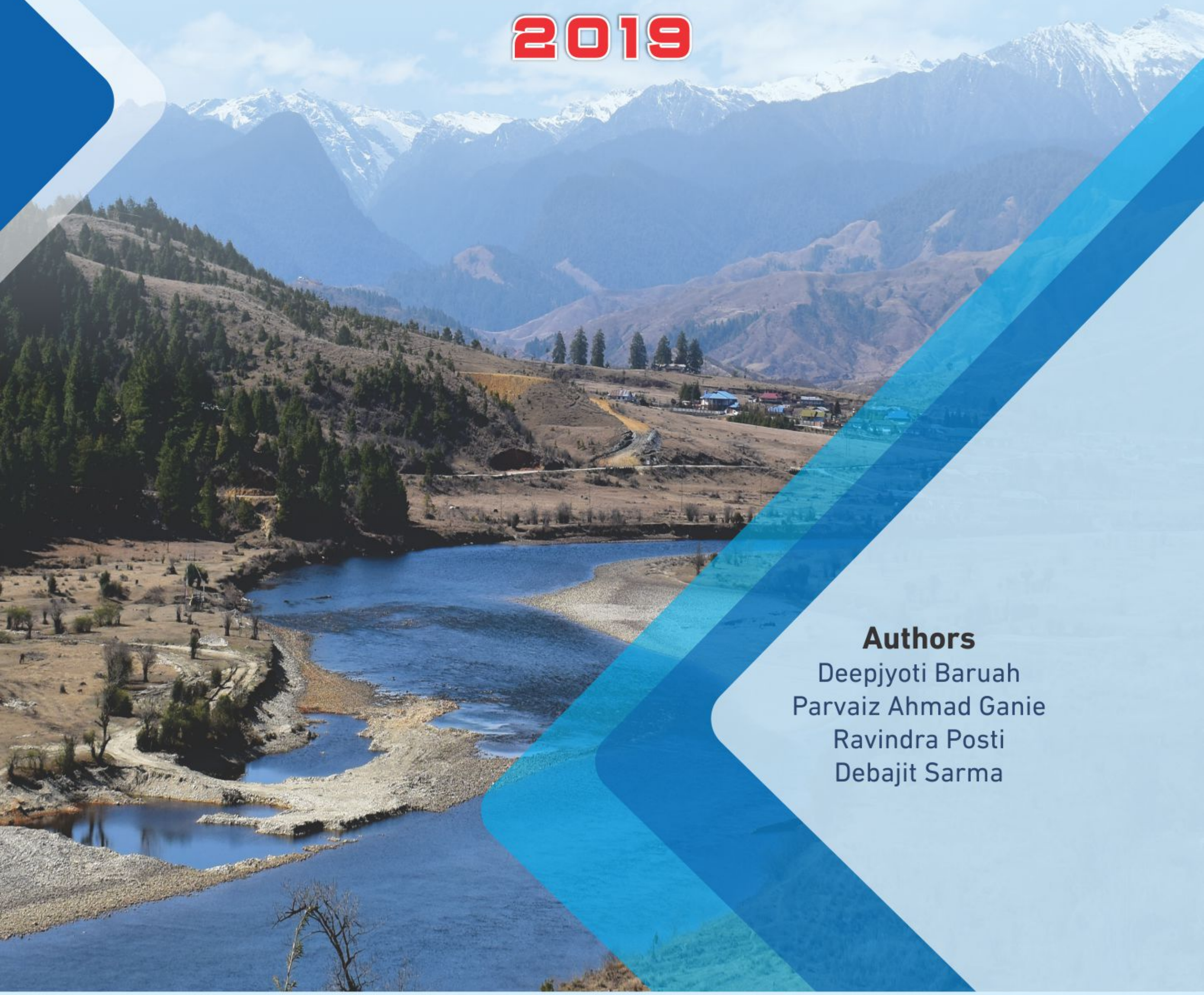
Bulletin No.32

TROUT FISHERIES DEVELOPMENT IN SHI YOMI DISTRICT, ARUNACHAL PRADESH: A ROAD MAP THROUGH GEOSPATIAL APPLICATION

2019



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FOREWORD

The hill regions of the country is bestowed with vast and varied aquatic resources which provides ample opportunity for the culture and capture fisheries. The most important need of the hour is the valid assessment of these available resources which are mostly in the domain of coldwater fisheries sector. The use of Geospatial Application has opened the avenues for immense opportunities in large scale mapping, digitized updating of existing resources, planning and decision making. Assessment of aquatic resources in hill regions has also become imperative due to natural and anthropogenic factors resulting on geomorphological change over a period time. Therefore, fisheries management in the coldwater sector requires multidisciplinary approaches to maximize fisheries production and in taking decisions for the sustainable utilization of the available aquatic resources.

