Assessment of Floral and Faunal Biodiversity of Bird Sanctuaries in Uttar Pradesh Using High-Resolution Remote Sensing Data and GIS

Vachani Rajamani*, Rohit Kumar Verma[#] and Gulzar Yadav[$]

Remote Sensing Applications Centre, Sector-'G' Jankipuram, Kursi Road, Lucknow 226 021

Department of Zoology, University of Lucknow, Lucknow-U.P.

*Email : vachani_rajamani@rediffmail.com

Importance of Biodiversity Conservation

India, a mega-biodiversity country, while following the path of development, has been sensitive to the needs of conservation. India's strategies for conservation and sustainable utilization of biodiversity in the past have comprised of providing special status and protection to biodiversity rich areas by declaring them as national parks, wildlife sanctuaries, and biosphere reserves, ecologically fragile and sensitive areas. It has helped in reducing pressure from reserve forests by alternative measures of fuel wood and fodder need satisfaction, by afforestation of degraded areas and wastelands, creation of *ex situ* conservation facilities such as gene banks and eco-development. The challenges before India are not only to sustain the efforts of the past but also further add to these efforts by involving people in the mission. Major threats to biodiversity include habitat alteration, over-harvesting, pollution, climatic change, and exotic species (either introduced or occurring naturally), and increase in human and cattle population. Of these, habitat alterations due to deforestation, habitat loss (land use change), fragmentation and degradation are the primary causes responsible for biodiversity depletion. It is realized that the threats to the species/ecosystems are the greatest in recent times, mainly due to human exploitation of biological resources. However, natural hazards because of their adverse impacts, also contribute to the loss of biodiversity. Thus, there is an urgent need to conserve gene pool *in situ* before it is lost forever. For this, the most appropriate method would be to assess the ecological sustainability by understanding the ecosystem/landscape complexities and their uniqueness.

## Technological Inputs for Biodiversity Database Creation

The advent of satellite remote sensing and sensor related technological advancements have made it possible to acquire precise vegetation classification and mapping; whereas the potential of floral and faunal biodiversity beyond mapping needs to be explored fully through intensive field methods. Spatial analysis tools such as geographic information system (GIS) are used in the present study to derive various maps depicting landscape parameters. Cutting edge technologies viz., satellite remote sensing, geo-informatics, bio-informatics internet tools etc. along with intensive field data are useful in the creation of the knowledge-base. Remote Sensing (RS) and Geographic Information System (GIS) are very effective tools to analyse these at various levels viz., macro-level, meso-level and micro-level. RS provides spatial data whereas GIS aids in database creation for future updation and retrieval. Remote sensing technology provides synoptic coverage of the Earth's surface and hence is an ideal tool for biodiversity characterization at various levels. Over the years, with the advancements made in the spatial resolution of indigenous remote sensing satellites say form 73 m in early nineties to about 1 m at present, there exists a huge advantage of precise mapping of areas for future monitoring of their spatial and biological features quickly.

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Further, the Geographic Information System (GIS) comes as a handy tool to carry out criteria-based spatial modelling. The spatial data on wetlands and their surrounding land use are generated using satellite remote sensing data through digital classification.

The Study Area

Uttar Pradesh forms a major chunk of the vast indogangetic plains being drained by some of the major river systems of the Indian subcontinent with the interspersion of innumerable natural wetlands some of which have been declared as bird sanctuaries.The state is characterised typically by the climate round the year ranging from hot and sultry summers to extremely cold and icy winters with the average temperature ranging from the highs of 45 °C to the lows of 5 °C and the average rainfall being received is about 1200 mm mainly during south west monsoon period received during the months of July-September.Uttar Pradesh has the distinction of having a vast array of bird sanctuaries which have been created for protection and conservation of unique wetland habitats, aquatic vegetation and other wildlife of these highly vivid ecosystems. There are about 13 bird sanctuaries which are distributed in four different ecoclimatic zones such as (i) indo-Gangetic plain, (ii) tarai region, (iii) vindhyan region, and (iv) semi-arid region and located in different districts of Uttar Pradesh which are proposed to be taken up in totality under this study in subsequent years. The names of such

