



To Determine the Structure and Function of Bhagar Oxbow Lake in Dumraon, Buxar, South Bihar, India

Suday Prasad^{1*}, Subodh Kumar², Tapan Gorai¹ and Ajay Kumar²

¹BPS Agricultural College, Bihar Agricultural University, Purnea-854302, India.

²VKS College of Agriculture, BAU, Sabour, Dumraon-808536, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author SP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SK, TG and AK managed the analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i2830948

Editor(s):

(1) Dr. Pavel K. Kepezhinskas, PNK Geoscience, Tampa, USA.

Reviewers:

(1) Arup Nama Das, University of Science and Technology, Meghalaya, India.

(2) Rajpar Muhammad Nawaz, Shaheed Benazir Bhutto University Sheringal, Pakistan.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/60694>

Original Research Article

Received 03 July 2020
Accepted 09 September 2020
Published 22 September 2020

ABSTRACT

The paper deals with the structure, function, and fisheries resources of Bhagar lake, South Bihar, one of the oxbow lakes in Dumraon (un-reported and un-described), from February 2018 to January 2020 under the state non plan research project. This lake is spread from Nauki par (Chakki) to Nainijore (Brahampur), Dumraon, (Buxar) with a large size wetland in dimension of 20 km length & 1 km width. Bhagar oxbow lake is U shaped, hydrological closed lentic type meander of the Ganga river, it is fed by the monsoon runoff and ingress of flood water from the river Dharmawati. The water depth of lake ranges between 1.5 to 3 meters in summer and depth 4 to 6 meters during the Monsoon months. Water temperature ranged from 16°C (January) to 30°C (August) whereas the pH value of lake water was found within 7.0 to 7.8. In aspect of biological properties of the lake, it was highly infested with submerged vegetation with dominancy of *Hydrilla cillata* and floating aquatic weeds (water hyacinth) such as *Eichhornia crassipes* with approximately 30 percent area coverage. This lake is rich sources of fishes with identified forty four species with example of annual fishes like *Mystus spp.*, *Puntius spp.*, *Channa spp.*, *Carps spp.*, small *Macrobrachium spp.* and several seasonal fishes, providing livelihood support to more than sixty five household, socio-cultural importance. It also gives protection to many wild mammals like

*Corresponding author: E-mail: sudaybausabour@gmail.com;

Blackbucks (*Antelope cervicapra*), swamp deer (*Rucervus duvaucelii*) and Nilgai (*Boselaphus tragocamelus*) during summer time. This lake is also wintering ground of the migratory birds such as Heron and Crane.

Keywords: Bhagar oxbow lake; ecology; livelihood; fauna; Dumraon; Bihar; India.

1. INTRODUCTION

All wetlands on the earth have some unique ecological function and it needs to be explored for better use of human well-being and wildlife species. India, with its changing topography and climate regimes, maintain various and unique wetland habitats [1]. These wetland ecosystems assume prominent impact in not only sustaining the regional and global ecological balances, but also provided that ideal environment for wild animals and plants [2,3]. Wetlands cover 7% of the earth's surface and delivers 45% of the world's natural production and ecosystem functions. They provides many resources and services with (e.g. water resources for domestic use and irrigation, ground water recharge, aquaculture, biodiversity, employments etc) that are ecologically and socio-cultural importance [4]. These wetlands are the traditional source of fish and fisheries, and also provide livelihood, to thousands of fishermen [5] and locally known as Bhagar, Beel, Jeel, Tal, Pat, Moun and Chauras. They covered more than 2 lakh hectares spreading over the eastern and north eastern state of India [6]. North Bihar is well-known for its wetland resources (natural and man-made water bodies) and fine extensive network of rivers arising from the Himalayas. Muzaffarpur wetland is a vital resource to provide food, water and recreation for human being as well as habitat for many diverged species of aquatic plants and animals. [7] reported that in north Bihar, 269418 ha, within 21 districts covered by wetlands that is equal to 4.96% total geographical area. Many research workers have been studied on north Bihar wetland in the different aspects such as ecosystem services and resource utilization pattern of an oxbow lake, Muzaffarpur [8], sustainable development of Kawar lake, Begusarai [9] and sustainable development of north Bihar through wetlands [7]. However, previously, no one has mentioned the occurrence of oxbow lake exist in South Bihar. In this regards extensive survey were made in south Bihar, especially Dumraon (Buxar) fish market and water resources under the state non-plan project on "Assessment of gonadal maturity and spawning behavior of Indian major carps in south Bihar". During this period, an interesting

observation on oxbow lake (local known as Bhagar), situated 15 km in the north east from the Dumraon railway station (found & spread between Chakki to Nainijore block) was documented.

