MAPPING OF POTENTIAL SIBERIAN CRANE HABITAT IN ETAWAH & MAINPURI DISTRICTS (UP) USING SATELLITE REMOTE SENSING TECHNIQUE

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Preface:

The Keoladeo National Park (KNP) of Bharatpur, Rajasthan is famous among other things for the overwintering population of highly endangered Siberian Crane. The drastic decline of the Siberian Crane population in the recent times in Keoladeo National Park has triggered a widespread debate on launching serious Conservation Programmes. One school of thought considers the possibility of dispersion of Siberi... Crane population, among the wetlands of Indo-Gangetic plains. There have been some isolated reports in the past and in fact during the last year, an aerial search was mounted. While this is a desirable method, there should also be some quick field reconnaissance. This will enable us to check present day habitat suitability in the erstwhile Siberian Cranes habitats of Etawah and Mainpuri districts.

Such a quick reconnaissance would be more effective if it is aided by remote sensing techniques, for we do not have the data on spatial distribution of wetlands.

It is a well accepted norm that for mapping wetland features, one needs scales of 1:50000 or higher. Since there was a proposal by the Space Application Centre, Ahmedabad to map wetlands of the country on 1:250000 scale, we also considered the option and have decided to interpret imagery at 1:250000 scale false colour composites of IRS LISS II sensor. We are of the opinion that unless a comparative picture of total area, distribution, size of the wetlands is known at both 1:250000 and 1:50000 scales, one cannot apply one or the other method on a nation wide basis. The products of this exercise, we believe are extremely relevant for conducting directed field searches for the Siberian Crane.

As a part of this exercise, we tried to make this pilot study as comprehensive as possible by including studies on physicochemical properties of select wetlands, their biota (primarily document plankton, vegetation, fishes and birds), and historical changes if any exist for these wetlands. As a result of this exercise we now have four separate reports dealing with each of these aspects viz., a) use of Satellite data use in mapping wetland habitat in Etawah and Mainpuri district, aquatic botany, fishes and birds.

The first section of this report accordingly deals with the mapping, the second on aquatic botany and habitat classification, the third on fishes and the fourth on detailed analysis of bird communities and conservation priorities. The detailed analysis from a classification perspective is underway and will form a second report on strategies, methods, constraints, manpower, resource requirements and suggested methodology and logistics.

CHAPTER I

INTRODUCTION

Wetlands are considered as most important ecosystem. The importance of wetlands have attained worldwide significance for their uniquely important components of landscape, potential area for water management and wildlife habitat conservation. Besides, wetlands function as transformers of chemical, biological and genetic materials (Mitch and Gosselink, 1986). Some of the wetlands provide unique habitats for a wide variety of flora , fauna and stopping place and refuge for waterfowl. Wetlands support species diversity and have a complex and important food web like any other natural habitat. Substantial work has been done for evaluation for temperate wetland in regular foods and improving water quality, but few comparable data is available for tropics. Considering the importance of wetlands, knowledge about inland water bodies, its distribution, present status are few important aspects required to be known for decision making for protection, conservation and optimal use.

In India inland water resources consisting of 0.16 million kilometer of rivers and canals; tanks and ponds constitute 1.9 million ha., 1.9 million hectares of reservoirs, 1.0 million hectares of jheels, oxbow lakes and direlict water and 1.5 million hectares of water logged lands in the command areas of reservoirs and tanks (Dwivedi, 1992). Inspite of having so much wetlands in inland areas we do not have sufficient scientific inputs for future development and restoration. The seasonal ponds which retains water from 3 to 9 months contribute to the fish production. Such seasonal wetlands estiamted to be more than one million hectare. World over increasing concern for wetland deterioration led to conservation of over 20 million hectares of wetlands in some 300 sites spread all over the world are listed under the Ramsar Convention, as being international importance almost exclusively for waterfowl (Dugan, 1986).

The increasing awareness towards wetland ecosystem has intensified need for reliable information on the status and extent of wetland resources. Considerable amount of field data need to be collected which is time consuming. Whereas satellite remote sensing gives a synoptic and repetative coverage can give better accuracy and reliable information. A number of studies related to limnological variables in lakes for site selection for acquaculture using application of remote sensing has been attempted (Kapetsky 1987). Remote sensing techniques have also been used for seasonal water spread study (Murthy et al, 1988; Palria and Muley, 1987). Lot of works has been done for mapping of coastal environment using orbital remote sensing. In the early eightees digital and visual analysis of satellite data (Landsat MSS) have provided information on condition, boundary and aerial extent of wetlands (Bartlett and Rlemas, 1980; Nayak and Sahai, 1985). Since then lot of progress has been done in sensor technology. This has been demonstrated by new generation remote sensing satellite in the better resolution. IRS LISS II and Landsat TM data proved to be good for wetland mapping of high and low waterline areas in the Gulf of Kachchh (Anon, 1991). Similar work has been reported in Harike wetland successfully employing IRS LISS I data (Gill, 1993).

In this present study IRS-1B LISS II false colour composite with band combination 4, 3, 2 have been used for wetland mapping for habitat analysis in two different scales i.e. 1:250,000 and 1:50,000. The sensor quality and resolution of LISS II have been found to be very good for wetland identification, its mapping based on seasonality and depth class.

STUDY AREA

Mainpuri and Etawah Districts of U.P. are situated on the south-western part of the state (Fig. 1). Etawah district has common border with Mainpuri district on its northern side. Mainpuri has a geographical area of 4343 sq km. and Etawah has 4326 sq km. Geographically the area is falling within the geocor-

dinates 78° 15"E to 80° 0"E and 26° 15'N to 27°40'N. Physiographically the area is plain with extensive alluvial plain. Two major rivers viz., Yamuna and Chambal forms the western and south-western border of the study area. These rivers form striking features of ravines along its course with coarse loam. Entire Mainpuri and Etawah districs are dotted with shallow lakes. These wetlands are formed essentially by meandering of rivers, forming unique variety of wetlands like oxbow lake, paleochannel, lakes as natural water bodies. Rest can be classified as manmade either agricultural fields or reservoirs. Some of these are perennial in nature. The irrigation canal network throughout the districts also add to the wetlands resource. Due to improper water a number of seepage wetlands are to be found. Soils in both the districts are primarily alluvial. Considerable area is covered with wastelands, in which salt affected land constitutes a major part. The salinity of land is due to constant waterloging and poor management of soils. Numerous bird species seasonally visit the wetland areas, which have become important habitat for migratory and resident waterfowl. Some of the waterfowl commonly observed are flamingo, painted storkbs, ibis, spoon bills, grey and purple herons beside Sarus crane. Wetlands in this area usually contain three types of vegetation, emergent, submerged aquatic and free floating vegetation. Following aquatic plants are common, *Ipomia reptans, Hydrilla verticillata, Spirogyra spp., Cladophora, Ceratophyllum demersum, Azolla pinnata, Lemma minor* etc.

DATA

Satellite Data

Satellite data products of February, 1993 were selected for visual interpretation. In this season maximum discrimination is possible between not only wetlands and other associated landuse/land cover classes but also within different wetland categories.

The following False Colour Composites (FCC) were used for the present study (Table 1).

Table-1

Sl. No.	Satellite	Sensor	Product	Ground Resolution	Path/Row	Scale
1.	IRS-1B	LISS II	FCC Band 4,3,2	36.5m	26/49, 26/48 & 26/49	1:250,000
2.	IRS-1B	LISS II Geocoded Data	FCC Band 4,3,2	36.5m	26/49, 26/48 & 26/49	1:50,000

Other Data Used

Survey of India Topographical Maps

54 I, J, M, N - 1:250,000
54 I/7,8,10,11,12,15,16; : 1:50,000
54 J/5,9,13,14; :
54 M/3,4,7,8; :
54 N/1,2,3,5,6,7,9,10,11,13; :

Ground truth data collected during June 1993

METHODOLOGY

The IRS-1B LISS II FCC on scales 1:250,000 and 1:50,000 were visually interpreted on the basis of tone, texture, shape, size, association etc. with limited field checks (Table 2 & 3). Proper classification scheme have been developed separately for both the scale (Table 4 & 5). Emphasise was given to different wetland types. In the case of mapping of wetland on scale 1:50,000,

TABLE - 2

IMAGE INTERPRETATION KEY FOR WETLANDS AND SURROUNDING LAND COVER

CATEGORIES ON SCALE 1:250,000 USING IRS LISS II FCC 4,3,2, OF FEBRUARY 1992

CATEGORY	TONE/ COLOUR	TEXTURE	SIZE	SHAPE	LOCATION	ASSOCIATION	REMARKS
. WATER BODIES							
RIVER	Dark Blue	Smooth	Varying in size and depth	Linear	Flood plain	Proximity to flood plain	
CANAL	Dark blue	Smooth	Varying in size and depth	Linear	along the agricultural land	amidst irrigated crop areas	
TANK	Blue	smooth	small	Rectangular	in the vicinity of villages	agriculture land and settlement	
WETLANDS	Light blue to dark blue	medium to coarse	Varying in size	Irregular	near canals, rivers and villages	saline soils, agri-cultural lands and river banks	Waterlogged areas mostly perennial or seasonal in nature
RIVERBEDS/ SANDY AREA	White to light yellow	fine	Varying in size	Irregular	along the rivers	river sand	
. DEGRADED LANDS							
SALT AFFECTED	White to light	fine to mottled	Varying in size	Irregular	around crop areas, rivers and adjacent	along the flood plain around crop	salinity is largely due to waterlogging and

CATEGORY	TONE/ COLOUR	TEXTURE	SIZE	SHAPE	LOCATION	ASSOCIATION	REMARKS
ON CROPPED AREA	Light grey	Coarse	Varying in size	Irregular	around villages and crop lands	In the vicinity of villages mostly fallow lands	grazing land patches also merges with fallow lands
FOREST	Dark red and maroon	rough	big or medium	Irregular	sloppy rugged areas	along river mostly on ravinous land	highly eroded dissected areas

TABLE - 3

IMAGE INTERPRETATION KEY FOR WETLANDS AND SURROUNDING LAND COVER
CATEGORIES ON SCALE 1:50,000 USING IRS LISS II FCC 4,3,2, OF FEBRUARY 1992

CATEGORY	TONE/ COLOUR	TEXTURE	SIZE	SHAPE	LOCATION	ASSOCIATION	REMARKS
WETLANDS							
- NATURAL							
KE/POND	Light blue to dark blue sometime with redish tinges due to vegeta-tion cover	smooth	Varying in size	Irregular	In the vicinity of villages, canal, river	Mostly in agricultural land or near the villages	
BOW LAKE	Blue to dark blue	smooth	moderate to big	crescent shape	Adjacent to river		Cut off portion of the meander
PALEO HANNEL	White or pink	smooth		Linear or meandering	Near river course	Alluvium near the river	Tonal discontinuity
LLED OXBOW	White to light yellow	coarse	moderate	crescentric	On flood plain near river	with cut off meander	Due to siltation now water is present
MANMADE							
NK/POND	Blue to	smooth	small or	Rectangle or	Adjecent to villages	Proxiaity to cultivation	Manmade feature for

	dark blue		medium size	circular	and near or within agricultural land	land and villages	storing water and pisciculture
WET SALINE SOILS/AGRI CULTURAL LANDS	Light blue to dark blue with red tinges	mottled	Varying in size	Irregular	Along canal and rivers in low depressions	Canal breech and flood plains	occurs due to rain and seasonal flooding
- SEEPAGE WETLAND	Light blue to dark blue with patchy red	medium to coarse	small to medium	linear or irregular	parallel to canal	associated with vegetation	Developed due to uninterrupted canal seepage

ATEGORY	TONE/ COLOUR	TEXTURE	SIZE	SHAPE	LOCATION	ASSOCIATION	REMARKS
WASTELANDS							
ALT AFFECTED AND	White to light blue subject to water cont-ent moisture	Fine to mottled	Varying in size	Irrigated	On the plains and valleys	Croplands and around the villages	Developed due to impeded drainage an capillary action during dry climate
GULLIED AND/ R RAVINOUS LAND	Light yellow to blueish tone	Medium to coarse	Varying size and depth	linear or irregular	Along river Yamuna and Chambal	Heaviely eroded loose sedi-ments due to water action along streams	Linear or dendritic pattern formed by water action
AGRICULTURE LAND	Light red to dark red	fine to mottled	small or medium square plots	square plots	Flood plains	Associated with canals and villages	

THEMATIC DESCRIPTION OF WETLAND, LANDUSE/LAND COVER CLASSES ON SCALE 1:250,000

River:

Rivers are the natural course of water flowing on the land surface. It may be seasonal or perennial in nature. In the study area two major perennial rivers flow i.e. Yamuna and Chambal. Beside these rivers other smaller rivers i.e. Senger etc. are also identifiable on satellite data on 1:250,000 due to the linear feature and dark blue tone of water with varying shape and size.

Canal:

Canal is a manmade feature linear in shape with uniform width. The branch canals having water content is clearly identifiable on FCC with dark blue tone. However, wherever canal is dry, it is not possible to detect this feature. In addition to this second order feeder canals are also not detectable and in such cases the second order canals are traced from topographical maps. Some of the branch canals visible on satellite data are Upper Ganga Canal and Lower Ganga Canal.

Tank:

Water tanks are mostly in the vicinity of villages. Its proximity to villages is clearly evident in Mainpuri and Etawah districts. This can be identified by its rectangular shape and dark to light blue tone. The tanks having more than 3mm x 3mm or 56.25 ha on ground are mapable in the present case.

Wetland:

Wetlands are clearly identifiable on scale 1:250,000. In the level II classification different wetland categories are

clubbed together. These categories are ponds, canal, seepage areas, waterlogged land and marshy land. Tone or colour varies from light blue to dark blue depending on the depth of water. These wetlands are having varying shape and size. It is possible to map these wetland categories on winter season data.

Riverbeds/Sandy area:

This category of land is confined to river bank areas. Mostly visible in Chambal and Yamuna rivers as islands. On satellite data it is identified by its white to light yellow tone with fine to mottled texture and irregular shape.

Salt affected areas, ravinous & Gullied land:

These are the wastelands described as degraded lands which can be brought under vegetative cover with reasonable effort and which are currently under-utilized (Anon, 1986). Salt affected

land is one of such category which adversely effects on the growth of the plants due to action or presence of soluble or high exchangeable sodium. Gullied and ravinous lands are narrow and deep channels cut by running water. These type of lands are conspiquous by its presence along Yamuna and Chambal rivers. This cateogry is identifiable with irregular shape and entranched drainage with its light yellow to light grey tone, course to medium texture and irregular shape.

THEMATC DESCRIPTION OF WETLAND, LANDUSE/LAND COVER CLASSES ON SCALE 1:50,000

WETLANDS
(NATURAL)

Lake/Pond:

These are natural features occuring in flood plains saturated with water either by surface congestion, high ground water table or flooding. On satellite F.C.C. give blue to dark blue tone depending on the depth of the water and tarbidity. With varying in size and smooth texture it is easy to map this category of wetland. Minimum mapable unit of 3mm x 3mm has been followed in level III classification.

Oxbow Lake:

Oxbows are defined as the bodies of permanently standing water that result from the cutoff of meanders. These oxbow lakes mvcxzare developed mostly by Ganga, Yamuna and other perennial rivers in the flood plains. It is characterised by its typical crescentric shape having blue colour.

Paleochannel:

It is the abandoned course of river, representing the former

. MANMADE

Tank/Pond:

It is easy to identify and map this category by its rectangular or circular shape confined mostly near the villages. The main use of this class to cater people needs for water and pisciculture. The big reservoirs with its characteristic shape are used for industrial purposes, as evident in Dibyapur in Etawah district. The clean water of tank will either give light blue or dark blue tone on FCC.

Wet Saline Soils/Agricultural Lands:

Quite common in both the districts. This condition occurs mainly due to rain and seasonal flooding. Stagnated water in the agricultural fields gives blue tone with red tinges of standing crop with mottled texture. Size of such areas varies. Wet saline soils give light blue tone due to the presence of moisture content in the soils. Amount of blue colour depends directly on moisture content present in the saline soils (Fig. 3).

Seepage Wetlands:

This class is confined to adjacent areas of the canal. The waterlogging takes place due to seepage of canal water in lowlying areas. Mostly this situation occurs in close promimity to canals. Size of the wetland differ due to amount of water seepage. Vegetation like *Typha* spp., water hyacinth and floating vegetation slowly colonise in this type of wetland. Therefore, tonal characteristic of this class is light to dark blue with pat chy red colour represented by vegetative growth. Tonal variation depending on the acquatic plant cover. Sometime acquatic plant cover may be tonally similar to rice cultivated field (Fig. 4).

Agriculture Land:

This category includes cropped areas and noncropped areas. Cropped areas are those land which has standing crop of Rabi season in February. Very clearly identifiable by its red to dark red tone with fine to mottled texture. Whereas, non cropped areas are mostly fallow land temporaly allowed to rest and devoid of crop cover. Such areas are seen in the images in light grey tone with coarse texture. Because this category is always interspersed with standing crop areas.

Forest:

Forest in the study area is mostly confined to bank of river Yamuna and Chambal. The forest is mostly composed of deciduous species. Some of the species grow in this area are *Capparis sepiaria, Acacia nilotica, Acacia leucophloca, Ziziphus mauritiana, Butea monosperma, Diospyrus melanoxylon* etc. Due to image scale constraint, it is not possible to map separately degraded forest, close forest, deciduous forest or forest plantation. In

the satellite image of February season, forest is identified by its dark red to maroon colour having rough texture in varying sizes with irregular shape.

WASTELAND

Salt Affected Land:

Salt affected areas appear in white tone generally in irrigated areas. It also appear in light blue tone subject to presence of soil moistrue. The shape and size of salt affected land vary from place to place. Using Level III classification, it is possible to map smaller patches of Ø2.25 ha 3mm x 3mm). This class is easily identified and differentiated because of their high reflectance (Fig. 5).

Gullied Land/or Ravinous Land:

The severe erosion of soil by running water results into formation of gullies. These intricate network of gullies developed on alluvium of low cohesion joining nearby streams form ravines (Anon, 199Ø). The gullied and ravinous lands are of common sight in Yamuna and Chambal river basin areas. They are identified by their dendritic pattern and linear shape with light yellow or bluish tone and coarse texture. Occasionally, some of the areas are inhabited by species like, *Prosopis juliflora, Acacia spp.* giving light red to light grey tone.

AGRICULTURE LAND

The present satellite data of February season shows Rabi crop in dark red colour. It is associated with irrigated and unirrigated cropland of wheat and other crop. In the irrigated areas, where intensive cultivation is done the texture is fine, whereas in unirrigated areas interspersed with fallow lands shows mottled texture.

DEPTH CLASSES

Quantitative Depth classification of the wetland has been attempted based on spectral response and ground truth information. Generally it has been observed that the wetland < 1m depth show light blue tone in the FCC. This tonal characterisation was calibrated during the field work. Two depth classes have been identified and mapped a) Deep water - with more than 1 meter depth; b) Shallow water - having less than 1 meter water depth. Ecologically this classification will have great significance.

SEASONALITY

The wetland in the alluvial plain are mostly found in small depressions. These depression are of varying size & depth. The shallow wetland with low recharge dry up during summer. An attempt has been made to classify such wetlands using winter season

dark and comparison with the Survey of India toposheets. The seasonal wetland are also cultivated during cetain period of the year due to better availability of the soil moisture. In 1:50,000 scale mapping, two classes have been made 1. Perennial 2. Seasonal. In the perennial wetlands water remains throughout the year, though the water level decreases considerably during summer season. In the seasonal wetlands many smaller water bodies i.e. ponds, small lakes dry up by June. Evaporation of water and consumption for agricultural needs are the two main reasons. In the present study perennial seasonal water bodies are discriminated using February season F.C.C. with extensive ground truth.

SELECTION OF SEASON

The post-monsoon period data is found to be most suitable for identification of inland wetlands. During December-February vegetative cover in the wetlands are descernible. Algal growth in the wetland is seasonal. Species like Typha and water hyacinth remain in green condition. Beside this, satellite data of February remain cloud free giving a clear picture of different land cover. classification of different water bodies is also possible with better accuracy.

SELECTION OF MAPPING SCALE

For the present study two mapping scales have been selected viz. 1:250,000 and 1:50,000. In the scale 1:250,000 thematic classes are generalised. Since, water bodies are distingly visible due to its blue colour and its morphology, it is possible to map it in generalised form. The wetland map on scale on 1:250,000 is useful for planning purposes. The map prepared in 1:250,000 can give qualitative classes whereas quantitative parameters like depth classes are not possible.

In 1:50,000 scale wetland map consisting of different wetland categories are clearly visible. The different wetland categories are seperately identified using elements like, tone,

texture, shape and size. Besides wetland categories other associated categories like, agriculture land, forest, saline soils areas are also visible on satellite data.

