

GIS Based Inventorization of Fishes in River Ganga



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Abstract

Geographic information system is being applied to various studies to efficiently manage information and project it for decision making and planning purposes. One such application of GIS has been in inland fisheries to inventorize availability and distribution of fish species in river Ganga at selected sampling stations. The stations were distributed in four stretches along the entire course of river Ganga from source to sea. Fish samples were not only taken from the main channel but also from adjacent landing centres. Data collected was organised and analysed in the GIS environment using ARC-GIS 9.3. The study was steered towards observing the species distribution in years 2017 and 2020 and changes that took place during that time span. Among other stations, Bijnor recorded the highest number of species while Harsil recorded the lowest number of species.

Keywords: River Ganga; GIS based data inventory; Fish availability; Abundance

Introduction

Geographic information system (GIS) can be recommended for designing of spatial survey through analysis of spatial data [1]. The application of GIS has been used for many different tasks in fishery biology that involve a spatial dimension, including mapping fish habitats and analyzing spatial and temporal changes in fish distributions, determining the effects of land use on fish populations [2-4]. A GIS can be used to assist with the design of surveys and provide a rational basis for the selection of sites from a river network [5]. Fish species and assemblage relationships with habitat have been studied using two primary approaches that relies on small-scale studies of microhabitat use or habitat partitioning and large-scale studies to test for assemblage patterns that are correlated with environmental variables [6]. Understanding the species - and assemblage-habitat relationships of large river fishes has been historically limited by the large size and spatial complexity of river ecosystems.

However, a GIS constructed with remotely sensed physical data that are spatially explicit for individual occurrences of organisms by species should provide ecologists with appropriate tools to detect habitat use patterns for species and assemblages in these ecosystems [4].

In India, the Ganga is revered as Mother Ganga and has been the source of life for thousands of years, being mentioned

in oldest scriptures [7,8]. Impact of manifold increase in human population along the bank of a river is adversely affecting the river waters through discharge of toxic contamination in most of the rivers and there is no exception for river Ganga. In fact, river Ganga passes through three very densely populated states, namely, Uttar Pradesh with 829 persons per sq. kms [9], Bihar with 1106 persons per sq. kms [9] and West Bengal 1028 persons per sq. kms [9]. This strong anthropogenic influence inflicted a sharp deterioration of water quality with increased levels of harmful elements in river water beyond permissible limits [10-13]. Hence, the obvious impact was also observed in the habitat of native fish species found in the riverine ecosystem. The alteration of habitat, illegal fishing, pollution, introduction of invasive fish species has become threatening to fish diversity as 29 fish species were recorded under threatened category in Ganga river [14]. In an effort to organise the fish species availability and distribution on GIS platform, an attempt was made to create an inventory of fish species in Ganga river system. This would not only account for the species available but would also be a repository from where data can be retrieved whenever required for further analysis, for example to calculate species abundance at a particular stretch. The study narrows down the broad and vast aspects of the river to focus upon the richness of fish species aggregating and distributed over the entire stretch of river Ganga. Analytical studies carried

out through remote sensing and GIS can give a structural support to decision makers and planners to assess the urban and rural impact upon sustainable management of aquatic biodiversity in river system of Ganga.

Materials and Methods

Study area

Ganga River is the most important source of water flowing through the northern to the eastern parts of the country

stretching across 77° 58' 47.44" E longitude to 88° 30' 37.89" E longitude and 22° 18' 6.43" N latitude to 31° 2' 49.31" N latitude. The present study was conducted at Nineteen sampling stations namely Harsil, Tehri, Haridwar, Bijnor, Narora, Farrukhabad, Kanpur, Prayagraj, Varanasi, Buxar, Patna, Bhagalpur, Farakka, Berhampore, Balagarh, Tribeni, Godakhali, Diamond Harbour and Frasersganj covering Uttarakhand, Uttar Pradesh, Bihar and West Bengal for data inventorization of fish availability as well as distribution (Figure 1).

