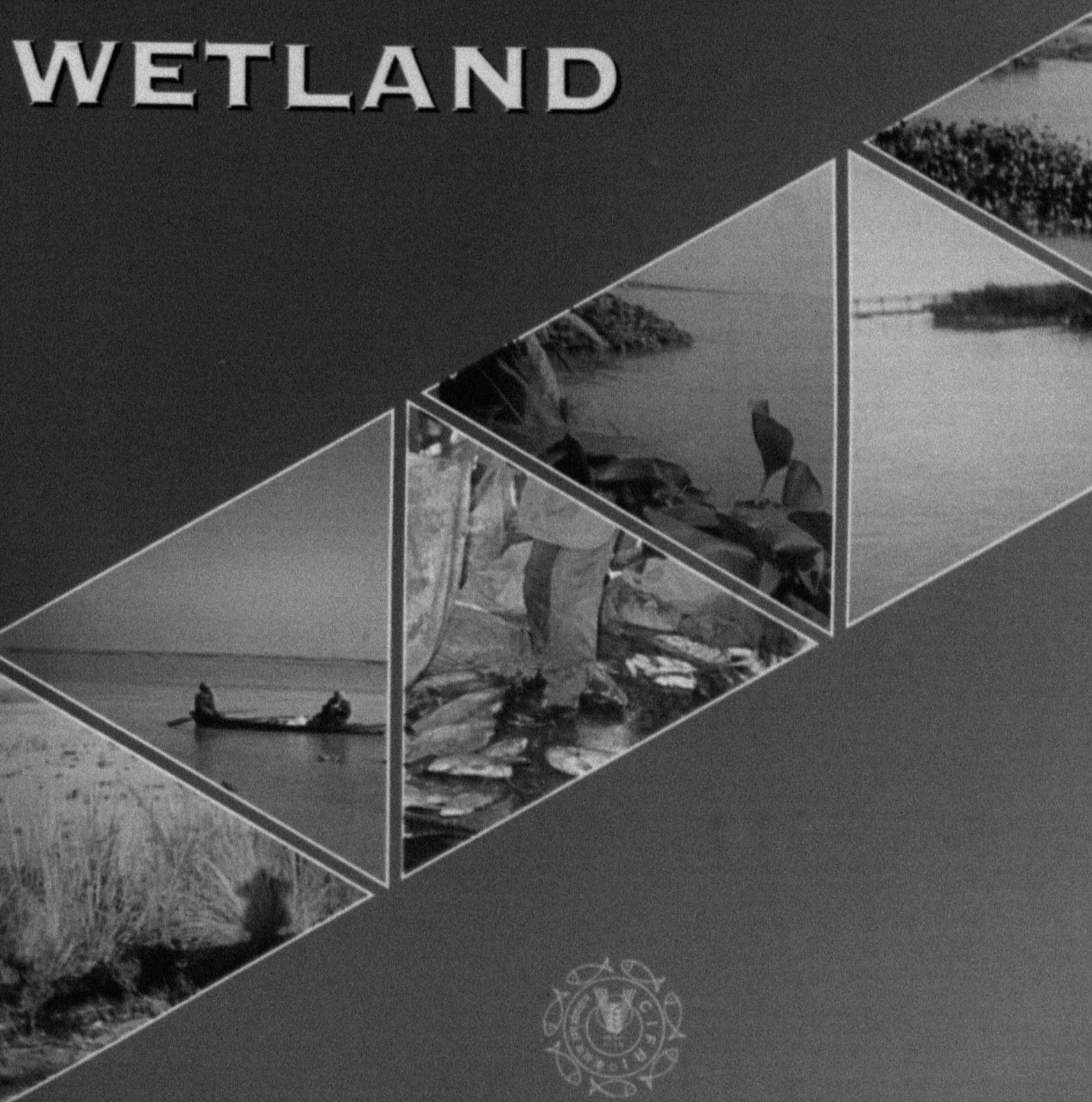
HARIKE WETLAND



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FOREWORD

Wetlands as is well known are very important for water quality improvement, hydrological control and overall stability of natural ecosystem. These are home to vast genetic resources both plant and animal origin, hence it is imperative on the part of the humanity to conserve Wetlands for long lasting effects.

Wetlands are either natural or man-made. Most of the natural wetlands have been eliminated due to human intervention while at the same time artificial Wetlands have emerged all over the world due to manipulation of water resources mainly rivers for various purposes. Harike wetland is one such man made lake which came into existence in 1952 by erecting a barrage at the confluence of Sutlej and Beas at Harikepattan in Punjab. It was declared a "Ramsar site" in 1990 by Govt. of India and is one of the six wetlands included in "Ramsar list".

Harike Wetland is home to large avi and fish fauna, but today it is facing an ecological crises. An increase in agricultural and industrial activities in catchment and surrounding areas has resulted in its deterioration over the years. The main cause of its degradation being siltation, weed infestation encroachment and pollution. All these ingredients except encroachment enter into the system through its 2 resources, Sutlej and Beas. In order to find out the level of pollutional influx brought in by two rivers and its impact on wetland ecosystem mainly fishery, a project "Evaluation of ecological and fish community structure of Indus System" is being undertaken by the scientists of Karnal Centre of CIFRI. Hartike wetland forms the part of the project work. This document summarises the findings on ecological biological characteristics and fish production potential of wetland carried over 3 years from 1999-2002.

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1. INTRODUCTION

Harike Wetland falls in Amritsar, Kapurthala and Ferozpur districts of Punjab. It came into existence in 1952 as a result of the construction of barrage at confluence of river Beas and Sutlej (main 2 rivers of Indus system within Indian territory) at Harikepattan, with the objective of providing drinking and irrigation facility to Southern Punjab and Rajasthan.