In addition to qualitative classes, it is possible to identify and map in minimum two water depth classes giving certain advantages for birds habitat analysis with the spatial distribution of wetland and related categories.

MAPPING UNIT

Satellite images is the best source available to obtain reliable information. The amount of information obtained is directly proportional to the scale of satellite False Colour Composite used for mapping. Areas having smaller dimensions than the size of the minimum mappable unit can not be mapped. Thus, the minimum mappable units are kept at 3 x 3 mm in two mapping scales with respective ground cover as shown below :

Scale of Map	level of Classification	Smallest mappable unit on the map	Area covered on the Ground
1:250,000	Level-II	3 X 3 mm	56.25 ha.
1:50,000	Level-III	3 X 3 mm	02.24 ha.

CHOICE OF 5 KM RADIUS AROUND WETLANDS

In the large scale mapping for wetlands and related categories on scale 1:50,000, 5 Km radius around wetlands have been mapped to include different classes i.e. Agriculture land, habitation, saline soils etc. This has been done because these categories directly influence the wetland habitat. Impact of biotic interference changes the water chemistry and water quality of the wetlands. Therefore, it was felt necessary to map adjoining landuses around wetlands.

LIMITATION OF SATELLITE REMOTE SENSING DATA

- Waterbodies which are smaller than 56.25 ha on 1:250,000 and 02.25 ha on 1:50,000 are not mappable. In such cases these wetlands are merged with nearest dominant category.

- The spectral signature of wetlands inhabited by *Typha* or water hyacinth and standing agricultural crops may appear similar particularly in small linear seepage wetland areas. It may be possible that such wetlands adjacent to agriculture land are misclassified into agriculture class.

- In the present case single date FCC (February) have been used. It may be possible that in few cases seasonality except i.e. perennial or seasonal nature of wetlands are

not correctly mapped.

RESULTS AND DISCUSSION

Wetland which constitutes as a major land cover class is possible to map with satellite remote sensing data. IRS-1B LISS II with a resolution 36.5 m is capable of identifying different wetland categories and associate land cover/landuse classes. The FCC has an added advantage of discriminating wetland with other wasteland and land cover classes due to their distinct spectral separability. Differentiation within Wetlands based on qualitative and quantitative parameters as the case may be is also possible. This has been noticed well in some categories like ponds, reservoir, lake, and oxbow lakes with distinct tonal change. However, it is partinant to mention here that small water bodies less than the prescribed mappable areas (3 X 3 mm) are merged with the nearest dominant classes. Such water bodies may be possible to map with even large scale satellite data using visual interpretation techniques. Similarly, digital image processing technique with its proven results in other resource mapping may be useful in classifying wetlands in different classes to a pixel level (36.5 x 36.5m). Area of both the districts were seperately computed on 1:250,000 and 1:50,000 scale (Table 6,7,8 & 9) and compared districtwise (Table 10 & 11).

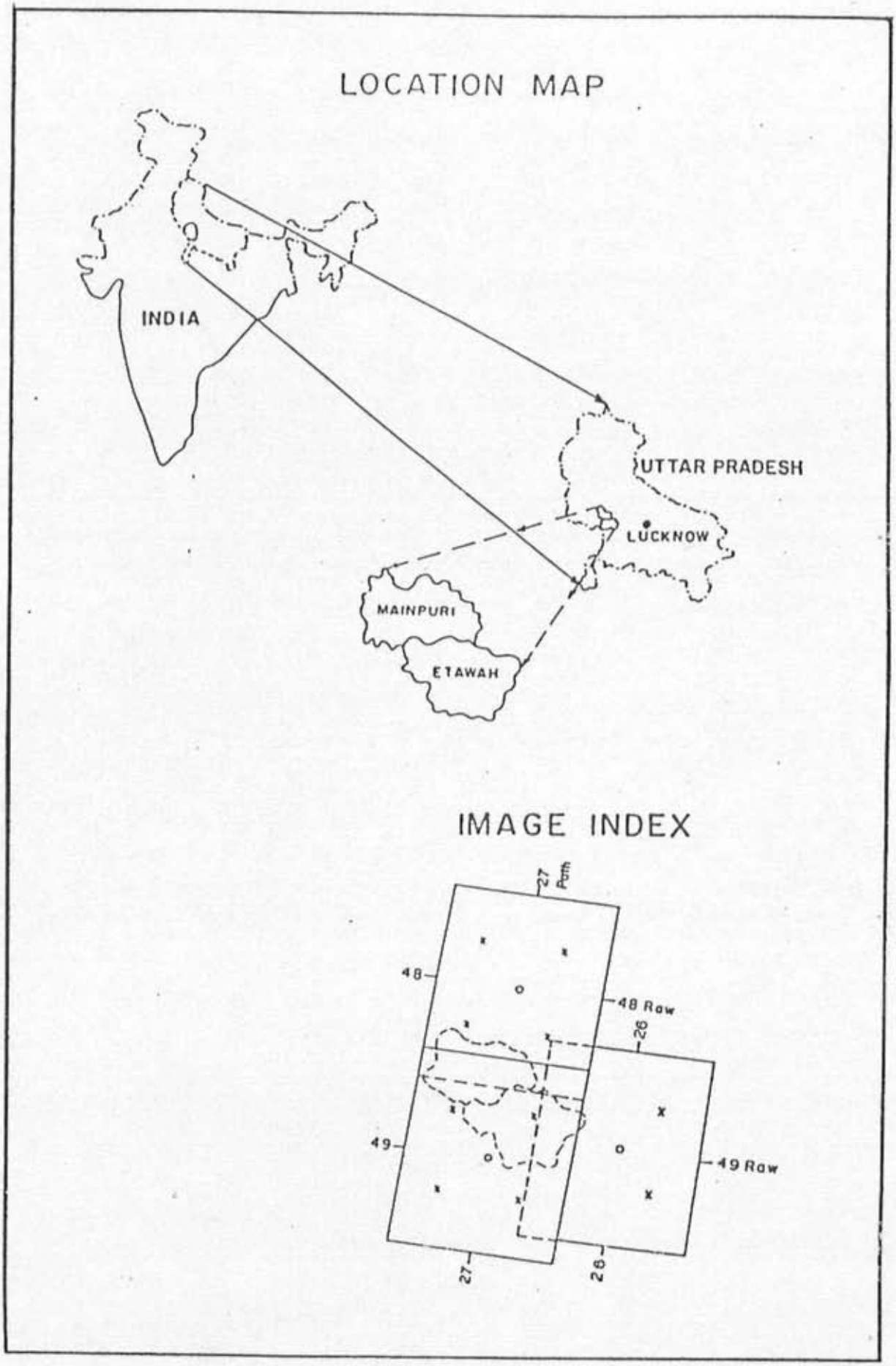

LOCATION MAP
INDIA
UTTAR PRADESH
LUCKNOW
MAINPURI
ETAWAH
IMAGE INDEX
27 Path
48
48 Row
26
49
49 Row
27
26

FIG. 1

TABLE 6

Area of Wetlands and other landuse/land cover classes estimated using visual interpretation techniques on scale 1:250,000 of IRS-1B LISS II FCC for Etawah District, U.P.

Categories	Area in Sq.km.	Percent of Geographical Area
* WATER BODIES		
- Rivers	76.88	1.78
- Canals	45.75	1.06
- Tanks	12.25	0.28
- Wetlands	53.13	1.23
- River beds/Sandy area	23.50	0.54
* DEGRADED LANDS		
- Salt Affected area; ravinous & gullied lands etc.	1192.50	27.57
* AGRICULTURE LANDS		
- Cropped Areas	2662.49	61.54
- Non cropped areas	169.50	3.92
* FOREST	76.13	1.76
* SETTLEMENT	13.87	0.32
District Area	4326.00	100.00

TABLE 7

Area of Wetlands and other landuse/land cover classes estimated using visual interpretation techniques on scale 1:250,000 of IRS-1B LISS II FCC for Mainpuri District, U.P.

Categories	Area in Sq.km.	Percent of Geographical Area
* WATER BODIES		
- Rivers	0.07	< 0.01
- Canals	3.01	0.07
- Tanks	--	--
- Wetlands	38.37	0.88
- River beds/Sandy area	2.98	0.07
* DEGRADED LANDS		
- Salt affected area; ravinous & gullied lands etc.	324.00	7.46
* AGRICULTURE LANDS		
- Cropped areas	3851.04	88.67
- Non cropped areas	89.00	2.05
* FOREST	19.64	0.45
* SETTLEMENT	14.89	0.34
District Area	4343.00	100.00

TABLE 8

Area Statistics of Wetlands and other landuse/land cover classes estimated using visual interpretation techniques on scale 1:50,000 of IRS-1B LISS II FCC for Mainpuri District, U.P.

Class Code	Area in Sq.Km.	Percentage of Geographical area	Class Code	Area in Sq.Km.	Percentage of Geographical area
WETLANDS			* WASTELANDS		
			Sa	443.94	10.222
1 Dp	11.33	0.261	Gr	9.14	0.210
1 Ds	3.55	0.082			
1 Sp	27.60	0.636	* AGRICULTURE		
1 Ss	5.28	0.122	A	2318.98	53.396
2 Dp	1.26	0.029			
2 Ds	--	--	* FOREST--		--
2 Sp	--	--			
2 Ss	0.60	0.014	* OTHERS		
3	1.45	0.033			
4	1.34	0.031	River	10.43	0.240
5 Dp	0.32	0.007			
5 Ds	--	--	Canal	--	--
5 Sp	--	--			
5 Ss	--	--	Settlement	29.17	0.671
6	478.75	11.023			
7	6.44	0.148			
Area covered by all classes	3349.58	or	77.12 %		

* Area of landuse/land cover classes within 5 km radius of wetlands.

Number indicates type of wetland
D/S indicates depth
p/s indicates seasonalites
For details refer table number 5

TABLE 9

Area Statistics of Wetlands and other landuse/land cover classes estimated using visual interpretation techniques on scale 1:50,000 of IRS-1B LISS II FCC for Etawah District, U.P.

Class Code	Area in Sq.Km.	Percentage of Geographical area	Class Code	Area in Sq.Km.	Percentage of Geographical area
WETLANDS			Gr	44.66	1.03
			*AGRICULTURE		
1 Dp	2.52	0.06			
1 Ds	0.03	0.001	A	1482.93	34.28
1 Sp	0.16	0.004			
1 Ss	2.93	0.07	* FOREST	4.28	0.10
2 Dp	-	-			
2 Ds	-	-	* OTHERS		
2 Sp	-	-			
2 Ss	-	-	River	73.46	1.70
3	-	-			
4	4.75	0.11	Canal	-	-
5 Dp	0.52	0.01			
5 Ds	-	-	Settlement	26.69	0.62
5 Sp	-	-			
5 Ss	-	-			
6	200.25	4.63			
7	13.81	0.32			
* WASTELANDS					
Sa	285.62	6.60			
Area covered by all classes	2142.61	49.53%			

* Area of landuse/land cover classes within 5 km radius of wetlands.

Number indicates type of wetland
D/S indicates depth
p/s indicates seasonalites
For details refer table number 5

TABLE 10

Comparative statement showing Wetlands in Etawah and Mainpuri Districts on scale 1:25,000

Wetland Classes	Etawah		Mainpuri	
	Area in Sq Km	Percent	Area in Sq Km	Percent
- Rivers	0.07	<0.01	76.88	1.77
- Canals	3.01	0.07	45.75	1.05
- Tanks	-	-	12.25	0.28
- Wetlands	38.37	0.88	53.13	1.23
- River beds/ Sandy area	2.98	0.07	23.50	0.54
Total area of wetlands	44.43	1.03	211.51	4.87

TABLE II

Comparative statement showing Wetland categories in Etawah and Mainpuri districts on scale 1:50,000

Category Code	Etawah District		Mainpuri District	
	Area in Sq.Km.	Percent of Geographical area	Area in Sq.Km.	Percent of Geographical
1 Dp	2.52	0.06	11.33	0.261
1 Ds	0.03	0.001	3.55	0.082
1 Sp	0.16	0.004	27.60	0.636
1 Ss	2.93	0.07	5.28	0.122
2 Dp	-	-	1.26	0.029
2 Ds	-	-	-	-
2 Sp	-	-	-	-
2 Ss	-	-	0.60	0.014
3	-	-	1.45	0.033
4	4.75	0.11	1.34	0.031
5 Dp	0.52	0.01	0.32	0.007
5 Ds	-	-	-	-
5 Sp	-	-	-	-
5 Ss	-	-	-	-
6	200.25	4.63	478.75	11.023
7	13.81	0.32	6.44	0.148
Total area	224.97	5.20	537.92	12.39

Number indicates type of wetland
D/S indicates depth
p/s indicates seasonalites
For details refer table number 5

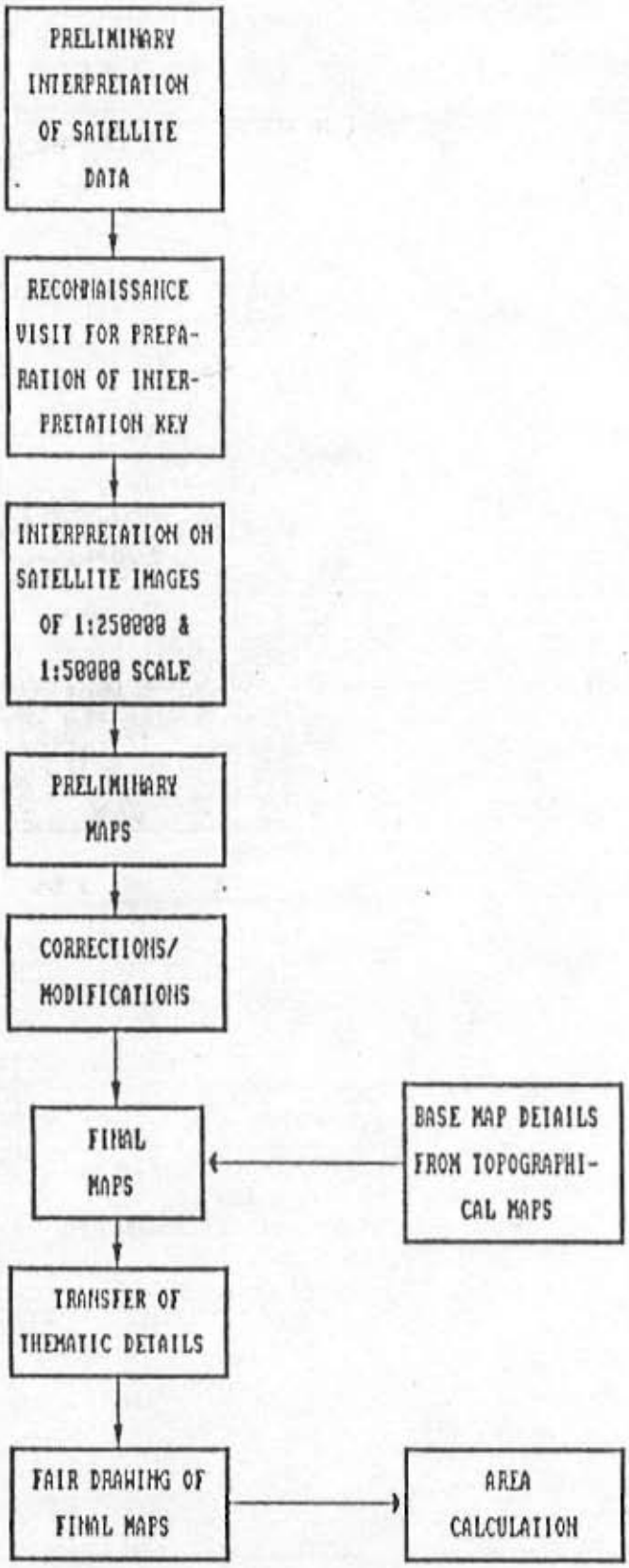
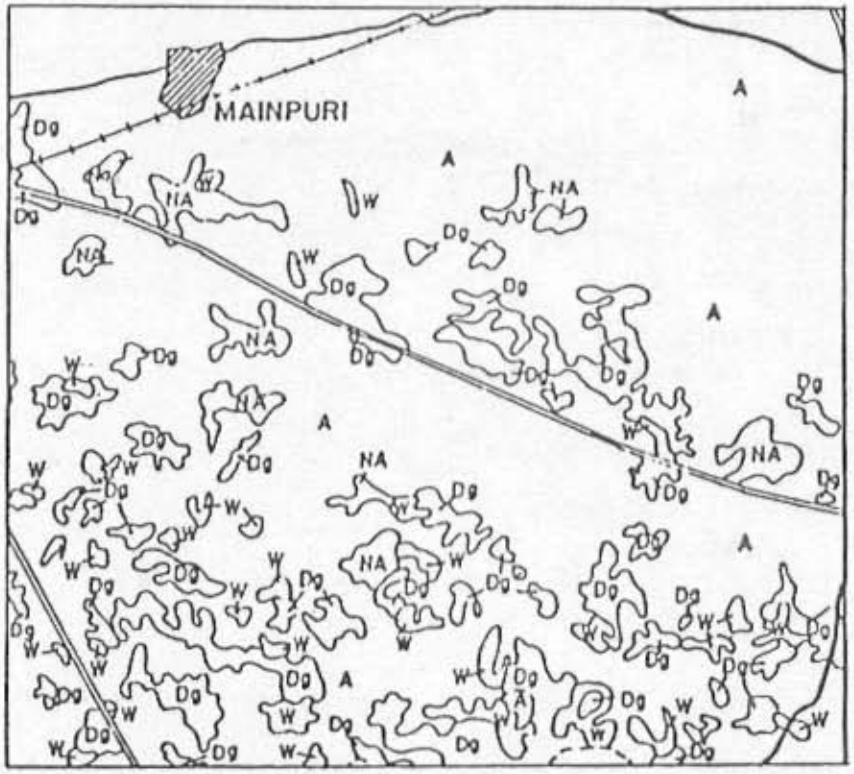


FIG. 2. FLOW DIAGRAM SHOWING METHODOLOGY FOR WETLAND MAPPING.

WETLANDS AND SURROUNDING LANDUSE MAP OF MAINPURI DISTT. (PART)

PREPARED FROM IRS-1B LISS 2 FCC



Scale 1: 50,000

M.1000 0 1 2 3 Km.

L E G E N D

WATER BODIES	RIVERS	R
	CANALS	
	TANKS	T
	WETLANDS	W
	RIVER BEDS / SANDY AREAS	
DEGRADED LANDS	SALT AFFECTED AREAS, RAVINOUS & GULLIED LANDS ETC.	Dg
AGRICULTURE LANDS	CROPPED AREAS	A
	NON CROPPED AREAS	NA
	FOREST	F

REFERENCE

BOUNDARY State Distt. Forest

Road

Railway line

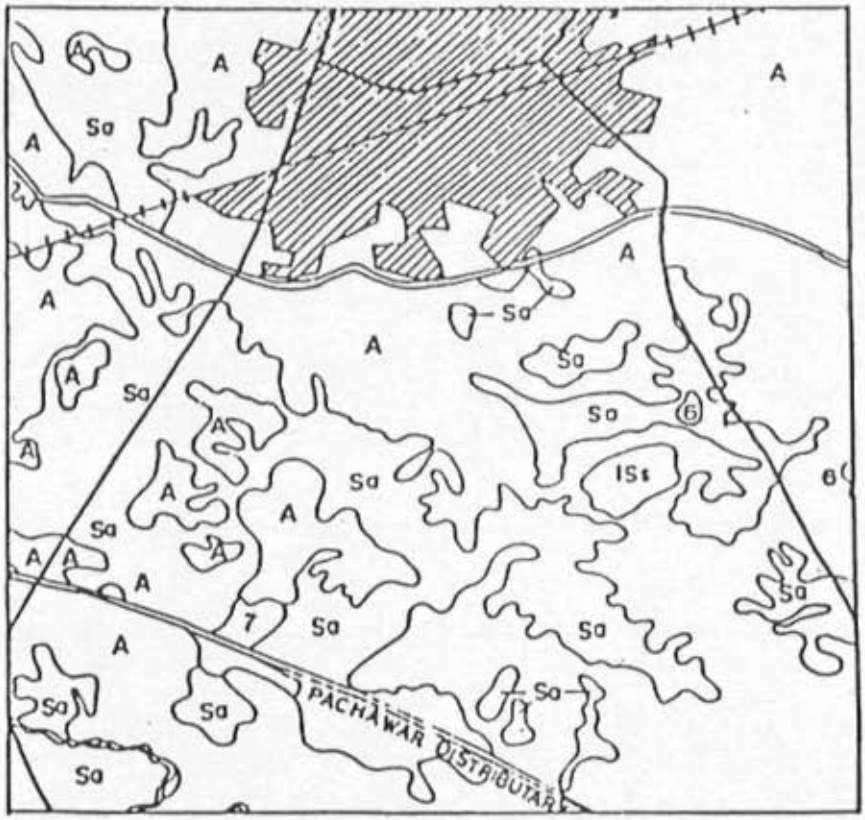
Streams

Settlements

Fig. 7

WETLANDS AND SURROUNDING LANDUSE MAP OF MAINPURI DISTT. (PART)

PREPARED FROM IRS-1B LISS 2 FCC



Scale 1 : 50,000

M. 1000 0 1 2 3 Km.

L E G E N D

WETLANDS

NATURAL	LAKE / POND	1
	OXBOW LAKE	2
	PALEOCHANNEL	3
	FILLED OXBOW	4
MANMADE	TANK / POND	5
	WET SALINE SOILS / AGRICULTURE LAND	6
SEEPAGE WETLAND		7
FOREST		F

WASTELANDS

SALT AFFECTED LAND	Sa
GULLIED / RAVINOUS LAND	G
AGRICULTURE LANDS	A

QUANTITATIVE DEPTH

DEEP WATER (> 1mtr.)	D
SHALLOW WATER (< 1mtr.)	S

SEASONALITY

PERENNIAL	P
SEASONAL	S

ANNONATION Lake / Pond - Deep water Perennial or 1Dp

R E F E R E N C E

SETTLEMENT		ROADS MAJOR, OTHERS	
CANNAL DOUBLE LINE, SINGLE LINE		RIVER / STREAM	
RAILWAY LINE		WATER BODIES	W

Fig

Results of the mapping on 1:250,000 scale shows that 2226 sq km of the total study area is covered by wetlands, which constitutes 2.6 % of the combined geographical area of both the districts. This also includes perennial rivers and canals supporting and sustaining many wetlands deep into the study area, which are otherwise scarce in surface water resources. Majority of ponds and lakes are confined to habitations. Numbers of perennial and seasonal water bodies are comprising an area of .....sq.km and .....sq.km respectively in the study area. Result shows that ETAWAH district has more wetlands 181.2.sq.km than MAINPURI district having 44.5.sq.km. Similarly, analysis of 1:50,000 data shows that ETAWAH district has 224.44 sq.km of wetlands as compared to MAINPURI district which has 537.92 sq.km of wetlands (Table 11).