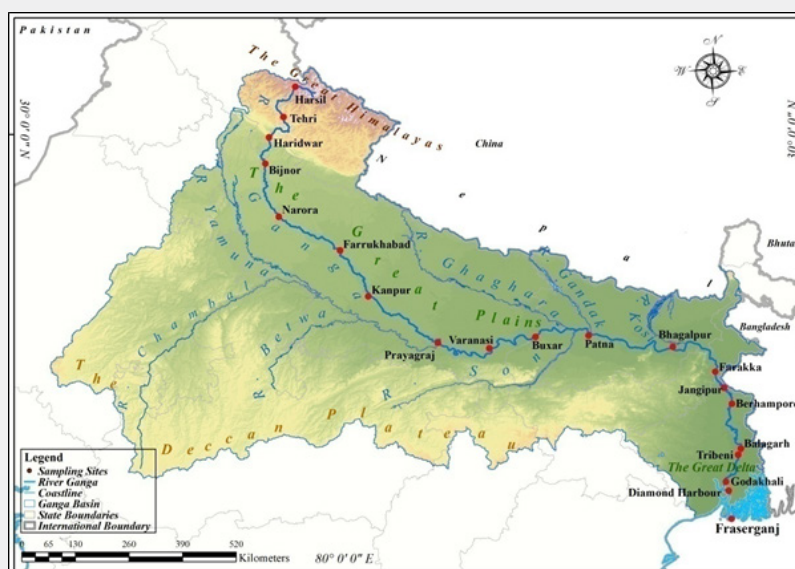


Figure 1: Map showing course of river Ganga along with the sampling stations.

The sampling stations were divided into 4 divisions. The study area is focused upon the stations observing the diversity of fish species as well as the accessibility at each sampling station along the river course. Stretch 1 spreads from Harsil to Bijnor and is known as the upper stretch, Stretch 2 spreads from Bijnor to Varanasi and is known as the Middle stretch Stretch 3 spreads from Buxar to Nabadwip and is known as the Lower stretch and Stretch 4 spreads from Nabadwip to Frasersganj and is known as the Estuarine stretch.

Collection and identification of fish sample

The fish samples were collected from the main river channel as well as adjacent landing centres. Various selective and non-selective gears like gill nets, seine nets, set barrier and falling nets, cast nets, drag nets, bag nets, traps etc. were selected for the fish catch from the selected sampling station during this period. The fish specimens were identified using the taxonomic characteristics as per [15-18].

Data analysis through GIS

Line format of vector data has been generated to demarcate the main channel of river Ganga. These have been used for mapping twenty sampling locations in the form of point vectors.

Each point represents an individual sampling station having all species information attached as attributes to the same table. The total number of fish species found along the river at all the stations taken together aggregated up to 190. Each species was distributed uniquely throughout this stretch and their distributions were represented in separate layers. This resulted in the creation of 190 layers as individual species distribution for each species. They were then used along with other layers to compute thematic layers and subsequently compose maps using ARC-GIS 9.3 software.

Results

The present study revealed that a total of 190 fish species were recorded along Ganga River stretch. The highest number of fish species was found at Bijnor (107 species) close to foothills of the Himalayas, followed by Narora which recorded the second highest number of fish species (95 species) and Farakka at the third highest position recorded (86 species) (Table 1 and Figure 2). Only two species have been recorded from Harsil in 2020 accounting for the lowest number of species recorded. A detailed species composition for Bijnor has been depicted in a map in (Figure 4).

Table 1: The changing pattern of fish species distribution during 2017-2020.

Stations	No. of Species (2017)	No. of Species (2020)	Change in No. of Species (2017 to 2020)
Harsil	1	2	1
Tehri	3	8	5
Haridwar	10	26	16
Bijnor	69	107	38
Narora	68	95	27
Farukhabad	37	83	46
Kanpur	48	83	35
Prayagraj	67	85	18
Varanasi	63	83	20
Buxar	58	79	21
Patna	53	67	14
Bhagalpur	60	68	8
Farakka	77	86	9
Berhampore	57	76	19
Balagarh	62	67	5
Tribeni	44	62	18
Godakhali	21	33	12
Diamond Harbour	34	38	4
Fraserganj	62	66	4