The wetland is known for its rich aquatic plant and animal diversity and attracts large population of avifauna. It supports rare, vulnerable and endangered faunal species which include the testudine turtle (*Gleoclemys hamiltonii*) and smooth Indian otter (*Lutra perspicillata*) both of which are listed in the IUCN Red list of threatened animals (Ladhar *et al*, 1994). It harbours large and diverse fish population and was vital source of fish for the people of Punjab, till the advent of new century

Harike is one of the six wetlands of international importance in India designated under "Ramsar Convention" and is known as "Ramsar site" since 1990. Ministry of Environment and Forests, Govt. of India, declared it as a "Reserve" in 1987 and as a Sanctuary in 1992, but fishing etc was allowed in the system. In the year 2000 the Sanctuary came under "Wild Life Act" and fishing was totally banned thereby making a great dent on the natural fishery resources of the state (Moza and Mishra, 2002).

2. PHYSIOGRAPHY

Harike one of the largest wetlands of Northern India is situated 31°13'N latitude, 75°12'E longitude. It was initially spread over an expanse of 148 sq. km . But now wetland/sanctuary is spread over 86 km^{-2} only, of this 45 km^{-2} is dry area and 41 km^{-2} wet area.

The wet area is actually reduced to 28 km^{-2} on account of siltation and encroachment. Within the wet area, actual deep water is only 17-18 km^{-2}, rest is marshy. Of the 18 sq. km deep water , open water is spread within 8-10 km only rest is infested with water hyacinth (PPCB, 1995). Water is lentic in several pockets and lotic in some portions. There are several islands and broken lands within the wetland.

3. ANTHROPOGENIC ACTIVITY AROUND THE WETLAND

Harike wetland is surrounded by agricultural fields an all sides and largely by township of Amritsar and Kapurthala districts. Effluents from these two districts and increased agricultural activities find direct access to this lake. In addition the wetland is influenced by domestic, agricultural and industrial waste of almost whole Punjab brought in mainly by river Sutlej via Budda Nalla and Chittibein and to lesser extent by river Beas and Kalibein.

Harike today is facing an ecological crisis. water hyacinth has invaded the system largely covering nearly 80% of open water surface. Its spread obstruct the free flow of water, increases siltation thereby raising bed level which in turn affects its productivity mainly fishery.

4. HARIKE ECOSYSTEM

Harike ecosystem was monitored by measuring (i) Availability of water resource within wetland (ii) Soil and water quality (iii) Primary production and (iv) Biotic communities – presence and composition at such a position which reflects the mineral and other load brought in by 2 rivers and mixing up of 2 resources.

Location taken up was at the right bank of "Reserve" at the influx of river Sutlej. (site i) Second site (ii) was at the left site at the influx of river Beas. Third site (iii) was at the confluence of two rivers in the middle, upstream of barrage.
Observations were taken up for a period of 3 years from 1999-2002 on seasonal basis (pre-post-monsoon and winter).

4.1 Availability of water (cusecs) at Harike Head Works (Fig. 1)

Harike Head Works has sufficient water except summers (April-May), as such paucity of water is not a problem for this Wetland.

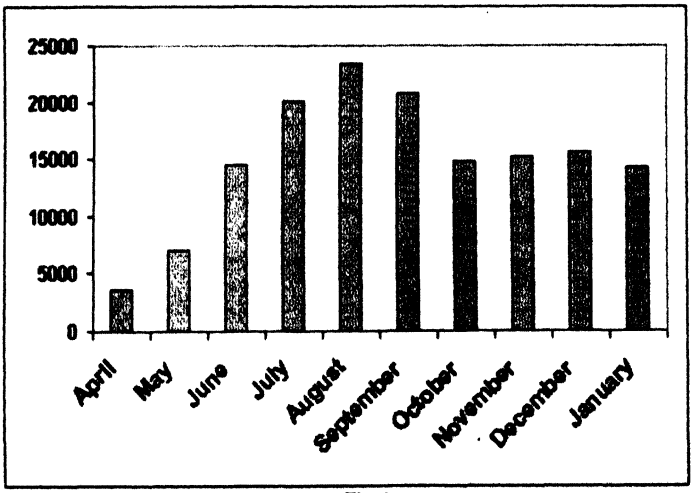


Fig. 1
Source Irrigation department, Harike Punjab

4.2 Soil quality

Texture

Wetland has sandy loam soil at the sites of inclusion of both the rivers (Table-2). Texture becomes sandy (61.75-76.33% sand) at the confluence site, may be due to settling of sand because of obstruction of barrage .

Characteristics

Soil of Harike is alkaline at all sites in all seasons. pH ranging between 7.25 to 8.04. Availability of organic carbon, 0.40-0.55%, available nitrogen, 9.4-26.4 mg/100gm, available phosphorus 0.44-1.05 mg/100g within Harike designate it as medium productive. Specific conductance range of 208-245 µmhos/cm along Sutlej bank site depict the area having good amount of dissolved solids in all seasons compared to Beas bank site, having conductance of 152-211.67 µmhos/cm. The values also depict that monsoons do not cause much dilution in influx of river Sutlej.

4.3 Water quality

Physical characteristics

Water temperature of wetland exhibited large fluctuation (Table 3). It being high 29-31°C during pre-monsoon, moderate, 25°C during post-monsoon and very low 14-14.3°C during winter.

Transparency also exhibited large variation 16.6-45.0 cm depending on the season as well as nature of contributory resource.

Chemical characteristics

pH of water was alkaline in the range of 7.11 to 8.14 except at Sutlej bank site (6.74) and confluence site (6.8) during winter indicating unhealthy condition of water along site - i during winter.