Wetland associated other landuse/land cover categories on scale 1:50,000 which has direct or indirect bearing on wetlands in five kilometer radius is in the order of ..... sq.km. in 1:50,000 scale maps of which Mainpuri has 10.43.sq.km. area (Table 8) and Etawah constitute 73.46.sq.km. area (Table 9). The thematic maps prepared using IRS 1B LISS II Geocoded data in 1:50,000 scale shows spatial distribution of these classes which may have direct implication on water chemistry and wetland ecosystem. To evaluate stress on these wetlands, it requires further study mainly on depending on wetlands by human population, seasonal monitoring of aquatic vegetation and terrestrial vegetation, which in turn support aquatic birds habitat.

Mapping of Wetland on 1:50,000 scale

It is possible to map 18 categories of wetland using single data (February) FCC with limited ground check. Wetlands of a minimum area of 3 X 3 mm on FCC or 2.25 ha on ground are mapped and further classified into depth and seasonality classes. Water hyacinth and Typha grass dominated wetlands which is otherwise misclassified into agricultural land in other sensor data is successfully classified into various wetland categories (except

in some cases of linear seepage wetlands) using February season data which shows distinct tonal contrast due to phenological difference of agriculture land (mostly dominated wheat and wetland species.

Mapping of Wetland on 1:250,000 scale

Entire districts of Etawah and Mainpuri have been mapped with level II classification. Minimum mapping unit of 3mm X 3mm on satellite FCC or 56.25 ha. on ground was kept. While doing so smaller wetland were generalised. Since, it was not possible to map in detail, the wetland categories were generalised i.e. river, canal, tank, wetland and river bed/sandy area. It was natural that in this Level II classification wetlands less than 56.25 ha. were not considered. Similarly, smaller patches of degraded land and agriculture land occuring in isolation were also generalised with the nearest dominant categories. Map prepared in this scale shows 425.7 sq.km. or 2.6 % of geographi-

cal area of both the districts as wetlands. Of which Mainpuri district has 49.45 sq km or ...1...% (Table 7).....and Etawah district constitute 181.2 sq km or .4.2.% of wetlands (Table 6). Wetland map on this scale may be good reconnaissance purposes.

Comparison between Wetland maps on scale 1:250,000 and 1:50,000

Wetland mapping on 1:250,000 and 1:50,000 scale have been attempted. Legend of both the types of maps were devised based on possibility of interpretability. On 1:250,000 scale mapping has been done using Level II classification. Where as on scale 1:50,000 detail mapping on Level III have been done. In the Level II wetlands were generalised and only 5 classes were possible to map. In Level III classification the wetland categories increased to sixteen, where, beside qualitative classes, quantitative classes were also mapped. The important observation in Level III classification on 1:50,000 was the canal network which is the main source of many wetlands, beside branch canal, the distributary canals also have been mapped. Similarly, seepage wetlands, wet saline soils/agriculture land have been identified on 1:50,000 scale which are ecologically very important. Same is not possible in 1:250,000 scale mapping.

CONCLUSIONS & RECOMMENDATIONS

Satellite remote sensing is an useful tool for detail characterisation of wetlands and surrounding landuse. It is quite clear from this study that different categories of wetlands are possible to map. However, the level of classification is subject to mapping scale. On scale 1:250,000 thematic details are much generalised and can be useful only for identifying sites for detailed inventory. The mapping on larger scale (1:50,000) however provide detailed characterisation of the wetland and surrounding landuse. Such information can be used for management planning.

The present day satellite sensor capability is restricted to giving visually prepared outpt upto 1:50,000 scale. Here we could identify different types of wetland having a size of 2.25 ha. But with the introduction of better resolution satellite data like IRS 1C in middle ninetees, it will be possible to achieve even better accuracy and even smaller waterbodies and potential areas of as small as 1125 m^2 can be mapped in 1:250,000 scale.

Among the other aerospace remote sensing, aerial photographs can still play a major role. Large scale aerial photographs on 1:10,000 or higher scale can suppliment the wetland information in selected areas, which have already been identified by satellite remote sensing techniques as potential habitat for sibarian crane habitat study. Therefore, for detail survey of important wetlands and their surrounding landuse should be done using aerial photographs on 1:10,000 scale and subsequent monitoring of the landuse activities in the vicinity of wetlands can be carried

out by satellite remote sensing techniques. Beside satellite remote sensing can be used for identification of additional biogeographical regions suitable for habitat suitability study.

REFERENCE

Anon, 1990. Description and classification of Landuse/Land Cover, National Remote Sensing Agency, Dept. of Space, Govt. of India, Hyderabad.

Anon, 1986. Manual of Procedure for Wastelands Mapping using Remote Sensing Techniques, National Remote Sensing Agency, Govt. of India, Hyderabad.

Anon, 1991. Manual for Mapping of Coastal Wetlands/Landforms and Shoreline Changes Using Satellite Data, Space Applications Centre (ISRO), Ahmedabad.

Bartlett, D.S. and Klemas, V. 1980. Quantitative Assessment of Tidal Wetlands Using Remote Sensing. Environmental Management. 4 (4) : 337-345.

Dang, P.J. 1988. The Importance of Rural Communities in Wetlands Conservation and Development, Ecology and Management of Wetlands, Vol. 2, Edit. by D.D. Hook and others.

Dwivedi, S.N., 1992. Inland Fisheries Need S & T Approach and New Policy Initiatives for Exponantial Growth and Generating Employment, Sustainable Management of Natural Resources, Malhotra Publishing House, New Delhi.

Gill, G.S. 1993. Landuse mapping of Har wetland and environs study conducted by the Punjab Remote Sensing Centre, Ludhiana. SPECKTRUM Newsletter of Speck System Pvt. Ltd., Hyderabad, 3 (1) April 1993; p 4-5.

Kapelsky, J.M. 1987. Satellite Remote Sensing to locate and

inventory small water bodies for fisheries Management and Acquaculture Development in Zimbabwe. CIFA/14, CIFA/87/INF. 15/August 1987, Food and Agriculture Organisation, United Nations Organisation.

Mitsch, W.J. and Gosselink, J.G. 1986. Wetlands, Van Nostrand Reinhold Company Inc., New York.

Murthy, T.V.R., Muley, M.V., Chakraborthy, M. Taamilarsan, V. Amminedu, E. Mehar Baba, G. Krishna. A and Rao, S.R. 1988. Water Quality Study in the Chilka Lake Using Landsat Data.

Nayak, S.R. and Sahai, B. 1985. Coastal Morphology - A Case Study in the Gulf of Khambhat. International Journal of Remote Sensing. 6 (3 & 4) : 559 - 568.

CHAPTER II

Report on the survey of wetlands of Etawah and Mainpuri districts of Uttar Pradesh

Introduction

Wetlands, often considered as wastelands, have been drained for agriculture, industry and housing, without realising their ecological and economic values.Wetlands are one of the most important ecosystems in the world, their productivity is twice that of the tropical rain forest (Maltby, 1986). 6% of the total surface area of the world is covered by wetlands. India has c. 40,49,373 h area under wetlands (Anon, 1989). Ignorance of their values has caused the disappearance of many and still continues to pose a serious challenge to the existance of several. The major threats to wetlands in India are draining and reclamation, construction of dams, overexploitation, pollution through pesticides and industrial effluents and discharge of waste materials. Even in a developed country like the USA, the loss of c. 80% of wetlands has been due to agriculture till recent years and the rate of loss per year (from 1950 -1970) was 1,85,000 h. Such statistics are not available in India. Demands on wetlands is on the increase for various development activities which necessitates an urgent action plan based on the ecological, economic and conservation values of each wetland. Realising the need to have an up to data information on the Indian wetlands, SACON proposes to survey and classify wetlands on 1:50,000 scale. In this context a pilot survey was launched in February and May 1993 in the districts of Etawah and Mainpuri (U.P.).

As Uttar Pradesh is the most populated state in India, not much of natural vegetation is left. Most of the forests and sanctuaries are situated in the north (Dudhwa, Corbett, Rajaji), the Himalayas (Nanda Devi) and in the south bordering M.P. (Ranipur). The fertile Gangetic plains is densely populated but also has some of the finest wetlands in India. Etawah and Mainpuri districts of U.P. occupy an unique place where a large number of natural shallow freshwater lakes or "Jheels" are situated. These Jheels are important habitats for both resident and migratory waterfowls. The great Ornithologist, A.O. Hume, who incidentally was one of the founders of the Indian National Congress, between 1858- 1867 saw Siberian Cranes in these two districts (Hume, 1868).

A holistic approach to the study of wetlands has been adopted in the present work. The physico-chemical, biological, socio-economic and conservation aspects of wetlands have been addressed.

Objectives

1. To inventory all the wetlands (size >/2 ha) in Etawah and Mainpuri districts of Uttar Pradesh.

2. To classify the wetlands according to their physical, biological, cultural and socio-economic values.

3. To assign conservation values to wetlands, so that priorities can be fixed for management and protection.

4. To assess the various pressures on the wetlands and suggest methods to mitigate them.

Methods:

It was decided to conduct a premonsoon (summer) and a post monsoon (winter) survey of the wetlands in Etawah and Mainpuri districts. The following aspects were taken into consideration for the study:

i) Mapping of the Wetlands using Satellite imagery

The traditional sources of data on location and size of wetlands are the SOI toposheets at scales of 1:50,000 and 1:250,000. It was observed during the field survey that many wetlands are not represented on the SOI or do not exist anymore. Since the vintage of maps is ten years or more and the wetland bodies are subject to multiple use, gross inadequacies in location and size are bound to occur. These maps are therefore less dependable in an inventory exercise. The more reliable sources are the visual/digital data products of medium/high resolution satellite sensors. We have examined IRS LISS II and Landsat TM FCC at 1:250,000 scale. It was observed that wetlands of size 50 ha or less are difficult to locate and map. Also it appears that the shape consideration are of paramount importance in the Indo-Gengetic plains. It was found during the survey that many wetlands are highly irregular in shape as some of these are paleochannels and meander cuts. It such cases it is difficult to map even a 50 ha wetland.

It was decided to obtain ancillary spatial data such as land use, cropping patterns and human settlements. Hence a FCC was considered to be more useful than any single band data for visual interpretataion. It was considered desirable to map wetlands at 1:50,000 scale rather than at 1:250,000. In fact, a preliminary survey of wetlands in these districts indicate that 93.5% are less than 50 ha in size nd are important waterfowl habitat. The inventorisation of wetlands by satellite imagery is being report seperately.

ii) Physico-chemical parameters (Temp, pH, salinity, transparency, Dissolved oxygen, conductivity, TDS) ...

measured at different points covering the entire water spread area of the wetlands. A portable digital kit (Naina) was used for the analysis. Secchi disc was used for measuring the transparency of water.

iii) Plankton: Samples were collected from different zones such as the vegetated, nonvegetated, deep, shallow, with plankton nets (bolting silk mesh size 25). For qualitative and quantitative estimations of plankton, the samples were concentrated by sedimentation and preserved in 5% Formalin. The estimation was done under a inverted microscope with the help of Sedgewick-rafter cell of 1 ml capacity.

Simpson's Diversity index (D) was used as it has been applied for both the phyto and zooplanktons (Winner, 1972).

iv) Macroinvertebrates:

Samples were collected by using bag nets & preserved in formalin.

v) Fishes : Visual observation & collection by bag nets.

vi) Socio-economic aspects and present status of wetlands:
The data was gathered with the help of a questionnaire (format enclosed), District Gazetteers and primay census data available with the District Information Officer in the districts.

vii) Morphoedaphic Index for wetlands:
The MEI, i.e. the ratio of the Total dissolved solids (expressed as conductivity) to mean depth, developed by Ryder (1965) for north temperate lakes (jenkins, 1982) and used successfully in African waters (henderson & Welcomme, 1974) has been employed as a means of estimating the potential productivity of a wetland.

viii) Ranking of Wetlands:
A water quality ranking has been prepared for wetlands as an alternative to the classical and rather ambiguous methods used to delineate wetlands as oligo, meso or eutrophic. The ranking method used by Michalski & Canroy (1972) for lake Alert study has been adopted here. The ranking has been designed to take into consideration a number of significant physical, chemical and biological features (Table). It is important to note that these parameters can easily be obtained at minimum expenditure and time. The parameters selected are vital to water quality assessments (such as Dissolved Oxygen), for public (depth) and fisheries (MEI).

For developing a rank, a rating scale of 10 was adopted, i.e. the absolute range for each parameter was therefore 1 to 10. Proportionate ratings between the maximum and mimimum

values for the wetlands were computed (Michalski & Canroy, 1972).

Rank for a wetland = 10(X - Y)/ Z - Y, where
X = Value for a given wetland
Y = Minimum value for all wetlands
Z = Maximum value for all wetlands

For parameter (e.g. Salinity) which is inversely related to water quality, the equation was revised to:

Rank for a wetland = 10(Z - X)/ (Z - Y)

The water quality ranking system places all the parameters on a common scale and allows for the objective placement of intermediate ranking wetlands in proportion to their absolute values. Rank values for each wetland may then be averaged.

LAND FORM

Etawah District:

The district derives its name from Etawah, meaning 'Int' or bricks and refers to the extensive brick industry spread over the district. It is situated between 26° 21' & 27° 1' north and 78° 45' & 79° 45' east . The total area is 4,327 sq.km.
The district has been divided into 4 tehsils: Etawah, Bharthana, Bidhuna and Auraiya, each having a number of blocks.

The district lies in the Indo-Gangetic plains, but its physical features are determined by the rivers (Yamuna, Chambal,Arind) which pass through it. It can be divided into 4 major portions (on the basis of distinct natural characteristics):Pachar, Ghar, Biharh and Par.

The northern portion of the district covering Etawah, Barthana and Bidhuna tehsils, has a number of lakes or Jheels.The presence of clay beds in depressions has made conditions favourable for the retention of water. The Ganga canal was introducted in the region in 1855 which originates from the head works at Haridwar.There are two major canals- the Kanpur branch and the lower Ganga canal.The whole district is served by about 1,358 km long irrigation canals and distributaries. The total area commanded by this canal system is 2.12 lakh ha.

Mainpuri district

Mainpuri district is situated between 26° 53'- 27° 31'N and 78° 27'-79° 26'E . The approximate area of the district is 8703 sq km.The district comprises of 5 tehsils, namely,

Jasrana, Shikohabad, Karhal, Mainpuri, and Bhongaon. The district is generally an extensive level plain land intercepted by few sand ridges on the western border, hills and undulations of the Kali and Isan rivers and the ravines along the Yamuna to the southwest.
Three well defined soil tracts can be distinguished in the district:

1. the northern sandy tract between the Isan and kali rivers.

2. the central loamy tract between the Isan and the Kak rivers on the north and the Sirsa on the south.

3. the southern mixed tract between the Yamuna and the Sirsa.

The district abounds in swamps and jheels, most of which dry up during the summer. Saman lake in Bhongaon tehsil has been recently declared by the Government of Uttar Pradesh as a waterbird sanctuary.

Geology

The districts have no minerals of economic importance. These districts form part of the Indo-Gangetic alluvium which consists of clay, sand, and limestone (Kankar).Clay is found all over the two districts and is used for making bricks, pottery, etc. Limestone is abundantly found in two forms - the block Kankar (Silia) which is used for walls and foundations and the nodular form (Bichhua) which is used for metalling roads.

Climate of the two districts:

It is characteristised by a hot dry summer and a cold winter. the year may be divided into the following seasonal cycle-

Winter	October- February
Spring	March - April
Summer	May - June
Monsoon	July - September

Agriculture:

Since the advent of the Ganga canal irrigation in the two districts, there has been a considerable progress in farming patterns particularly in the extent of double-cropping *(dofasli)* and planting of high yield varieties instead of local varieties.
Principal crop- the Kharif (autumn)crops are mainly millet (Bajra, Jowar, paddy, maize). These are sown usually with *arhar*. Bajra is chiefly grown in light sandy soil while Jowar is grown in the stiffer and better soils. The latter is grown in considerable amounts in Etawah and Barthana tehsils of Etawah district as a fodder crop. Several local varieties of rice known as *Lehipasai* are grown in the catchment area of wetlands (which are inundated during winter).These varieties are resistant to the waterlogged soil conditions. Kharif cereals are small pulses such as black and green gram.

The Rabi (spring) crop consists of wheat, gram, and barley. Other Crop: sugarcane, oil-seeds (groundnut, linseed, rape-seed) vegetables, fruits, tobacco, potato,onions, spices and condiments.

Socio-Economic Profile

If the wetland areas in general are understudied, wetland socio-economy is more so. There has been a lack of hard data on the dependence of local people on wetlands, therefore the present discussion on the socio-economic profile is based on fragmented data available with the National Informatics Centre (Primary census data), district gazetteers and personal observations. It was seen that agriculture forms a major occupation (70-90%) of the people in the region while fish and livestock workers are less than 1%. Fishing and cultivation of macrophytes forms a very marginal occupational category. Field observations gives an estimate of >1% of the worker population who are reported to be primarily dependent on fisheries. Few wetlands such as Bhanwant, Sauj and Hardu had Singhara and Lotus cultivation. These wetlands are leased out by the district authorities to Kahars, a local fishermen community) for a period of 5 years. These people usually are unable to raise the money and hence middle men step in. The lease gives them the right to harvest the macrophytes and also to net fishes by pumping out the water. The dependancy of people on wetlands has been enumerated in Table .

General profile of the wetlands:

The northern portion of Etawah district covering Etawah, Barthana and Bidhuna tehsils has a number of lakes or

Jheels. The clayey soil with natural depressions makes it favourable for the retention of water. The river system comprises the Yamuna and its tributaries the Chambal and Kunwari; Sengar and its tributary the Sirsa; Arind and its tributaries the Ahneya and Puraha.

Yamuna is the major river covering about 148 km through the district. The Major carps and catfishes are found in its waters.

Mainpuri district too has a number of jheels, most of which dry up during summer. Saman wetland in Bhongaon tehsil has been recently declared by the Government as a waterbird sanctuary.The major rivers flowing through the district are the Yamuna (69 km long course), Kali nadi (54km),and Isan river (72 km).

All the wetlands in Etawah and Mainpuri districts are shallow (1-5 m depth) and a large number of them (45%) are seasonal. These wetlands are limnologically not very different with respect to their hydrological regimes, location and morphology.

Physico-chemical and Biological profile of Wetlands:
Data on the wetland morphometry, physico-chemical features, plankton and fish diversities are provided in figs.....

