority of the villagers.

Table 8.6: Attitudes of people towards the management of Baan Ganga

	Chandrapuri Bangar	**Idrishpur**	**Sherpur Bela**	**Mandavela**
Alternative available in absence of resources from Bann Ganga	Agriculture	Agriculture, Employment, labour, business, shops	Agriculture, labour	Agriculture, Business,
Should Bann Ganga be developed as tourist spot	Yes (600)	Yes (195)	Yes (658)	Yes (608)
Do you agree if restriction is imposed on extraction of resources from Bann Ganga	No (700)	Yes (195)	Yes (650)	Yes (550) No (439)

Figures in parenthesis represent the total number of responses

8.3 Discussion and conclusion

A wetlands perspective on rural development recognizes the multiple uses and services of wetland ecosystems, as well as the interactions among different ecosystem units and across different scales of activity. It gives special attention to the livelihoods of poor people dependent upon wetlands and sets socioeconomic challenges within an ecological context not only in the present but also for the future. Overtly it may appear that the local people in the surrounding villages do not have much dependence or do not derive many benefits from the Baan Ganga. However, in this area agriculture is the major land use. This has been largely facilitated by availability of water, the water table in this region being high. The survival of the local livelihoods is thus heavily dependent on the survival and health of this system. However, in

this area as well in the surrounding areas, it is apparent that during the last few years, the water table is going down (Dhananjaya Prasad, Local Range Officer, Pers. Comm.) probably due to reclamation of smaller wetlands for development activities such as construction, roads building etc. Development planners have often assumed that wetlands used and managed in a relatively natural state are worth little when weighed against the benefits of converting them to more 'productive' uses. In the Baan Ganga area, encroachment of the wetland and conversion into is a major problem. Till the recent past the area was largely inaccessible du wetpo poor road network. Moreover being a part of the Gangetic flood plains, it was cut off for over 6 months in a year. Therefore not much attention was given to these areas. The extent of area under encroachment is not clear and can only be assessed after surveying and demarcation of the area (UFD, 2002-12) These encroached lands are being used for agriculture.

Participation of people is the key to successful conservation of this wetland: An codevelopment committee meeting in progress

Photo: Dhananjaya Prasad

There is a great potential to develop this area as a Community Reserve under the aegis of the Indian Wildlife (Protection) Amendment Act (WLPA) 2002. A large proportion (*c* 80,000 ha) of the land along the Baan Ganga wetland is owned by the *Gram Panchayats* and the local people and only a small proportion (*c* 600 ha) is owned by the forest department (Dhananjaya Prasad, Local Range Officer, Pers. Comm.). Moreover Uttranchal state has the pride of place in having declared two Conservation Reserves, the only two in the country so far. This can emerge as the first Community Reserve in the state and the country. However, it is difficult to develop stakes of people in the conservation of this wetland as they derive very few direct benefits from this wetland. In such a situation a sustainable approach would focus on finding out

the non use values of the Baan Ganga wetland. Villagers see tourism as one of the major use of the wetland and hence such programs that enhance eco-tourism and local economy should be formulated and implemented, with involvement of local people. So far the local people are indifferent to the flora and the fauna including the birds as they do not see any benefits or loss to them due to these. But they are willing to cooperate with the State for developing this as a tourism site as they can foresee direct economic and developmental benefits to themselves from such an initiative. Many studies have emphasized that the attitude of local people is one of the ultimate factors determining the improved management and conservation effectiveness of the natural ecosystems (Struhsaker et al., 2005).