Other chemical characteristics like dissolved oxygen, total alkalinity, total hardness, dissolved solids and specific conductance show Harike aquatic resources delineated into different compartments. The areas under the influence of Beas river has sufficient DO, 6.0-8.8 mg/l, productive alkalinity 72.0-94.67 mg/l. Water hardness range of 87.5-107.5 mg/l. Total dissolved solids range of 87.0-106.5 mg/l and specific conductance of 175.3-215.0 µmhos/cm do not warrant much organic load.

The area under the impact of Sutlej river had very low DO, 3.6-4.4 mg/l, high alkalinity of 97.0-152.67 mg/l. Total hardness, 112.5-166.7 mg/l, total

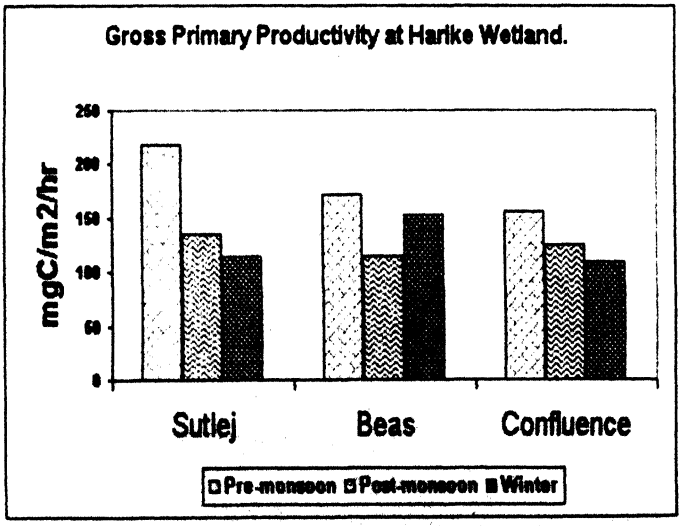
dissolved solids 139.5-195.7 mg/l and specific conductance of 282.0-356.67 µmhos/cm warrant high organic load in the area.

The area at confluence site - iii show the impact of both the resources. The site has conducive DO. 7.0-7.3 mg/l and total alkalinity, 77.7-112.9 mg/l. Water hardness ranged between 88.8-115.0 mg/l. Total dissolved solids ranged between 116.7-122.7 mg/l and specific conductance 231.0-258.7 µmhos/cm. The above values show that water characteristics of wetland are overall conducive for productivity except the Sutlej bank site during winter.

The phosphate range of 0.02 to 0.19 mg/l at all sites in all seasons also confirm the productive nature of wetland.

4.4 Primary productivity

Gross primary production of the wetland differed at different sites (Table 4). It being highest in the areas under the impact of two rivers compared to confluence site in all seasons. The productivity was high during pre-monsoon at all sites compared to post-monsoon and winter. The decrease in gross production along Sutlej bank site during winter may be under the impact of pollution as is observed by its soil and water characteristics.



4.5 Biotic communities

4.5.1 Plankton

Standing crop of plankton did not vary much within the wetland during the tenure (Table 5a). It ranged between 267-300 u/l along Sutlej bank, high during pre-monsoon than other seasons. The density along Beas bank site was comparatively more 325-350 u/l, high during post-monsoon to winter and at confluence site the density was midway between two, 300-333 u/l low during winter.

Plankton composition unlike density exhibited marked variation at 3 sites. At site no.(i), the population composition had 69% phytoplankton and 31% zooplankton. Phytoplankton were contributed almost equally by the bacillariophyceae (29.15-26.13%), chlorophyceae (23.3-20.6%) and myxophyceae (21.6-17.75%). Zooplankton population was contributed by rotifers (8.3-11.11%), copepods (4.7-20.8%) and cladocerans (nil-16.63%). Dominance of cladocerans during winter season confirm that during winter polluted ingredients especially organic in nature increase in Sutlej thereby in Harike.

Microphytic vegetation along site (ii) had 77% of phytoplankton and 23% of zooplanktons. Phytoplankers were contributed by bacillariophyceae (30.9-39.78%), chlorophyceae (20.52-30.9%), myxophyceae (14.4-15.4%) and dinophyceae (nil-4.2%). Zooplanktons were contributed by rotifers (3.7-8.92%) and copepods (9.7-15.4%) only. Comparative low presence of blue-green algae and absence of cladocerans at this site in all seasons denote that the amount and nature of effluent brought in by Beas is comparatively less polluted than Sutlej.

Microphytic vegetation at confluence site (iii) was 81.4% phytoplankters and 18.6% zooplankters. Phyto were contributed by bacillariophyceae (27.15-29.20%), chlorophyceae (30-40%), myxophyceae (16.36-23%). Zooplankters were contributed by rotifers (10.80-16.30%), copepods (nil-8.3%). Dominance of chlorophyceae, presence of considerable myxophyceae and rotifers exhibit this site eutrophic.

4.5.2 Periphyton

Standing crop of periphyton exhibited variation at different sites (Table 5b)and in different seasons. Over all density was low during pre-monsoon and high during post-monsoon.

At site (i), the density was less. It being nil during pre-monsoon and ranged between 367-350 ucm^2 during post-monsoon to winter. The composition like plankton was equally contributed by bacillariophyceae (30.26-37%),

chlorophyceae (36.93-27.64%) and myxophyceae (32.22-37.2%). Presence of blue-green algae almost equal to diatoms in open water system denote the site polluted.

At site (ii), periphyton crop ranged between 150-433 ucm^2 low during pre-monsoon and high during post-monsoon The population was formed of bacillariophyceae (33.3-48.02%), chlorophyceae (34.90-50%) and myxophyceae (16.6-21.90%). Obvious changes in periphyton concentration and composition show that concentration of nutrient load brought by Beas varied significantly in different seasons compared to Sutlej. It being high during pre-monsoon than other seasons.

Site (iii) exhibited comparatively less changes in periphyton density (200-400 ucm^2) and composition. Bacillariophyceae (53.3-49.6%), chlorophyceae (36.65-30.3%) and myxophyceae (10.0-19.4%) had almost similar contribution towards total population in different seasons. Dominance of diatoms depict this site less polluted than other two.