Temperature, depth, pH and turbidity constitute the more important physical parameters on which the productivity of a wetland depends. All organisms, including fishes, possess well defined limits of temperature tolerance. The water temperature recorded was in the range of 16° to 35.6° C. Fishes such as the major carps usually tolerate this range. The depth of a wetland has an important bearing on the physical and chemical qualities of water.The depth in the present case was upto 5 m. Benthic macrophytes were present in almost all the wetlands and the sunlight penetrated upto the bottom. Turbidity of natural waters is usually due to either suspended inorganic substances such as silt and clay or due to plankton. All the wetlands surveyed were with minimum turbidity except for Gulabpur tank (SOI toposheet 54/I/15).

Plankton: A total of 15 genera of three different algal groups, Chlorophyceae, Bacillariophyceae and Myxophyceae were recorded in the wetlands (Table). Chlorophyceae was high in Panwah while Myxophyceae was maximum in Bhanwant.

Populations of four groups of zooplankton ,namely Cladocera, Copepoda, Ostracoda and Rotifera were estimated.
In all the samples the Ostracods were very few in number.

TABLE I

Plankton recorded from the Wetlands

PHYTOPLANKTON

Chlorophyceae	*Volvox*, *Eudorina*, *Scenedesmus*, *Ulothrix*, *Microspora*, *Spirogyra*, *Closterium*, *Staurastrum*.
Bacillariophyceae	*Cymbella*, *Fragilaria*, *Synedra*
Myxophyceae	*Oscillatoria*, *Anabaena*, *Microcystis*, *Spirulina*.

ZOOPLANKTON

Cladocera	*Daphnia lumholtzi*, *Daphnia* spp., *Diaphanosoma* sp., *Macrothrix sp.*, *Chydorus sp.*
Copepoda	*Cyclops* spp.
Rotifera	*Keratella*, *Brachionus*, *Lecane*, *Monostyla*, *Trichocerca*
Ostracoda	*Cypris*, *Stenocypris*.

Fish and fisheries: The major rivers namely the Yamuna and Chambal and the Ganga canal have the usual major carps and catfishes. Some of the wetlands which are in proximity to the Ganga canal or its distributaries also get a fair quantity of these fishes during the rainy season. These wetlands are usually leased out by the district authorities to the fishermen belonging to Kahar caste, for a period of 10 yrs. The rate being about Rs 500/- per hectare. The yield ranges from 15 to 20 quintals / ha. In Mainpuri district 36 lakh seeds of major carps were released (92-93) in 168 tanks,(281.849 ha) out of a total of 344 tanks (427.867 ha). It was noticed that although the Government was selling the fish seeds (major carps: *Catla catla, Labeo rohita & Cirrhinus mrigala*) at a highly subsidised rate of Rs 55/- per hundred, there were few takers.

A survey of the wetland fish fauna indicated the predominance of common species such as *Puntius conchonius, Chela laubuca, Esomus danricus, Clarias batrachus, and Colisa fasciatus.* Altogether 31 species were encountered with Chambal river having the maximum species richness. Wetlands such Prethipur and Isan nadi has the minimum richness. It was surprising to notice the presence of large schools of grey mullet, *Rhinomugil corsula*,in the Chambal river at Pinahat. This fish swims in the subsurface zone of the river and possesses aerial vision.This comes quite handy while escaping the fishing nets.

The various fishing gears in operation in the area are:

Seine nets:extensively used in the canals for catching major carps and catfishes.
Cast nets:commonly used in the jheels where there is less aq.vegetation.

Usually the fishermen use a peculiar method of fishing by emptying out the water from the wetland with the help of diesel operated pumpsets and buckets and then catching them by hand.

The fish fauna of the two districts has been given in the Appendix.

Amphibia

Three species were recorded, namely,*Bufo melanostictus* Sch. *Rana cyanophylictis* Sch and *Tomopterna* sp.

Reptilia
Thirteen species of reptiles ranging from the marsh crocodile (in Chambal river to the common garden lizard) were recorded from the study area.
(Table)

TABLE (I

Major groups of Nonplanktonic 1nvortebrates collected In the samples

Group		Habi tat
Turbel1ar1 a	PIanar1dae	E,
011gochaeta	Tubificidae	B
Nematoda		B,
Tardi grada		B
Insecta		
Di ptera	Chaobori dae	B,
	Chi ronomidae	M
Ephemeroptera	Ephemeri dae	E
Hemi ptera	Belostomatidae	N
	Corixidae	N
	Gerri dae	N
	Neplda e	N
	Notonecti dae	N
Coleoptera	Chrysomeli dae	N
	Dytlsci dae	B
	Hydrophi1idae	N
Mol1usca	Gastropoda	E,
	Bivalvia	8

B = Benthos; E = Epiphyton; M = Endoparasite of macrophytes; N = Neuston; P = Plankton.

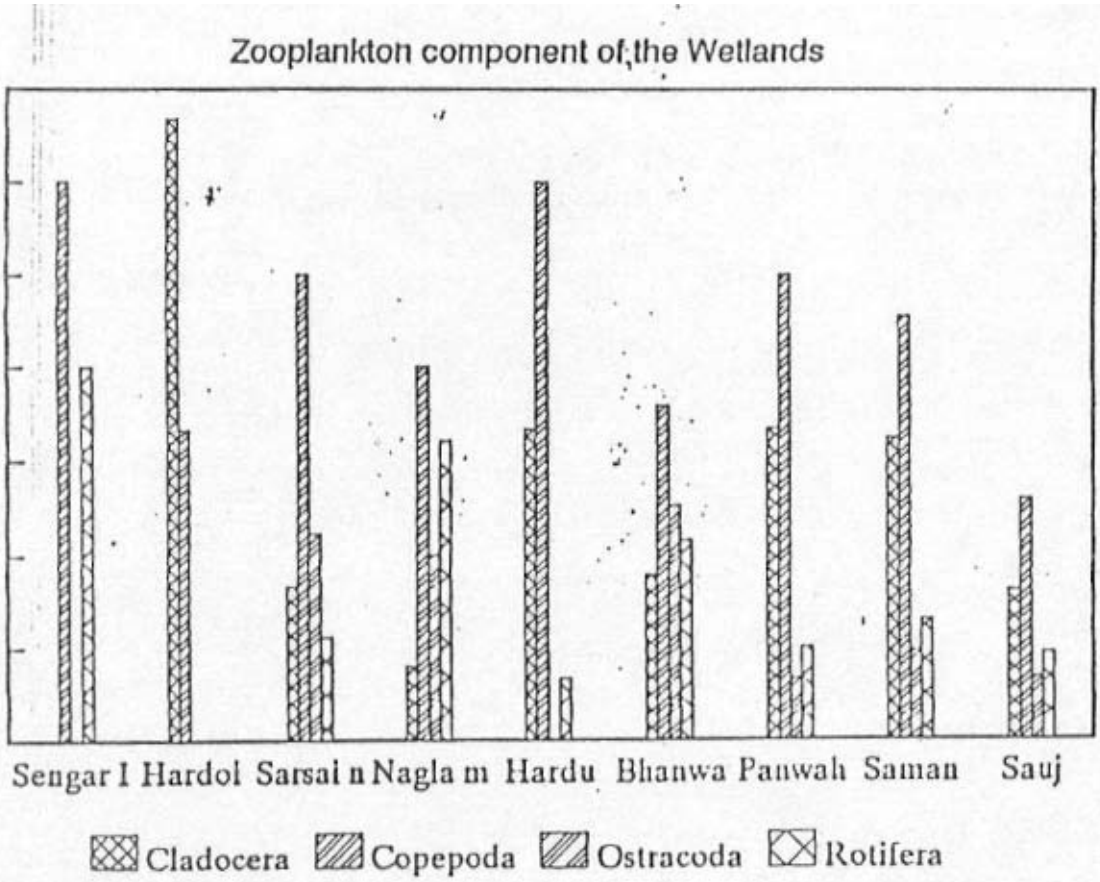

Zooplankton component of the Wetlands
Sengar I
Hardol
Sarsai n
Nagla m
Hardu
Bhanwa
Panwah
Saman
Sauj
Cladocera
Copepoda
Ostracoda
Rotifera

Fig 1

Mammals

Although the mammalian fauna is diverse, 1n the two districts, their population 1s not high because of lack of cover and sparseness of natural vegetation. The common mammalian species found in the two districts (sight records & local information) are the Langur, Nilgai, Mongoose and the Jackal.

Ranking of Wetlands

The wetlands of Etawah and Mainpuri districts were ranked by taking a selected water quality parameters such as,depth, morphoedaphic index (MEI), salinity and plankton diversity. The individual ranking for each parameter was then averaged (Table). It will be seen from the Table ( ) that none of the wetlands have an average ranking of over 5.5 1n a range of 0 - 10 scale. A careful examination of the wetlands reveal two groupings: 1) wetlands ranking between 1.6 to 3.6, 2) wetlands ranking between 3.6 and 5.5. About half the number of wetlands *(52%)* were 1n the later range. This shows poor water quality conditions for almost all the wetlands.

Ranking of Wetlands according to proportionate ratings of select parameters
(Plankton, Depth, Mlil, Fish sp. richness.Saliiiily)

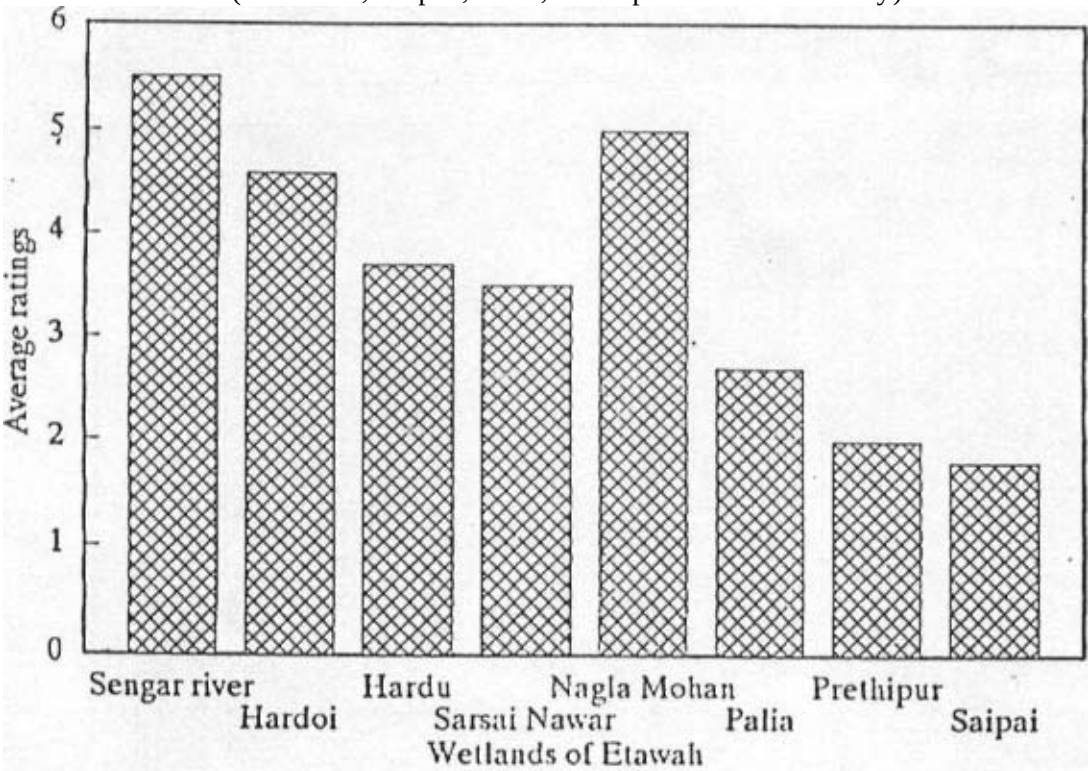


Fig 2.

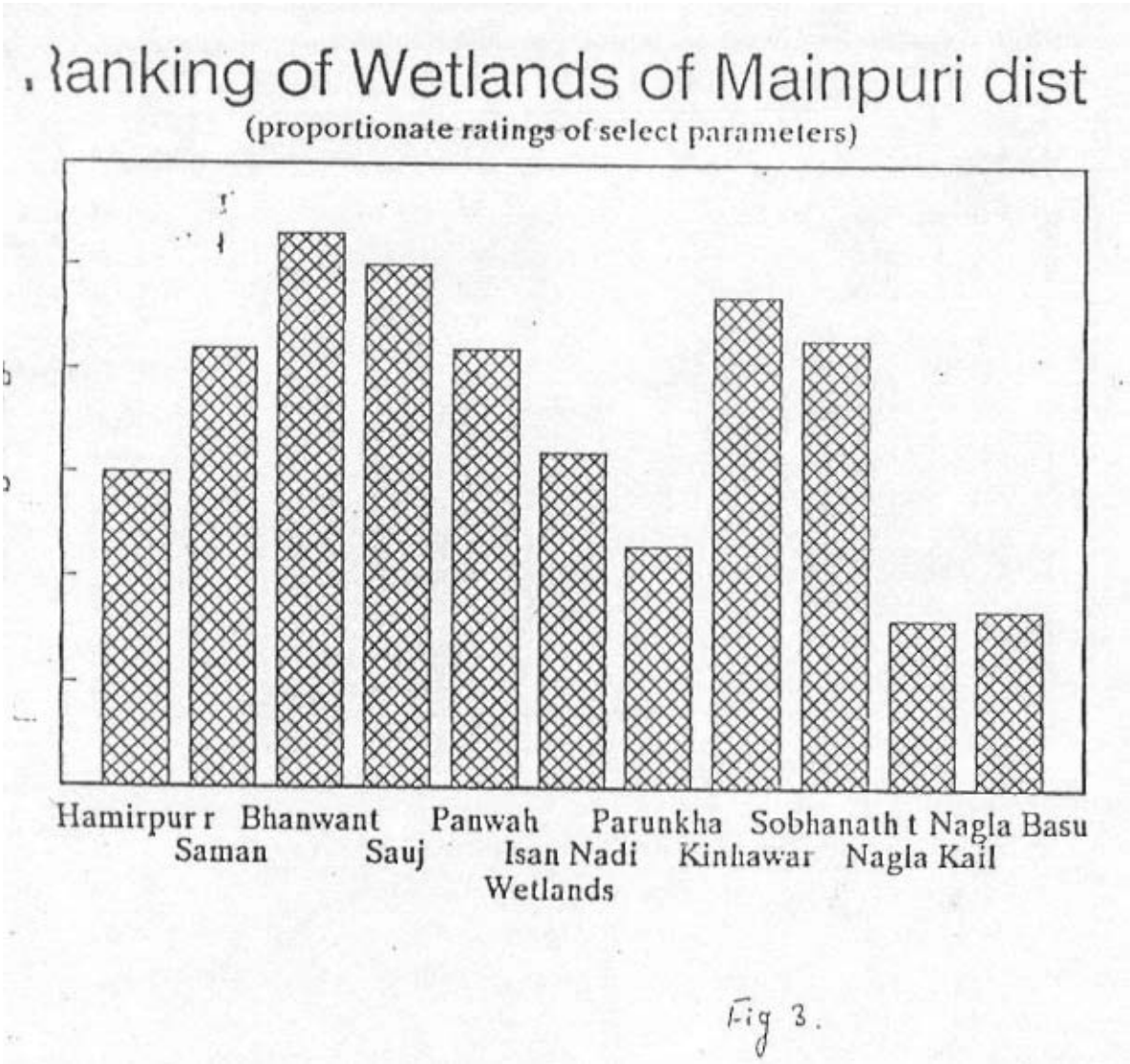

Ranking of Wetlands of Mainpuri dist
(proportionate ratings of select parameters)
Hamirpur r Saman
Bhanwant Sauj
Panwah Isan Nadi
Parunkha Kinhawar
Sobhanath t Nagla Kail
Nagla Basu
Wetlands

Fig 3.

REFERENCES

Simpson, E.H. 1948 Measurement of diversity. Nature, 163:688.

Winner, R.W. 1972. An evaluation of certain Indices of eutrophy and maturity in lakes. Hydrobiol. 40-2:223-245.

Jenkins, R.M. 1982. The Morphoedaphic index and reservoir fish production. Trans.Am.Fish.Soc. 111:133-146.

Henderson, H.F. and Welcomme, R.L. 1974. The relationship of yield to MEI and number of fishermen in African inland fisheries. CIFA, Occ.paper No.1, 19pp. Rome, FAO.

List of Fishes recorded from the 2 districts

Notopterus Chitala (Ham)
Cirrhinus mrigala (Ham)
Ctenopharyngodon idellus (Val)
Labeo calbasu (Ham)
L. gonius(Ham)
L. pangusia(Ham)
L. rohita(Ham)
Osteobrama cotio cotio(Ham)
Puntius chola(Ham)
P. conchonius(Ham)
P. sophore(Ham)
P. ticto(Ham)
Tor mosal (Ham)
T. tor (Ham)
Chela laubuca (Ham)
Salmostoma bacaila (Ham)
Barilius barna (Ham)
Esomus danricus (Ham)
Parluciosoma daniconius (Ham)
Garra gotyla gotyla (Gray)
Aorichthys seenghala (Sykes)
Mystus cavasius (Ham)
Wallago attu (Ham)
Clarias batrachus (Linn)
Heteropneustes fossiles (Bloch)
Chanda nama (Ham)
Rhinomugil corsula (Ham)
Colisa fasciatus (Schn)
Channa marulius (Ham)
C. punctatus (Bloch)
Mastacembelus armatus (Lacepede)

TABLE VII

Reptiles and Mammals found in the study area

Reptiles

Marsh crocodile	*Crocodylus palustris* (Lesson)
Gharial	*Gavialis gangeticus*
Indian Python	*Python molurus* (Linn)
Dhaman or rat snake	*Ptyas mucosus* (Linn)
Checkered keelback	*Xenochrophis piscator* (Schn)
Common Indian Krait	*Bungarus caeruleus* (Schn)
Indian Cobra	*Naja naja* (Linn)
Indian mud turtle	*Lissemys punctata* Lacepede
Indian Pond Terrapin	*Melanochelys trijuga* (Sch)
Gecko	*Hemidactylus* spp
Garden lizard	*Calotes versicolor* (Daudin)
Indian Chameleon	*Chamaeleon zeylanicus* Laurenti
Monitor	*Varanus bengalensis* (Schn)

Mammalia

Langur	*Presbytis entellus* (Dufresne)
Nilgai	*Boselaphus tragocamelus*
Sambar	*Cervus unicolor* Kerr
Leopard	*Panthera pardus* (Linn)
Jungle cat	*Felis chaus* Guldenstaedt
Jackal	*Canis aureus* Linn
Hare	*Lepus nigricollis* F. Cuvier
Porcupine	*Hystrix indica* Kerr
Mongoose	*Herpestes edwardsi* (Geoff)
Squirrel	*Funambulus* sp

CHAPTER III

AN ORNITHOLOGICAL CLASSIFICATION AND EVALUATION

In India there have been attempts to study wetland systems, though limited in approach to the biological component of the system, on a wide geographical scale(SAC 1992, Patnaik 1990). In most of these studies invariably the avian component was always overlooked. Hence, a proposal was mooted to survey, map and classify Indian wetlands from physical, chemical,biological,and social perspective form Salim Ali Centre for Ornithology and Natural History (SACON). As a prologue to such an attempt a feasibility survey was carried out in the Indogangetic plain. The wetlands of Mainpuri and Etawah districts of Uttar Pradesh were taken for such a study. Hume (1864) had reported Siberian Cranes from Saman wetland in Mainpuri district.

As a part of this preliminary survey in Etawah and Mainpuri districts of U P, I enumerated the avifauna from wetlands during winter of 1992-1993 and summer of 1993. The purpose of surveying these wetlands in winter and summer was to sample the system in its two extreme spectrum of seasonality and in turn, to incorporate the information to classify them and prioritize the conservation efforts for them. Herein, I report the results form the study and discuss the conservation priority from an ornithological perspective.

METHODS

Though there are many methods available for counting the birds of wetlands, I employed the absolute count as I found it good to achieve the objectives of this survey. Hence, I followed the round count method (Poysa and Nummi 1992) to estimate the population. In a round count, the observer circles the the wetland on foot and count the birds. If the size of the wetland is small then it is not mandatory to circle the wetland. The count can be made from one or more vantage points. Since we had to cover many wetlands within limited number of days, counts were made in different times of a day. When the number of individual species was very large, say more than 1000 then only a visual estimate is attempted rather than absolute counting.

ANALYSIS OF DATA

Though the maximum diversity approach for conservation has been criticized for its lack of appreciation for landscape ecology (Noss 1983) diversity of habitats and species has been a primary consideration for deciding which sites should be preserved (Goeden 1979, Margules and Usher 1981). I drew from the maximum diversity concept in prioritizing the conservation efforts needed for different wetlands. The stability, as resilience or as persistence of the system, is affected by the number of interacting elements in the system (Kikkawa 1986). The measure of species diversity is also a measure of system stability as it quantifies the elements of system.

