ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 4(M), pp. 26432-26436, April, 2018

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

APPLICATIONS OF GEOSPATIAL TECHNIQUES FOR CONSERVATION OF WETLANDS AND ITS CORRESPONDING AVIFAUNA: AN INDEPTH STUDY OF THOL BIRD SANCTUARY

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DOI: http://dx.doi.org/10.24327/ijrsr.2018.0904.2057

ARTICLE INFO

Article History:

Received 17th January, 2018
Received in revised form 21st February, 2018
Accepted 05th March, 2018
Published online 28th April, 2018

Key Words:

Climate change; wetland; avifauna; geospatial; hydroperiod; Thol bird sanctuary

ABSTRACT

Climate change is perceived as one of the main dangers to the survival of species and integrity of biological systems around the world. The range of literature on the biological and hydrological systems have anticipated the impacts that would occur because of climatic change, which has been made more clear with reseraches in the past couple of decades. Wetland frameworks are weaker and especially vulnerable to changes in amount and nature of these climatic shifts. It creates the impression that climate change may have its most articulated impact on wetlands through changes in hydrological cycle : particularly, the nature and fluctuation of the hydroperiod and the number and intensity of extraordinary events. This study was carried out with the objective to understand the pressures on wetland (Thol bird sanctuary) and its avifauna by using geospatial techniques. The geospatial information thus generated was then linked with precipitation and avifaunal information gathered through field reconnaissance surveys periodically to understand the wetland dynamics and for monitoring future changes, providing recommendations for conservation.

INTRODUCTION

Climate change is a well documented cause of major threats to the degradation of ecological systems and for extinction of numerous species (Hulme 2005). Pressures on wetlands are in all likelihood to be mediated through modifications in hydrology, direct and indirect consequences of adjustments in temperatures, in addition to land use change (Ferrati *et al*. 2005). Examples of impacts attributable to projected modifications in intense climate events (Ramsar STRP: 2002) encompass: alterrations in base flows; altered hydrology (intensity and hydroperiod); expanded heat pressure in natural world; prolonged range and activity of some pest and sickness vectors; accelerated flooding, landslide, avalanche, and mudslide damage; accelerated soil erosion; elevated flood runoff ensuing in a decrease in recharge of some groundwater aquifers; reduced water resource amount and quality; increased chances of fires; accelerated coastal erosion and damage to coastal homes and infrastructure; increased harm to coastal ecosystems including coral reefs and mangroves and an increment in tropical cyclones. Under presently anticipated future climate scenarios, the spread of exotics will probably be greater, that may boom pressure on watersheds and ecosystems (Root *et al*. 2003).

Wetland systems are vulnerable towards climate change and specially vulnerable towards modifications in amount and quality of water delivered into them. It appears that changes in climate can also have its most significant effects on wetlands through changes in hydrological regimes: especially, the nature and variability of the hydroperiod and the quantity and severity of severe events. However, different variables related to climate may additionally play essential roles in determining local and nearby impacts, consisting of extreme temperatures and changed evapotranspiration rates, altered biogeochemistry, altered amounts and types of suspended sediment depositions, oxidation of organic sediments and the physical effects of wave energy (Burkett and Kusler 2000).Climate exchange will affect the hydrology of each wetland ecosystems basically through changes in precipitation and temperature regimes with extreme global variability. From the perspective of assessment of climatic variability and the effect on wetlands, those

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ecosystems need to be viewed inside the broader context of their spatial vicinity in a watershed inside a particular place. Given the diversity of wetland types and their characteristics, the impacts of climate change can be relatively wetland specific, thus the precise remedial measures are also wetland specific. It will be critically vital to determine particular predicted scenarios of regional climatic shifts so that the remedial measures correnctly align with the changing climate. This may additionally prove to be difficult and will take a sizable academic attempt to convince governments and groups to spend money on monitoring (Erwin, K. L.2009).