2. MATERIALS AND METHODS

2.1 Study Area

An oxbow lake locally known as Bhagar is situated 15 km to north east from the Dumraon railway station in Buxar district, Bihar (one of the seventh largest state of India) between 25°18 degree to 25°45 degree North latitudes and 83°772 degree to 84°40 degree East longitude (Fig. 1). This lake is spread from Naukipar (Chakki) to Nainijor (Brahampur), Dumraon (Buxar). Some important villages like Chakki, Gaight, Sapahi, Pandepur, Mahuar and Nainijore are situated nearer to the bank of anoxbow lake. The oxbow lake is 20 km long x 1 km wide. It is formed U shaped as a result of the shifting of the course of Ganga. Due to lapse of time and raising of an earthen embankment, the connecting channel has become defunct. Bhagar oxbow lake is fed by the monsoon run off and ingress of flood water from the river *Dharmawati*.

Bhagar oxbow lake is a meander of river Ganga. During survey, a local washerman named Shri Bihari Rajak (75 Years old) of village Gaight, Dumraon (Buxar) said that the main Ganga had flowed through this region of Bhagar upto during 1960-1970. The river Ganga has changed its path due to the deposition caused by flood occurred during the year 1970-1976 and after that Bhagar oxbow lake had come into existence. Connecting channel with main Ganga has been hindered & to somewhat defunct due to sediment deposition and formation of earthen embankment with lapse of time. Earlier 1975, Bhagar lake was the best source of fish production including large sized freshwater prawn during the period. In the present context, Bhagar oxbow lake suffering with very less fish & shell fish production because monsoon runoff and ingress of flood water from the river Dharmawati (drooping into the river Ganga) is the main source for feeding of lake.

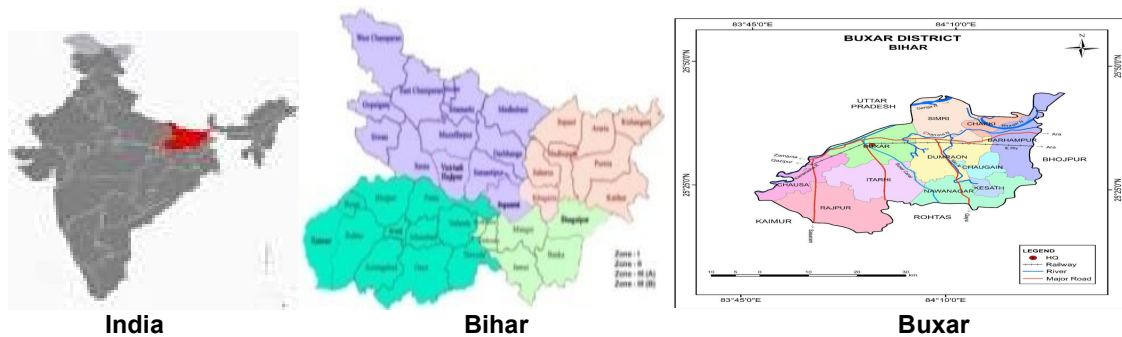


Fig. 1. Map of India, Bihar, and District Buxar showing study area
(Source: 9)

2.2 Wetland Survey

Extensive surveys were performed in the morning to evening time on the specific months by motorcycle, car and boat to investigate the structures and functions of oxbow lake from February 2018 to January 2020. Identification of fishes was done on the basis of its external characters. The tools used in this research were water depth measuring meter, handheld pH meter, thermometers, global positioning system (GPS), digital camera and boat. Location of villages was measured with GPS as tabulated in Table 1. Google earth image of the study area focusing Dumraon, Bhagar oxbow lake was down loaded and presented in the Fig. 2a. The GIS map of study area was generated with open source GIS such as Quantum GIS and presented in Fig. 2b.