Thus, the conservation priority of wetlands from ornithological angle is hypothesized as a function of the structural parameters of the avifaunal community (diversity, richness, evenness) and the area of wetland.

As I wanted to compare communities in terms of the distribution of individuals among the species I used Shannon Weaver diversity and Pielou's equitability indices to calculate diversity and evenness and used the following formulae:

Shannon-Weaver's (1949) Diversity Index $H' = \text{sum } P_i \log P_i$

Pielou's (1975, 1977) Equitability Index $(J') = H'/\ln S$

Where P_i is the proportion of i^{th} species and S is the total number of species.

The Shannon'-Weaver index of diversity is the most commonly used index in community ecology (Ludwig and Reynold 1988, Kikkawa 1986). It is a measure of the average degree of uncertainty in predicting to what species an individual chosen at random from a collection of S species and N Individuals will belong. There are two major caveats against the use of these indices in expressing the community structure ie. 1) accumulation of species with increasing area is ignored and 2) many combinations of species richness and relative abundance can produce the same value of the index (James and Rathbun 1981).

As the size and species richness are related linearly, in the present study diferences in the size of the wetlands were considered as one of the important factors in deciding the priority of each wetland and therefore we need not be worried about the sensitivity of Shannon-Weaver's index to the sample size. Moreover, though a relatively little work has been done in defining the minimum acceptable size of any conserved area, it is probably a reasonable maxim that the larger the area, or extent, of a site, the more valuable it is for wildlife conservation (Usher 1986)

Since the equitability values describes the distribution of species abundance in a community it is intuitive to give higher conservation priority for those wetlands having highest equitability values. This is deemed wise because wetlands with waterfowl communities having more evenness means that the habitat requirements of different species coming under different guilds are satisfied.

RESULTS AND DISCUSSION

WINTER

Altogether 34 wetlands were surveyed during winter Out of the these, birds were present only in 33 wetlands. A total of 74 species of birds were recorded during the survey (Table 1) and the total abundance was estimated as 20660. The highest number of birds recorded was 5776 in Saman followed by 5045 in Bidhuna (Fig. 1).

The composition of wetland avifaunal groups had certain pattern (Fig.2); the migrant ducks were the most dominant group (72%) in all the wetlands, followed by coots (11%) and rails (5%). Among the migrant ducks the order of dominance was: Pintail, Gadwal, Common Teal, Wigeon and Garganey Teal. Interestingly, the pochards and waders were not significantly contributing to the composition of the wetland avifauna of Mainpuri and Etawah. The explanation for this phenomenon lies in the habitat requirement of these two groups. Pochards and waders prefer openwater areas and drying shallow marshes (shore) respectively for their feeding activities. Only very few of the wetlands had habitats preferred by pochards and waders. Hence their number was low compared to the migrant anatids. The heronry species were also fewer in number when comparing with certain similar areas like the Keoladeo

is neither seen nor reported inside or in the vicinity of all these wetlands. This is because most of the wetlands were of small area and when the area is large enough as in the case of Saman Bird Sanctuary, the habitat required for the heronry species was not available.

Common breeding birds of these wetlands include Purple Moorhen, Pheasant-tailed Jacana, Bronzewinged Jacana, Sarus Crane, Cotton Teal and Indian Moorhen.

ORNITHOLOGICAL CLASSIFICATION AND EVALUATION OF WETLANDS DURING WINTER

Abundance, richness, species diversity and Equitability were broken into priority categories within themselves. Abundance were log transformed before breaking them to categories.

I categorized abundance into four, richness into four, species diversity into three and equitability into five groups. Out of the total 33 wetlands 12.12%, 30.30 %, 42.42% and 15.15% were grouped under 1-10, 10-100, 100-1000 and 1000-10000 abundance classes respectively (Table 2). Similarly, 36.36%, 36.36%, 18.18% and 9.09% of the total wetlands were grouped under 0-10, 10-20, 20-30 and 30-40 classes respectively in the case of richness (Table 3). The three classes of species diversity namely 0-1, 1-2 and 2-3 had 9.09%, 54.54%, and 36.36% of the total wetlands respectively (Table 4). Equitability distributed the wetlands in 6.06, 6.06, 21.21, 36.36, and 30.30 percentages in 0.0-0.2, 0.2-.4, 0.4-06, 0.6-.0.8 and 0.8-1.0 categories respectively (Table 5).

It is not desirable to give higher conservation priority for those wetlands with higher values for any one of these components. Instead, priority should be given for wetlands having higher abundance, higher richness, higher Shannon's diversity, and higher equitability. But, this in most cases leads us into confusion in singling out wetlands for conservation action.

SUMMER

During summer only 26 wetlands had birds. A total of 38 species was recorded during the survey (Table 6). The total abundance of birds was around 4000. The highest population recorded was 757.5 in NTPC tank (Fig. 3). The highest richness (19) was in Saman followed by NTPC and Hardu. The NTPC tank, an

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Where the R and A are the Bird species richness and Area of the wetland respectively.

Hence the area per se need not be taken for the evaluation and rating of a given site for prioritization. Since the richness is incorporated in the Shannon's diversity index and the richness positively correlated with diversity index (r=0.642, P=0.0001, df=29 in winter and r=0.758, P=0.0001 df= 23 in summer) the richness need not be considered for prioritization along with diversity index. Pielou's equitability index was correlated significantly with diversity index (r=0.535, P=0.002, df=29) during winter and negatively during summer, though not significant (r=-0.227, P=0.399, df=14). Biplots of the wetlands with equitability and diversity indices on X and Y axes were attempted to identify the wetlands for conservation efforts both during winter and summer.

Based on the community of wetland birds during winter (Fig. 5) the wetlands with diversity value ranging from 2 to 2.87 and equitability values ranging from 0.69 to 0.98 can be considered as priority group one. This class includes wetlands such as Mohan, Sarsai, Hardoi, Sengar2, Sengar1, Hardu, Kinahwar, Mankapur, Saipai, Bhanwant, and Nigoh. The second priority group includes Palia, Harhai, Saman, Panwah, Sauj, Panrokha, Kangarul, Shobanath and Bidhuna and the diversity and equitability values for this group ranged from 1.54 to 1.99 and 0.52 to 0.77 respectively.

During summer three priority groups for conservation action could be recognized (Fig. 6) The first group with only one member namely Saman with values for Shannon's diversity and equitability 2.21 and 0.75. The second priority group with values of diversity and equitability indices ranging from 1.99 to 1.05 and 0.92 to 0.51 respectively and includes wetlands such as Mohan, Harhai, Bhanwan, Sauj, Hardu, Mnkapur, Panrokha, Malwan, Sengar, Aurayia, Kangraul, NTPC Tank, Hameedpur, Rosemar, Banihara and Hardoi.

CONCLUSIONS

The wetlands were prioritized for conservation efforts based on the Shannon's diversity Index and Pielou's Equitability index.

The indices based approach for determining the conservation priority is of limited value as it does not consider the network of wetlands as one conservation unit.

Most of the migrant waterbirds coming to our country keeps moving from place to place in their migratory routine. And the major portion (33.8%) of the avian community in the wetlands studied during winter was constituted by the migrants. In addition to the purely migrant birds, around 48 are partly migrant or locally migrant or nomadics. Hence for them a net work of wetlands rather than few single large reserves are must for their survival here. According to Ali & Ripley (1988) all the nomadic species and some of the local migrants listed here (Appendix 1) shift from place to place depending upon the water and drought conditions. Thus if one area suffers from drought most of the nomadic residents can move into a different area. We had 17% purely resident birds in the sample. They should be looked after by making one or more large perennial reserves. Theus, the entire network of wetlands comprising a few large ones and a number of smaller ones might be more important for the survival of both migrant and resident birds of wetland.

From a monsoonal wetland of this sort from the Indogangetic region itself, Bupathy (1991) reported that most of the migrant ducks utilized the agricultural lands in a daily routine basis for feeding activities. Individual ecosystems, the traditional focus of ecology, should not be seen as separate entities (Hansson 1977). Almost all systems are "open" and exchange energy, mineral nutrients, and species (Noss 1983). Therefore, while proposing reserves for water birds one should give attention to the surrounding landscape in which the wetlands are embedded.

The wetlands with water in summer should be given more priority because the resident water birds are dependent on them.

The reserve design has been discussed by many people on single large or several small (SLOSS) reserve dichotomy (Eichrlich 1989). The answer for reserves design for waterbirds should not be scholastically discussed around the single large or several small proposition. I would say that we should change the proposition of SLOSS in to a "Few Large And Several Small" (FLASS) for the conservation of waterbirds

REFERENCES

Ali, S. and D. Ripley (1983): Handbbok of the birds of India and Pakistan, Compact Edition, Oxford University Press, Delhi, India. pp.737

Anonymous (1992):Costal Environment, Project report, Space Application center, Ahamadabad.

Bupathy, S. (1991): Ecology of migratory waterfowl. Ph.D Thesis, Rajasthan University, Jaipur, India.

Eichrlich, P.R (1989):Ecology and resource management- Is ecological theory any good in practice. In Perspective in ecological theory. Eds. Jonathan Roughgarden, Robert M. May and Simon A. Levin. pp.306-318.

Goeden, G.B (1979): Biogeographic theory as management tool. Environmental Conservation Vol.6:27-30.

Hansson, L. (1977): Landscape ecology and stability of population. Landscape Planning. Vol.4:85-93.

James, F.C. and S. Rathbun (1981): Rarefraction, relative abundance, and diversity of avian communities. The Auk Vol.98:785-800.

Kikkawa J. (1986):Complexity, diversity and stability In Community Ecology: pattern and process. Blackwell Scientific Publication, Melbourne Australia pp. 41- 62.

Ludwig, J.A and Reynold J. F. (1988): Statistical Ecology: a premier on methods and computing, Wiley Interscience publication, John Wiley and Sons. New York.pp. 85-103.

Margules, C. and M.B. Usher (1981): Criteria used in assessing wildlife conservation potentaial: a review, Biological Conservation, Vol. 21:79-109.

Mitch, W.J. and J.G.Gosselink(1993): Wetlands. 2nd Edition, VNR New York, pp:722.

Noss, R.F.(1983): A regional landscape approach to maintain diversity. BioScience Vol.33(11):700-706

Patnaik, S. N, N K Mahalik, S P Bhunia, H S Das, C Das and B S Mohanty (1990): Mapping and characterization of wetlands along eastern coast of Orissa. Project report submitted to DOEN, Govt. of India.

Pielou, E.C. (1975): Ecological Diversity. Wieley, New York.

Pielou, E.C.(1977): Mathematical Ecology. Wiley, New York.

Pimm, S.L and M.E.Gilpin (1989): Theoretical issues in conservation biology. In Perspective in ecological theory. Eds.Jonathan Roughgarden, Rober M. May and Simon A. Levin. pp.287-305.

Poysa, H. and Nummi P.(1992): Comparing two methods of data collection in waterfowl habitat use studies. Bird Study, Vol.39:124-131.

Shannon, C.E. and W. Weaver(1949): The Mathematical Theory of Communication. University Illinois Press, Urbhana, IL.

Usher, M. B.(1986): Wildlfe conservation evaluation: attributes, criteria and values. In Wildlife conservation evaluation (Michael B Usher Ed.).pp 3-44.

Table 1: Bird species recorded from Mainpuri and Etawah districts of Uttar Pradesh during winter 1992-1993

S.NO	COMMON NAME	SCIENTIFIC NAME	STATUS
1	Little Grebe	*Podiceps ruficollis*	RESE,NOMA
2	Large Cormorant	*Phalacrocorax carbo*	RESE,LMIG,PMIG
3	Indian Shag	*Phalacrocorax fuscicollis*	RESE,NOMA
4	Little Cormorant	*Phalacrocorax niger*	RESE,NOMA
5	Darter	*Anhinga rufa*	RESE,NOMA
6	Grey heron	*Ardea cinerea*	RESE
7	Purple Heron	*Ardea purpurea*	RESE,LMIG,PMIG
8	Pond Heron	*Ardeola grayii*	RESE,NOMA
9	Cattle Egret	*Bubulcus ibis*	RESE,AMIG
10	Large Egret	*Ardea alba*	RESE,NOMA
11	Median Egret	*Egretta intermedia*	RESE,NOMA
12	Little Egret	*Egretta garzetta*	RESE,NOMA
13	Painted Stork	*Mycteria leucocephala*	RESE,NOMA
14	Openbilled Stork	*Anastomus oscitans*	RESE,NOMA,LMIG
15	Whitenecked Stork	*Ciconia episcopus*	RESE
16	Blacknecked Stork	*Ephippiorhynchus asiaticus*	RESE
17	White Ibis	*Threskiornis aethiopica*	RESE,NOMA&/LMI
18	Black Ibis	*Pseudibis papillosa*	RESE
19	Glossy Ibis	*Plegadis falcinellus*	RESE,NOMA,PMIG
20	Spoonbill	*Platelea leucorodia*	RESE,NOMA,PMIG
21	Greylag goose	*Anser anser*	MIGR
22	Ruddy Shelduck	*Tadorna ferruginea*	MIGR,PRES
23	Pintail	*Anas acuta*	MIGR
24	Common Teal	*Anas crecca*	MIGR
25	Gadwall	*Anas strepera*	MIGR
26	Wigeon	*Anas penelope*	MIGR
27	Garganey Teal	*Anas querquedula*	MIGR
28	Shoveller	*Anas clypeata*	MIGR
29	Redcreasted Pochard	*Netta rufina*	MIGR
30	Common Pochard	*Aythya ferina*	MIGR
31	White-eyed Pochard	*Aythya nyroca*	MIGR
32	Tufted Duck	*Aythya fuligula*	MIGR
33	Cotton Teal	*Nettapus coramandelianus*	RESE
34	Comb Duck	*Sarkidornis melanotos*	RESE,NOMA
35	Brahminy Kite	*Haliastur indus*	RESE,LMIG
36	Marsh Harrier	*Circus aeruginosus*	MIGR
37	Greated Spotted Eagle	*Aquila clanga*	RESE,PMIG
38	Lesser Spotted eagle	*Aquila pomarina*	RESE
39	Sarus Crane	*Grus antigone*	RESE,NOMA
40	Whitebreasted Waterhen	*Amaurornis phoenicurus*	RESE
41	Indian Moorhen	*Gallinula chloropus*	RESE,PMIG
42	Purple Moorhen	*Prophyrio prophyrio*	RESE,LMIG
43	Coot	*Fulica atra*	RESE,MIGR
44	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	RESE,NOMA
45	Bronzewinged Jacana	*Metopodius indicus*	RESE
46	Whitetailed Lapwing	*Vanellus leucurus*	MIGR

S.NO	COMMON NAME	SCIENTIFIC NAME	STATUS
47	Peewit Lapwing	*Vanellus vanellus*	MIGR
48	Redwatled Lapwing	*Vanellus indicus*	RESE,AMIG
49	Blackwinged Stilt	*Himanotopus himantopus*	RESE,PMIG
50	Little Ringed Plover	*Charadrius dubius*	RESE,MIGR
51	Kentish Plover	*Charadrius alaxandrinus*	RESE,MIGR
52	Curlew	*Numenius arquata*	MIGR
53	Spotted Redshank	*Tringa erythropus*	MIGR
54	Common Redshank	*Tringa totanus*	MIGR,RESE
55	Marsh Sandpiper	*Tringa stagnatilis*	MIGR
56	Greenshank	*Tringa nebularia*	MIGR
57	Green Sandpiper	*Tringa ochropus*	MIGR
58	Wood Sandpiper	*Tringa Glareola*	MIGR
59	Common Sandpiper	*Tringa hypoleucos*	MIGR,PRES
60	Fantail Snipe	*Gallinago gallinago*	MIGR,PRES
61	Temminck's Stint	*Calidris temminckii*	MIGR
62	Ruff & Reeve	*Philomachus pugnax*	MIGR
63	Whiskered Tern	*Chlidonias hybridus*	RESE&/BMIG
64	Lesser Pied Kingfisher	*Ceryle rudis*	RESE
65	Whitebreasted Kingfisher	*Halcyon smyrnensis*	RESE,NOMA
66	Yellowheaded Wagtail	*Motacilla citreola*	MIGR
67	Grey Wagtail	*Motacilla cinerea*	SBMI
68	Pied Wagtail	*Motacilla alba*	MIGR
69	Large Pied Wagtail	*Motacilla maderaspatensis*	RESE
70	Drongo	*Dicrurus adsimilis*	RESE
71	Europian Starling	*Sturnus vulgaris*	MIGR
72	Pied Myna	*Sturnus contra*	RESE,NOMA
73	Bank Myna	*Acredotheres giginianus*	RESE
74	Common Myna	*Acredotheres tristis*	RESE

RESE= RESIDENT, MIGR= MIGRANT, LMIG = LOCAL MIGRANT, OMIG = OCCASSIONAL MIGRANT, PMIG = PARTIAL MIGRANT, NOMA= NOMADIC, AMIG = ALTITUDNAL MIGRANT, & = AND, / = OR, PRES = PARTIAL RESEDENT

Table 2: Showing four priority groups of wetlands based on log transformed Abundance data - Winter

1-10	10-100	100-1000	1000-10000
1 Sengar	1.Sobanath	1.Sauj	1.Saman
2 Pretipur	2.Saipai	2.Malawan	2.Bidhuna
3 Isha	3.Palia	3.Rosemar	3.Kangrul
4 Modi	4.Utrarar	4.Salempur	4.Harhai
	5.Mankapur	5.Sarsai	5.Gulabpur
	6.Sengar1	6.Nigoh	
	7.Saidpur	7.Hardoi	
	8.Basu	8.Hardu	
	9.Mohri	9.Bhanwant	
	10.Rohan	10.Panrokha	
		11.Kinawar	
		12.Panwah	
		13.Mohan	
		14.Kail	

Table 3: Showing four priority groups of wetlands based on Richness- Winter

0-10	10-20	20-30	30-40
1.Panrokha	1.Nigoh	1.Mohan	1.Hardoi
2.Salempur	2.Gulabpur	2.Sauj	2.Saman
3.Sobhanath	3.Sengar1	3.Bhanwant	3.Sarsai
4.Kail	4.Kinhawar	4.Hardu	
5.Saidpur	5.Bidhuna	5.Kangarul	
6.Utrara	6.Saipai	6.Harhai	
7.Rohan	7.Rosemar		
8.Pretipur	8.Sengar2		
9.Basu	9.Malawan		
10.Isha	10.Mankapur		
11.Modi Bridge	11.Palia		
12.Mohri	12.Panwah		

