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GIS Application in Mapping and Development of Trout Fisheries Resources along Yargyap Chu Drainage in Eastern Himalayas

Deepjyoti Baruah*,Ravindra Posti, Parvaiz A. Ganie and KishorKunal

ICAR-Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital (Uttarakhand)

ABSTRACT

A study was carried out by using Geo-informatics on the basic morphometry of the aquatic resources of Shi Yomi district of Arunachal Pradesh in the Eastern Himalayas with an objective to develop strategic plans for trout fisheries development along the drainage system of river YargyapchuatMenchukha circle. The river Yargyapchuflows a distance of 53 km and have a stream frequency of fourth order. The upland lake resourcesaccounts6 in numbers and covers an area of 39.15ha.Eight categories of Land Use Land Cover (LULC) were classified for the Menchukha circle where the major percentage of land is covered by forest (80percent) followed by snow area (10percent), wasteland (9percent) and agricultural land (1percent). The slope class developed from Digital Elevation Model (DEM) shows 41percentof the total geographic area was within 0-21 degree slope, 50percent area in 21-35 degree slope and 9percent area within 36-78 degree slope. Furthermore, the elevation class up to 2000m MSL and above encompasses 76percentand 24percentof the total geographic area respectively. These selected input feature classes were superimposed in the spatial analyst ArcGIS v 10.7 to determine 27.84 ha in the slope range of 0-10 degreeas highly suitable and 22.34 ha in the slope range of 10-20 degree as moderately suitablefor trout fish farmingin the Menchukha circle of Shi Yomi district.

Key Words: Coldwater, Eastern Himalayas, Fisheries, Resources and Spatial.

INTRODUCTION

The district of Shi Yomiin Arunachal Pradesh is locatedbetween94°00′–94°60′Elongitudeand28°15′ – 29°00′ N latitude sharing international boundaries withChina in the north and district boundaries with Upper Siang in the east, Upper Subansiriin the west and West Siang in the south (Fig. 1). The Shi Yomidistrict encompasses an area of approximately 2803.02 km^{2}and is divided into four administrative circles *viz.,* Menchukha, Monigong, Tato and Pidi with the district headquarters at Tato. All these circles experience very moderate climate in summer and autumn (March to May and October to November) and extreme cold during the winter season (December to February). The South-West monsoon season from June to September brings heavy rainfall to the district. Most of the high peaks in this district are covered with snow during winter. The river Yargyapchu flows through the valley of Menchukhacircle and the name Men-chu-kha means medicinal water of snow where 'men' is medicine, 'chu' is water and 'kha' is snow (Baruah *et al*, 2018).

Recreational fisheries in the form of angling together with trekking, rafting, paragliding and camping have become much prevalent in recent times on the river Yargyapchu. The river is known for harbouring the exclusive exotic brown trout (*Salmotruttafario* L, 1758) and rainbow trout {*Oncorhynchusmykiss*(Walbaum, 1792)} along with seven more fish species belonging to four families in this eastern Himalayan belt of the country (Anon, 2014).The existing fish diversity and the aquatic resources of the region are largely influenced by the nature of these terrains varying climate from sub-tropical in the south to temperate and alpine in the north (Baruah and Singh, 2018). Despite of having such vast resources in this

Corresponding Author's Email: deep_baruah@rediffmail.com

region, very less attention has been made for their judicious utilization to develop income generating avenues and a means of nutritional security among the rural mountain dwellers of Eastern Himalayas. Therefore, a study was conducted by integrating GIS tools and ground information in developing a supportive database for framing strategic developed action plans for trout fisheries improvement in hill locked Menchukha valley of Arunachal Pradesh.

MATERIALS AND METHODS

Spatial Analysis

The area, district boundaries and aquatic resources of Shi Yomi district were identified and demarcated using the shape file data and Toposheetson scale 1:50000. Land use land cover (LULC) classification was adopted using NRSA 1995 classification scheme for making eight major land use classes. The Digital Elevation Model (DEM) and slope map of the study area was obtained from USGS (https://www.usgs.gov). The road network was digitized and road buffer was generated on similar lines. Digital globe Quick Bird and ASTER satellites data were imported on to the system and were subsequently geo-referenced, digitized and mapped for the resources of Shi Yomiusing suitable geo-processing tools of ArcGIS v 10.7.

Non-spatial Analysis

Different locations within the Menchukha circle of Shi Yomi district was marked by handheld GPS GARMIN Oregon 650. Water samples were collected and estimated from various aquatic resources during field survey with officers and local fishermen adopting the standard methods (APHA, AWWA and WPCF, 2005). Fish samples were collected by using cast nets and line fishing (Baruah, 2014)andthe morphometric and meristic counts of the specimenswere recorded (Jayaram, 1999).