Apart from this, few information's and past history of Bhagar oxbow lake was also collected through formal communication with fishermen, washer-man and local people. This water body (Bhagar oxbow lake) was identified in consultation with relevant literature previously published by [10,11] Buxar district survey report, [12], personal communication made with Dr. Archan Kanti Das, Principal Scientist, ICAR, Central Inland Fisheries Research Institute (CIFRI), Barrackpore Kolkata and District Fishery Officer, Buxar (Bihar). The observations of this oxbow lake were compassed with another oxbow lake, which situated in North Bihar.

2.3 Data Analysis

The geographical locations measured in GPS system was spatially superimposed on geographical information system (GIS) map in Q-GIS software and Polygon features of Bhagar

oxbow lake was also depicted. The line features of National Highway, Dharmavati River and levee of Ganga were prepared. Measured data are presented in tabular and photographs.

3. RESULTS AND DISCUSSION

In the present study it is observed that Bhagar is hydrological closed lentic type oxbow lake, its fed by another river Dharmavati during flood time rainy season (Fig. 2a & b). Water, substrate and the biota are the most important factor to consider for wetland characterization [13]. The physically identify of freshwater oxbow lakes is mainly based on a) the established with connectivity channels b) without connecting channels, c) lake falling in between the embankment and d) the river which are flooded during the monsoon and half-formed lakes between the embankment and the river which are engulf by the river during monsoon [10,12]. Those most dynamic wetlands directly and indirectly livelihood millions of people by providing various services in both tangible and non-tangible terms [14,15]. Wetlands occupy 15.26 Million hectares with 1.5% of total geographical area in India, which support about a fifth of the known biodiversity whereas, Bihar has an estimated area of 4.03 Million hectares under wetlands [8]. As estimated 4735 ha area under oxbow lakes is available in the North Bihar with major concentration in East and West Champaran districts, followed by Muzaffarpur, Begusarai and Samastipur [16].

3.1 Importance of Bhagar Oxbow Lake

The Bhagar oxbow lake has been provided that different use water resources which comprise water for irrigation, domiciliary necessities, fisheries resources, production, frivolous uses, ground water recharge, flood control and silt

seizure. This Bhagar oxbow lake is important in supporting flora and faunal species diversity. In the present study it is observed that the some vertebrates (Fishes, Amphibians, Reptilians' etc) and invertebrates (Shell fishes, insects etc) be influenced by on Bhagar swamplands for their entire life cycle while some other species only associated and depend on with these areas during certain stage of their life details presented in Table 2. [1,14,17] also reported the importance

of wetlands, mainly including water for irrigation, fisheries; non-timber forest goods water supply; and regeneration. They were also reported as a major services comprises of carbon sequestration ground water recharge, nutrient removal, toxic retention, bio diversity and flood control. [18,19] reported regarding hydrological condition are a key morphogenic factor and they also shape the aquatic environment of the oxbow lakes.