Fig.1:ABUNDANCE OF AVIFAUNA IN DIFFERENT WETLANDS OF MAINPURI AND ETAWAH DISTRICTS OF U P DURING WINTER 1992-93

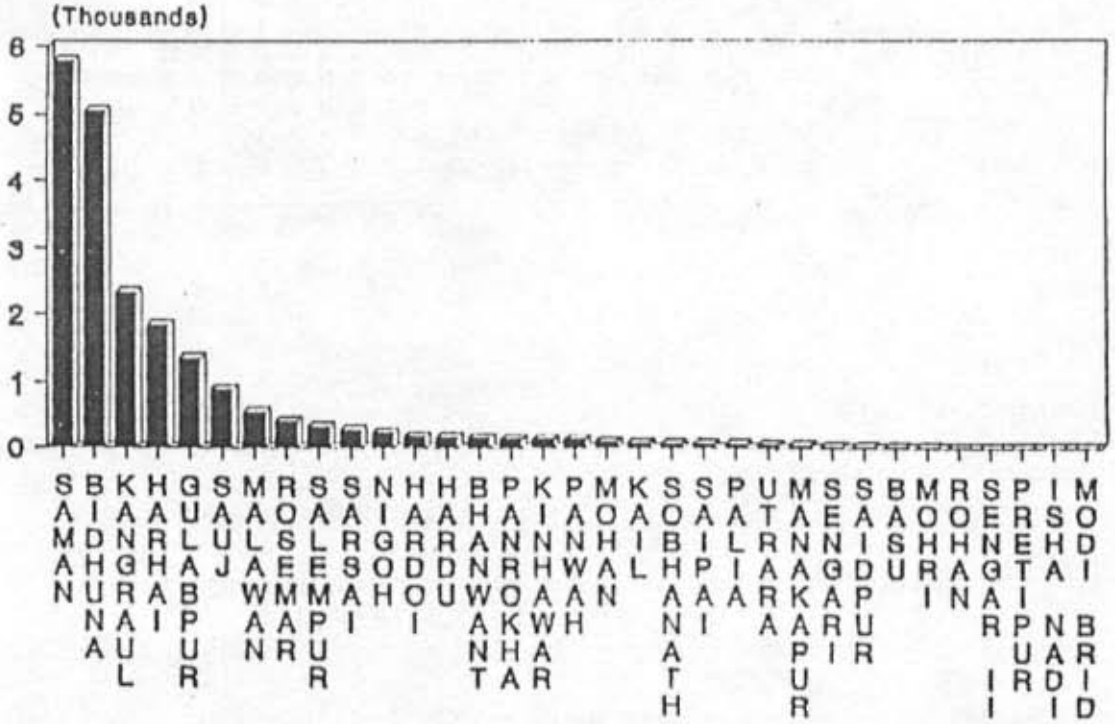


Fig.2:PERCENTAGE COMPOSITION OF DIFFERENT GROUPS OF BIRDS DURING WINTER

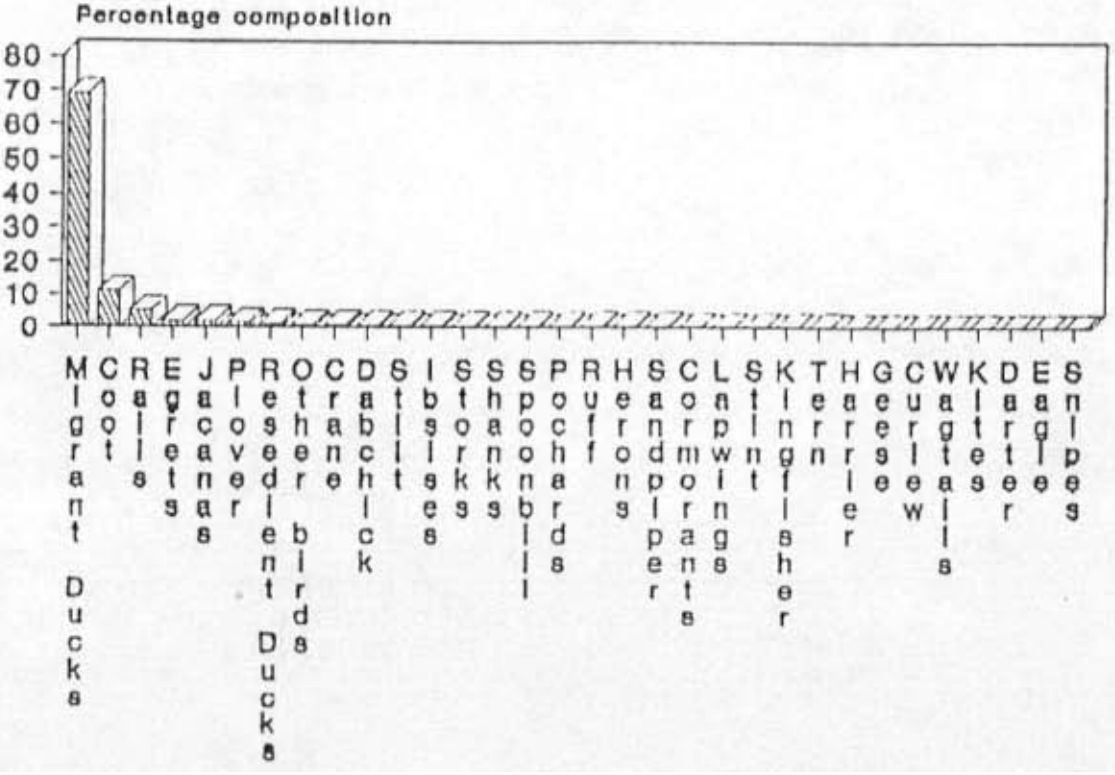
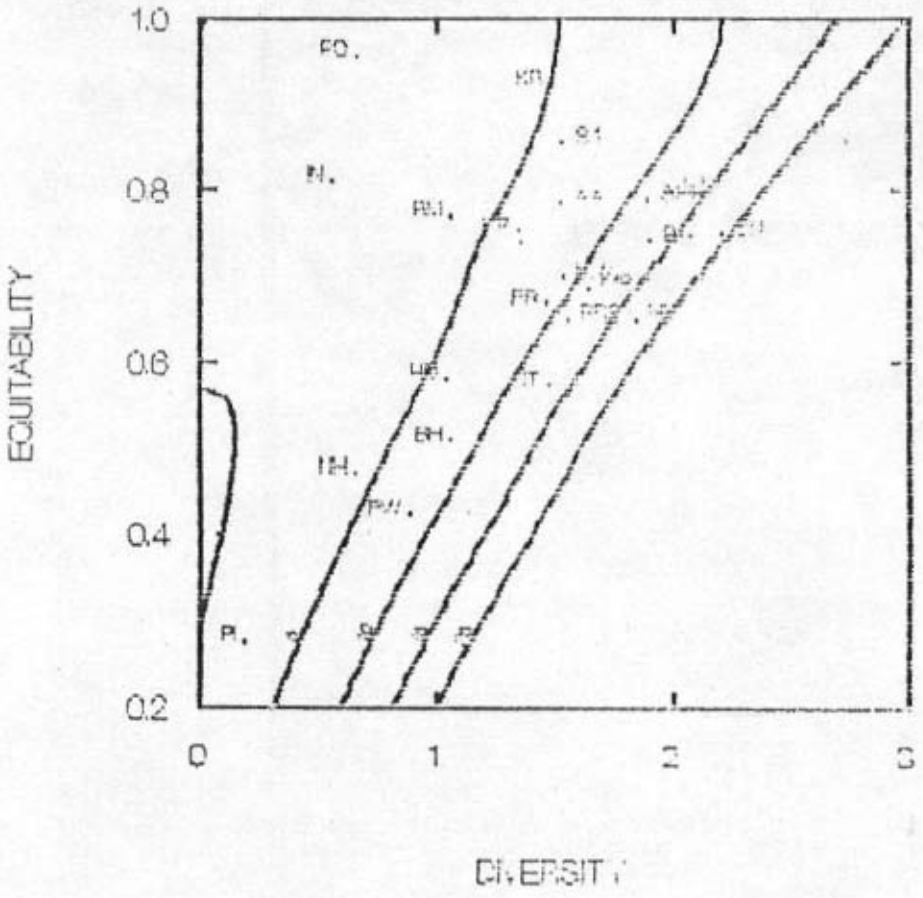


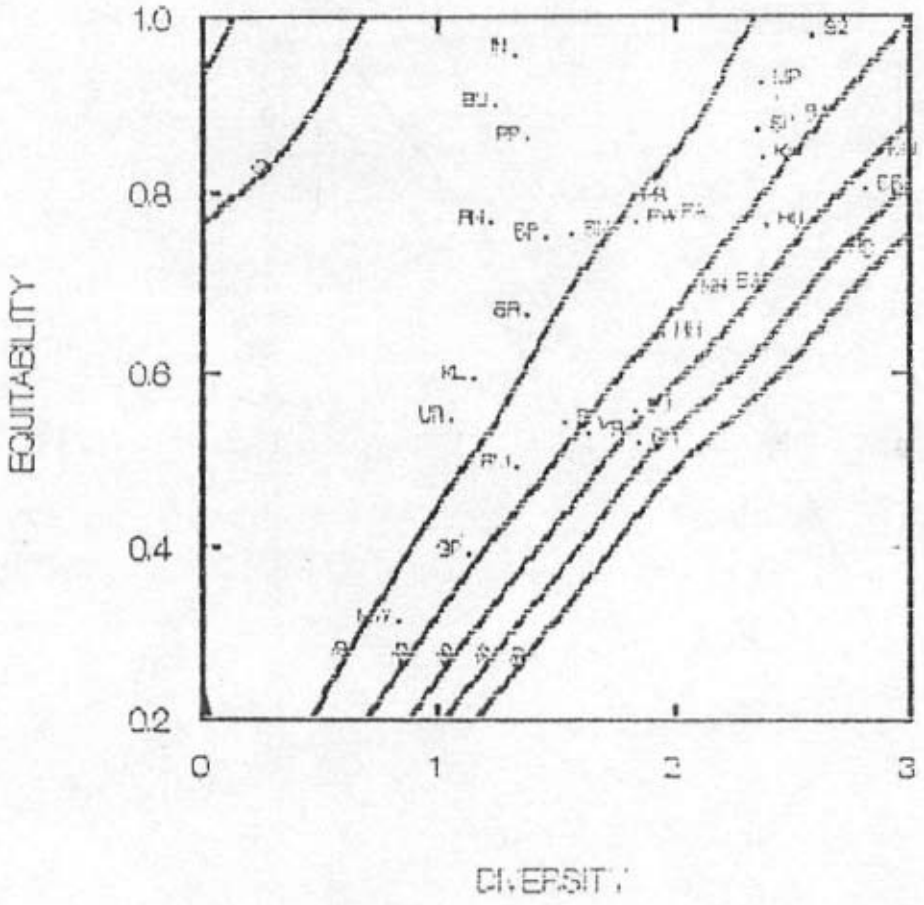
Fig.5: The biplot of diversity and equitability of wetlands contoured on richness to categorize the wetlands during summer.



List of wetlands with code name

1) Aurayia	= AA	11) Mankapur	= MP	21) Saman	= SN
2) Banihara	= BH	12) Mohan	= MN	22) Sauj	= SJ
3) Bhanwan	= BW	13) Nigoh	= NH	23) Sengarl	= sl
4) Hameedpur	= HP	14) NTPC	= NT		
5) Hardoi	= HD	15) Panrokha	= PR		
6) Hardu	= HU	16) Panroka-ST	= PRS		
7) Harhai	= HH	17) Panwah	= PW		
8) Isha Nadi	= IN	18) Puri	= PI		
9) Kangarul	= KR	19) P.Dibyapur	= PD		
10) Malawan	= MW	20) Rosemar	= RM		

Fig.6: The biplot of diversity and equitability of wetlands contoured on richness to categorize the wetlands during winter.



List of wetlands with code name

1) Basu	= BU	11) Kinhawar	= KW	21) Rosemar	= RM
2) Bhanwant	= BW	12) Malawan	= MW	22) Saidpur	= SP
3) Bidhuna	= BA	13) Munkapur	= MP	23) Saipai	= SI
4) Gulabpur	= GP	14) Mohan	= MN	24) Salempur	= SR
5) Hardoi	= HD	15) Nigoh	= NH	25) Saman	= SN
6) Hardu	= HU	16) Palia	= PA	26) Sauj	= SJ
7) Harhai	= HH	17) Panwah	= PW	27) Sobhanath	= SH
8) Isha Nadi	= IN	18) Panrokha	= PR	28) Utrara	= UR
9) Kail	= KL	19) Pretipur	= PP	29) Sengar1	= S1
10) Kangarul	= KR	20) Rohan	= RN	30) Sengar2	= S2

31) Sarsai = SS

Table 6: Bird species recorded from Mainpuri and Etawah districts of Uttar Pradesh during summer 1993

S.NO.	COMMON NAME	SCIENTIFIC NAME	STATUS
1	Little Grebe	*Podiceps ruficollis*	RESE,NOMA,PMIG
2	Indian Shag	*Phalacrocorax fuscicollis*	RESE,NOMA
3	Little Cormorant	*Phalacrocorax niger*	RESE,NOMA
4	Grey heron	*Ardea cinerea*	RESE
5	Purple Heron	*Ardea purpurea*	RESE,LMIG,PMIG
6	Pond Heron	*Ardeola grayii*	RESE,NOMA
7	Cattle Egret	*Bubulcus ibis*	RESE,AMIG
8	Large Egret	*Ardea alba*	RESE,NOMA
9	Median Egret	*Egretta intermedia*	RESE,NOMA
10	Little Egret	*Egretta garzetta*	RESE,NOMA
11	Night Heron	*Nycticorax nycticorax*	RESE,NOMA
12	Painted Stork	*Mycteria leucocephala*	RESE,NOMA
13	Openbilled Stork	*Anastomus oscitans*	RESE,NOMA,LMIG
14	Whitenecked Stork	*Ciconia episcopus*	RESE
15	Blacknecked Stork	*Ephippiorhynchus asiaticus*	RESE
16	White Ibis	*Threskiornis aethiopica*	RESE,NOMA/LMIG
17	Black Ibis	*Pseudibis papillosa*	RESE
18	Spoonbill	*Platelea leucorodia*	RESE,NOMA,PMIG
19	Lesser Whistling Teal	*Dendrocygina javanica*	RESE,LMIG
20	Spotbill Duck	*Anas poecilorhyncha*	RESE,NOMA,OMIG
21	Wigeon	*Anas penelope*	MIGR
22	Garganey Teal	*Anas querquedula*	MIGR
23	Cotton Teal	*Nettapus coramandelianus*	RESE,LMIG
24	Comb Duck	*Sarkidornis melanotos*	RESE,LMIG
25	Sarus Crane	*Grus antigone*	RESE,LMIG
26	Whitebreasted Waterhen	*Amaurornis phoenicurus*	RESE
27	Purple Moorhen	*Prophyrio prophyrio*	RESE,LMIG
28	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	RESE,NOMA
29	Bronzewinged Jacana	*Metopodius indicus*	RESE
30	Redwatled Lapwing	*Vanellus indicus*	RESE,AMIG
31	Blackwinged Stilt	*Himanotopus himantopus*	RESE,LMIG
32	Avocet	*Recurvirostra avosetta*	RESE,PMIG
33	Green Sandpiper	*Tringa ochropus*	MIGR
34	Whiskered Tern	*Chlidonias hybridus*	RESE&/MIGR
35	Lesser Pied Kingfisher	*Ceryle rudis*	RESE
36	Whitebreasted Kingfisher	*Halcyon smyrnensis*	RESE
37	Large Pied Wagtail	*Motacilla maderaspatensis*	RESE
38	Pied Myna	*Sturnus contra*	RESE,LMIG

RESE= RESIDENT, MIGR= MIGRANT, LMIG = LOCAL MIGRANT, OMIG = OCCASSIONAL MIGRANT, PMIG = PARTIAL MIGRANT, NOMA= NOMADIC, AMIG = ALTITUDNAL MIGRANT, & = AND, / = OR

Table 7: Showing priority groupings of wetland based on log transformed Abundance data -Summer

4.54%	54.54%	49.90%
1-10	10-100	100-1000
1.Isha Nadi	1.Malawan	1.NTPC
	2.Mohan	2.Harhai
	3.Banhara	3.Saman
	4.Panwah	4.Panrokha
	5.Nigoh	5.Hardu
	6.Kangrul	6.Bhanwan
	7.Hamidpur	7.Hardoi
	8.Auraiya	8.Mankapur
	9.Puri	9.Sauj
	10.P.Dibyapur	
	11.Rosemar	
	12.Sengar	

Table 8: Showing four priority groups of wetlands based on Richness -Summer.

13.63%	45.45%	27.27%	13.63
0-5	5-10	10-15	15-20
1.Isha	1.Hardoi	1.Panrokha	1.Saman
2.Puri	2.Malawan	2.Bhanwan	2.NTPC Tank
3.P.Dibyapur	3.Bhanlhara	3.Mohan	3.Hardu
	4.Panwah	4.Harhai	
	5.Auraiya	5.Sauj	
	6.Hameedpur	6.Mankapur	
	7.Sengar		
	8.Kangarul		
	9.Rosemar		
	10.Nigoh		

Table 9: Showing priority groups of wetlands based on Species Diversity - Summer

9.09%	36.36%	27.27%	31.81%	4.54%
0.0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5
1.Isha	2.Rosemar	1.Malawan	1.Mohan	1.Saman
2.Puri	3.Bhanihara	2.Sengar	2.Harhai	
	4.Panwah	3.Auraiya	3.Panrokha	
	5.Panwah	4.Kangrul	4.Bhanwan	
	6.Hardoi	5.Hameedpur	5.Sauj	
	7.P.Dibyapur	6.NTPC	6.Hardu	
	8.Nigoh		7.Mankapur	

Table 10: Showing priority groups of wetland based on Equitability - Winter

9.09%	18.18%	59.09%	13.63%
0.0-0.4	0.4-0.6	0.6-0.8	0.8-1.0
1.Hardoi	1.Bhanihara	1.Isha Nadi	1.P.Dibyapur
2.Puri	2.Nigoh	2.Mohan	2.Kangrul
	3.NTPC	3.Harhai	3.Sengar
	4.Panwah	4.Sauj	
		5.Auraiya	
		6.Rosemar	
		7.Hameedpur	
		8.Saman	
		9.Bhanwan	
		10.Panrokha	
		11.Malawan	
		12.Mankapur	
		13.Hardu	

CHAPTER IV

WETLAND PLANTS OF ETAWAH & MAINPURI

A wetland is characterised by extensive growth of macrophytic vegetation. Not only are the vascular plants used for food, fodder, medicine and other economic purposes, but, in addition to algae, are important in maintenance of a balanced aquatic environment. In addition to maintaining an oxygen balance essential to fish life and other biota, water plants provide a suitable environment for the production of aquatic invertebrate organisms which serve as food for fish. They also contribute in keeping water temperature at low levels in addition to acting as biological sinks. Besides, numerous aquatic plants are utilised for food and/or protection by many species of water fowl (Zagic, 1971).

The wetlands of this region are extended flood plains and oxbow lakes that seasonally change their morphometry and water depth frequently. The habitat favourable for the luxuriant growth of macrophytes supports large number of aquatic fauna and migratory birds. Though wetlands are viewed as a single functional unit, their vegetation may show considerable differences in species composition and structure usually forming mosaic pattern. Keeping this fact in view, the study was undertaken as a part of the wetland survey of the Etawah and Mainpuri districts to evaluate the diversity of plant resources and its use pattern.

METHODOLOGY:

The plants were collected with the help of a hook from deep water habitat and hand picked from shallow water zones. All the species were properly washed, dried with blotting paper and identified. Transect method was followed to study the density in percentage, association pattern, occurrence and phenology. by the help of 1 sq.m quadrat.

The study was conducted in two seasons (winter and summer). The plant collected were analysed for species richness, diversity, frequency of occurrence in each wetland and association pattern.
Richness was estimated by taking the actual number of species present in wetlands. Diversity (H') was calculated using the Shannon-Weiner function (Shannon - Weiner, 1949) with the natural logarithms:
H' = Sum pi * ln Pi
Where pi is the proportional abundance of pi th species.
Dominance in both the seasons is shown by taking proportion of the occurrence of the species(Table***). The association of species was discussed by the help of single linkage method for both the seasons.

RESULT & DISCUSSION:

REVIEW OF EARLIER WORK

The aquatic plants have rarely drawn enough attention to be considered worthy of ecosystem analysis. However, some workers realised the importance and drew attention for the aquatic plants. The study on hydrophytes and marshland plants had been carried out by a number of workers in Indo-gangetic plain under different botanical explorations (Maheswari,1960; Duthie, 1923). Very few attempts have been made to study the aquatic vegetation in this area (Maheswari & Tomar, 1982; Singh & Tomar, 1980; Trivedy & Sharma, 1965). In the recent past, Prasad (1988) enumerated the wetland plants of Keoladeo National Park with a note on their phenology and habitat.

VEGETATION ANALYSIS

Wetlands of both the districts maintain rich plant resources which were explored during the survey.The survey gives an account of the vegetation types, floristic composition, phenology, and distribution of aquatic plants. The vegetation, depending on the life form and position in the wetlands consists of free floatings, rooted floatings, submergents and emergents. All the four vegetational zones are charecterised by specific types of life forms and each type embaraśsinga distinct assemblage of plant species. The hydrological factors seems to govern the occurrence various macrophytic communities and their association. Water depth and its associated influences are opined to influence the occurrence and and extent of individual plant species. However, for submerged plants, the turbidity of water is an additional factor in determining the extent of their colonisation. Most of the waterbodies during summer had high turbidity which resulted in absence of submerged vegetation. It is evident from the checklist of occurrence of plant species that the emergents have wide distributional amplitude in the wetland systems. As the gangetic plain wetlands have gone through the ages with frequent changes in water level in every season, it could be concluded that the zonal sequences of wetland communities are as seral stages of hydrosere succession.

The observation and data obtained clearly indicate that a distinct relationship of water, substrate and plant community types can be found on the basis of floristic dominance. The earlier work in the nearby districts of Kheri and Sitapur on aquatic plants (Maheswari & Toomar 1982) when compared with the present data, explains the changes in

vegetation types. Some plants namely Nelumbo nucifera, Nymphaea nouchali, Pistia stratiotes etc were common during the last survey are rarely met with while the dominance of some emergents was noticed during the recent survey.
Forty four species of vascular plants occurred in quadrat samples taken during the winter and twenty nine during summer (Table **). Both the districts experiences comparatively low rate of rainfall for which the aquatic habitats are mostly seasonal. Some of the low lying areas get water either due to breach in irrigation canal that support hydrophytes to some extent.