RESULTS AND DISCUSSION

Drainages

The river Yargyapchu is the major drainage in the Menchukha circle of Shi Yomi district flowing for a distance of 53 km before it joins river Siyom near the district headquarter Tato (Fig. 2). The river Siyom further travels downstream to merge into the river Siang in East Siang district. The length of river Siyomwithin Shi Yomi district is about 59 km gorging through very steep slopes in the upper section at Monigongcircle.The river Siang is the main source of water to the mighty Brahmaputra in Assam.

Stream Order

The first step in drainage basin analysis is the labelling of streams order wise and it was estimated the river Yargyapchu is afourth order stream. The first order streams are the most in numbers followed by second order and so on in all the circles (Fig. 3). The first order streams within the Menchukha valley are 296 in numbers and flows for a combined distance for 481.03 km; the second order streams are 75 in numbers and has a combined length of 139.25 km; the third order streams are 29 in numbers and flows for a distance of 85.95 km; the fourth order streams are 4 in numbers and flows for a distance of 74.69 km. The first order streams are snow fed and therefore they remain perennial always and pour their water into second and third. The final order stream (here the fourth order) is generally advised not to be considered for establishing a trout farm due to the chances of getting the drainage overflowed with excess water causing a flood situation. Therefore, the sites along the first, second or third order streams are selected for construction of trout raceways and ova houses based on the gradient in the Menchukha circle.

Upland lakes

Upland lakes form an important geographical component of Eastern Himalaya as a source for the development of aquaculture and recreational fisheries for revenue generation. From the geo-spatial analysis, it was found that the district of Shi Yomi is bestowed with 41 numbers of upland lakes covering an area of 219.74 ha. The total number of upland lakes in the Menchukha circle is 6 situated at an altitudinal regime between 3500-

4000m MSL (Fig. 4).The developmental drift of a water body is mainly determined by its location and its connectivity with the road transport lines, especially in a hill locked areas where railway and air connectivity is not prevalent. The buffer analysis showed that all of the upland lakes are scattered within the range of 5-10 km from their nearest road transport lines (Fig. 5). The road buffer analysis provides herewith the necessary information on the possibilities of transportation of critical inputs in the form of fish seeds, feeds and individuals in this hilly terrain of the eastern Himalayas, in order to design strategic plans for development of these wetlands on fisheries perspectives.

Land use and land cover (LULC)

Information on land use and land cover allows a better understanding of the land utilization aspects for planning and management activities as it is considered as an essential element for modelling and understanding the earth feature system. Eight categories of LULC were classified for Menchukha circle of Shi Yomi district (Table 1). Forest covers 80percent of the total area and occupied by hills and mountains. Snow area occupies 10percent of the total area and 6 upland lakes were found scattered at an altitude ranging between 3500-4000m MSL in Menchukha circle. Wasteland occupies 9percent of the total area which may consist of marshy, swampy and unutilized water-logged areas. Agricultural land occupies 1percent of the total area of the region. Human habitation is sparsely distributed in the district. Fig. 6 shows the distribution of the major land use land cover categories of the study area.

Digital elevation model and Slope

A digital elevation model **(**DEM) is defined as 'any digital representation of the continuous variation of relief over space' (Burrough, 1986), where relief refers to the height of earth's surface with respect to the datum considered such as Mean Sea Level (MSL). The DEM studies infer herewith that the Menchukha circle is classified into four different elevation gradients (Fig. 7). The elevation class ranging from below 1000m to 2000m MSL encompassing 76percent of the total geographic area can provide the most suitable sites for undertaking aquaculture activities provided the other conditions are conducive. The elevation class ranging from 2000m to 3000m MSL encompassing 24percent area represent moderate aquaculture suitability sites.

The percentage share of different slope degree classes of the study area is represented herewith by a colour map (Fig. 8). The slope class 0-21 degree in green colour comprising 41percent of the total geographic area has better probability in considering potential sites for undertaking fisheries developmental activities as compared to slope class 21-35 degree (50 % area) and the slope class 35-78 degree (9% area) of the Menchukha region.

Table 1. Land use land cover categorization of Shi Yomi district.