The microphytic vegetation of Harike was mainly formed of *Navicula, Nitzschia, Diatoma, Cymbella, Synedra* among diatoms. *Spirogyra, Ulothrix* and *Crucigenia* among green algae. *Spirulina, Microcystis* and *Phormidium* among blue-green algae

Branchionus, Polyarthra, Filinia among rotifers. *Daphnia* among cladocerans and *Cyclops* among copepods.

4.5.3 Macrobenthos

Macrobenthic density of Harike varied largely between the 3 sites (Table5c) mainly during post-monsoon. Maximum variation was at site (i). It being 389 um^{-2} (pre-monsoon), 477 um^{-2} (winter) and 1619 um^{-2} (post-monsoon). Population was mainly formed by Ephemeroptera nymphs (0.9-5.0%), Odonate nymphs (nil-34.23%), Chironomids (20.0-34.23%), molluscs (nil-22%), Oligochaetes (14.40-35.70%). Other groups like Hemiptera (10%), Coleoptera (15%), Water Nematodes (14.24%) and Ostracodes (9.95%) were present seasonally (Table 5 c).

Presence of Ostracodes (9.95%), tubificids (29.88%) and chironomids (21.41%) compared to 22% of mollusc population during post-monsoon show that monsoon do not cause much dilution in Sutlej river system hence at this site also as the site is influenced by the above said river.

The macrobenthic density at site (ii) varied between 348-133 um^{-2} , high during pre-monsoon and low during post-monsoon. Macrobenthic population at this site had absence of oligochaetes mainly tubificids, ostracods, water

nematods and has presence of sufficient molluscans (23.02-74.87%) showing the site less polluted mainly during post-monsoons (Table 5 c).

Macrobenthic density at site (iii) ranged between 977-117 u/m^2 high during pre-monsoon and low during winter. The population composition like density showed seasonal fluctuations. It was contributed by mollusca (66.6%) and oligochaetes (27.7%) during pre-monsoon, mollusca (50%) and chironomids (50%) during post-monsoon and mollusca (80%) and oligochaetes (20%) during winter.

Presence of 50% chironomids during post-monsoon only and its absence during pre-monsoon and winter show the wetland ecosystem in the middle recovers during post-monsoon and is more under the influence of Beas characteristics than Sutlej. As change in chironomid dominating community to oligochaete dominating community are first signs of eutrophication (Reddy & Rao, 1987). The absence of oligochaetes mainly tubificidae at site (ii), its seasonal presence at site (iii), and continuous presence at site (i) in nut shell exhibit source and extent of eutrophication within Harike.

4.5.4 Macrophytes

Harike wetland provides habitat to large vegetation, 34 species of aquatic macrophytes both submerged and emerged have been recorded from the system (Bath *et al.* 1998), but only 8 species were encountered during the present survey mainly due to site location (Table 5d). Both Sutlej and Beas banks, site i and ii of lake have lotic character. Site iii, the confluence in the middle upstream has been reported poor in aquatic vegetation earlier also (Bath *et al.*, 1998).

Macrophytes were present in all seasons at all sites, the over all density being low 0.050 – 0.096 kgm^{-2} during post-monsoon and high 1.16-2.08 kgm^{-2} during winter. Maximum seasonal fluctuation in biomass was observed at Sutlej bank (site i). It being 0.50 kgm^{-2} in post-monsoon and 2.08 kgm^{-2} in winter and 1.4 kgm^{-2} in pre-monsoon. Beas bank site (ii) had biomass of 1.4 kgm^{-2} in pre-monsoon, 1.0 kgm^{-2} in post monsoon and 0.096 kgm^{-2} in winter. At confluence site biomass ranged between 0.080 kgm^{-2} (winter), 1.16 kgm^{-2} (post-monsoon) and 1.0 kgm^{-2} (pre-monsoon). The various species encountered at different sites during different seasons were as flows.

In addition to these, 2 emerged macrophytes *Typha* sp. and *Phragmite* sp. were present all over the edges of the banks at site i and ii.

Table 5 (d). Site-wise presence of macrophytes at Harike

Site	Sutlej Bank			Beas Bank			Confluence		
Name of species	Winter	Pre-mon.	Post-mon.	Winter	Pre-mon.	Post-mon.	Winter	Pre-mon.	Post-mon.
Hydrilla verticulata	+	-	+	+	-	-	-	-	+
Ceratophyllum echinatum	+	+	-	+	+	-	+	+	-
Vallisneria spiralis	-	-	-	+	-	+	-	-	+
Chara sp.	-	-	-	+	-	+	-	-	+
Nymphaea sp.	-	-	-	-	+	+	-	+	+
Nelumbo nucifera	-	-	-	-	-	+	-	+	+
Naias sp.	-	-	+	+	-	+	-	+	+
Eichhornia cressipes	+	+	+	+	-	+	+	+	+

4.5.5 Macrophyte associated fauna

Macrophyte associated fauna exhibited large intra site and inter seasonal variation in density and population composition (Table 5e). The density was observed no way related to macrophyte biomass. It being low at all sites (11-17 ukgm^{-2}) during winter when water temperature of lake on an average was 14°C and vegetation was at its peak, 1.0-2.08 ukgm^{-2} . Sutlej bank site had highest meiofauna density during pre-monsoon, 62 ukgm^{-2} compared to post-monsoon (17 ukgm^{-2}) and winter (15 ukgm^{-2}). The associated fauna along Beas bank was highest during post-monsoon 39 ukgm^{-2} than pre-monsoon (19 ukgm^{-2}) and winter (11 ukgm^{-2}). The density fluctuation at confluence resembled site i (Table 5 e).