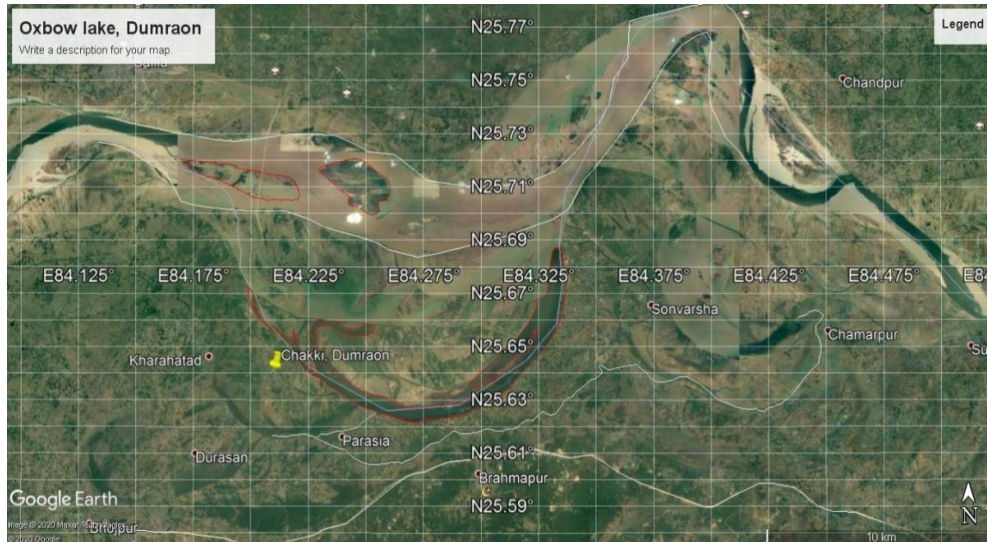


Fig. 2a. Google Earth image of Bhagar Oxbow lake, Dumraon, Buxar

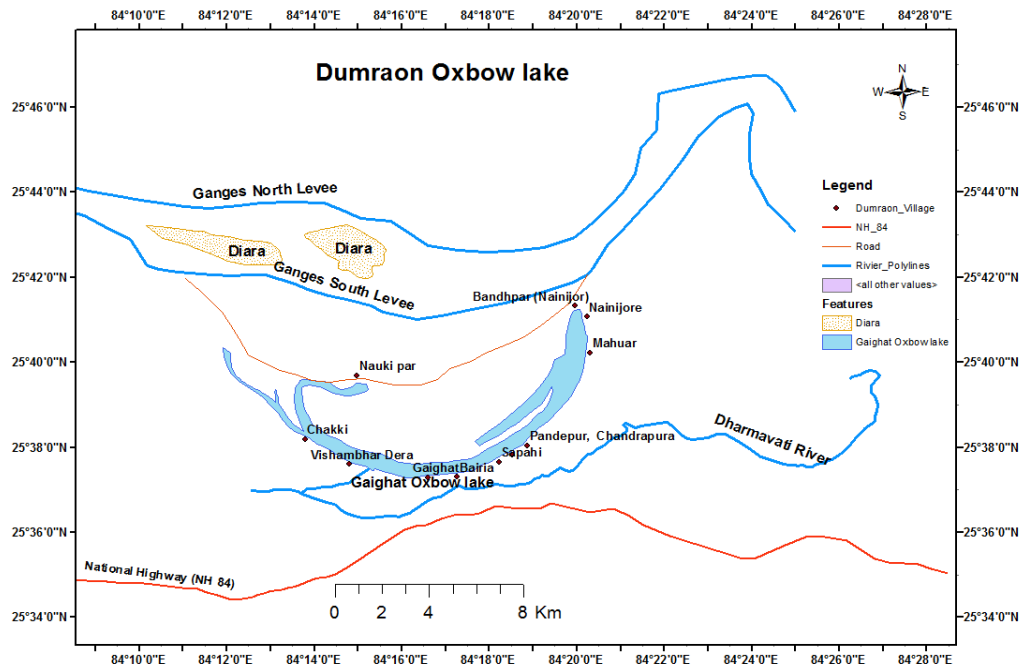


Fig. 2b. GIS map of Bhagar Oxbow lake, Dumraon, Buxar

Table 1. Village situated on bank of Bhagar Oxbow lake, Chakki to Nainijore, Dumraon

| S. N. | Name of the village | Longitude (E) | Latitude (N) | Water depth during summer (meter) |
|-------|------------------------------|---------------|--------------|-----------------------------------|
| 1 | Nauki par (near embankment) | 84.2500 | 25.6620 | 1.0 |
| 2 | Chakki | 84.2300 | 25.6360 | 1.0 |
| 3 | Vishambhardera (nala par) | 84.2460 | 25.6270 | 1.0 |
| 4 | Gaighat | 84.2760 | 25.6230 | 1.5 |
| 5 | Bairia | 84.2880 | 25.6230 | 1.5 |
| 6 | Sapahi | 84.3030 | 25.6280 | 1.5 |
| 7 | Panchphorwa, dallupur | 84.3090 | 25.6310 | 2.0 |
| 8 | Pandepur, chandrapura | 84.3140 | 25.6350 | 2.5 |
| 9 | Mahuar | 84.3380 | 25.6710 | 3.0 |
| 10 | Nainijore (near embankment) | 84.3370 | 25.6850 | 3.0 |
| 11 | Bandhpar (Nainijor) | 84.3330 | 25.6890 | 3.0 |

Table 2. Bhagar Oxbow lake uses in different services

| S. N. | Uses | S. N. | Uses | S. N. | Uses |
|-------|--------------|-------|----------------------------|-------|-------------------------|
| 1 | Irrigation | 5 | Nutrient reach soil | 9 | Flood control |
| 2 | Fisheries | 6 | Wild life biodiversity | 10 | Invertebrates diversity |
| 3 | Domestic | 7 | Ground water recharge | 11 | Vertebrates diversity |
| 4 | Fodder grass | 8 | Refuge for migratory birds | 12 | Agriculture |