Sr. No	Land use category (Area in ha)	Menchukha Circle	Shi Yomi District
1	Agricultural land	4.08	4.08
2	Built up	2.32	4.10
3	Forest	621.37	2136.56
4	Grassland & Grazing land	0.18	0.46
5	Shifting Cultivation	3.16	15.83
6	Snow / Glacier area	75.31	486.55
7	Wastelands	67.11	189.11
8	Water bodies	2.97	10.93

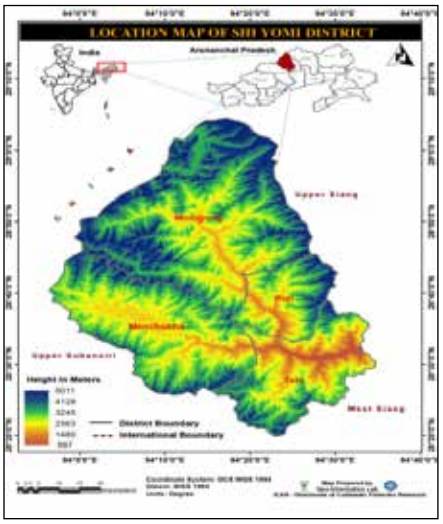

Fig. 1: Location of Menchukha valley in Shi Yomi district in India

Fig. 2: The major aquatic resources of Shi Yomi district

Fig. 3: Stream order in Menchukha circle

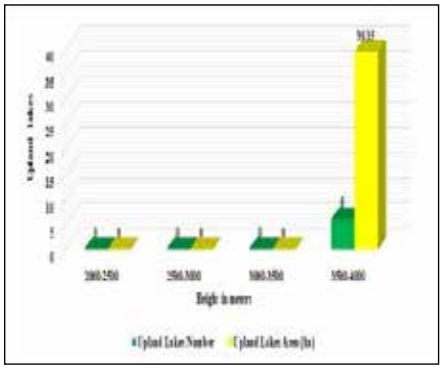

Fig. 4: Altitudinal distribution of upland lakes at Menchukha

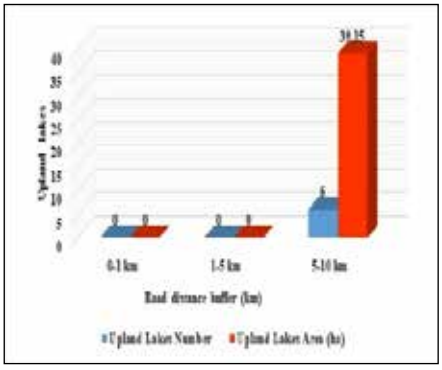

Fig. 5: Distribution of upland lakes from the road

Fig. 6: LULC of Menchukhacircle

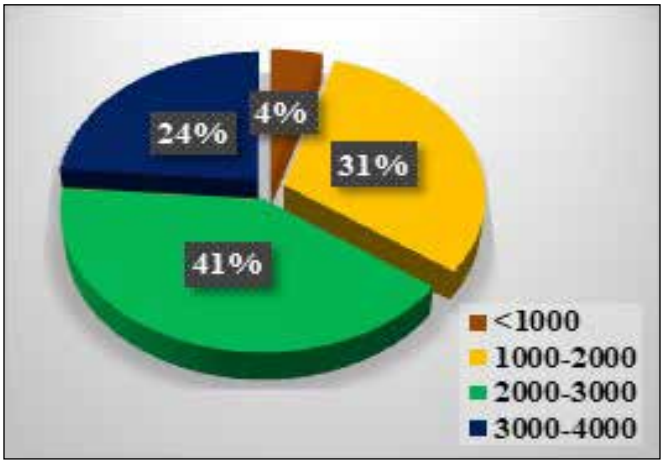

Fig. 7: Percentage share of different elevation gradients of Menchukha region

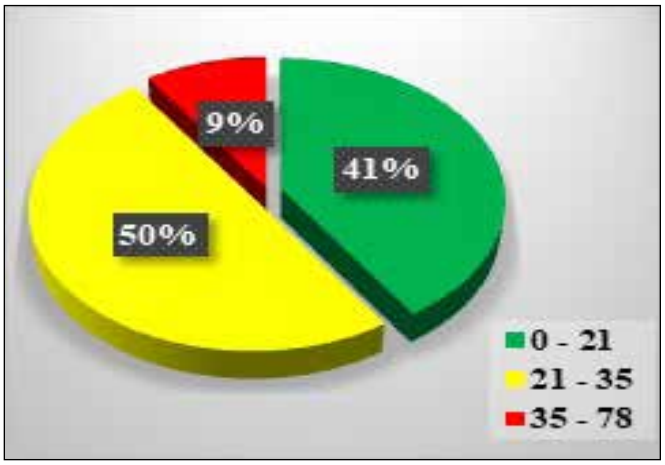

Fig. 8: Percentage share of different slope degree classes of Menchukha region

The trout fisheries

The most sought after the trout group for recreational and aquaculture avenues in the coldwater regime of the Menchukha valley are the brown trout (*Salmotruttafario*Linnaeus, 1758) and rainbow trout {*Oncorhynchusmykiss*(Walbaum, 1792)} respectively.