In present study, shape-file data collected from North-Eastern Space Application Centre (NESAC), Umiam; toposheets from Survey of India were used together with Digital globe Quick Bird and ASTER satellites data to map the aquatic resources of a newly curved out district Shi Yomi in the state of Arunachal Pradesh. The document contains comprehensive information on the aquatic resources of Shi Yomi District with commercial fisheries importance, which can be used by the stakeholder as a roadmap for fisheries management, planning and development. The effort made by the authors is appreciable in bringing out this technical bulletin.

(Debajit Sarma)
Director

CONTENTS

1. Introduction

Arunachal Pradesh – the Land of the Rising Sun, encompassing with an area of 83,743 km^{2}and lying between 26.28° N and 29.30° N latitude and 91.20° E and 97.30° E longitude is the largest state in the North eastern region of India sharing international boundaries with Bhutan in the west, China in the north and Myanmar in the east. The states of Assam and Nagaland flank its Southern and South eastern borders. The State is administratively divided into 25 districts at present. The people have a rich heritage of arts and crafts with their own distinct and diverse culture, dialects and lifestyles. The state is inhabited by 28 major tribes and 110 sub-tribes, and therefore is considered as the 12th mega biodiversity region of the world and is the richest biotic province of Republic of India (Agarwal, 1999). The landscape of the state is characterized by dense forests, turbulent streams, roaring rivers, deep gorges, lofty mountains, snow-clad peaks and rich diversity of flora and fauna. The climate varies from sub-tropical in the south to temperate and alpine in the north with large areas experiencing snowfalls during winter. The state is bestowed with five major river drainages viz., Kameng, Subansiri, Siang, Lohit and Tirap. All these river valleys are snow fed and give rise to numerous numbers of aquatic resources in the form of rivulets, streams, reservoirs, lakes, rice-fish terraces, ponds and tanks. Fishes are habitual living components of these water bodies. It is reported that the Indian Himalayan Region holds variety of fish species of which most thrive in coldwater aquatic bodies. The upland water resources of the Indian Himalayan Region (IHR) stretching from Jammu & Kashmir to Northeastern states comprises 258 species, belonging to 21 families and 76 genera, out of which, a maximum of 255 coldwater fish species are recorded from Eastern Himalayas, 203 from the West and Central Himalayas and 91 from the Deccan plateau (Vass *et al*., 2005). A checklist by Sarma *et al*., (2018) classified 6 orders, 18 families and 54 genera, enlisting 138 endemic species which represents about 32.7% of total reported fish species of Northeast India (422 species) and about 53.5% of total upland species (258 species) recorded from India. The river system of Arunachal Pradesh is reported to harbour 213 species of fishes belonging to 11 orders, 31 families and 93 genera (Bagra *et al*., 2009), 259 fish species under 105 genera, 34 families and 11 orders (Gurumayum *et al*., 2016), of which 108 species under 54 genera and 17 families belong to coldwater region (Gurumayum and Tamang, 2017). A total of 44 species of fishes belonging to 4 orders and 9 families' wereidentified in river Siyom of Shi Yomi district of Arunachal Pradesh. The most dominant species of fishes are categorized under family Cyprinidae followed by Balitoridae (Bagra and Das, 2010). Similarly the fish diversity of the other major drainage of Shi Yomi district (Fig. 1) namely Yargyap chu is comprised of 7 species belonging to 4 families with Cyprinidae and Balitoridae families represented by 2 species each (Final Report for Menchukha Hydro Power Private Limited, 2014). The low diversity of fish species in Yargyap chu may be attributed owing to very cold temperatures in this high altitudinal regime.In addition, exotic fish species such as rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792); brown trout, *Salmo truta fario* Linnaeus, 1758; and common carp, *Cyprinus carpio* Linnaeus, 1758 has been introduced in the river. The brown trout has been reported to have a good population at Yargyap chu as reported by the avid anglers and local villagers of the region. The identification and management of habitats of these 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,satelliteimagery 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 (Everitt *et al*. 2003, Tugend and Allen, 2004). The integration of GIS with site suitability criteria depicted in this technical bulletin is expected as supportive data base in framing strategies and developing action plans for fisheries improvement in hill locked state of Arunachal Pradesh.