3.2 Ecological Profile and Wildlife Hot Spots

The ambient temperature was noted its lowest of 14°C in January and steadily increased, maximum to 46°C being in July-August, whereas water temperature of Bhagar oxbow lake ranged from 16°C January to 30°C August. The pH value of lake water was found within the permissible limit i.e. 6.5 to 8.5 as per the ISI standard [20]. Highest value of (7.8) pH was observed during July and lower value of pH (7.0) in November-December. The transparency values were found to be within the range of 15 cm. (August) to 83.5 cm (February). It is a shallow water body with depth ranging between 1.0 to 3 meters in summer (Table 1); however a maximum depth of 4-6 meters during the monsoon months has also been recorded in certain pockets after the ingress of flood water from the river Dharmawati. Approximately 30% area of this lake is highly infested with submerged vegetation and aquatic weeds. Among them the floating weeds such as *Eichhormia crassipes* (floating) and *Hydrilla cillata* (submerged) are predominant (Fig. 3). [12] Reported regarding macrophyte communities, and the attached microflora are fundamental in structuring microbial metabolism and biogeochemical cycling at the ecosystem level of organization. Bhagar oxbow lake is the natural resources known for its high biological diversity,

many migrated birds species such as Heron and Crane from western and European countries come during winter. [21] reported regarding wetlands are useful for breeding area for wildlife and provide a refuge for migratory birds and numeral of species of wandering birds documented from India is between 1200 and 1300, which is about 24% of India's total bird's species. [22,23] also reported regarding wetlands were viewed as habitat sites for wildlife and significant international ramifications both as trans-boundary systems and as networks of habitats vital for migratory species, particularly with respect to integrated management of migratory birds.

It was observed that blackbucks (*Antelope cervicapra*) and blue bulls or nilgai (*Boselaphus tragocamelus*) spend the entire summer within the surrounding of the Bhagar oxbow lake plain areas like Simri, Chakki and Brahampur block for water & food (Fig. 4). This might be that, during summer, most of the water resources at upper part of Dumraon dry up. Hence it indicated that Blackbucks (*Antelope cervicapra*), swamp deer (*Rucervus duvaucelii*) and Nilgai (*Boselaphus tragocamelus*) migrated from the low laying plain (south) to the north plain of Dumraon due to scarcity of food and water [3,24,25] reported that blackbucks in summer may be wandered from long distance in search of water and food.



Fig. 3. Floating and submerge aquatic weeds in Bhagar Oxbow lake, in Dumraon



Fig. 4. Nilgai, *Boselaphus tragocamelus* & blackbucks, *Antelope cervicapra* in Dumraon



Fig. 5. Fin fishes and shell fishes harvested from the Bhagar oxbow lake in Dumraon

3.3 Fisheries and Livelihood

The oxbow lakes are considered as biologically profound environments as they play a dynamic role in the enrollment of fish populations in the riverine ecologies and afford nursery ground for larval stages of commercially important fishes in the northern and north eastern states of India [16]. The oxbow lake has provided more than 65 residential fishermen over the year. Fishing with hooks and lines is a hobby to many people residing near the Bhagar oxbow lake. During the summer period the average quantity of the fish harvested from the lake was 200 kg/day, while it was 300 kg/day during the monsoon seasons. In general, fishing activity is at its peak during the monsoon season. The monsoon is breeding season for most of the fishes. As per fishermen, the fish catch per unit efforts is decreasing continuously. It was observed that generally most of the fishermen are very poor, less literate or uneducated.

In the present investigation, forty four (44) species of fishes were identified in Bhagar oxbow lake. Some fish species like *Mystus spp.*, *Puntius spp.*, *Channa spp.* Gastropods and *Macrobrachium spp.* were found almost in all season. Some species such as *Anabas testudineus*, *Heteropneustes fossilis* and *Glossogobius giuris* were seasonal fishes especially during summer season. Fish species like *Notopterus notopterus*, *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Sperata aor*, *Mystus cavasius* and *Wallago attu* have been found abundant during monsoon season (migrating from Ganga river through Dhamawati river) under flood situation (Fig. 5). The local fisherman opined that carnivorous fishes like *W. attu*, *H. fossilis* and *Channa marulius* are becoming rare. Fish and shell fishes are a very important food stuff in developing countries due to its high protein content and somewhat other purposes viz, medicinal; nutritional values [26,27,6] reported that flood plain wetlands are highly sensitive and fragile in nature representing the transitional state between terrestrial and aquatic ecosystems. [5] reported regarding fish transportation & marketing in Dumraon and Buxar, he documented the main source of fishes in these fish markets came from Bhagar oxbow lake.