MAP SHOWING THE LOCATIONS OF DIFFERENT BIRD SANCTUARIES IN UTTAR PRADESH

BIRD SANCTUARIES TAKEN UP FOR STUDY IN 2013-14
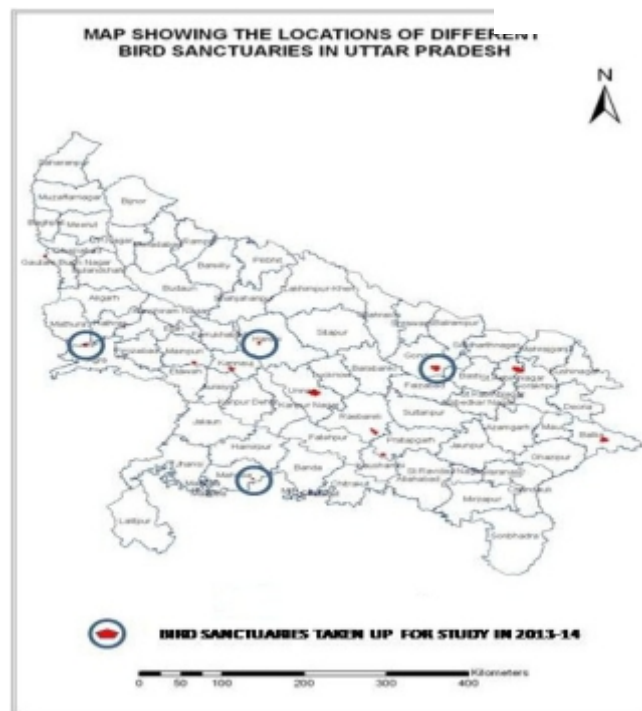
wetlands/bird sanctuaries are given below:Four out of the total of thirteen bird sanctuaries in the state situated in different agroclimatic zones were identified and taken up for the study of floral and faunal biodiversity assessment in the year 2013-14 using the latest technology of high-resolution satellite data and GIS techniques alongwith appropriate field survey methods. They are: (i) **Sandi** in Hardoi district under indo-Gangetic, (ii) **Sur Sarowar** in Agra district under semi arid, (iii) **Parvati-Arga** in Gonda district under tarai, and (iv) **Vijaysagar** in Mahoba district under vindhyan agro-climatic zones.

| Sl. No.	Name of Bird Sanctuary/ Wetland	Toposheet No.	Geographic coordinates (From, To)
1.	Sur Sarowar, Agra	63 J/01	77^0 49' 58"- 77^0 50' 49" E 27^0 14' 34" - 27^0 15' 50" N
2.	Sandi, Hardoi	54 M/15	79^0 58' 04"- 79^0 38' 36" E 27^0 18' 05" - 27^0 19' 34" N
3.	Parvati-Arga, Gonda	63 J/01	82^0 07' 38"- 82^0 10' 58" E 26^0 54' 19" - 26^0 57' 30" N
4.	Vijaysagar, Mahoba	54 O/15	79^0 54' 12"- 79^0 59' 08" E 25^0 17' 10" - 25^0 18' 08" N

The Methodology

The project involves the use of high-resolution remote sensing digital data for classification of wetland/sanctuary areas as well as collection of field information on floral and faunal biodiversity in order to characterize each wetland/sanctuary. The satellite data Cartosat-1 mono and R2 LISS IV FMx product were procured from National Remote Sensing Centre (ISRO), Hyderabad. The above data were georeferenced and merged using the specific software in order to arrive at 2.5 m spatial resolution.The digital data were used to derive the important information of the wetlands such as areal extent, water spread area, vegetation cover, and other general landuse/landcover features such as settlements, roads, inlet, and outlet drainages etc. found around the wetlands including the buffer area through digitisation process. For this purpose, two season data i.e. pre-monsoon (April-May) and post-monsoon (October-November) were used in order to depict the temporal variations of the wetlands.

1. **Satellite Data Mapping :** Remote sensing data (Resourcesat-2 LISS IV Fmx having a spatial resolution of 5.8m and Cartosat-1 Mono having a spatial resolution of 2.5m) procure-ment, georeferencing, projection, merging, and mapping/digitization of wetlands.

2. **Sampling Methods:** Field sampling was carried out for pre-monsoon (April to May) and post-monsoon (October to December) seasons. In each season, atleast three surveys were done with appropriate time interval. Separate sampling methods were followed for aquatic and terrestrial species of flora as well as fauna such as line transect and quadrat methods. With reference to the turbidity of wetlands, three broad categories such as low, medium and high were used for the selected wetlands based on the satellite data.

3. **Research Tools/Instruments :** Sweep net / Drag net was used for surface-dwelling species and quadrats for terrestrial floral and faunal species during the field survey. For site location of different groups of species, hand-held GPS were used. Further, binoculars were required for distant viewing and identification of mainly avian species which are found in and around wetlands.