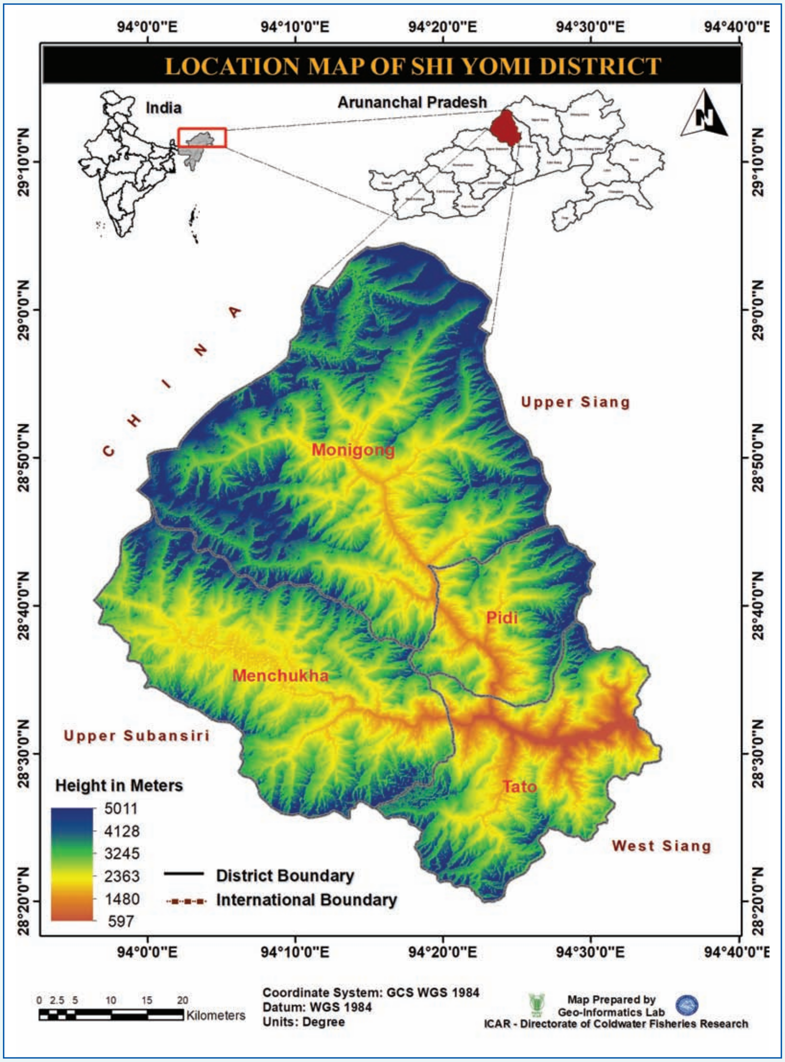

Fig. 1: Location Map of Shi Yomi District

2. Methodology

2.1 Spatial Analysis

The area and the boundaries of Shi Yomi district were identified and demarcated using the shape file data provided by North-Eastern Space Application Centre (NESAC), Shillong. Boundary points of the four circles namely Menchukha, Monigaon, Pidi, and Tato of the district Shi Yomi were located after discussion with the Fisheries officials of Government of Arunachal Pradesh. Digital globe Quick Bird and ASTER satellites data were imported on to the system and were subsequently geo-referenced, digitized and mapped using suitable geo-processing tools of ArcGIS v 10.7, an Environmental Systems Research Institute, Inc. (ESRI, Inc.), USA software of GIS. NRSA 1995 classification scheme was adopted for making eight (8) major land use classes, i.e., i) Agricultural lands; ii) Built-up land; iii) Forests; iv) Grassland & grazing land; v) Shifting cultivation; vi) Snow/glacial area; vii) Wastelands and viii) Water bodies. The DEM of the study area was obtained from USGS (https://www.usgs.gov) and classified into different elevation classes by employing the spatial analyst tools of the ArcGIS v 10.7. Similarly, the slope map was generated dynamically from DEM by employing the spatial analyst tool of the ArcGIS v 10.7. The road network buffer was generated by employing the Buffer analysis using the spatial analyst tool extension of the ArcGIS v 10.7 wherein digitized road network was used as input feature class. Based on the maps generated on land use land cover and aquatic resources, the land and fisheries resources (river and wetland), soil maps of Shi Yomi district of Arunachal Pradesh were estimated quantitatively respectively using GIS analysis tools. Toposheets (82 L/2, 82 L/6 and 82 L/7) of 1969-70, 1962-64 and 1963-64 respectively of Survey of India on scale 1:50000 were used for naming the aquatic resources. For the purpose of spatial analysis of the location of the wetlands along the major transport lines, buffer analysis was conducted with the help of ArcGIS v 10.7. The digital elevation model (DEM) was successfully processed for generating