Despite the fact that the biological impacts of environmental change are progressively clear (Root *et al*. 2003), the confirmation is unequal across all the biological systems. The IPCC predicts that global temperatures will rise from 1 to 5C during the 21st century. This increase in temperature will affect coastal biota directly and lead to changes in precipitation and an acceleration of sea level rise. Predictions of increase in temperature in the tropical regions also point towards an increase water vapour movement towards higher latitudes. Thus, it is likely that, in general, lower latitudes will experience a decrease in precipitation and higher latitudes will experience an increase in rainfall (Day *et al*. 2005).

Status of Wetland in Gujarat

Total wetland area estimated is 3474950 ha, which accounts for about 17.56 % of geographical area of the state. Turbidity of water is in general high in both the seasons (National Wetland Atlas of Gujarat, 2010). In Gujarat, the coastal and inland wetlands cover 35.8 % and 6.0 % of the total wetland area respectively in India. The state recognised the value of important wetlands related to geo-morphology, ecology, flora and fauna and constituted nine Protected Areas - one national park, seven sanctuaries and one conservation reserve to preserve a total area of 13,052 sq. km. Additionally, eight wetlands of national conservation significance have been identified and notified by the Ministry of Environment & Forests, Government of India for their conservation in partnership with the local communities. The wetlands in Gujarat are distributed throughout the state ranging from highly arid zone in Kachchh to humid in Valasad, Surat, Dangs and some areas of Bharuch. In the semi-arid region they are distributed in the districts of Rajkot, Bhavnagar, Gandhinagar, Mehsana, Ahmedabad and parts of Banaskantha. The wetlands located in the sub-humid zones are distributed in Sabarkantha, Panchmahal, Kheda, Vadodara and Bharuch. It would certainly not be an overstatement to call Gujarat the state of wetlands.A study conducted by SAC, Ahmedabad in 1998 estimated wetland area in the country about 75,819 sq. km. of this, Gujarat's contribution is about 27,175 sq. km. that consists about 36% of the total. Gujarat is blessed to have both wetland categories – inland and coastal. Since the state is holding the longest coastline of the country, it is obvious to have vast coastal wetlands in here. Out of the total of 27,175 sq. km. the area of 25,083 sq. km. is categorized under coastal wetland and 2,092 sq. km. under inland wetland. Thus, coastal and inland wetlands cover 92.3% and 7.7% of the total wetland area respectively (GEER, 1998). Gujarat is unique in considering its wealth of natural and man- made water bodies of wetlands. Gujarat state recognizes geomorphologic, floral and faunal values of important wetlands and constitutes seven sanctuaries to preserve total area of 13,052 sq. km. five such wetlands in the state have been established as sanctuaries primarily for conservation of waterfowl. These are Nalsarovar, Khijadia, Porbandar, Great Rann of Kachchh and Thol. According to GEC (1999), North Gujarat has 1, 10,706.25 hector are under wetlands. There are total 159 wetlands in this region. All categories of wetlands are found in this region, except marsh/swamp. Because of North Gujarat's proximity to the Gulf of Kachchh and its desert conditions, a large area (45.57%) of the total wetland area in the region is under mudflats. Present study area "Thol Lake Wildlife Sanctuary" of Mehsana district in North Gujarat along with Pariej and Kanewal in Kheda district in central Gujarat are well known for their high diversity and population of the wintering waterfowl.

Objectives

***Main Objective*:** To study the dynamics of inland wetland using geospatial techniques and its avifaunal biodiveristy.

Specific Objectives

1. To collect and analyze rainfall data for Thol bird sanctuary within a timeframe of years 2001-2016 in order to understand the rainfall pattern in the region.
2. To analyze satellite data (IRS LISS III and Google Earth Pro imagery) related to TBS(Thol bird sanctuary) for mapping and monitoring the study area along with its land use land cover study.
3. To collect and analyze multi temporal avifaunal data.
4. To provide set of recommendations for site specific conservation.