The wetland management program generally involves activities to protect, restore, manipulate, and provide for the functions and values emphasizing both quality and acreage by advocating sustainable usage of them (Walters, 1986). Management of wetland ecosystems requires an intense monitoring, increased interaction and co-operation among the various agencies (state departments concerned with environment, soil, natural resource management, public interest groups, citizen groups, agriculture, forestry, urban planning and development, research institutions, government, policy makers, etc). Such management goals should not only involve buffering wetlands from any direct human pressures that could affect the wetlands normal functions, but also in maintaining important natural processes that operate on them that may be altered by human activities. Wetland management has to be an integrated approach in terms of planning, execution and monitoring requiring effective knowledge on a range of subjects from ecology, economics, watershed management, and planners and decision makers, etc. To achieve this it is important to go beyond protection measures for certain areas, habitats or landscape features, and impose binding requirements for coordination of sectoral policies at the scale of an ecological unit. All this would help in understanding wetlands better and evolving a more comprehensive solution for long-term conservation and management strategies.

9.0 Concept Plan for Nature Interpretation and Conservation Education

- Bitapi C. Sinha

This Concept Plan deals with nature interpretation and Conservation Education for the visitors and public use of the Baan Ganga wetland. The goal is a safe, visually coherent, appropriately sequenced and enjoyable experience with a focus on Conservation education centre, exhibits and self guided activities. Signs and exhibits, when designed and fabricated and installed will welcome, orient and educate visitors to the facilities and the resources of the wetland. Through the signs, exhibits and brochures visitors will be better informed about how to enjoy their visit and how to manage their activities to avoid impacting the area. Most visitor questions will be anticipated and answered by the exhibits so personal contact with the Forest Department staff will not be necessary to understand the purpose and objective of the refuge.

Before the implementation of the conceptual plan there is a need to :

* Clearly identify the potential target audience for the program
* Identify themes
* Research information
* Allocate Budget

Conservation Education Centre Concept Design and Function

The conservation education centre should be located at the entrance of the wetland. The Forest Chowki close to Idrishpur or the watch tower at Baan Ganga would be appropriate sites for such a centre. The centre would serve the education and awareness needs of both the visitors to the Baan Ganga wetland and for the villagers living in and around the area. At present there are no visitors to the Wetland. In future, the visitors can be school children, wildlife enthusiast, bird watchers students and casual visitors.

Since the area is submerged during monsoon the design and location should take care of this. The education centre exterior design and placement should welcome visitors and set the tone for the experience inside. The placement should make it visually obvious but not obtrusive to the visitors. The building exterior should visually complement the natural surroundings.

Upon entering the conservation education centre, visitors will be greeted at the reception desk in the alcove. Behind the desk on the wall would be the location map of the Baan Ganga wetland which would give the visitors a clue as to where they are. Leaving the alcove, the visitors would enter the larger exhibit room through the right entrance, where exhibits are on display. The text in the panels would be minimum and would be bilingual i.e. English and Hindi.

Panel 1: Biophysical setting of the Baan Ganga wetland

The panel would depict the Baan Ganga wetland ecosystem and its physical characteristics like soil, geomorphology, geology and climate. Ecological processes associated with wetland like precipitation, Mean monthly minimum and maximum temperature, ground and surface water etc.

Panel 2: Aquarium

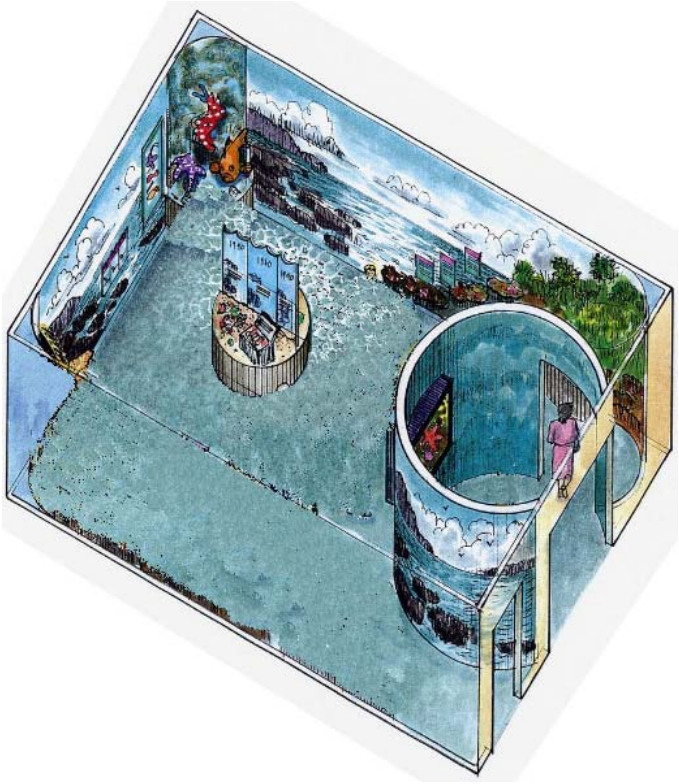
The live exhibit would depict the fish fauna of Baan Ganga wetland. The area is rich in freshwater commercial as well as ornamental fishes. Of the 40species of fish reported from Baan Ganga 10 species can be kept in the aquarium at the conservation education centre (Sivakumar, K per comm). The importance of fish fauna in a wetland and the prospect of fisheries would also be depicted so that the local people are aware of why and how to protect the wetland and also take up fisheries as an alternate source of income.