The macrophyte associated fauna showed maximum diversity at site i and iii compared to site ii . Site wise variation in composition is given in Table 6.

Table : 6 : Site-wise presence of macrophyte associated fauna at Harike

Site	Sutlej Bank Site-1			Beas Bank Site-2			Confluence Site-3		
Name of sp.	Pre-mon.	Post-mon.	Winter	Pre-mon.	Post-mon.	Winter	Pre-mon.	Post-mon.	Winter
Shrimps	-	-	-	+	+	-	-	-	-
Cladocera									
Macrothrix sp.	+	-	-	-	-	-	-	-	-

Daphnia sp.	-	+	+	-	-	-	+	-	-
Ephemeroptera									
Baetis nymphs	+	-	-	-	-	-	-	-	-
Odonates									
Hagenius sp.	-	-	-	-	-	-	+	-	-
Epicardulia sp.	-	-	-	-	-	-	-	-	+
Enllagoma	-	+	-	-	-	-	-	+	+
Coleoptera									
Berosus larvae	-	+	-	-	+	-	-	-	-
Elmidae larvae	-	-	-	-	-	-	+	-	-
Belostoma sp.	+	-	-	-	+	-	-	-	-
Hydrocanthis sp.	-	+	-	-	-	-	-	-	-
Octhebius sp.	-	+	-	-	-	-	-	-	-
Dytiscus sp.	-	+	-	-	-	-	-	-	-
Hydroparus sp.	-	-	-	-	+	-	+	-	-
Hemiptera									
Hebrus sp.	-	-	-	-	-	-	-	-	+
Lacotrepes sp.	+	-	-	-	-	-	-	-	+
Ostracoda									
Cypris sp.	-	-	-	+	+	-	+	-	-
Acari									
Hydrachna sp.	-	-	-	-	-	-	-	-	+
Mollusca									
Gyraulus sp.	+	+	+	+	+	-	+	-	+
Valvata sp.	+	-	-	+	-	-	-	-	-
Lymnae curricularia	+	-	-	-	+	+	-	-	-
L. pinguis	+	-	-	-	+	+	+	-	-
L. columella	-	-	-	-	+	+	-	-	-
Pleurocerca sp.	-	-	-	+	-	-	-	-	-
Aplexa	-	-	-	-	-	+	-	-	-
Corbicula straitella	-	-	-	-	-	+	-	-	+
Diptera									
Culicoides	-	-	-	+	-	-	-	-	-
Chironomus larvae	+	+	+	+	-	-	+	bloom	-
Oligochaeta									
Nais sp.	-	-	-	-	-	-	+	-	-
Placobdella sp.	-	-	+	-	-	-	+	-	-
Glossiphonia sp.	-	-	-	+	-	+	-	-	-
T. tubifex	+	-	-	-	+	+	+	-	+
Limnodrillus sp.	+	-	-	-	-	-	-	-	+
Branchiura sp.	+	-	-	-	-	-	-	-	-

5. FISH AND FISHERY

5.1 Fish population

Harike is home to large fish population contributed mainly by 49 fish species, enlisted in Annexure-I.

Punjab State Council for Science and Technology has also enlisted 50 species which included *Hypopthalmicthys molitrix, Ctenopharyngodon idella* and *Tilapia* (Per. Comm..) . but during current observation these 3 fish species were never encountered at Harike landing center. rather another exotic –Thai magur, *Clarias gariepinus* was observed intermittently in catch adjoining wetland since Sept.2002.

Besides this eurythermal carps, *Labeo dero* and *L. dyocheilus* showed their presence although rarely.

5.2 Fish resources (Table 7)

Harike wetland used to be major source of fishery to the state of Punjab till 1999. But with implementation of "Wild Life Act" from the year 2000, this resource is out of bounds for fishing activity. The effect of prohibition has caused twofold decrease almost 54-56% in total production of Sutlej fishery.

The estimated fish biomass of Harike envisaged from Harike-Pattan landing center was 28.67 t/month during 1999-2000 when Wetland was open to fishing. The biomass reduced to 10.40 t/m during 2000-01 and 12.95 t/m during 2001-02, when fishing was banned, thereby showing a decrease of 62-55% in fish catch at Harike within a span of 2 years without any untoward calamity except the prohibition of fishing within Bird Sanctuary/Wetland area (Table 7 a).

Table 7. Change in fish biomass and composition along Sutlej in relation to change in fishery resources between 1999-2002

a)

Biomass : Total catch Tons/month	1999-2k	2k-2001	2001-02
R. Sutlej	60.51	27.92	26.45
Harike-Pattan	28.67	10.67	12.95

b)

Composition	Total	Percentage composition				
Station/Year	landing t/month	IMC	Minor carps	*C. carpio*	Catfishes	Misc.
Ludhiana						
1999-2k	11.27	72.05	2.40	-	17.83	7.72
2k-2001	2.12	32.49	18.40	5.66	18.87	23.58
2001--02	3.12	28.84	7.69	2.24	10.58	50.68
Jallandhar						
1999-2k	7.63	26.73	43.38	25.56	-	4.33
2k-01	-	-	-	-	-	-
Harike						
1999-2k	28.67	12.80	32.91	22.78	11.91	19.50
2k-01	10.40	26.63	11.63	8.96	23.65	29.13
01-2k	12.95	37.92	6.33	18.07	7.26	30.42

The same picture of fish resources emerges when fish biomass of whole river Sutlej is considered between these 3 years (Table 7 a). Survey indicated total estimated fish landing of Sutlej was 60.51 t during 1999-2k (Harike open to fishing). The catch reduced 27.92 t/m and 26.45 t/m during 2001-02, exhibiting a decrease of 54-56% in total production when Harike was closed for fishing, thereby indicating that Wetland/Sanctuary area holds more than 50% of Sutlej fishery.