Study Area

The Study Area for this proposed study would cover double the area of Eco-sensitive Zone of Thol Wildlife Sanctuary. In other words, the study area would cover area encompassed by 10 km radius from the boundary of the Thol Wildlife Sanctuary. This study purchase the landscape surrounding Thol. The detail information about Thol is described below. (With same satellite data). Thol wetland that is being protected as Thol Wildlife (Bird) Sanctuary is situated in Mehsana District of Gujarat State, India between 23°15' and 23°30' N latitudes and 72°30' and 72°45' E longitudes. Geographically, Thol Wildlife Sanctuary falls in Kadi Taluka, head quarter of Mehsana district, North Gujarat region and as per Rodgers and Panwar classification system, it is located in the Gujarat-Rajputana (4B) biotic province of Semi-Arid Biogeographic Region (4). (Jessica,P 2012).Due to its popularity amongst the bird fraternity, the area was notified as Wildlife (Bird) Sanctuary through the notification GVN-53-88-WLP-1386-162-V2 dated 18th November, 1988 under section 18 of Wildlife Protection Act, 1972 (GEER,2002). Thol Wildlife Sanctuary is amongst the eight national wetland sites, which has been identified and declared for conservation.

Area of Thol Wetland and Thol Wildlife (Bird) Sanctuary: Thol Wildlife (Bird) Sanctuary encompassing Thol irrigation reservoir (popularly known as "Thol Talaav" or "Thol lake") occupies total area of 699 ha (6.99 sq.km.) and its periphery is 5.62 km long. Being an irrigation reservoir constructed by the erstwhile Gaekwad rulers in 1912, Thol wetland provides water for agriculture to six villages which are spread over 55.95 sq. km. The catchment area of water body which covers 320

sq.km. islocated to its north and North East so the spreads is from Kadi taluka to Mehsana district and Kadi taluka to Gandhinagar district (GEER, 2002).

Waterbird Data: Parallel to satellite data collection/selection and analysis and climate data collection, collection and analysis of Gujarat Forest Dept.'s water bird census data was also carried out. Water bird census data for Thol was collected from Gujarat Forest Department (Sanand) from year 2004 till year 2016. The waterbird census data analysis for the wetland was carried out to reveal the changes in species richness and abundance of the waterbirds using open water area of the wetland for foraging purpose. An attempt was made to correlate changes (reduction or increase) in water spread with rainfall data and habitat/land use cover status derived through analysis of the remotely sensed satellite data. In the proposed study, delineation, mapping and monitoring of the land use/cover categories of the surrounding landscape of the Thol wetland and wetland itself.

MATERIALS AND METHODOLOGY

Remote Sensing – A Tool for Mapping and Monitoring of Landscape

Surrounding Wetland Ecosystem: As a science, remote sensing is inter - disciplinary field, drawing on the talent of engineer and natural scientist. It is the science which deals with inventorying, monitoring and assessment of natural resources and phenomenon through analysis of data obtained from a remote platform. Remote sensing through aerial photography and orbital satellite images is being used globally to study wild life species (including waterfowl) utilizing wetlands as their habitats. With this technique, habitat condition of wild life species can be recorded *in-situ* and later analyses to derive ecological information for the benefit of the wild life. Compared to the aerial photography, orbital satellite remote sensing is more use full due to its respective and synoptic coverage and improving spatial and spectral resolution. "Remote sensing means sensing of earth's surface from space by making use of the properties of electromagnetic wave emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment."

Habitat of wildlife species refers to the place in an ecosystem where it lives. Thus, the habitat of waterfowl actually represents a particular set of environmental conditions (forming structural components of the ecosystem) which are essential to fulfill their requisites like feeding, resting, roosting and breeding. Remotes sensing through standard aerial photographs and orbital satellite images is being utilized globally to study wildlife species (including waterfowl) utilization wetlands as their habitats. It helps to solve the geo-locational and attribute based queries, present the results of work in the form of publication-quality maps and to create interactive displays that link reports, graphs, tables, drawings, photographs, and other elements to the data. It can be easily customized in order to tailor the interface to suit the needs of the organization, build new tools to automate the work, and develop standalone applications based on mapping components. The study utilized LISS3 imagery from Resources at-I and Google Earth Pro imagery (2007 and 2017) for the various geospatial analysis like land use land cover change analysis, Hydrological profile, Vegetation Profile, Land based features available for perching, roosting and foraging of avifauna. Ground surveys were carried out for the species identification, listing of various waterfowls and other avifaunal biodiversity.