Trout angling

The river Yargyapchu flowing through the valley of Menchukha harbour a good population of brown trout stocked since 30 yrs, as a result of concerted effort made by the Department of Fisheries, Govt. of Arunachal Pradesh in the past. The largest catch of the brown trout recorded during the present investigation was of 3 kg in weight and 55 cm in length. The average catch of the brown trout in the river was of 16.70 cm in length and 100-150 g in weight. The earlier catch of brown trout recorded in the river was of 12.5 kg size as reported by the avid anglers of the valley (Baruah *et al*, 2019). Brown trout, therefore, can be an ideal candidate species in the region for promotion of angling fisheries on a tourist platform by inviting avid anglers worldwide and organizing angling competitions based on 'catch and release' practice. In this pursuance, GPS coordinates were taken over the probable breeding grounds of the brown trout along the river Yargyapchu and its adjoining streams. These GPS coordinates were put into a line for considering a10 km stretch of the river as 'Trout Protected Zone' (Fig. 9) as a measure for conservation and propagation of brown trout. The field analysis of the abiotic and biotic components of the river water was found extremely conducive for trout survival and auto recruitment (Table. 2).

Trout aquaculture

The success of any aquaculture project or fish farming depends to a large extent on the proper selection of the site to be developed into a fish farm or fish hatchery. The utilization of Remote Sensing and Geographic Information Systems (GIS) is considered to be the most favourable option by employing different input feature classes. The features taken as input criteria to designate the probable potential areas for trout farming in Shi Yomiwere - Drainage network buffer for 200m,

Table 2. Major water quality parameters of river Yargyapchu and its adjoining streams.

Water quality parameters	Dorjeeling Phujchu	Dolong Phujchu	Gyapchu	Gyapchu	Yargyapchu
Temperature (°C)	8.90±0.42	12.70±0.20	8.43±0.12	13.40±0.26	8.50±2.26
Air temperature (°C)	12.33±0.58	13.67±1.53	13.00±0.00	14.67±0.58	13.00±1.00
pH	8.53±0.12	8.00±0.20	7.57±0.06	7.30±0.10	8.07±0.42
DO (mg/l)	6.70±0.41	6.70±0.10	7.06±0.04	7.71±0.07	7.09±0.13
Total hardness (mg/l)	75.00	75.00	75.00	75.00	75.00
TDS (ppm)	25.33±1.15	24.67±1.15	12.00±0.00	37.33±1.15	30.00±2.00
Turbidity (NTU)	<10.00	<10.00	<10.00	<10.00	<10.00
Conductivity (µS/cm)	010	011	00	020	001
Nitrate (mg/l)	<0.10	<0.10	<0.10	<0.10	<0.10
Iron (mg/l)	<0.20	<0.20	<0.20	<0.20	<0.20
Fluoride (mg/l)	2.50	2.50	2.50	2.50	2.50
Chloride (mg/l)	10.00	10.00	20.00	20.00	10.00
Altitude (m msl)	1967	1931	2030	1957	1934