The following flow chart depicts the overall methodology:
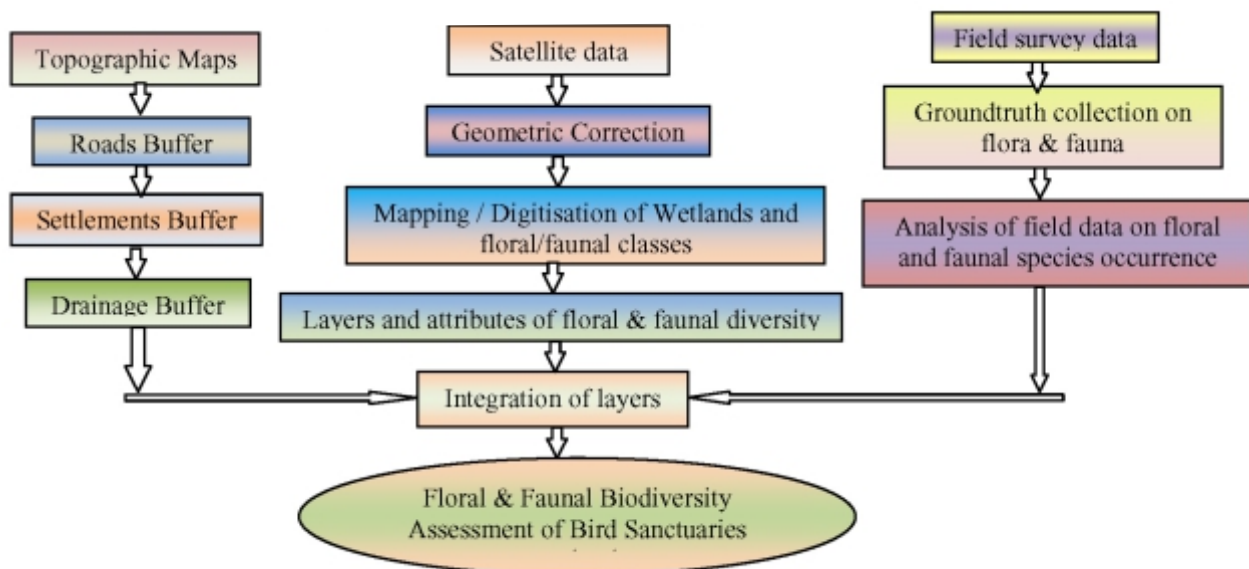
Data Used

As this project is focused primarily on the use of high-resolution remote sensing data and GIS tools in order to depict the latest scenario of the pre-monsoon and post-monsoon status of the wetlands, the following datasets have been procured and used for mapping purpose.

List of R2-LISS IV FMx satellite data

Name of Bird Sanctuaries/ Districts	Path & Row	Date of Acquisition	
		Pre-monsoon	Post-monsoon
Sur Sarowar / Agra	097-052	29.04.2013	25.12.2013
Sandi / Hardoi	099-052	09.05.2013	17.11.2013
Parvati-Arga/ Gonda	101-052	19.05.2013	27.11.2013
Vijaysagar/ Mahoba	099-054	15.04.2013	11.12.2013

List of Cartosat-1 Pan/Mono data

Name of Bird Sanctuaries/ Districts	Path & Row	Date of Acquisition	
		Pre-monsoon	Post-monsoon
SurSarowar / Agra	529-272	10.06.2013	14.10.2013
Sandi / Hardoi	541-272	29.05.2013	04.12.2013
Parvati-Arga/ Gonda	552-2730 &553-273	7.04.2013	22.11.2013
Vijaysagar/ Mahoba	542-280 (with 20% shift)	29.05.2013	04.12.2013

Observations and Results

As per the requirement of the database for the project, the output includes spatial and non-spatial data from primary and secondary sources. The different primary, derived and non-spatial data requirements are shown in the following table:
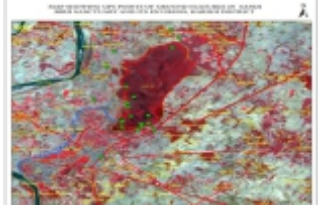
Primary Layers	Derived Layers	Non-spatial information
Wetlands status	Seasonal changes of waterspread & their surrounding	Field data on Biodiversity
Roads	Road buffer	Socio-economic data
Villages	Village buffer	Surroundings of wetlands
Rivers, Canal	Drainage	Inlet and Outlet sources
Ground Features	GPS maps	Locations of ground features associated with the wetlands
Littoral Survey	Floral & Faunal transects/quadrats	Field data on Biodiversity
Limnological Study	Analysis of water samples	Seasonal data on Physico-chemical water quality parameters