Land use / Cover studies: The methodology employed for preparation of Land use and land cover map included:

- Data collection
- Image interpretation
- Field based surveys
- Correlating field and GIS mapping to create land use and cover map

Data collection

- Gathering data from Google Earth Pro and Bhuvan, high resolution multispectral and LISS 3 imagery respectively
- Historical maps and literature based evidences to correlate with current mapping
- Field surveys in all different seasons to gather weather, hydrology and terrain data.

Interpretation of satellite data: The downloaded satellite imagery was imported to Arc GIS 10.4 software and georeferencing of the imagery was done by using overlaying google based maps on the non georeferenced imagery of the study area. Unsupervised classification was carried out, corrections and merger of classes were made based upon the ground surveys.

Fieldbased surveys: An in depth ground study was carried to corroborate the interpreted data with the actual ground features and phenomenons. The ground truth consisted of photographing ground based features along with recording the GPS co ordinates of the study area.

Land use Land cover mapping: Projection was given to the Google Earth Pro images and unsupervised classification was carried out. The ground truthing data was then compared with the land use land cover classes to make the requisite corrections. Once the final corrections were made the legends, scale bars and north were added to complete the land use land cover mapping, thus creating the map of the same.

RESULTS AND DISCUSSIONS

Land use / Cover studies: Land use land cover classification broke down the area into 5 different categories namely Waterbody, Vegetation, Cleared agricultural land or Fallow, Build up area and agricultural land.

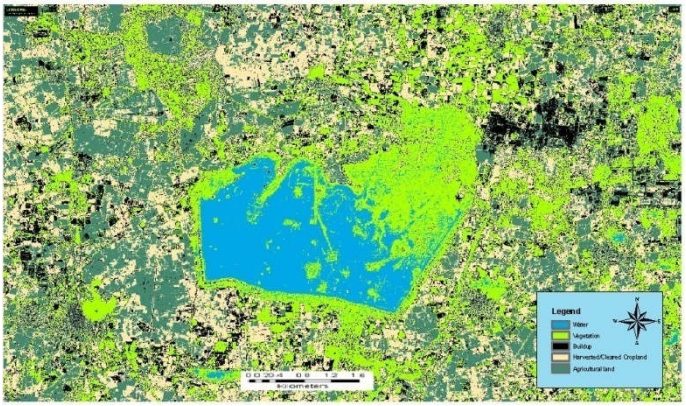

Figure 1 Land Use and Land Cover Map of the Study Area

The major area of the sanctuary consists of the actual water body and vegetation. The remaining land surrounding the sanctuary consists of agricultural land and fallow with a considerable amount of buildup land. Land Use and Land Cover Map of the study area is shown in the figure(1).

Avifaunal surveys: Avifaunal surveys were carried out based upon the hydrological characteristics of the the wetland depending upon the water quantity across the wetland topography. Observations were carried out in the winters from morning 6 AM to noon 12 PM using photographic equipments 1) Canon 7D MK II 2) Telephoto zoom lenses 300mm (Tamron) and 500mm (Sigma). The surveys were carried out for the whole season multiple times. The observations thus recrded were based upon identification standard field guides like Grimmett *et al*. 1998, Salim Ali, 2002. The bird species were then categorised according to their migratory and conservation statuses. The resultant species that were observed at the study area which are threatened according to the IUCN redlist, are listed as follows (Table No. 1):

Table 1 List of Threatened Avifaunal Species Recorded In the Study Area

Sr.No.	Common Name	Scientific Name	Migratory Status	Conservation Status
(1)	Greater Spotted Eagle	*Clanga clanga*	RM	VU
(2)	Imperial Eagle	*Aquila heliaca*	RM	VU
(3)	Lesser Flamingo	*Phoenicoparrus minor*	RM	NT
(4)	Oriental Darter	*Anhinga melanogaster*	RM	NT
(5)	Black-headed ibis	*Threskiornis melanocephalus*	R	NT
(6)	Painted Stork	*Mycteria leucocephala*	R	NT
(7)	Sarus Crane	*Antigone antigone*	R	VU
(8)	Spotbilled Pelican	*Pelecanus philippensis*	RM	VU
(9)	ferruginous duck	*Aythya nyroca*	RM	NT
(10)	Black Tailed Godwit	*Limosa limosa*	RM	NT
(11)	Asian Woollyneck	*Ciconia episcopus*	R	VU

NT - Near Threatened, VU – Vulnerable, R – Resident, M – Migratory, RM- Resident-Migratory.