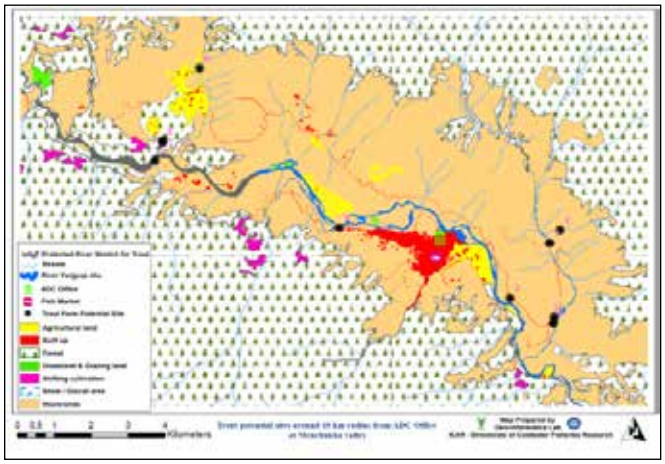

Fig. 9: Map on trout protected area and potential sites for trout aquaculture

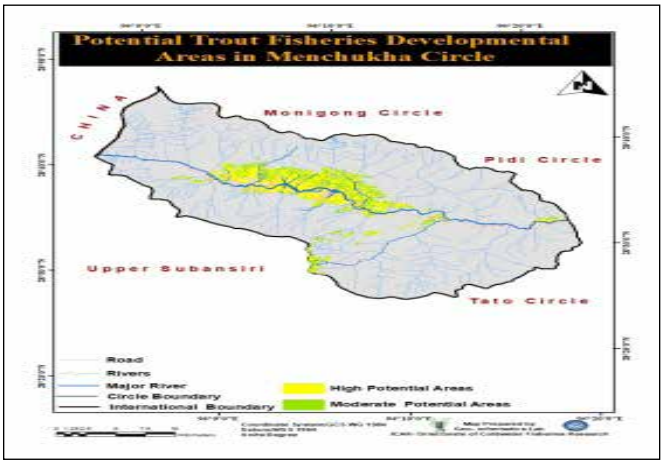

Fig. 10: Map of potential fisheries development areas

Road network buffer for 5 km, Slope class of 0-10 degrees and 10-20 degrees of the region and Land Use Land Cover (LULC) comprising wasteland and agricultural land. Based on these above facts, the selected input feature classes were superimposed in the GIS environment and probable trout fish farming areas were identified (Fig. 9&10). An area of 27.84 hain the slope range of 0-10 degree and an area of 22.34 ha in the slope range of 10-20 degree was found suitablein the entire Menchukha circle of Shi Yomi district for undertaking trout farming.The two lone trout hatcheries established in the State of Arunachal Pradesh along Nuranang stream (27.535 N, 92.050 E) at 3674 m MSL in Tawang district and Shergaon (27.133 N, 92.277 E) at 1980m MSL in West Kameng district can serve the source of trout eyed eggs or young ones for Menchukha trout farms(Baruah*et al*, 2017).

CONCLUSION

The identification and management of habitats of these trout fishes can be much effective with spatial assessment of the aquatic resources and understanding the range of land use pattern affecting their distribution. Advancements in spatial technologies such as global positioning systems, geographic information systems, remote sensing, satellite imagery and toposheets blended with non-spatial information revolutionized the ability to spatially represent resources relevant to the decision context by integrating hardware, software and data for capturing, managing, analyzing, and displaying geographically referenced information. The integration of GIS with site suitability criteria depicted in this communication is expected as supportive database in framing strategies and developing action plans for fisheries improvement in remote hill locked state of Arunachal Pradesh.

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REFERENCES

Anonymous(2014).Environmental Impact Assessment for Pemashelpu HE Project (81 MW). West Siang district, Arunachal Pradesh, Final Report,RSEnviro link Technologies Pvt Ltd.

APHA, AWWA and WPCF (2017). Standard methods for examination of water and wastewater, 23rd edition. American Public Health Association, 800, Street, NW, Washington DC.

Baruah D (2014). Indigenous bamboo-made fishing implements of Assam. *J Krishi Vigyan* **3** (1): 37-41.

Baruah D and Singh N D (2018).Rice-Fish Cultivation of Apatanis: A high altitude farming system in Arunachal Pradesh. *J Krishi Vigyan* **7**(1): 187-191.

Baruah D, Ganie P A, Kunal K, Posti R, Chisi K and Yonggam T (2019).Trout fisheries resources and potentialities at Menchukha region of Arunachal Pradesh. *Aquaculture Asia* **23**(3): 30-39.

Baruah D, Kunal K, Sarma D, Ahmad P, Sharma P, Singh A Kand Singh N D (2018). Aquatic biodiversity in upland streams of kameng drainage in Arunachal Pradesh. *J Krishi Vigyan* **7**(1): 10-15.

Baruah D, Kunal K, Sarma D, Singh A K, Kamut K and Thungon P K (2017). Trout fisheries in the uplands of Arunachal Pradesh: Resources and opportunities. *Aquaculture Asia* **21**(2): 3-11.

Burrough PA (1986). Principles of Geographic Information Systems for Land Resource Assessment, Monographs on Soil and Resources Survey No. 12, Oxford Science Publications, New York.

Jayaram K C(*1999)*. *The freshwater fishes of the Indian region*. Narendra Publishing House, Delhi-110006, India.551 p.

National Remote Sensing Agency (NRSA) (1995).Integrated Mission for Sustainable Development.Guidelines for Field Survey and Mapping, 52.

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