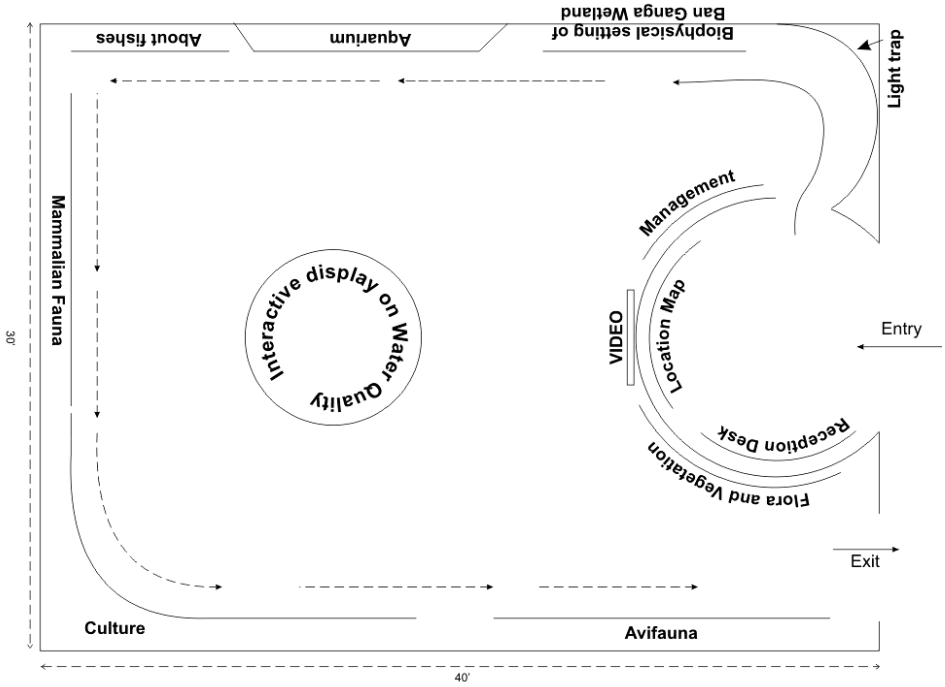
Panel 3: Mammalian Fauna

Endangered fauna found in the area would be depicted and their habitat requirements and threats to the species would be discussed. The panel would also discuss about leopards and how to keep safe distance from the carnivore.

Panel 4: Culture

The area is surrounded by villages with agriculture fields, where mostly sugarcane is grown. The panel would depict the local people's dependency on the wetland and would also suggest alternates to counter the severe anthropogenic pressure. This panel would be in the form of diorama.





Panel 5: Avifauna

A combination of shallow and deep water habitat makes the Baan Ganga an ideal waterfowl habitat. Large numbers of both migratory and resident birds have been recorded in this area. The panel would depict pictorially the migrant and resident birds and their behavior. Calls of birds would also be included in the panel to make it interactive for visitors and the children coming to the conservation education centre.