The spatial extent of all the four wetlands as digitised from the satellite data of pre-monsoon and post-monsoon seasons in terms of hectares are given in the following table:

Name of Bird Sanctuaries & District	Geographical Area (ha)	
	Pre-monsoon	Post-monsoon
Sur Sarowar / Agra	183.27	204.062
Sandi / Hardoi	260.88	286.11
Parvati-Arga / Gonda	497.37 + 202.89	568.42 + 237.85
Vijaysagar / Mahoba	78.83	203.65

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Satellite data-derived maps of different wetlands in Pre-monsoon and Post-monsoon seasons

G.P.S. map of Sursarowar, Agra	G.P.S. map of Sandi, Hardoi	G.P.S. map of Parvati-Arga, Gonda	G.P.S. map of Vijaysagar, Mahoba
Pre-Monsoon status of Sur Sarowar, Agra	Pre-Monsoon status of Sandi, Hardoi	Pre-Monsoon status of Parvati-Arga, Gonda	Pre-Monsoon status of Vijaysagar
Post-Monsoon status of SurSarowar, Agra	Post-Monsoon status of Sandi, Hardoi	Post-Monsoon status of Parvati-Arga, Gonda	Post-Monsoon status of Vijaysagar

Sur Sarowar Bird Sanctuary

Floral Biodiversity

The seasonwise observations/occurrence of different types of flora are given below: Herbs and Shrubs (37 Nos),Trees (35 Nos), Aquatic plants: Submerged-Nil,Free-floating hydrophytes(3 Nos), Rooted-Floated leaved-Nil,and Emergent Plants(5 Nos).

A comparative view of the flora in different seasons of the year (2013-14)

	Rainy		Winter		Summer	
	Species	Family	Species	Family	Species	Family
Herbs / Shrubs	23	16	19	14	32	22
Trees	35	20	35	22	34	19
Aquatic	08	07	12	08	06	05

Faunal Biodiversity

The seasonwise observations/occurrence of different types of fauna are given below: 62 Species under 38 families of birds were seen in this Bird Sanctuary. The other faunal biodiversity which were seen are **Pisces-** Rohu, Mangur, Sol, Kachhna, and Lachi ,Baam, Kochia, Nain, Singhi, Chilwa, Sour, Girai, Tengan, Parhan (Fresh water shark) etc. **Mammals -** Hedgehog, Squirrel *(Funambulus-* *pennanti)* and common monkey *(Macacamulatta),* Mongoose *(Herpestesedwardsi)* Nilgai *(Baselaphu-* *stragocamelu),* Monkey *(Macacamulatta),* were seen in this survey. **Reptiles -** included one species of Indian Rock Python (*Python molurus*) seen near Python Point. **Insecta-** various types of Butterfly found in Sur Sarowar were: 1. Blue Pansy, 2. Plain Tiger, 3. Peacock Pansy, 4. Pioneer, Dragon fly present in numbers. **Mollusca** included one species of Pilaampullaria (Ghongha).

Sandi Bird Sanctuary

Floral Biodiversity

Herbs and Shrubs (35 Nos); Trees (27 Nos); Aquatic plants: Submerged Plants (4 Nos); Free Floating Hydrophytes(5 Nos); Rooted Floated leaved (6 Nos); Emergent Plants(11 Nos)

A comparative view of the flora in different seasons of the year (2013-14)

	Rainy		Winter		Summer	
	Species	Family	Species	Family	Species	Family
Herbs / Shrubs	25	16	29	19	25	15
Trees	29	19	30	20	29	19
Aquatic	40	25	31	16	18	16

Faunal Biodiversity

The seasonwise observations/occurrence of different types of fauna are given below: 58 Species under 35 families of birds were seen in this survey in Sandi Bird Sanctuary. The other fauna which was seen are given below: **Pisces** include the following types which inhabit the wetland: Rohu, Baam, Kochya, Magm, Nain, Singhi, Chilva, Sour, Girai, Taingan, Parhan etc. **Mollusca**, *Pilaampullaria* (Ghongha) was observed during field survey in plenty which is feed by cranes and storks. Mammalia include Nilgai *(Baselaphustragocamelu)*. **Insecta** various types of Butterfly, Dragon fly, Water Spider were found. The Butterflies include: 1. Plain Tiger, 2. Pioneer.