Gujarat Forest Department has been leading waterbird statistics at Thol wetland since 2004 at an interim of 2 year regular intervals. According to these censuses, populace of the waterbirds utilizing open water zone (which is the transcendent territory region for sustenance and roosting) has expanded from 3,591 inidividuals in winter 2004 to 40,432 individuals in winter 2016.It was observed that there has been increment by 36841 individuals (1025.92 %),increase in populace of waterbirds in the vicinity from 2004 to 2016. If the whole populace pattern of open water region's waterbirds from 2004 to 2016 was considered (including populace status of 2004, 2008, 2012, 2016), an expanding pattern was observed. One of the components influencing waterbird population at any wetland is water accessibility, or as such, water-level that is showed as water-spread zone. In this way, Stewart (2016) has expressed that the accessibility of water is a critical wetland highlight to the birds of wetlands Bancroft (1989) and Kushlan (1978) too have stressed the significance of water accessibility in wetland for waterbirds by expressing" waterbird populations are specifically impacted by the measure of accessible foraging habitat (other than its quality)" and what can be a better than a wetland with vast amount of open water areas for Open Water Foragers. Along these lines, in the present scientific investigation on Thol wetland, an endeavor was made to relate expanding populace pattern of vast water territory's waterbird (i.e., open water foragers. from winter 2004 to winter 2016 with the pattern of vast water area(the most predominant water environment) of Thol wetland for nearly a similar time frame. The pattern, which is delineated in Fig. 2 and 3 demonstrates an increasing pattern of precipitation and the dependent avifauna respectively. On the other hand, it can be construed that with the expanding pattern of Open Water territory (i.e., expanding water accessibility or quantity of water) from 2004 to 2016, the populace pattern of Open Water Foragers (waterbirds) too was observed in an incremental climb. In this way, the examination has demonstrated a sort of positive connection between degree of Open Water and the population of waterbirds.

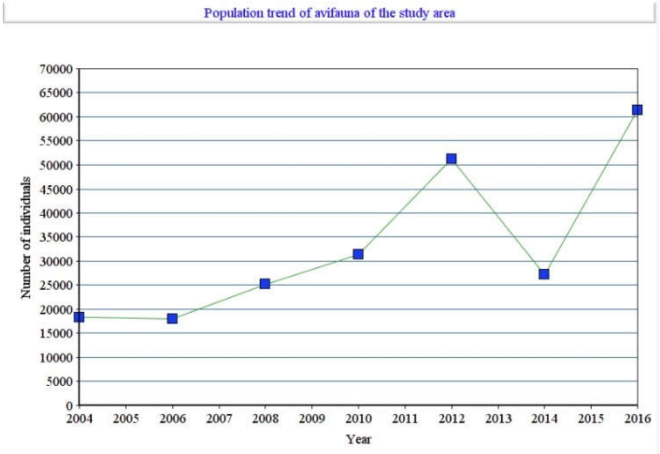

Figure 2 Population Trend of Avifauna of The Study Area.

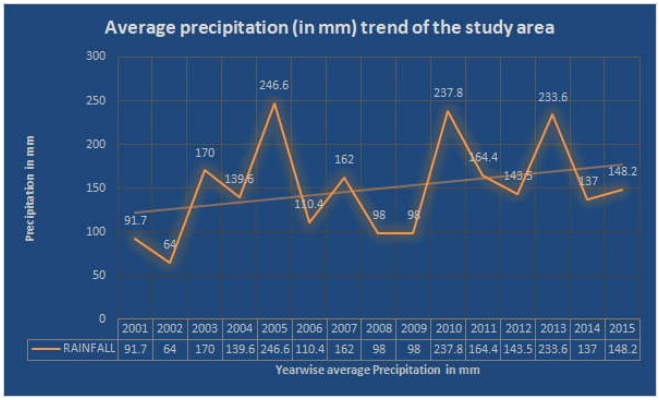

Figure 3 Average Precipitation (in mm) Trend of the Study Area.