Free floating forms include Azolla pinnata and Eichhornia crassipes which are frequently found in most of the wetlands while Pistia stratiotes was rare and seen in Hardu. The rooted floating leaved species comprised of Nelumbo nucifera, Nymphaea nouchali, Nymphoides cristata, N.indica, Potamogeton natans, Trapa bispinosa etc. Nymphoides species was observed in 11 wetlands where as Nelumbo nucifera and Nymphaea nouchali which are considered to be the common wetland plants are rarely met with. It was observed that they either live as co-dominants with emergents or occupy the zones just beneath them. The submerged macrophytes are the second largest group and occupy the deeper regions of the lake and mainly dominated by Potamogeton pectinatus, Hydrilla verticillata, Ceratophyllum demersum and Najas graminea. Emergents were dominated by Ludwigia adscendens, Marsilia quadrifolia, Paspalum distichum, Scirpus tuberosus and Eleocharis dulcis during winter. It was observed that the species completely dried out when water receded during summer.

During the survey some of the amphibious plants were overlooked and ignored as the study was intended for survey of wetland habitat and role of aquatic plants in the system. The species like Ipomoea carnea, Polygonum sps. and Vetiveria zizanioides which were encountered in and around (close vicinity) of the waterbody forming a part of the habitat were accounted.

In spite of the fact that a close relationship exists between the distribution of plant community and water depth (Spence, 1982), the observations made during the survey did not explain the relation clearly. Some of the floating leaved species which prefer about one meter water depth also encountered in 45 - 50 cm water depth at several places. The observation supports the view that the aquatic plants have a greater degree of adaptability to environmental stresses compared to other plant communities (Maltby, 1986).

RICHNESS

Wetlands are often subjected to expansion and contraction in area with changes in the water level due to the fluctuations in receiving water and rainfall. The highest species richness was found in Bhanawant of Mainpuri district having 25 species followed by Saman with 17 species during winter(Table***). During Summer, the richness was high in Saman with 16 species followed by Hardu with 13 species. The change in this pattern can be attributes to the water level changes. The species richness of Bhanawant was less because of drying up of major parts of wetland area. This proves that the species richness in vegetation varies, depending on the period of flooding. The reason could also be due to high turbidity of the wetlands which has been established by earlier workers (Sculthrope, 1960; Mitsch & Gosselink, 1993). Kaul (1983) had opined that the higher turbidity and eutrophication of waterbodies have an adverse effect on the aquatic vegetation.

DIVERSITY

Areas flooded for long periods have lower species diversity than less frequently flooded area (Ramakrishna,1990).
The wetlands are grouped according to the species diversity(Table ***). The diversity was high in Bhanwan followed by Saman and during summer, in Saman and Hardu. Both these wetlands receive water during summer from Ganga canal.

ASSOCIATION:

The association of macrophyte species in wetlands were established by single linkage method. Nine types of associationship existed during winter whereas seven types during summer (Fig.**). The tree diagrame showing similarity of wetlands during winter and summer brings wetlands like Hardu, Mankapura, Bhanwat and Saman as close neighbour. The presence of Siberian crane food plants in those waterbodies also explains the association pattern.

USES

Traditional uses of the aquatic plant species have been documented by several workers (Sesavatharam, 1991). At few places (Sauj, Bhanwant, Panwah) people cultivate and commercially exploit macrophytes (Nelumbo nucifera for

leaves, petioles and underground parts; Paspalum distichum as fodder; Trapa bispinosa for fruit and Ipomoea aquatica for leaves) to some extent. The information is scanty on the uses of Typha, but people do use for different purposes.
Some of the species are useful for waterfowls (Table**). It shows that both migratory and resident bird depend on macrophytes either for food or roosting.
Many wetland plants are economically important, some are staple food, others for medicine or fodder. Uses like thatching and basket making, fuel wood etc are also noteworthy. The local wild species of rice "Lehi pasai" is a staple food of the local people. The plants namely, Trapa bispinosa and Nelumbo nucifera are cultivated and nurseries of those species are maintained in the deep parts of the waterbody during summer. Bhanwant, Panrokha and Sauj are example of such wetlands.

STATUS

In the recent past, conservation strategies for aquatic plants have been emphasised by different workers (Jain, 1991; Kaul, 1983).
The IUCN Threatened plant committee has tentatively identified a number of possible threats to plants in general. Plants growing in aquatic habitats have adapted themselves in to very specialised habitat conditions and aquatic ecosystems cover much smaller surface area and usually also comprise smaller number of taxa per unit area. Thus the aquatic plants more seriously threatened.

DIRECT USE:
Direct threats like over exploitation of economically important species, as well as removal of plant growth as weeds are rare in the wetlands of Etawah & Mainpuri. Sustainable uses are in practice at several places like Sauj and Bhanwant where people do not remove the underground part completely of *Nelumbo nucifera*. Similarly they maintain nursery of *Trapa* during summer and release the plantlets after monsoon.

HABITAT ALTERATION:
There was no information on the landuse pattern on the catchment of the wetlands. During the survey, we collected information which shows the chances of alteration of habitat is relatively more. Wheat, pulses, mustard and vegetables are major crops cultivated around the wetlands. Besides, some wetlands are close to human habitation, hence used as public convanience place. The agricultural run off and domestic sewage drained into the system might lead to eutrophication which causes drastic change in biomass of

aquatic plants and alter their species composition (Philips et.al,1978; Ikusima,1983). While the growth of few species is accelerated, other species decline rapidly. Most of the waterbodies namely, Saman, Hardu, Hardoi, Sauj and Bhanwant are suffering from the affects of the agricultural run off and domestic sewage.

POPULATION DEPLETION:

It is a common practice in India to remove enmass the vegetation from wetlands to make the waterbody available for cultivation of water chest nut (Trapa bispinosa) and for fish. The process results in the depletion of some other taxa (Subramaniam,1960). Some of the economically important species namely, Nelumbo nucifera, Nymphaea nouchali, reported during earlier botanical exploration (Maheswari & Tomar, 1982; Singh & Tomar,1980) and were of common occurrence. During the survey both the species were met in few occasions. The population depletion may be due to either unsustainable level of exploitation (Jain, 1991) or habitat alteration due to eutrophication as observed in Kashmir wetlands (Kaul and Bakaya, 1973; Pandit, 1984).

CONSERVATION:

It can be concluded that the threat to aquatic vegetation of the study area is due to the alteration and destruction of the habitat. Conservation and restoration of the habitat would help immensely in this direction.

Case study of Saman waterbird sanctuary:

General Location : U.P. State/Mainpuri district/Bhongaon tehsil/Saman grampanchayat.
45 Km from Etawaah;125 km from Agra.

Toposheet : No 54/M/4

Area : 526.30 ha

Protected area : declared on 23 May 1990 (GO 5121/14-3-84/89)

Rainfall data : not available

Soil type : loamy

Water source : rain fed. Canal water is needed during the summer months(@ Rs 50,000 per yr). There is a canal connection with another nearby wetland, Sauj, which is situated close to the Ganga canal and may be getting an overflow from it.

Temperature : 21° C

pH : 7.5 to 8.5

Turbidity : clear water.

Ecological features: the wetland shows clear zonation : open water,shallow marshy & vegetated zones.

Fauna :

Insecta	Diptera	*Chironomus* larvae
	Odonata	Dragonfly nymph
	Coleoptera	Dytiscus
	Hemiptera	*Sphaerodema, Nepa, Gerres*
Mollusca		*Pila* and *Lymnaea* spp.
Pisces		*Puntius sophore, P.ticto, Chela laubuca,Esomus danricus, Parluciosoma daniconius, Mystus spp., Clarias batrachus, Heteropneustes fossilis, Colisa fasciatus, Channa spp. Mastacembelus armatus.*

Land ownership : The wetland has a peculiar ownership feature as given below:

owned by the grampanchayat	69.70 acre
" private	841.66
" forest dept	365.05

handed over by the District authorities to the forest

department	39.43
TOTAL	1315.84 acre or 528.30 ha.

Current land use :

a) at site Fishing is still being carried out although it has been declared as a sanctuary. The fishing permits were given to five local fishermen (of the Kahar caste) by the district collector in 1986 for 10 yr period at the rate of Rs 500/ per hac. and hence the fishermen insist on their fishing rights.These fishermen do not use nets, rather they pump out the water and collect the fishes.This method is a destructive way of fishing as it does not leave behind some brooders for the next season. Poaching of birds has been stopped by the Range Officer based at Saman, although it is still prevalent in the surrounding area. 15 cases of poaching were registered during the last year and fines of Rs 500-600 were recovered.

b)catchment area: Crops like wheat,paddy and mustard are still cultivated on the private land. Two villages are situated at one corner of sanctuary, and therefore the villagers use the area as a thoroughfare.Grazing of pigs and cattle is permitted.

Tourism: none

Disturbances/threats to the wetland:

Encroachment- by villagers who insist on planting their crop in the sanctuary area.

Disturbance- the villagers pass through the nesting/breeding sites to reach their villages.

Aq.weeds: large portions of the water area are now covered with water hyacinth.

Previous research work: Only the forest working plan is available which gives meagre information.

The administrative setup:

Range forest officer	1no.
Forester	2no.
Boatman	1no.

Two boats are presently available (gifted from the Chambal Nat.Park). These large size boats meant for use in rivers are inoperational at present.

REFERENCES:

Duthie, J.F. 1923. Flora of the upper gangetic plain and of the adjacent Siwalik and Sub Himalayan tracts. Vol. 1-3.

Edward Arnold. 610p.Weaver, J.E. and F.E.Clement. 1929. Plant Ecology. Tata McGraw Hill Publishing Company, New Delhi.

Kaul, V. 1983. Conservation of plant resources in aquatic ecosystems with reference to some aquatic habitats of Kashmir. In. Jain, S.K(ed.). Conservation of aquatic plant resources. BSI publication. pp.118-131.

Maheshwari, J.K. (1960) The vegetation of Marshes, swamps and riverside in Khandwa district, M.P. J. Bombay nat. Hist. Soc. 57: 371-387.

Maheshwari, J.K and Tomar, R.P.S. 1982. A contribution to the wetland flora of Sitapur district, UP. J.Bombay nat. Soc. 80. 529-538.

Prasad, V.P. 1988. Wetland flora of Keoladeo National Park, Bharatpur. Jour. Econ.Tax. Bot.

Sculthrope, C.D. 1967. The biology of aquatic vascular plants.

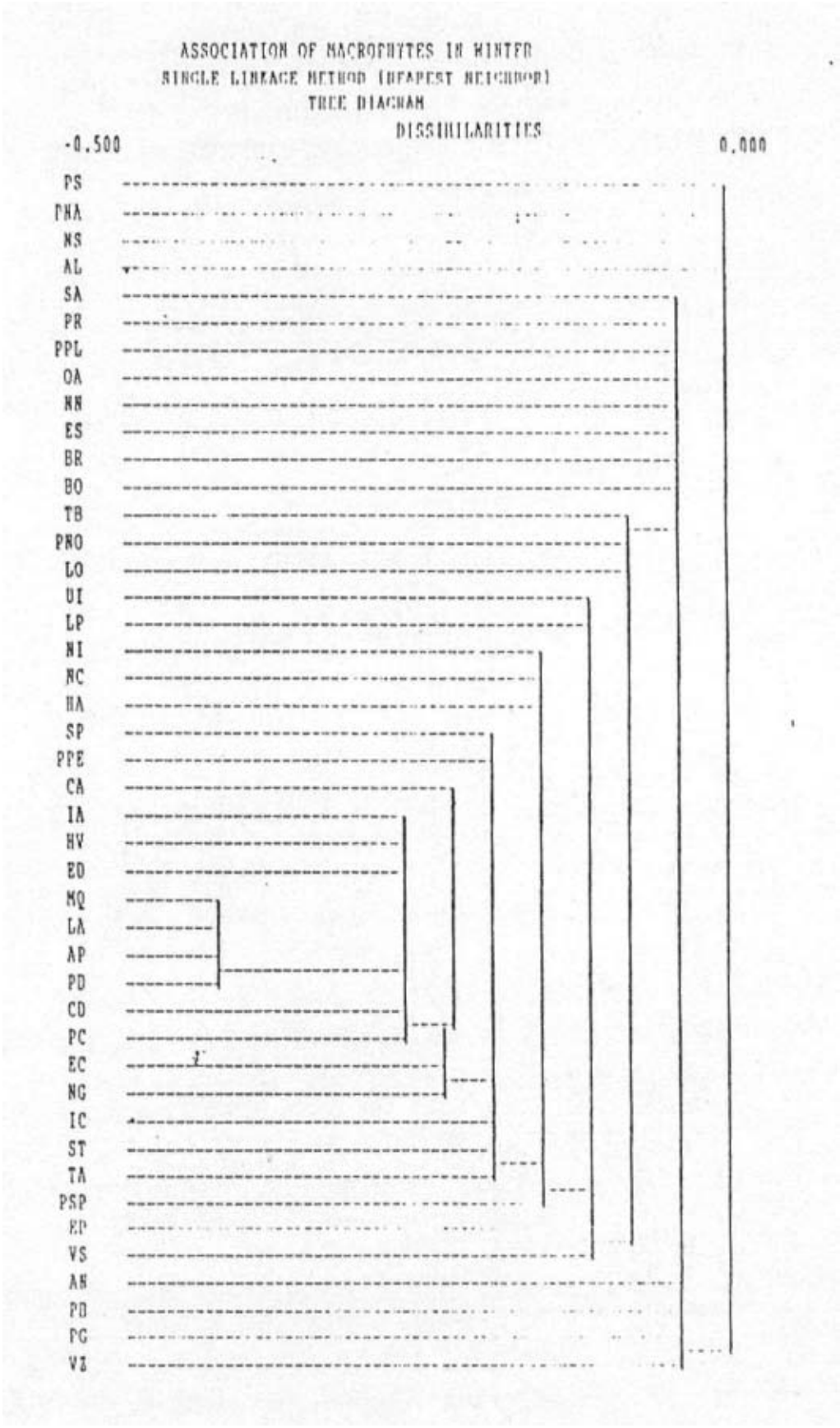
Singh, K.K and Tomar, R.P.S. 1980. Aquatic and Marshland flora of Kheri district, UP. J.Bombay nat. Hist. Soc. 79. 261-274.

Trivedi, B.S. and Sharma, P.C.1965. Studies on the hydrophytes of Lucknow and environs.1. Distribution and habitat, with reference to ecological classification. Proc. Nat. Acad. Sc. India. 35:1-14.

Zagic, J.E. 1971. Water pollution, Disposal and Reuse. Vol. II Marcel Dekker, INC., New York, 472-473.

AQUATIC PLANT SPECIES IN ETAWAH & MAINPURI DISTRICTS
FREQUENCY OF OCCURRENCE
Winter veg survey in 28 wetlands * Summer veg survey in 11 wetlands

CODE	SPECIES NAME	PRESENCE DETAILS WINTER	Frequency	SUMMER	Frequency
Free floating					
AP	Azolla pinnata	15	53.6	1	9.1
EC	Eichhornia crassipes	8	28.6	5	45.5
LP	Lemna perpusilla	6	21.4	0	0.0
PS	Pistia stratiotes	1	3.6	1	9.1
SP	Spirodella polyrhiza	7	25.0	4	36.4
Floating leaved(Rooted)					
AN	Aponogeton natans	2	7.1	0	0.0
NN	Nelumbo nucifera	2	7.1	1	9.1
NS	Nymphaea stellata	1	3.6	0	0.0
NC	Nymphoides cristata	6	21.4	4	36.4
NI	Nymphoides indica	5	17.9	0	0.0
PNa	Potamogeton natans	1	3.6	0	0.0
Submergents					
TB	Trapa bispinosa	3	10.7	2	18.2
BO	Blyxa octandra	2	7.1	0	0.0
CD	Ceratophyllum demersum	9	32.1	6	54.5
HV	Hydrilla verticillata	12	42.9	9	81.8
NG	Najas graminea	9	32.1	2	18.2
OA	Ottelia alismoides	2	7.1	1	9.1
PC	Potamogeton crispus	18	64.3	4	36.4
PNo	Potamogeton nodosus	3	10.7	2	18.2
PPe	Potamogeton pectinatus	8	28.6	4	36.4
UI	Utricullaria inflexa	5	17.9	3	27.3
VS	Vallisneria spiralis	4	14.3	3	27.3
Emergents					
CA	Cyperus alopecuroides	7	25.0	3	27.3
ED	Eleocharis dulcis	9	32.1	3	27.3
EP	Eleocharis palustris	5	17.9	0	0.0
HA	Hygrorhyza aristata	6	21.4	4	36.4
IA	Ipomoea aquatica	9	32.1	4	36.4
LO	Limnophyton obtusifolium	3	10.7	0	0.0
LA	Ludwigia adscendens	16	57.1	3	27.3
MQ	Marsilia quadrifolia	14	50.0	4	36.4
PR	Panicum reptans	2	7.1	0	0.0
PD	Paspalum distichum	15	53.6	5	45.5
PS	Pseudoraphis spinescens	5	17.9	2	18.2
SA	Scirpus articulatus	2	7.1	0	0.0
ST	Scirpus tuberosus	10	35.7	2	18.2
TA	Typha angustata	7	25.0	3	27.3
Semi-aquatic					
AL	Astracantha longifolia	1	3.6	0	0.0
BR	Brachiaria ramosa	2	7.1	0	0.0
ES	Echinochloa stagnina	2	7.1	0	0.0
IC	Ipomoea carnea	6	21.4	0	0.0
PB	Polygonum barbatum	2	7.1	1	9.1
PG	Polygonum glabrum	2	7.1	1	9.1
PPl	Polygonum plebejum	2	7.1	0	0.0
VZ	Vetiveria zizaniodes	2	7.1	1	9.1


ASSOCIATION OF MACROPHYTES IN WINTER
SINGLE LINKAGE METHOD (NEAREST NEIGHBOR)
TREE DIAGRAM
DISSIMILARITIES
-0.500
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PS
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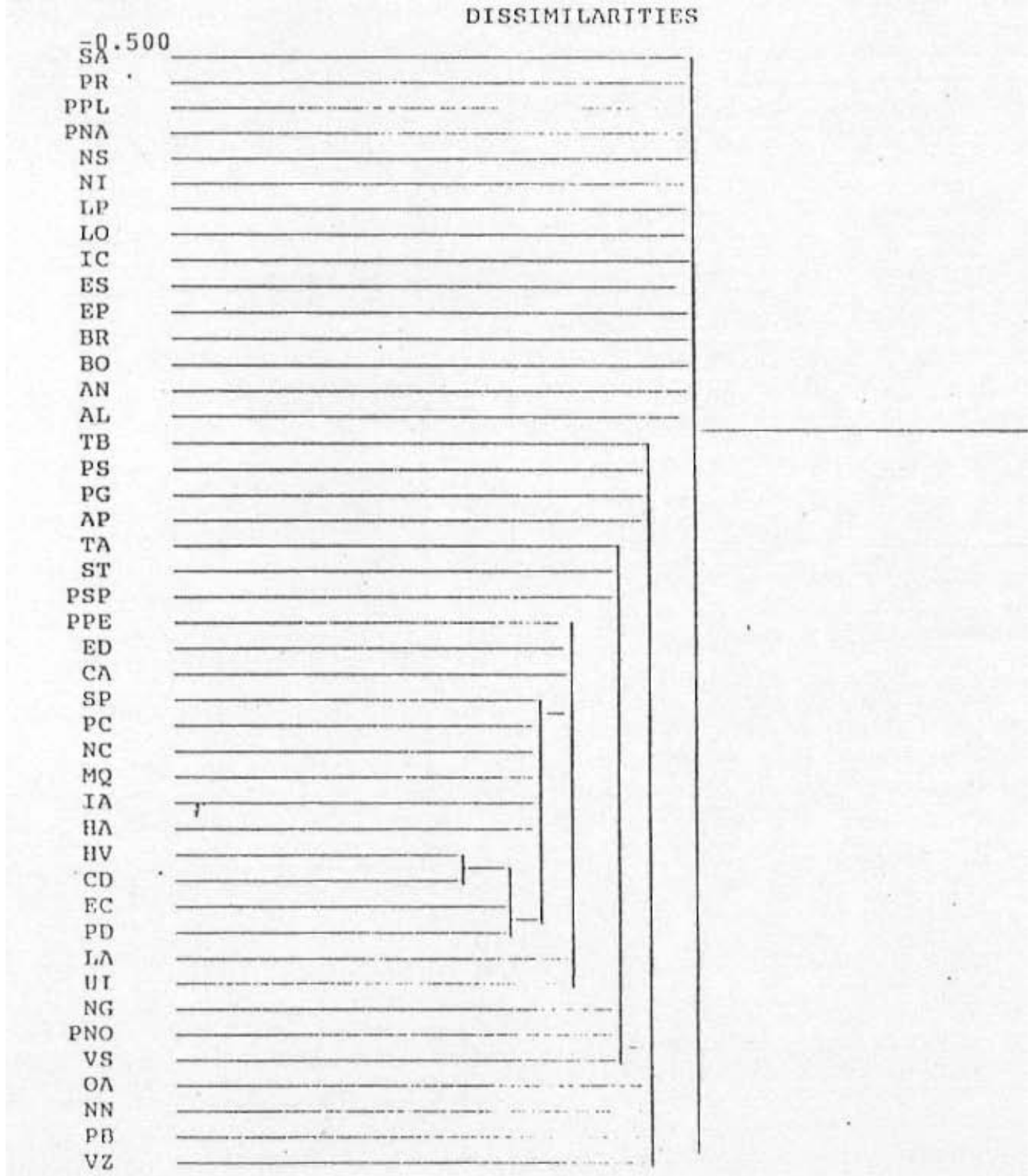
VI