3.4 Opportunities and Possibilities

There are 20,000 species of fishes in the world and more than 40% species of fishes live in freshwater [16]. Bhagar oxbow lake is a habitat

to harbored birds, mammals, reptiles, amphibians, fishes and invertebrates. It is also wintering ground of the migratory birds such as Heron and Crane in the south western part of Bihar. Detail of opportunities & possibilities of the lake was summarized in Table 3.

Table 3. Opportunities and possibilities in Oxbow lake South Bihar

| S. N. | Possibilities |
|-------|---|
| 1 | National level swimming training centre |
| 2 | National level Boating training centre |
| 3 | National level disaster training centre |
| 4 | Freshwater fin Fish, & Shellfishes breeding & culture |
| 5 | Makhana and Singhara culture |
| 6 | Migratory birds Vihar |
| 7 | Wildlife conservation centre |

3.5 Types of Gear and Craft and Fishing Rights

Most of the fishermen used traditional fishing gear like lifts net, cast net, gill net & hooks lines. Butavoided fry net, due to bannedimposed by government. Among these, lift net and cast net were used by certain fishermen from time to time. The occurrence of weeds indicated the extreme eutrophication that is a factor towards the un-conductive ecological regime for fisheries development. The fisheries development in the lakes has to be centeredon the utilization or control of macrophytes to achieve the goal of sustainability. Small size fresh water prawn *Macrobrachium* species and other shell fishes such as *Pila globosa*, *Bellamya sp.* and *Lamellidence marginalis* dominantly occurs in the lake. They are ecological bio indicators, extensive consume detritus during the summer months. The fisheries resources of oxbow lake are auctioned annually by local fishermen co-operative society (Brahampur). The fishing right over this oxbow lake is vested under the jurisdiction of government or semi-government agencies.

4. CONCLUSION

Based on findings, it is concluded that Bhagar oxbow lake is rich in fin fishes and shell fishes diversity, offer livelihood support to fishermen and rich in biodiversity to attract migratory birds such as Heron and Crane and also protect many wild mammals such as Blackbucks (*Antelope cervicapra*), swamp deer (*Rucervus duvaucelii*) and Nilgai (*Boselaphus tragocamelus*) migrated

from the low laying plain (south) to the north plain of Dumraon due to scarcity of food and water.