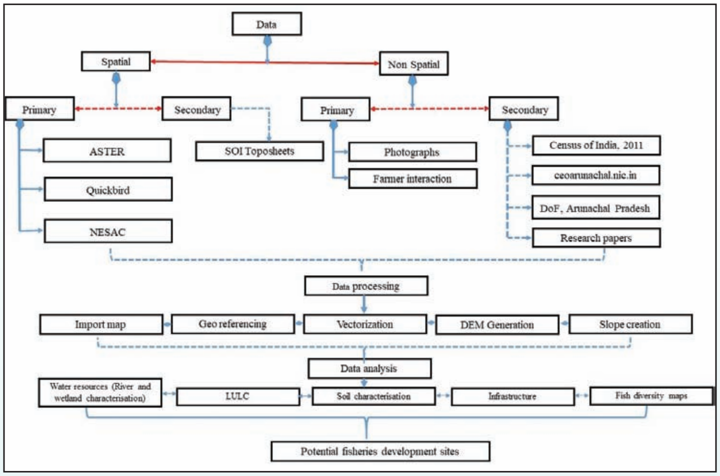

Fig. 2: The flow chart of the methodology followed for data analysis

the stream network and other supporting layers. The parameters such as stream order, stream length and stream frequency were studied by following the methodologies of Horton (1945), Strahler (1952), Chorley (1957) and employing the standard hydrological module of ArcGIS v 10.7. The flow diagram including data procurement, data processing and data analysis of developed methods for delineation of the study area is as shown in Fig. 2.

2.2 Non-spatial Analysis

The water samples were collected from Menchukha circle of Shi Yomi district from different locations marked by handheld GPS GARMIN Oregon 650. Water samples were collected during field survey such as temperature (^{O}C), pH, dissolved oxygen (mg/l), CO_2 (mg/l), TDS (ppm), hardness (mg/l), Turbidity (NTU), nitrate (mg/l), Iron (mg/l), Fluoride (mg/l) and Chloride (mg/l) and were estimated adopting standard methods (APHA, AWWA and WPCF, 2005) and the average value for the different locations are presented in later section of this document.

3. Aquatic resources of Shi Yomi district

The aquatic resources in this bulletin have been addressed to the major rivers, their connecting channels, streams and the wetlands in the form of upland lakes. An attempt was undertaken to study the basic morphometry of major river basins, labeling of streams orders and estimating the area of wetlands, their location, connectivity to road and the altitudinal regime.

3.1 Drainages

Shi Yomi district has two major drainage systems–Siyom and Yargyap chu (Fig. 3). The length of river Siyom within Shi Yomi is about 59 km with very steep slopes in the upper section of the river valley. The river originates from Monigong Circle and flows through Tato, Payum, Kaying, Darak and Aalo Circles of West Siang and finally joins the river Siang in East Siang district. The important tributaries of the Siyom or Yomgong drainage are river Jishing, Siri, Shiet Shir, Sittin, Pabon and Shishit.

Yargyap chu is the other major drainage flowing through the Menchukha circle. This river flows for a distance of 53 km before it joins river Siyom near the district headquarter Tato. Other important rivers draining into Yargyap chu are Netsang Gongphu chu, Gaptse chu, Segang Shuru, Shuruphujo, Sae chu, Dutangphu chu, Shashirongishi and Bum chu etc.