ASSOCIATION OF AQUATIC MACROPHYTES IN SUMMER

DISTANCE METRIC IS 1-S2
SINGLE LINKAGE METHOD (NEAREST NEIGHBOR)

EE DIAGRAM

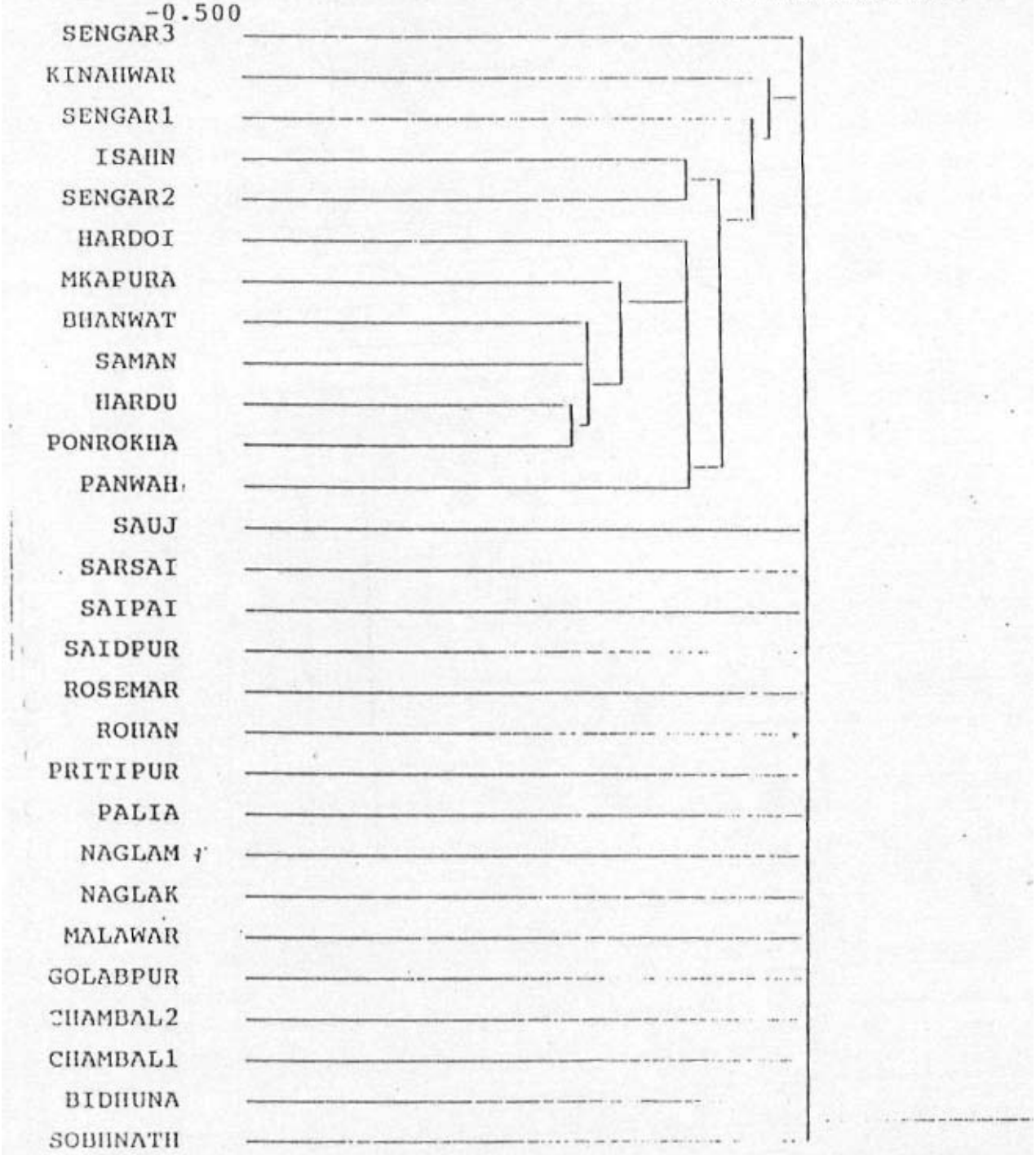


SIMILARITY OF DIFFERENT WETLANDS IN SUMMER

SINGLE LINKAGE METHOD (NEAREST NEIGHBOR)

TREE DIAGRAM

DISSIMILARITIES



SIMILARITY OF DIFFERENT WETLANDS IN WINTER

DISTANCE METRIC IS 1-S2

SINGLE LINKAGE METHOD (NEAREST NEIGHBOR)

TREE DIAGRAM

DISSIMILARITIES

-0.500 0.00

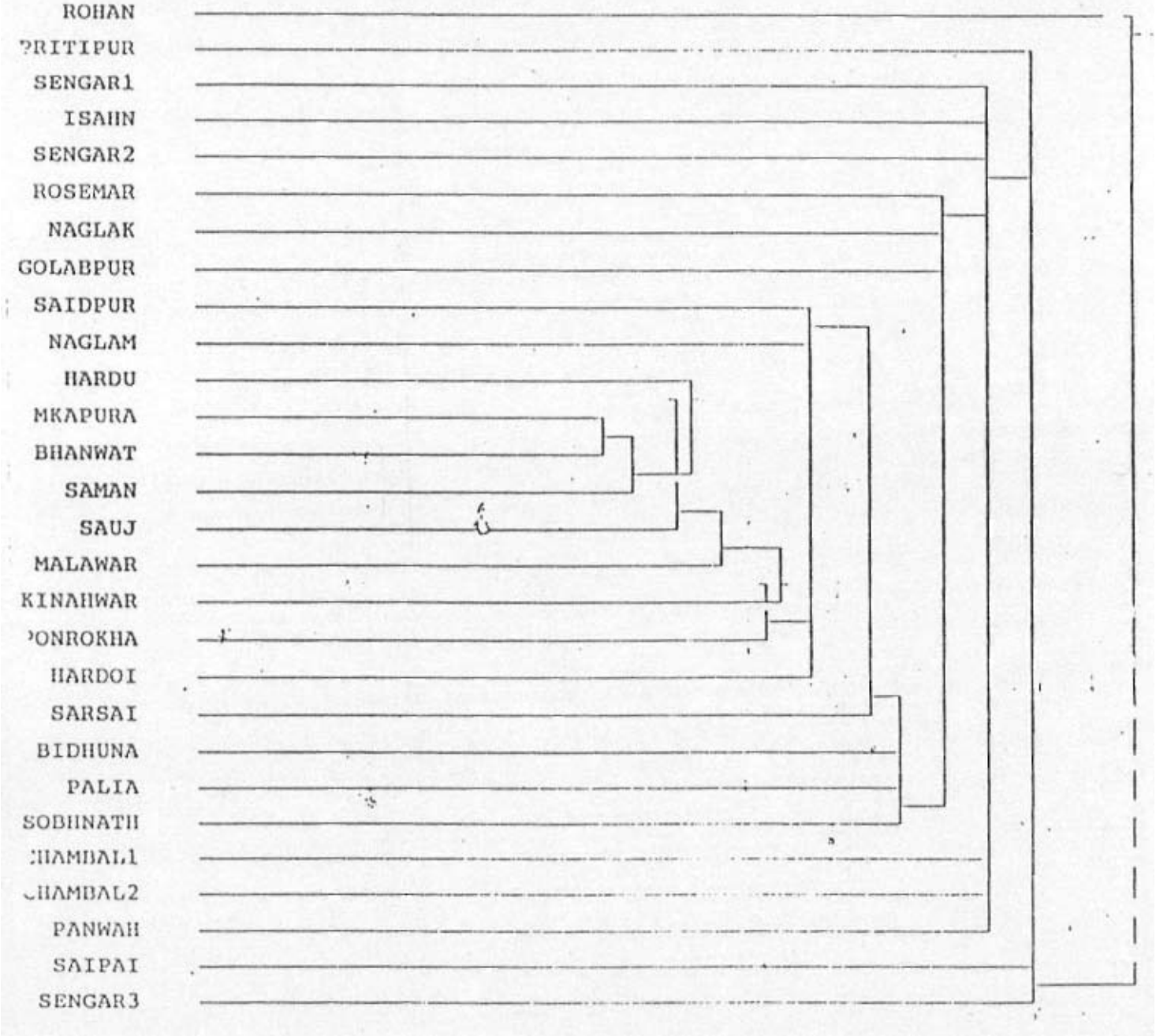


Fig.1.Comparison of plant species occurrence during winter and summer

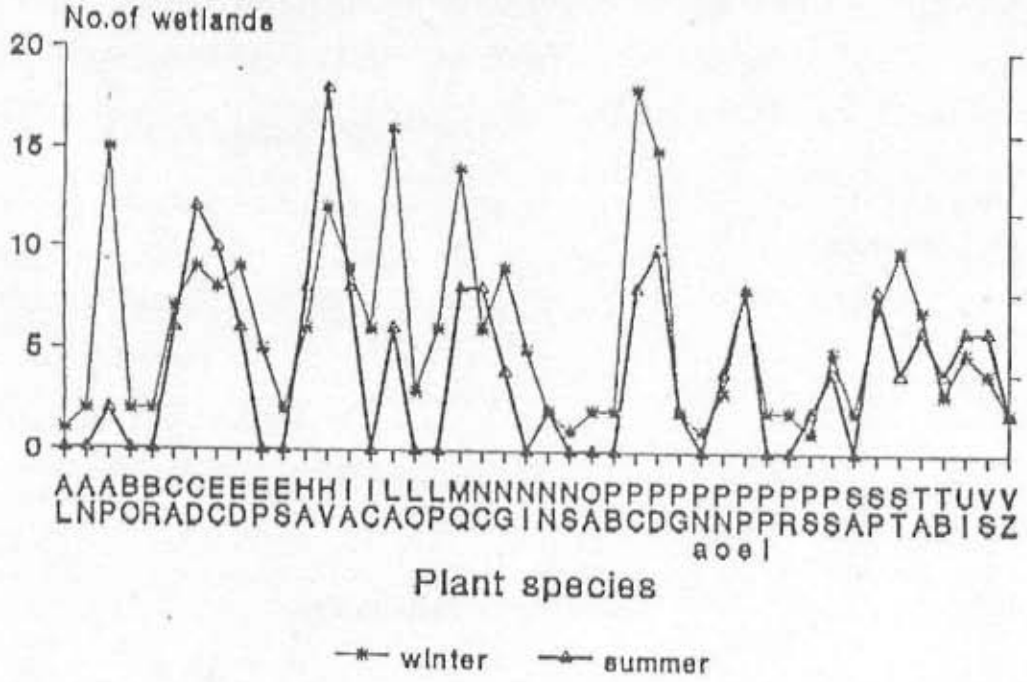
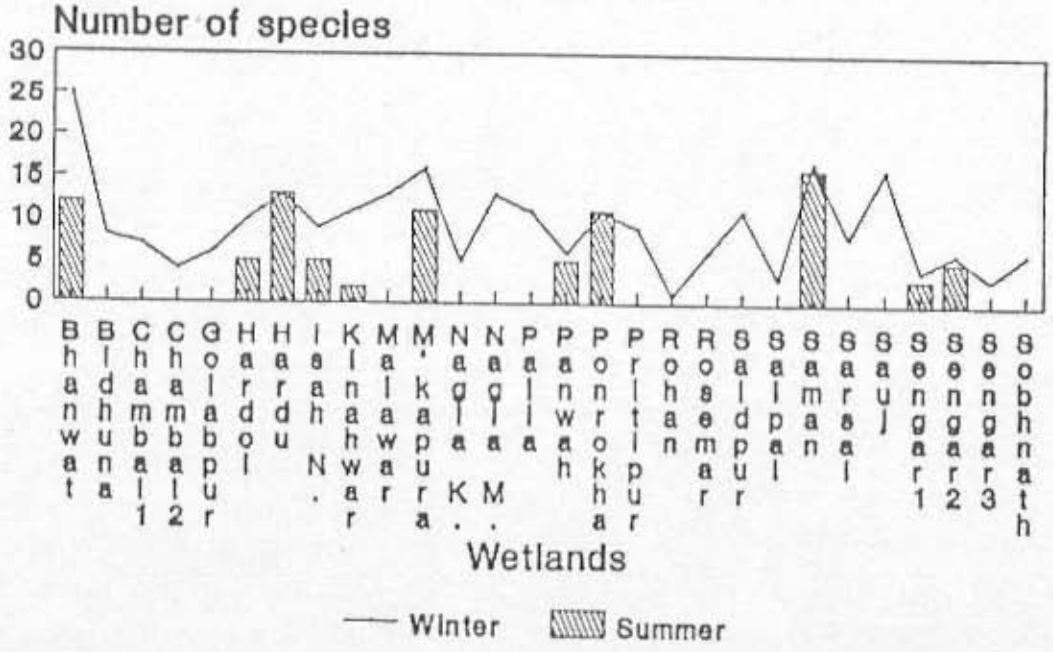


Fig.2.Distribution of aquatic plant during winter and summer.



Ecological features:
(Brief description of the main habitats and vegetation types present, zonation, etc.)

Land tenure/ownership:
(details of ownership Govt./private)

a)Site

b) Surrounding/catchment area

Current land use/principal human activities in:

a) Site

Fishing (Open/regulated/prohibited)

Hunting (Open/regulated/prohibited)

Cultivation of edible macrophytes

Sewage, effluent,solid waste disposal

Irrigation

Others

b) Surrounding/ Catchment area

Brick

Fuel wood collection

Forestry

Pottery

Grazing

Agriculture(coconut/ others)

Cultural Values : Historical/Archeological/ Religious

Current Recreation & Tourism:

No. of tourists/season

Tourist season

Tourist attraction Boating/bird watching/fishing/nature walk

Total revenue from tourism:

Disturbances/threats:

Eutrophication/siltation/pollution/diversion of water supply/reclamation/excessive tourism/over - exploitation/over -grazing/over-fishing/enchroachment/reduced arrival of migratory birds

Conservation measures(if any):

protection area/restriction on development/closed for hunting or fishing

Conservation measures proposed but not implemented:

legislation/

Previous research work (ref)

Any other information you feel is important:

Noteworthy Fauna:

Birds

Common name	Scientific name	Remarks M/R	Counts

(M - migratory; R - resident)

Waterfowl wintering/breeding (season & approx no./spp. details)

Any breeding colonies in nearby areas:

Mammals/ Reptiles/Amphibians/Fishes/

Common name	Scientific name	Remarks

Appendix 2

Wetlands	Toposheet No.	Nearby Village(s)	Tehsil	Current Status	Area (ha)
Etawah district					
1. Senger River	54°N/1 26°45'-26°58' 79°0'-79°5'	Abhinaypur, Amritpur Bulakipura, Kripalpur Lalpur, Nagla Nainsukh	Etawah	Permanent	
2. Rohan Talab	54°N/1 26°58'-26°55' 79°5'-79°10'	Gulabur, Gauradayalpur, Nagla Puth, Rohan, Mathiyar Adupur	Etawah	Dry.Covered with water hyacinth.	4
3. Hardoi Tal	54°N/1 26°55'-27°.0' 79°0'-79°5'	Hardoi, Rakuiya, Simra, Manipur, Balbhadrapur.	Etawah	Permanent	10
4. Sarsai nawar	54 N/1 & N/5 26°55'-27°0' 79°15-79°20'	Sarsai Nawar, Naglabalsingh Girdhapur, Chandrapura Daulatpur		Permanent	6
5. Mohri	54 N/5 26°55'-27°0' 79°15'-79°20'	Mohri, Bahadurpur Pachar Nagla bandah, Nandpur haveli Nagla Bhage, Nandpur haveli	Bharthana/ Bidhuna	Temporary	2
6. Sengar river	54 N/2 26°45'-26°48 79°10'-79°15'	Prithvirampur, Nagla nandan, Patia, Chatorpur, Morhi Biraundhi	Bhathana	Permanent	
7. Palia Tank	54 N/9 26°45'-26°58' 79°30'-79°35'	Palie, Lukhar Dawra, Purva Tal Alipur , Usharha	Bidhuna	Temporary	4
8. Prethipur Tank	54 N/5 26°45'-26°58' 79°35'-79°40'	Chhari, Prethipur	Bidhuna	Temporary	3
9. Nagla mohan	54 N/5 26°45'-26°58'	Nagla mohan, Pariyapur Munika pura, Nagla Radhe,	Bharthana/	Temporary	5
10. Hardu	54 N/9 26°45'-26°58' 79°35'-79°40'	Hardu, Lakhana, Pirthipur	Bidhuna	Permanent	50

11. Saipai (Brick Kiln on the road side)	54 J/8 26°55'-27°0' 78°55'-79°0'	Nagla subhan Saiphai, Naglasurajman	Etawah	Temporary	3
12. Hamirpur ruru	54 N/5 26°53' - 26°48' 79°30'-79°45'	Hami & Kudarkot	Bidhuna	Temporary	5
13. NTPC tank	54 N/5 26°30'-26°35' 79°25'-79°35'	Dibiapur	Auraiya	Permanent	>100
14. Chambal river	54 J 26°35'-26°45' 78°45'-79°0'	Pinahat		Permanent	

Mainpuri District

15. Nagla Kail	54 M/4 27°10'-27°15' 79°0'-79°5'	Nagla Kail Nagla Garhia, Bichhiya	Mainpuri/ Bhongaon	Temporary	2
(3) 16. Bhanwant	54 M/4 27°5'-27°10' 78°0'-78°10'	Bhanwant, Kishorpur Nagla mangalpur, Jitwarpur, Sagamai	Bhongaon	Permanent	>100
(13) 17. Isan nadi	54 M/8 27°5'-27°10' 79°15'-79°20'	Dharmangadpur, Ahamkaripur Kunui, Nagla Udai, Gajianpur	Bhongaon	Permanent	
(4) 18. Mankapur	54 M/8 27°5'-27°10' 79°15'-79°20'	Mankapur, Chilgarh, Nagla Tapra, Nagla Ramai, Bara	Bhongaon	Temporary	4-5
(5) 19. Paraunkha	54 M/8 27°5'-27°10' 79°15'-79°20'	Paraunkha, Nagala laik, Nagla Lalpur, Bara, Nagla sewa	Bhongaon	Permanent	6
20. Killi Tank	54 M/8 79°15'-79°20'	Killi, Nagla Gundha, Mohakampur, Dhirpur Nagla Khauja	Bhongaon	Dry	
(12) 21. Nagla Banu	54 M/8 27°10'-27°15 79°20'-79°25'	Naglabanu, Janaura, Shyampur, Bhatpura Bairagpur	Bhongaon	Temporary	>3

22. Sobhnath Tal	54 M/3 79°18'-79°15' 27°15'-27°20'	Bhongaon Township	Bhongaon	Temporary	3
(7) 23. Panwah	54 I/15 27°25'-27°38' 78°58'-78°55'	Panwah, Nagla ghani Bharatpur	Mainpuri	Permanent	>40
(6) 24. Kinhawar Tal	54 M/3 27°28'-27°25' 79°5'-79°18'	Kinhawar, Khatana, Dhanwan, Harchandpur Nagla Banjaran.	Mainpuri	Temporary	25
25. Nagla Chamaran	54 M/3 27°15'-27°20' 79°05'-79°10'	Nagla chamaran, Malpur Nagla gangora	Mainpuri	Dry	-
26. Nagla Ramnagar	54 M/3 27°15'-27°20' 79°0'-79°05'	Nagla ramnagar, Mirzapur, Dayalpur, Airwa	Mainpuri	Temporary	3
27. Inauli	54 M/3 27°15'-27°20' 79°0'-79°05'	Inauli, Sikandarpur, Nagla Saraiya, Nagla Gurubakas	Mainpuri	Dry	
(11) 28. Saidpur Tank	54 M/3 27°15'-27°20' 79°0'-79°05' 54 I/15	Saidpur, Bhaghuli, Rajpura, Dewalpur Saidpur Bagholi, Karanpur	Mainpuri	Temporary	4
(8) 29. Rosenar	54 I/15 27°28'-27°25' 78°55'-79°0'	Rosenar, Jagatpur, Gangupura, Durgpur Bhanpur	Mainpuri	Temporary	5
(9) 30. Gulabpur	54 I/15 27°28'-27°25' 78°55'-79°0'	Santapur, Nagla chamaran Gulabpur, Kakamal, Rajalpur	Mainpuri	Temporary	3