As regards availability of various fish groups within Wetland, it is presumed that Harike is home to maximum commercial species mainly Indian major carps (IMC). The observations regarding fish composition at Harike landing center during 1999-2k is not true reflection of its population, because the excessive fish produce especially IMC were transported directly to fish markets of Ludhiana and Jallandhar for higher renumeration.

The fish composition of Harike during 2000-01 and 2001-02 is somewhat true reflection of Wetland as the catch is of adjoing Sanctuary area and the produce is mainly disposed off at Harike itself.

Sectorial variation in total biomass and fish composition between the two time periods 99-2k and 2000-02 at those landing centers which are under the influence of market i.e. Ludhiana, Jallandhar and Harike-Pattan depict the nature of fishery prevalent within Wetland.

Taking Harike landing center catch as base line data, fish population during 99-2000 was dominated by minor carp (32.91%) followed by common carp (22.78%). IMC (12.80%) and large catfishes (11.91%) formed subsidiary contribution towards total population (Table 7 b). But during subsequent years

(2k-02). IMC population was more than double 26.63% and 37.92% respectively (Table 7 b). on the contrary IMC population recorded sharp decrease from 72.05% (99-2000) to 32.49% (2000-01) and 28.84% (2001-02) at Ludhiana and no Sutlej fishery at Jallandhar. This shows that Indian major carps disposed off at Ludhiana and Jallandhar till 1999 were mainly from Wetland System.

6. CONCLUSION

Ecological studies of Harike has shown that water quality and trophic status of Beas zone within wetland has over all good conditions, but soil, water and biotic communities exhibit degraded conditions along Sutlej side especially during winter when ingress of water within that side is less.

As regards fishery, the assumption is that 18- 28 sq. km of Bird Sanctuary (water area) hold more than 50% of total population of river Sutlej (240 km within plains).

Now the question arises, is it feasible to allow to continue this much of population to be carried by such small water area, which is prone to silting and bumper growth of macrovegetation. As far as Wild Life Act goes "No activity can be allowed within the premises of Sanctuary" but for better survival and growth of any population harvesting play a dynamic role. Further observations show that Sanctuary area sustain good amount of IMC and these are prone to decline in open water due to anthropogenic activity (Mishra & Moza, 1998).

7. RECOMMENDATIONS

1. The feeder source of wetland especially river Sutlej needs an action plan on the lines of "Yamuna Action Plan" to lessen its pollutional load.
2. Chittibein a tributary/Nalla which joins Sutlej just 8 km above wetland boundary bring industrial and domestic effluents from such far off places as Nawanshehar and Jallandhar. This Nalla needs cleaning. The effluent discharge especially from leather factories of Jallandhar needs to be disposed off only after treatment.
3. Weeds need to be removed continuously from the system.
4. Desiltation of Wetland should be taken up, as siltation is significantly reducing the open water area.
5. Urgent need to check encroachment.
6. To utilize wetland resources judiciously fishing may be allowed for some limited period within Sanctuary, so that interest of both migratory birds as well as fishery are protected, for this some sort of understanding should be developed at highest level.

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ANNEXURE-I

LIST OF FISHES IN HARIKE WETLAND

1. *Notopterus chitala*
2. *N. notopterus*
3. *Channa punctatus*
4. *C. marulius*
5. *C. striatus*
6. *Heteropneustes fossilis*
7. *Clarias batrachus*
8. *Catla catla*
9. *Labeo calbasu*
10. *L. rohita*
11. *L. bata*
12. *L. gonius*
13. *L. dyocheilus*
14. *L. dero*
15. *Cirrhinus mrigala*
16. *C. reba*
17. *Mastacembelus armatus*
18. *M. panchalus*
19. *Ambassia ranga*
20. *A. nama*
21. *Oxygaster sp.*
22. *Puntius sophore*
23. *P. tetrarupagus*
24. *P. chrysopterus*
25. *P. puntius*
26. *P. striatus*
27. *P. conchonius*
28. *Botia birdi*
29. *Wallago attu*
30. *Mystus vittatus*
31. *M. bleekeri*
32. *M. seenghala*
33. *M. tengra*
34. *Colisa fasciatus*
35. *Bagarius bagarius*
36. *Rita rita*
37. *Amphipnous cuchia*

38. *Cyprinus carpio specularis*
39. *C. carpio communis*
40. *Chela bacaila*
41. *Lapidocephalichthys guntea*
42. *Trichogaster lutius*
43. *Osteobrama cotia*
44. *Nandus nandus*
45. *Gobius giuris*
46. *Gudisia chapra*
47. *Ompok pabda*
48. *Eutropiichthys vacha*
49. *Clarias gariepinus (Tahi magur)*

Table 2. Seasonal fluctuations in Wetland bed soil characteristics.

Parameters / Sites	Seasons	Sand (%)	Silt (%)	Clay (%)	pH	Organic carbon (%)	Available nitrogen (mg/100g)	Available phosphorus (mg/100g)	Sp. conductance (µmhos/cm)
Sutlej Bank	Pre-monsoon	53.95	27.85	18.2	7.5	0.40	11.9	0.44	245
Beas Bank		45.45	32.75	21.8	7.25	0.50	9.14	0.54	209
Confluence		66.89	21.97	11.13	7.77	0.35	26.49	1.04	198.33
Sutlej Bank	Post-monsoon	65.43	28.17	6.4	7.71	0.32	13.34	1.05	208
Beas Bank		63.33	25.33	11.33	7.75	0.20	18.17	0.89	211.67
Confluence		61.75	28.85	9.4	8.34	0.44	18.18	1.32	271
Sutlej Bank	Winter	56.03	35.47	8.5	7.80	0.55	12.95	0.76	233.33
Beas Bank		59.87	27.67	12.47	8.04	0.24	15.73	0.58	152
Confluence		76.33	16.33	7.33	8.03	0.39	13.49	0.91	181

Table 3. Seasonal fluctuations in wetland water characteristics.