CONCLUSIONS

From climate point-of-view, the Thol wetland area had experienced the trend of increasing rainfall (both, total annual and average annual rainfall) from winter 2004 to winter 2015. Subsequently, the trend of water availability/amount in wetland (measured as extent of open water area) and waterbird population dependent on open water area has also exhibited increasing trend. Thus, it can be inferred that on the multi-year basis (i.e., for relatively long term period), rainfall (an important climatic parameter) has beneficially affected the Thol's ecosystem and its waterbirds.

Population of Open Water foraging waterbird groups like ‘ducks and geese’ and ‘spoonbill and ibis’ remained highest or second-highest among all the open water’s waterbird species in winter 2004 when waterspread was too limited as also in winter2016 when water spread was relatively good (3.20 sq.km). In spite of increasing rainfall trend on multi-year basis, factors such as extraction of water by humans for fulfilling irrigation water needs had considerable impacts on water availability (in terms of open water area) and in turn on

population of open water birds (like ducks and geese). The number of industries that are in the vicinity are also responsible for the pollution in the surround landscape.

Recommendation

Thol Bird Sanctuary (TBS) is one of the significant wetlands in India with a range of migratory and resident species of avifauna observed. This research had recognized the capability of TBS as an universally critical wetland not only because of the sheer number of species found but also as home, courtship and nesting grounds for vulnerable Sarus Crane and other 10 near threatened or vulnerable species. It has been observed that however TBS is confronting lesser human disturbances in contrast with Nal Sarovar Bird Sanctuary, there are multiple evidences of imminent and possible future hazards. The most significant one being the area of ONGC oil wells within the actual sanctuary site and its catchment area. It must be observed frequently to check for oil spills and subsurface leakages which can have a deadly impact on the avifauna of the site. Additionally the significant part of the sanctuary is covered by rural area which is given to neighborhood individuals for development at very low rates. This creates a regular disturbance to the avifaunal species. The withdrawal of water for irrigation which is tranported to the nearby farmland through canals and smaller artificial channels which increases pressure on the wetland ecology. A proper system should be made to move these canals outside the boundary of the sanctuary and the water inside the wetland must be monitored through regular surveys limiting the excess exploitation of the wetland waters. The other issue to the wetland is the frequent movement of domesticated animals like goats, sheeps, cows, buffaloes etc through the wetland for grazing, disturbing the birds that are dependent upon the open pristine grounds. This was observed as a major threat to the avifaunal species during ground surveys. This must be taken care of by the forest department in order to reduce any sort of disturbance caused to the birds. Additionally this study has represented an evidence that a continuous and detailed analysis must be carried out for acquiring a continuous data that can be used for constantly monitoring and conserving the wetland area. The current study had its limitations in terms of climatic data, historical geospatial and remote sensing data. Major disturbances also include the recreational use which has no limitations on the visitors generating the waste that is been dumped into the wetland. Proper care must be taken by the concerned authorities in order to reduce the waste generated and putting stricter bans on dumping of any waste within the sanctuary boundaries. Increasing the awareness and sensitiveness towards the birds and their habitat through planned school and college trips with concerned experts, photographers, to provide the required information regarding conservation and ethical treatment of the wildlife. It is being proposed to carry out further peripheral studies of avifauna in the villages, farmlands, water tanks and other smaller water bodies surrounding the TBS in order to understand the dispersal and movement, thus enhancing our knowledge of the avifauna.

Acknowledgements

The author would like to express immense amount of gratitude towards the co authors and the Department of Botany, Bioinformatics and Climate Change Impacts Management, Gujarat University.

Disclosure statement: Not applicable/None

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