Panel 6: Flora and Vegetation

The Baan Ganga River is rich in aquatic vegetation. The panel would depict both the wetland as well as the island vegetation. Importance of different species for the fauna and avifauna would be emphasized. Along with pictorial depiction, herbarium too would be displayed. Vegetation would be classified into natural vegetation and those that occur due to biotic and abiotic disturBaance. This would help visitors understand what is good for the wetland system and what should not happen.

Panel 7: Management

The panel would describe the management issues and also describe the initiatives taken by the Forest Department.

Interactive Display

In the centre of the hall there would be an interactive display on Geo hydrology and Water Quality. Effluent from the sugar factory located nearby is drained into the Wetland. The display would depict the water quality and also talk about what happens to the ecosystem when the water is contaminated and how it affects humans and the biodiversity of the area.

Video

The centre would have a Plasma wall mounted display screen on which films on the wetland and other related issues are screen for the audience.

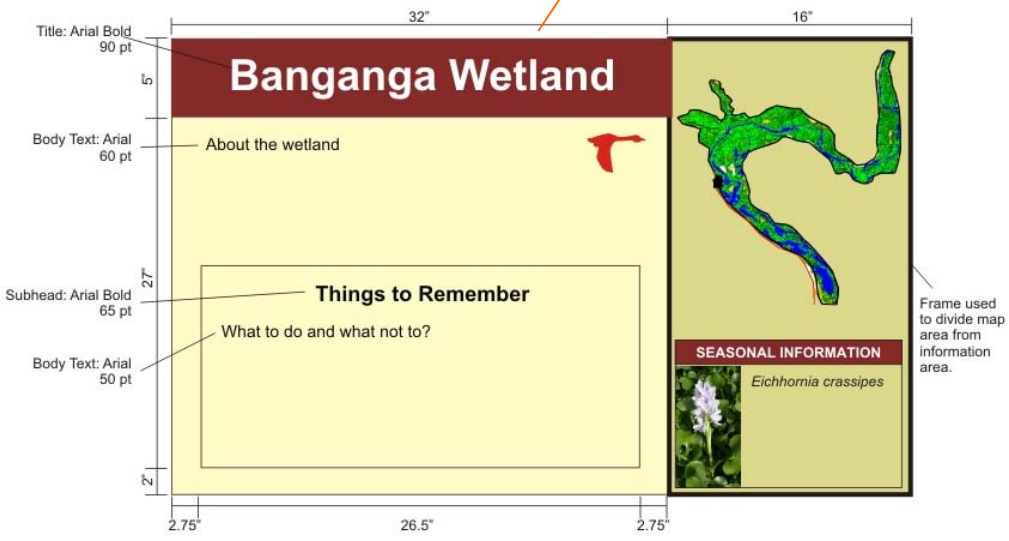
Signs and Visitor Circulation

A minimum number of signs are needed to welcome, direct or control visitors at Baan Ganga. These signs are described below.

Entrance/Orientation Kiosk

The entrance sign kiosk will house a detailed map of the wetland, showing boundaries, indicating “you are here” and pointing out major points of interest. The kiosk will also list the rules to be followed while on the visit to the wetland.