Season	Pre-monsoon			Post-monsoon			Winter		
Site/Parameters	Sutlej	Beas	Confluence	Sutlej	Beas	Confluence	Sutlej	Beas	Confluence
Water temperature (°C)	31.0	30.5	29.0	25.0	25.3	25.0	14.0	14.2	14.3
Transparency (cm)	14.5	22.5	18.0	45.0	16.6	26.3	31.8	25.3	22.7
pH	7.95	8.14	8.12	7.27	7.43	7.37	6.74	7.11	6.8
DO (mg/l)	4.4	6.0	7.0	4.9	7.8	7.3	3.6	8.8	7.07
CO_2 (mg/l)	-	1.5	-	3.3	7.0	4.5	3.7	3.0	3.0
T. alkalinity (mg/l)	97.0	72.0	84.0	103.3	77.3	77.7	152.67	94.67	112.7
TDS (mg/l)	139.5	106.5	117.3	143.3	87.0	116.7	195.7	96.7	122.7
Total hardness (mg/l)	112.5	87.5	88.8	134.8	93.3	115.8	166.7	107.5	115.0
Sp. conductance (µmhos/cm)	282.0	215.0	237.67	290.0	175.3	231.0	357.67	194.3	258.7
Silicate (mg/l)	1.8	1.5	1.2	2.6	1.5	2.2	2.1	1.2	1.05
Phosphate (mg/l)	0.09	0.08	0.02	0.19	0.16	0.18	0.15	0.09	0.11

Table 5 .Seasonal Fluctuation in biotic communities.

(a) . Plankton density and composition

Site	Season	Total density (u/l)	Percentage Composition						
			Baccillariophyceae	Chlorophyceae	Myxophyceae	Rotifers	Copepods	Cladocera	Himiptera
Sutlej bank	Pre-monsoon	300	29.15	21.8	20.8	8.3	20.8	-	-
Beas bank		325	30.9	30.9	15.4	7.1	15.4	-	-
Confluence		333	29.20	40.0	18.80	10.80	-	-	3.2
Sutlej bank	Post-monsoon	267	28.86	23.3	17.73	11.11	6.6	11.11	-
Beas bank		350	39.78	22.52	15.13	3.7	15.13	-	3.7
Confluence		333	27.15	31.0	23.0	10.83	8.3	-	-
Sutlej bank	Winter -	267	26.13	20.6	21.36	10.26	4.7	16.63	-
Beas bank		350	33.71	28.95	14.45	8.92	9.7	-	4.2
Confluence		300	28.41	30.26	16.36	16.36	4.2	-	-

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Table 5 (b) . Periphyton density and composition.

Site	Season	Total density (u/cm²)	Percentage Composition						
			Baccillariophyceae	Chlorophyceae	Myxophyceae	Rotifers	Copepods	Cladocera	Himiptera
Sutlej bank	Pre-monsoon	Nil	-	-	-	-	-	-	-
Beas bank		150	33.3	50.0	16.6				
Confluence		200	53.3	36.65	10.0				
Sutlej bank	Post-monsoon	367	30.26	36.93	32.66				
Beas bank		433	48.02	38.28	17.32				
Confluence		400	51.85	31.11	17.04				
Sutlej bank	Winter	350	37.0	27.64	37.2				
Beas bank		383	43.38	34.90	21.20				
Confluence		333	49.6	30.53	19.4				

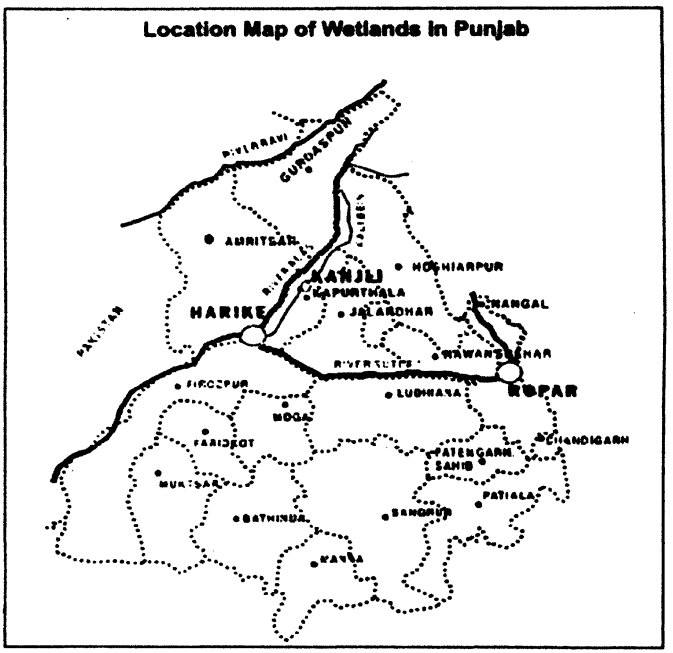
Table 5 (e) . Seasonal fluctuations in Biotic communities, Macrobenthos-density and composition.

Species / Site	Season	Total density (n/m^2)	Percentage Composition							
			Ephi.	Odonata	Hemip.	Coleop.	Diptera (chironomids)	Molluscs	Oligoch.	Others
Sutlej bank	Pre-monsoon	389	5.0	-	10.0	15.0	20.0	-	35.70	14.24 (Nematodes)
Beas bank		348	-	-	-	-	39.42	40.78	-	7.69 (Culicoids) 6.25 (Crustaceae)
Confluence		977	-	-	-	-	-	66.6	27.7	6.20 (Misc.) 5.5 (Crustaceae)
Sutlej bank	Post-monsoon	8619	2.72	11.0	-	-	21.41+2.48	22.0	29.88	9.95 (Cypris)
Beas bank		133	-	-	-	-	25.06	74.87	-	-
Confluence		267	-	-	-	-	50.0	50.0	-	-
Sutlej bank	Winter	477	0.9	34.23	-	-	34.23	16.21	14.40	-
Beas bank		288	-	16.5	-	-	59.97	23.01	-	-
Confluence		117	-	-	-	-	-	80.0	20.0	-

Table 5 (e) : Macrophytes associated fauna, density and composition (%) at Harike.