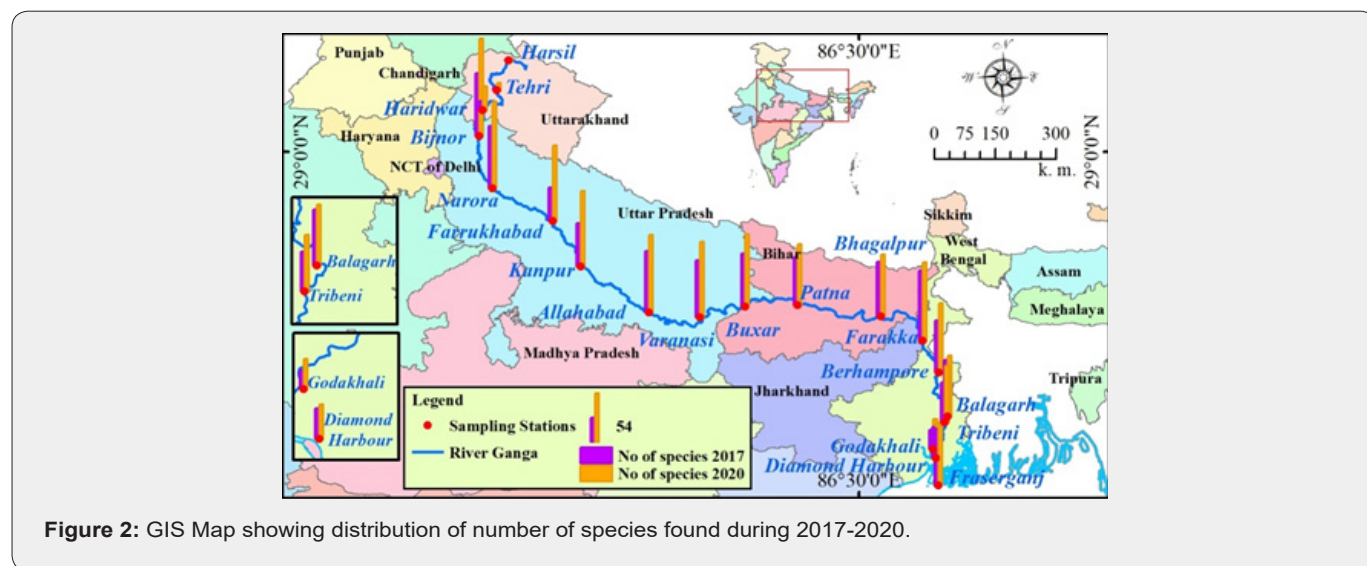


Figure 2: GIS Map showing distribution of number of species found during 2017-2020.

A change in the number of species from 2017 and 2020 has also been observed in this study. An encouraging fact has been observed as an increase in the number of fish species for all of the sampling stations (Figure 3). The highest observed being for Farukhabad and the lowest for that of Harsil. The observation also shows an average increase of more than 50% in the number of fishes species considering all the sampling stations from the source to the sea. Farukhabad has shown the highest amount of increase with a difference of 46 species between 2020 and 2017.

This was followed by Bijnor and Kanpur both having a difference of more than 30 species between 2020 and 2017. Narora, Buxar and Varanasi have recorded a difference of 20 and more than 20 species each between the same time span. Berhampore, Tribeni, Prayagraj, Haridwar, Patna and Godakhali all have recorded an increase of more than 10 species from 2017 to 2020. Rest of the stations, namely, Farakka, Bhagalpur, Tehri, Balagarh, Diamond Harbour, Fraserganj and Harsil have a difference of less than 10 species increase between 2017 and 2020 (Figure 4).



Figure 3: GIS Map showing increase in number of species found in each sampling station during 2017 – 2020.

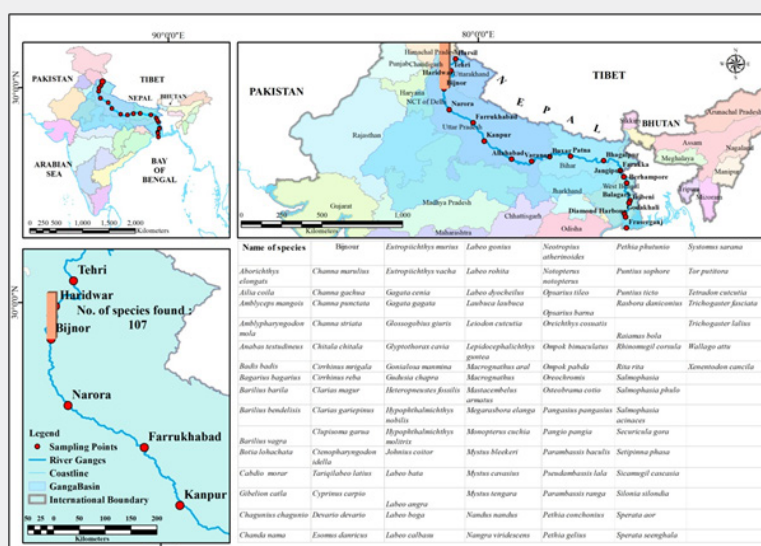


Figure 4: Location of sampling stations with their species composition.