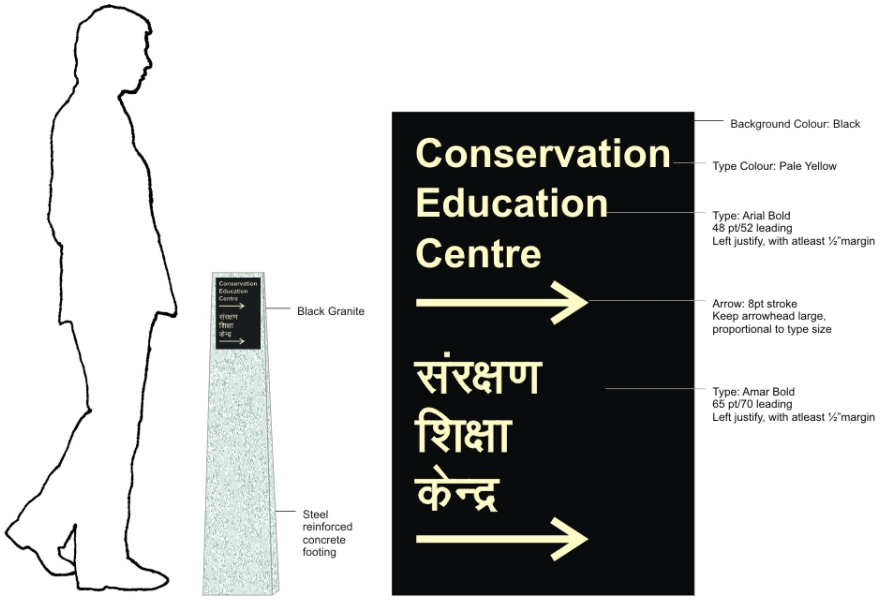
The kiosk will be so placed that all visitors to the wetland will have to pass through the kiosk. Thus the kiosk can also be the site for entry permit and holding area for the visitors.



Pathway Directional Signs

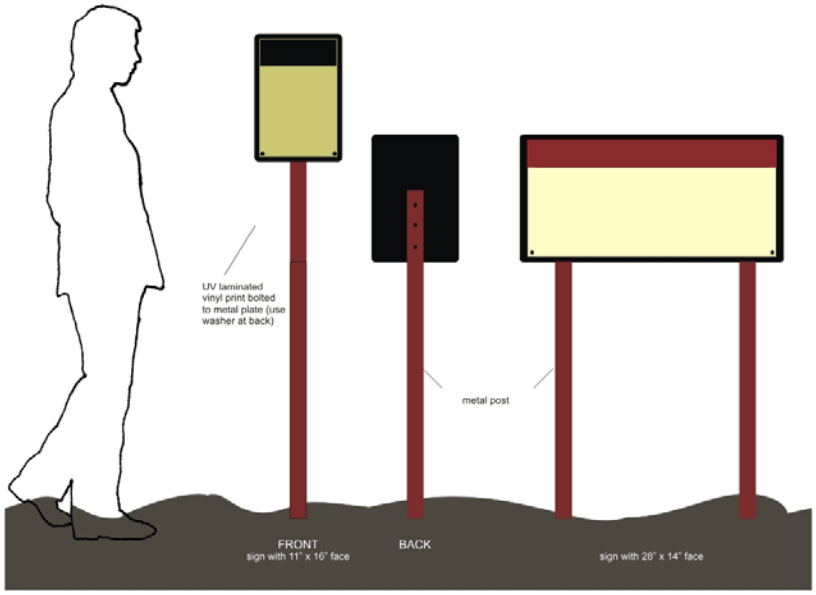
In order to regulate the flow of visitor’s pathway directional signs should be placed at regular intervals so that the visitors are aware which way to go. The signs should lead them to all the major facilities that are available for the visitors such as toilets, drinking water, boat ghat, conservation education centre and the exit.

Since the area is inundated during monsoon therefore the signs have to be sturdy so as to withstand flood. Steel reinforced concrete footing with granite sign panel is recommended.



Temporary Signs

Since the area is flood prone therefore not all signs can be permanent. Some signs can be made temporary which can be removed just ahead of the flood period, which would also coincide with the closing of the area for visitation. These signs can be placed for interpreting seasonal or temporary things like flowering of some plants or migratory birds which arrive in the area during a particular period.



Publications

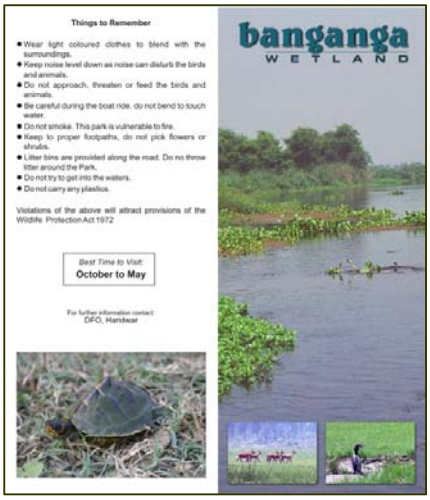
All publications should have a mast head so that the viewer can know which department has produced it. This would also a means of publicity for the area and the department. Following publications for the area are proposed:

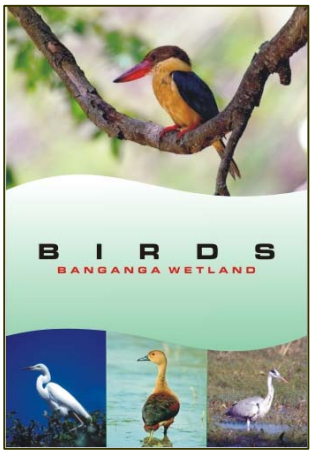
* Park Brochure
* Checklist of Birds
* Plant identification guide
* Posters
* Outreach Material

Publications can be priced and the money generated can be ploughed back through village ecodevelopment committee. The revenue can be used for replenishing the stock of publications and also maintaining the conservation education centre.

Park Brochure

The brochure would consist of all the information that would be required by a visitor for planning the visit and also what one can expect to see in the area. The brochure would also have the Things to remember i.e what one is allowed to do on the trip within the wetland and what is prohibited. It would also give information on the timings and the period when the wetland would be open for visitation.





Checklist of Birds

Baan Ganga has large number of resident and migratory birds which have been recorded . Presence of raptors such as Marsh Harrier and Osprey in good numbers indicate the health of the wetland region. The area can be promoted as a birding site for bird lovers and students. In order to assist the students a checklist of birds should be prepared. This checklist can be

regularly updated with the help of Birdwatchers and new records mentioned.

The checklist can be produced both in Hindi and English so that the students from the neighboring schools and colleges can also be benefited.

Plant Identification Guide

Since most of the facilities in the Baan Ganga wetland would be self guided therefore it is important that the visitors have some aid to assist them in knowing about the wetland. The plant identification guide would be a source of information for wetland flora . Visitors can use the guide to know about the plants in the wetland and on the islands.

The guide would be pictorial with line drawing depiction of the plant. It will have the Botanical name, common name, flowering and fruiting period, importance to the habitat and to the fauna.

Posters

A series of 4 pictorial posters is recommended namely:

* Fishes
* Flowering Plants
* Fauna
* Importance of a Wetland

These posters can be sold as souvenirs for the visitors and can also be used as out reach material for the local villagers and school children . The posters can be produced in two languages i.e. Hindi and English.

Outreach Material

Since students, local villagers and children are also potential visitors to the area , therefore it is important to reach out to them through publications and other means.

These materials can be used during special events day such as World Environment Day 5th June, Wildlife Week 2-8th October and Wetland Day 2nd February. Special events increase public awareness of an environmental

issue and motivate people to participate by focusing their attention on a particular issue.

The materials can be activity booklets like draw and color, sheets or cards. The material produced has to be in Hindi and in easy to understand language. The activity booklets can be used by school children and on successful completion of the activity they can be given a **Certificate** which would motivate the children to learn more about their surrounds.

Environment clubs too can be formed in schools and colleges located around the wetland and activities can be undertaken in the clubs.

Audio Visual

Films are an important media of mass communication and it works well in rural settings where very few people are literate. Series of 20 minutes film on the wetland ,its importance, threats and its mitigation can be prepared with strong visual content. The commentary can be in Hindi for use in the villages but English commentary can be superscripted for use in the Conservation Education Centre. The film should be professionally done on DG Beta Pro Formats and sound recorded on DAT (Digital Audio Tape). The DVD is easy to handle and maintain. Not only this, now most of the rural areas one can find DVD players through which the films can be shown on television screen for small audience and through LCD projector for large audience.