Parvati-Arga Bird Sanctuary

Floral Biodiversity

The seasonwise observations/occurrence of different types of flora are given below: Herbs and Shrubs (30 Nos), Trees (21 Nos),Aquatic plants: Submerged Plants (4 Nos), Free Floating Hydrophytes (3 Nos), Rooted Floated leaved (4 Nos), and Emergent Plants (6 Nos).

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A comparative view of the flora in different seasons of the year (2013-14)

	Rainy		Winter		Summer	
	Species	Family	Species	Family	Species	Family
Herbs / Shrubs	21	13	24	16	28	17
Trees	21	14	21	14	21	14
Aquatic	25	21	18	15	16	13

Faunal Biodiversity

The seasonwise observations/occurrence of different types of fauna are given below: 47 Species under 28 families of birds were seen in this survey in Parvati-Arga Bird Sanctuary. The other fauna which was seen are given below: **Pisces** include the following types which inhabit the wetland: Rohu, Baam, Kochya, Nain, Girai, Taingan, Parhanetc. **Insecta** Butterflies includes 1. Plain Tiger 2. Common Mormon 3. Peacock Pansy, 4. Rounded Pierrot. Mammalia Nilgai *(Baselaphustragocamelu)*. **Reptiles** Brahminy Skink *(Mabuya-carinata)*, Garden Lizard *(Varanus bengalensis)*.

Vijaysagar Bird Sanctuary

Floral Biodiversity

The seasonwise observations/occurrence of different types of flora are given below: Herbs and Shrubs (40 Nos),Trees (46 Nos), Aquatic plants: Submerged (4 Nos), Free-floating hydrophytes (5 Nos), Rooted Floated leaved (6 Nos), and Emergent plants (6 Nos).

A comparative view of the flora in different seasons of the year (2013-14)
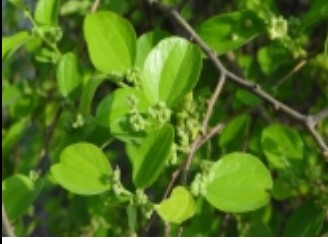
	Rainy		Winter		Summer	
	Species	Family	Species	Family	Species	Family
Herbs / Shrubs	37	21	38	20	36	19
Trees	46	24	46	25	46	25
Aquatic	23	16	26	19	19	15

Faunal Biodiversity

53 Species of 29 families of birds were seen in this survey in Vijaysagar Bird Sanctuary. The other fauna which was seen are given below: Piscesinclude Rohu, Sour, Manghur, Taingan, Baam, Kochya, Nain, Singhi, Sour, Girai, Taingan, Parhan etc. **Insecta** include: Dragon fly (Asiatic red tail), Common feature Bee, Pied paddy skimmer, Water Scorpion. Butter fly - Common grass yellow, Plain Tiger, Rounded Pierrot, Pioneer, White Orange Tip. **Mammalia** Nilgai *(Baselaphustragocamelu)*. Reptiles Garden Lizard *(Varanus bengalensis)* was found.

Floral Biodiversity

Common/Local Name: Amaltas /Gurmala Botanical Name: *Cassia fistula* Family: Caesalpiniaceae Habit/Habitat: Littoral	Sub-Division: Algae Division: Cyanophyta Class: Cyanophyceae Habit/Habitat: Free floating	Common/Local Name: Goat Weed Botanical Name: *Ageratum conyzoides* Family: Compositae Habit/Habitat: Littoral	Common/Local Name: KhajaMoti Patti Botanical Name: *Hydrillaverticillata* Family: Hydrocharitaceae Habit/Habitat: Submerged
Common/Local Name: JalKumbhi Botanical Name: *Eichhorniacrassipes* Family: Pontederiaceae Habit/Habitat: Free floating	Common/Local Name: Duck weed Botanical Name: *Lemna minor* Family: Lemnaceae Habit/Habitat: Free floating	Common/Local Name: KhajaMoti Patti Botanical Name: *Hydrillaverticillata* Family: Hydrocharitaceae Habit/Habitat: Submerged	Common/Local Name: Van Laung Botanical Name: *Jussiaearepens* Family: Onagraceae Habit/Habitat: Littoral
Common/Local Name: Canchara Botanical Name: *Commelinabengalensis* Family: Commelinaceae Habit/Habitat: Littoral	Common/Local Name: Kathber/ Shruby Plum Botanical Name:*Zizyphusxylopyra* Family: Rhamnaceae Habit/Habitat: Littoral	Common/Local Name: Palas/Dhak/Tesu Botanical Name:*Butea monosperma* FamilyPapilionaceae Habit/Habitat: Littoral	Common/Local Name: Bhant/ Bather BotanicalName:*Clerodendrumviscosum* Family:VerbenaceaeHabit/Habitat: Littoral