Discussion

The use of GIS in ecological studies allowed identification of the habitat resolution as well as perform as a repository system for fish distribution along Ganga River stretch. The associated fish distribution and assemblages are predicted to change with this physical variation [19,20], but details for long stream reaches or entire streams are still unknown. The fish distribution and habitat specific classification were reported based on GIS framework and the habitat was found greatest for fish species richness with quality of entire stream as well as suitable water quality [21]. Temporal variation in physical attributes of streams [22] is expected with flow events including floods, droughts, or anthropogenic alterations (dams, dewatering, etc.) [23-25] and associated fish distribution and assemblages are predicted to change [26]. It may be assumed from [24] and the current analysis, that with every occasion of fresh supply of water brought by tributaries,

moribund condition within the river water has been rejuvenated to support increased number of species. Highly populated areas with point and non-point sources of contamination do diversely affect species richness in a river system [27]. Fish species may decrease or increase in abundance based on their traits [28], but detailed studies of fish assemblage responses to temporal variation in physical stream habitat only exist for small streams and short reaches [29].

The presence of a very high number of fish species in Bijnor cause presence of less pollutant at upper stretch of Ganga as the river water was found suitable for drinking after disinfection, irrigation and other household purposes [30] may be indicative of the large volume of mineral rich fresh water brought down from upper reaches by river channels at the foot hills which act as an influencing ecological factor for fish species richness and their distribution [31]. At Narora, contamination of river water has not

yet set in to adversely affect the richness of species found at the particular station. Harsil and Tehri have a highly elevated location and lesser volume of water that negates the favourable conditions for a higher number of species to be found there. The rise in species richness at Haridwar, may be attributed to the confluence of rivers Alakananda and Mandakini, which enrich the ecosystem as well as enhance fish diversity [32]. At middle stretch of Ganga River, from Farukhabad up to Farrakka Barrage, variation was observed in fish species diversity among different stations. There was a significant increase in number of fish species, indicating improvement of aquatic habitat. The responsible factors for alteration of fish habitat may be hydrological diversion, dam construction, pollution, siltation, overfishing and introduction of exotic fish species [14]. In stark contrast to this within a distance of approximately 127.26 kms south east of Farrakka Barrage at Berhampore there is a sudden drop in species to 76 which may be attributed to the construction of Farakka barrage affecting the natural riverine environment for many fish species along with estuarine fishery as well as associated factors [33]. However, the fish species diversity was recorded quite low at Balagarh (67) and Tribeni (62). The major reason may be pollution arising from thermal effluent from Tribeni Thermal power plant and also industrial effluent from adjacent industrial areas.

As the river passes from Tribeni through the metropolitan city of Kolkata, it reaches Godakhali only about 30kms south – east of the city. The stations of lower estuary like Godakhali, Diamond Harbour and Fraserganj receive tidal waters from the estuary that enrich the ecosystem. Hence, the environment became favourable for fish species assemblage. Higher number of fishes were recorded from lower estuary of river Ganga as the estuarine zone establish the connection between freshwater and adjacent marine areas, providing passages for migratory fish species for different biological activities [34]. Though, the usages of destructive fishing gear had obvious effect on fish juvenile catches [35] thereby, leading to rapid declination of fish stock in estuarine ecosystem.

Additional applications of GIS were also reported earlier to examine habitat use (niche breadth) and availability of suitable habitat for stream fishes [36] found high variation in seasonal niche breadth and available habitats using a GIS for a stream fish assemblage. In the present study, the overall changes in fish diversity were observed in increasing trend through the stretch of river Ganga. To visualize the changing pattern of fish structure on a GIS platform makes it simpler for understanding. The increasing trend of fish assemblage structure indicates the improving water quality of riverine health condition. Large riverine systems are most significant resource for human. Community specific fish-based index has been developed earlier for assessing as well as monitoring the large riverine ecology [37,38] as fish was identified one of the suitable biological indicators for evaluating condition of aquatic health [39].

Conclusion

The GIS database can behave as a repository of all data that can

be mined for every customized need of clients. Representations in tabular format is vastly different from those of graphical format with the later giving a clear understanding of not only the figurative values but also an easy procedure to understand impression of associated information. In an attempt to represent distribution of richness of fish species, GIS can enable the creation and maintenance of a data repository in the form of a database. Appropriate maps generated in accordance with definite client requirements can simplify understanding of complex interactions of natural phenomenon graphically represented through ARC-GIS. Fish species richness at sampling stations has found a technologically advanced method of representation by GIS. With progress of research and advanced specialized needs of humanity, this could be adapted to develop more sophisticated fishery information system.

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