10.0 General Recommendations

- Bivash Pandav and G.S. Rawat

Baan Ganga Wetlands represent a remnant Terai habitat in Uttaranchal and supports a variety of wetland fauna and flora including endangered swamp deer, hog deer, saras crane, marsh crocodile. This area has also emerged as a prominent wintering ground for a number of migratory water birds, The area serves as a corridor for the movement of swamp deer between Hastinapur WS and Jhilmil Jheel Conservation Reseve. This adds to the conservation significance of the area.

Based on the rapid ecological assessment of Baan Ganga Wetlands in Laxar Range of Haridwar Forest Division, Uttaranchal, following recommendations are made for better conservation and management of the area:

i. Land survey and demarcation of boundaries: Presently there is no clear demarcation of reserve forest, revenue land and other land use categories in Baan Ganga area. It is recommended that the Forest Department, in consultation with revenue department and local people should take up demarcation of the area for future management of various land use practices in a holistic manner.

ii. Based on the ecological information generated through this study a comprehensive conservation plan for the area needs to be developed. The plan should include control of illegal grazing by feral cattle from the adjoining districts, control of pollution by sugar mills, development of eco-tourism facilities and linking with alternate livelihoods for the poorer section of the society, conservation education and regular monitoring of wetlands and constituent floral and faunal elements. This area needs to be included with Jhilmil Jheel Conservation Reserve and should be managed together as a single unit.

iii. It is well established that the health of riverine wetlands is strongly influenced by the stream flow which determines the physicochemical

characteristics such as water temperature and habitat diversity. Creation of bunds and diversion of water in the upstream areas of Baan Ganga will severely affect its ecology. Hence it is strongly recommended that water flow in Baan Ganga should be maintained and no intervention should be allowed in future in the stream flow by constructing barriers etc.

iv. Current methods of traditional fishing may be continued with following conditions:

a. Not more than 15 fishermen should be allowed for fishing at any given time.
b. Traditional boats, less than 6 gill nets, less than 50 bamboo traps and less than 10 spears should be allowed at any given time.
c. Mesh sizes of the gill nets should not be less than 3 X 3 cm.
d. Fishing should be allowed after the onset of winter i.e. first week of December to 15 May of every year which allows winter visiting water birds to settle here before starting of fishing.
e. Fishermen should not be allowed to camp in the mounds/islands of the Baan Ganga but they may be allowed to camp on the bank of the southern part of the river. This will help the birds and swamp deer to wander without disturbances.
f. Fishermen should not be allowed to use any destructive fishing methods such as dynamiting, electrifying, poisoning etc.
g. A proper guideline for fishing needs to be developed with the consensus of Gram Panchayat, State Forest Department and Fisheries Department.

v. Recommendations for fisheries development: In Baan Ganga area, more than 35% of fishes have been assessed as highly threatened and 50% of fishes are in lower risk but near threatened. Hence, it is proposed to go for small scale culture fisheries in nearby village ponds. Discussions in this regard had been organized with village Pradhans of this region. Villagers have agreed for culturing native fish species such as rohu, murrel, catla etc in their village ponds provided the State Government helps them in this regard. It is recommended that the State Forest Department along with the State Fisheries Department can take up a project to promote aquaculture in this region using existing water bodies with native fish species. This will significantly reduce pressure on the Conservation Reserve and its biodiversity.

vi. Removal of water hyacinth should follow a two pronged approach. Firstly the larger reservoirs of water hyacinth located upstream need to be cleared by flushing such patches out during monsoon and also manually removing from the water bodies. This should be followed by periodic removal of water hyacinth from the down stream areas. Efforts should be made to compost the water hyacinth and use it as a green manure.

vii. *Phragmites* and *Typha* patches along the river bank and in the islands provide ideal shelter for swamp deer as well as breeding sites for the resident water birds. Removal of *Typha* and *Phragmites* patches through cutting and burning needs to be regulated and this could be allowed only from the pre-designated areas on rotational basis.

viii. The conservation reserve supports a sizeable population of migratory waterfowl, a wide variety of fish, endangered swamp deer and is an ideal destination for ecotourism. Development of an interpretation centre highlighting the biological and conservation significance of the community reserve would enhance the tourism potential of the area.

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