Species / Site	Season	Total density ($n kg^{-1}$)	Percentage Composition									
			Crus.	Clad.	Eph.	Odo.	Hemi.	Coleop.	Diptera	Ostr.	Acari	Oligo.	Mollus.
Sutlej bank	Pre-monsoon	62	-	29.57	5.12	-	1.53	3.26	27.84	-	-	13.97	38.36
Beas bank		19	2.77	-	-	-	-	-	36.93	27.77	-	1.4	31.10
Confluence		30	-	7.0	-	1.11	-	12.0	7.77	18.01	-	10.18	38.73
Sutlej bank	Post-monsoon	17	-	33.3	-	5.16	-	30.88	20.77	-	-	-	9.9
Beas bank		39	16.6	-	-	-	-	-	-	30.30	-	3.3	50.0
Confluence		Bloom	-	-	-	-	-	-	Bloom	-	-	-	-
Sutlej bank	Winter	15	-	22.72	-	-	-	-	54.54	-	-	9.09	13.63
Beas bank		11	-	-	-	-	-	12.5	-	-	-	31.25	56.25
Confluence		17	-	-	-	50.93	7.83	-	-	-	6.0	11.76	23.48

Location Map of Wetlands in Punjab

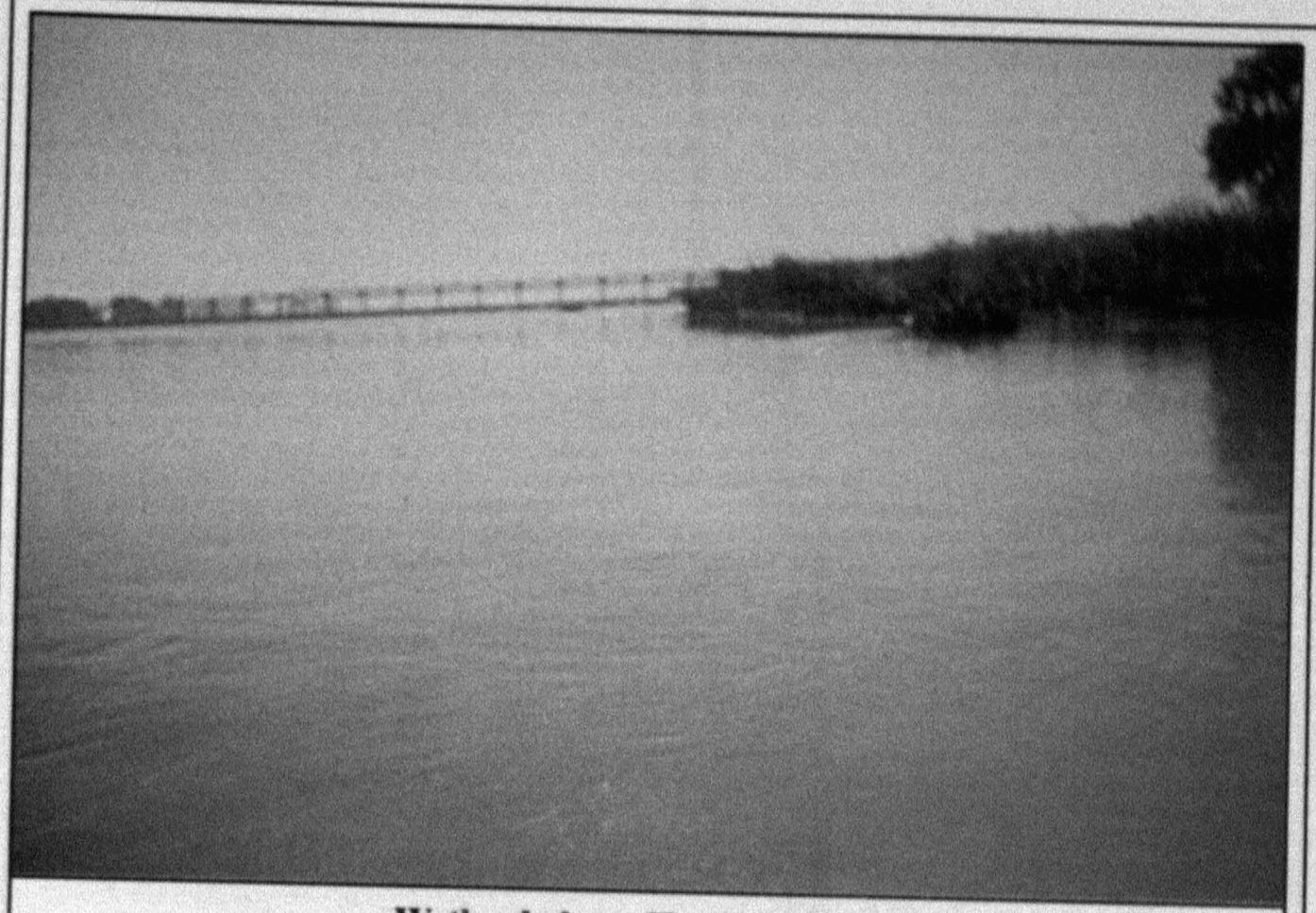


Presence of birds and broken lands within Wetland

Fishing activities at Harike-pattan landing centre

Harike Wetland, confluence site, full of silt

Culmination of R. Beas into Harike



Wetland above Harike barrage

Culmination of R. Sutlej into Harike