ACKNOWLEDGEMENT

The first Author indebted to Honor'ble Vice Chancellor and Director Research, Bihar Agricultural University (BAU), Sabour, Bhagalpur for the financial assistance under research project no. BAU/SNP/NRM/Rabi/2017-6. Authors also wish to express his gratitude to the Associate Dean cum Principal, Bhola Paswan Shastri Agricultural College, Purnea for Co-operation in executing the serving work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Prasad SN, Ramachandra TV, Ahilya N, Songupta T, Kuma A, Tiwari AK, Vijayan VS, Vijayan L. Conservation of wetlands of India- A review. *Tropical Ecology*. 2002; 43(1):173-186.
2. Yim KQ, Ni JR. Review of wetland studies. *Acta Eco. Sinica*.1998;18(5):539-546.
3. Prasad S, Singh DK, Kumar U, Kumar S. Biodiversity and ecology of wild mammals in Dumraon, Buxar, Bihar. *J. Exp. Zool. India*. 2020;23(1):643-648.
4. Panigrahy S, Murthy TVR, Patel GL, Suthar NM, Kundu N, Paul M, Basu N. National wetland Atlas: Bihar Space Application Centre (ISRO), Ahmadabad and Institute of Environmental Studies and Wetland Management (IESWM), Kolkata. 2010;222.
5. Prasad S. Fish transportation and marketing in Dumraon and Buxar South Bihar India. *Journal of Entomology and Zoology Studies*. 2020;8(4):1634-1638.
6. Sinha VRP, Jha BC. Threatened wetlands need rehabilitation to enhance fish production in India. *Proc. Nat. Acad. Sci. India, Sect-B*. 2008;78:67-80.
7. Jha V, Verma AB, Jha P, Jha M. Wetlands in North Bihar provide a basis to its sustainable development. *Journal of Aquatic Biology and Fisheries*. 2014;(2): 843-851.
8. Kumar M, Prusty AK, Jeniffer PN. Ecosystem (provisioning) services and resource utilization pattern of an oxbow lake in Muzaffarpur urban Agglomeration, Bihar. *The Ecoscan*. 2013;(3):289-295.
9. Roy SP, Ramanand R, Prabhakar AK, Singh JP. Sustainable development of Kawar lake, Begusarai (North-Bihar, India), Proceedings of Taal 2007: The 12th World Lake Conference (editors, Sengupta M, Dalwani R.). 2008;1578-1585.
10. Sinha M, Jha BC. Ecology and fisheries of Oxbow lakes (Mouns) of North Bihar: A threatened ecosystem. *CIFRI, Bulletin*. 1997;74:1-109.
11. Sathi, Planners District survey report of minor minerals, Buxar, Ministry of Environment, Forest and Climate Change Notification. 2018;3611(E):1-70.
12. Wetzel RG, Sondergaard M. Submersed macrophytes for the microbial community and dynamics of dissolved organic carbon in aquatic ecosystems. In the structuring of submersed macrophytes in lakes Jepperson E, ma. Sondergaard MO, Sonddergaard SK. Christofferson (eds). Springer-verlag NY; 1998.
13. Boavida MJ. Wetlands: Most relevant structure and functional aspects, *Limnctica*. 1999;17;57-63.
14. Turnor RK, Bergh JC, Vanden MJ, Soderqvist T, Barendregt A, Straaten JV, Maltby E, Van Ierland EC. Ecological economic analysis of wetlands: Scientific integration for management and policy. *Ecol. Econ*. 2000;35:10:7-23.
15. Finlayson CM, Bellio MG, Lowry JB. A conceptual basis for the wish use of wetlands in Northern Australia. Linking information needs - integrated analyses, divers of change and human well-being. *Marine and Freshwater Research*. 2005; 56:269-277.
16. Chauhan DPS. Fisheries developmental scope in wetlands. *Fishing Chimes*. 2006; 26(1):243-251.
17. Bassi N. Kumar, Sharma DMA, Saradhi PP. Status of wetlands in India: A review of extent, ecosystem benefits, threads and management strategies. *Journal of Hydrology: Regional Studies*. 2014;(2):1-19.
18. Ward JV, Tocker K, Arscott DB, Claret C. Reverine landscape diversity. *Freshwater Biology*. 2002;47;517-539.
19. Obolewski K, Lewczuk KG, Ozgo M, Astel A. Connectivity restoration of flood plain lakes: An assessment based on macro-invertebrate communities. *Hydrobiologia*. 2016;774:23-37.
20. Bis-2296, Tolerance limits for inland surface water subject to pollution; 1982.

21. Agrawal M. Migratory birds in India: Migratory birds dwindling. In Nature. 2011; 21.
22. Mack GD, Flake LD. Habitat relationships of waterfowl broods on South Dakota Stock pond. J. Wildlife Management. 1980; 44:675-700.
23. Davidson NC, Stroud DA. Water bird flyways and the history of international co-operation for water bird conservation. In: Finlayson CM, Middleton B, MC Innes RJ, Enverard M, Irvine K. Van Dam AA. Davidson NC. Editors, the wetland Book1: Wetland structure and function management and methods. Dordrecht: Springer; 2016.
24. Prasad S, Singh DK, Chaudhary SK. Residential population structure and abundance of Nilgai *Boselaphus tragocamelus*, (Pallas) in Bihar, India. Currant Journal of Applied Science and Technology. 2020;39(13):110-117.
25. Meena R, Chaurasia V. Forage availability and feeding preference of blackbuck, *Antelope cervicapra* (Linn.) in Sorsan, Rajasthan, India. International Journal of Current Advanced Research. 2017;06(11): 7370-7373.
26. Prasad S, Kumar S, Kanaujia DR. Production performance and potential of freshwater prawns in India. Proc. Zool. Soc. India. 2005;4(1):17-25.
27. Prabhakar A, Roy SP. Ethno-medicinal uses of some shell fishes by people of Koshi river basin on North Bihar, India. Ethno Med.2009;3(1):1-4.

© 2020 Prasad et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/60694>