Faunal Biodiversity

Common/Local Name: Rock Python Zoological Name: *Python molurus* Family: Boidae Habit/ Activity : Python Point of Bird Sanctuary	Common/Local Name: Hedgehog Zoological Name: *Atelerix albiventris* Family: Erinaceidae Habit/ Activity : Forest Area	Common Name : Painted Stork Scientific Name:*Mycterialeucocephala* Family: Ciconidae	Flocks of Cattle egret, Little egret and Oriental white ibis with their nests

Common/Local Name: Lesser pied kingfisher Zoological Name: *Cerylerudis* Family: Alcedinidae Habit/ Activity : Wetland tree/ Perching	Common/Local Name: Purple Heron Zoological Name:*Ardeapurpurea* Family: Ardeidae Habit/ Activity : Perching	Common Name : Red Veined Darter Scientific Name:*Symptetrumfonscolombii* Family: Libellulidae	Common Name : Dhaman / Rat Snake Scientific Name:*Ptyasmucosus* Family: Coludridae
Common Name : Leopered Butterfly Scientific Name:*Phalantaphalantha* Family: Nymphalinae	Eggs of Bronze winged jacana	Photograph showing the project team below the watch tower in Vijaysagar wetland	Common/Local Name: Pachera Zoological Name: *Pungshuratectum* Family: Geoemydidae Habit/ Activity : Wetland water

Limnological studies

Water samples were collected from different places of the wetland during different seasons of the year and were analysed for various water quality parameters such as: pH, Colour, Transparency, Alkanlinity, Conductivity, DO, BOD, COD, Total Hardness, Chloride, Calcium, Magnesium, RSC, SAR and Heavy Metals and their mean was calculated.

Conclusions

High resolution data of Cortosat-1 mono and LISS- IV FMx for the pre and post monsoon seasons were used for mapping of four wetlands and their surroundings. The geographical area (ha) of each wetland was calculated. Further, GPS measure-ments taken during field surveys for different ground features were also plotted on a separate map.The baseline database, highlighting the wetland bird sanctuary and their aquatic terrestrial features in terms of their spatial extent, floral biodiversity components and their bionomics based on field observation and analysis, is an integration of different layers of information in GIS compatible digital database. Remote sensing based derived maps on 1:10,000 scale were used to portray their spatial extent and associated characteristics of the selected wetland. The digital database on the physical conditions and floral biodiversity richness of different wetland/bird sanctuary as observed during different seasons has been supplemented by the base layer information such as road network, drainages, settlement network, forest etc. in the buffer area of about 2.0 km surrounding the wetland. Since the biodiversity of bird sanctuary are subject to various threats due to anthropogenic pressures, there exists an indispensable scope for continuous monitoring of such prime wetland in future say at 5, 10, 15 years by the concerned agencies for their status assessments through repetitive studies and quick field surveys using the database generated under this study. In the present context, the paper is aimed at the study of biodiversity of Sur Sarowar wetland which have been already declared as bird sanctuary and hence assumes importance in terms of (i) conservation of aquatic habitats, (ii) database

creation on floral biodiversity with specific reference to birds, and (iii) utilization of potentials of eco-tourism etc., for optimal development of the wetland for the benefit of all concerned.

Based on this pilot study, the methodology could be extended to other important Wetlands/ Bird Sanctuaries of Uttar Pradesh where the biodiversity exists and hence necessitates our attention for their conservation too.Further, there exists an advantage of the information and models being generated could be used to explore the potential of eco-tourism etc., as per the priorities and agenda set by the State level Steering Committee on Wetlands. As three categories of wetlands exist in the state, viz. (i) Protected wetlands under Forest Dept. which are declared as sanctuaries for wildlife conservation, (ii) Community wetlands which are unprotected under gram sabha etc. and (iii) Private wetlands,

the model generated in this study can be replicated to wetlands of (ii) and (iii) type of wetlands as above.Scientifically much more work is required to be carried out for the lesser known aquatic plants, facing various degrees of threats and there is an urgent need to document the inventory of their habitats.

Acknowledgements

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