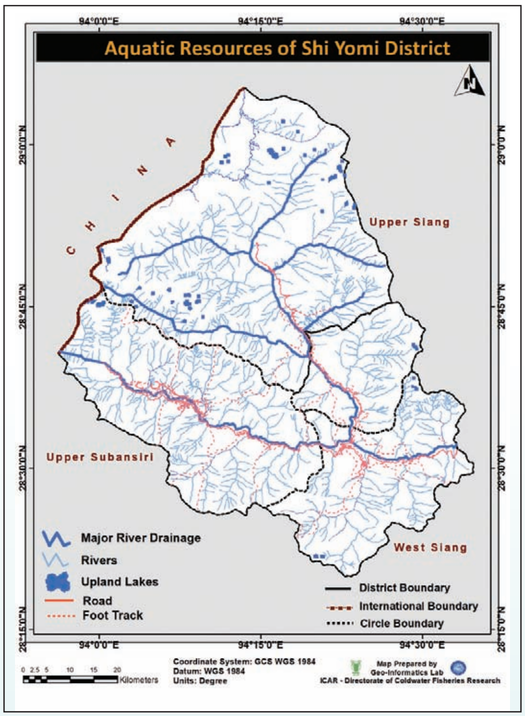

Fig. 3: The river resources of Shi Yomi District

3.2 Wetlands

Wetlands 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 wetlands in the form of upland lakes covering an area of 219.74 hectare. Approximately 68% of these wetlands are situated at an altitude ranging from 4000-5000m MSL and 32% of the wetlands lies in the altitudinal regime of 3000-4000m MSL. The average size of the wetlands (in area) under the altitudinal regime of 4000-5000m MSL is 7.08±12.17 hectare and under 3000-4000m MSL is 3.55±4.42 hectare. The minimum and maximum size of these wetlands under 4000-5000m msl is 0.09 and 51.98 hectare whereas the minimum and maximum size of wetlands under 3000-4000m msl is 0.03 and 18.74 hectare respectively.

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 about 70.09% of the wetlands are scattered within the range of 10-20 km from their nearest road transport lines followed with 53.90% within 5-10 km. In both the cases, the wetlands are laid at an altitudinal regime of 4000-5000m MSL. The distribution of these upland wetlands in accordance to their distance from the nearest road connectivity is depicted in (Fig. 4). As roads are considered the best mode of transportation for supply of critical inputs in the form of fish seeds, feeds and individuals in this hilly terrain of the eastern Himalayas, the buffer analysis provides herewith the necessary information for designing strategic plans and programmes for development of these wetlands on fisheries perspectives.

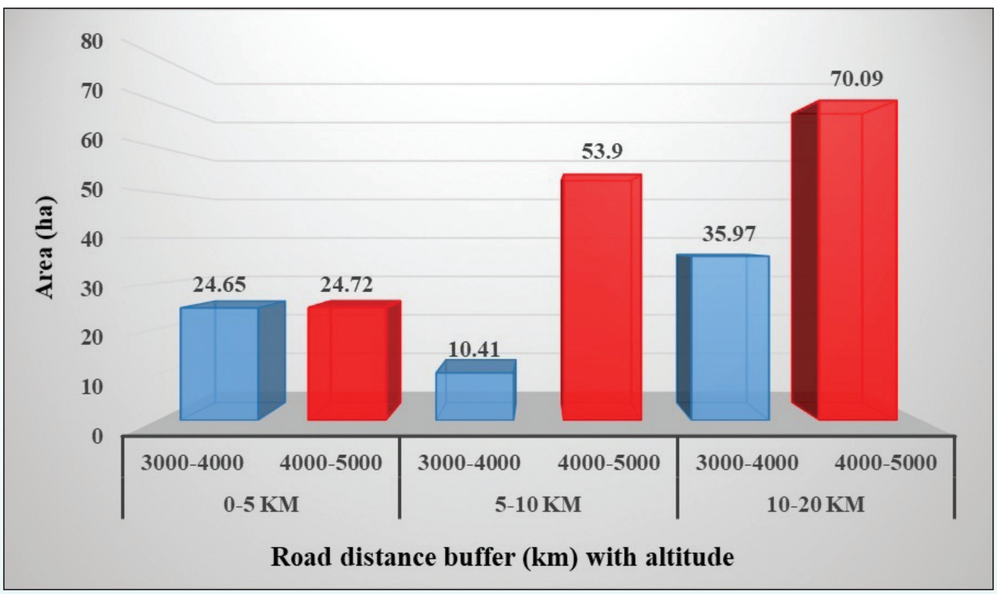

Fig. 4: Distribution of wetlands (area wise) at different altitudinal regimes and accessible distance in Shi Yomi district

3.3 Stream Order

The first step in drainage basin analysis is the labelling of streams order wise and it was estimated that both the rivers are of fifth order. The first order streams are maximum in numbers followed by second order and so on in all the circles. Also the first order streams flow for a total length of 1592.51 kms in the entire region with maximum in Monigong circle and least in Pidi circle (Fig. 5). Likewise, the second order streams flow for a total length of 419.65 kms with maximum in Monigong circle and least in Pidi circle. In the case of third order streams, total cumulative flow length is about 247.62 kms, out of which maximum is in Monigong circle (107.26 kms) followed by Menchukha, Tato and Pidi respectively. The fourth order streams which are formed when two third order streams join together flow for a distance of about 180.99 km of which 74.69 km is covered in Menchukha circle while the remaining distance is covered in Monigong, Tato and Pidi in decreasing order respectively. As fifth order stream, the river flows for a distance of 16.95 km only in Monigong circle of the district. The details of frequency and length of different stream orders of each circle of the district are presented in Table 1 and Fig. (6-10).

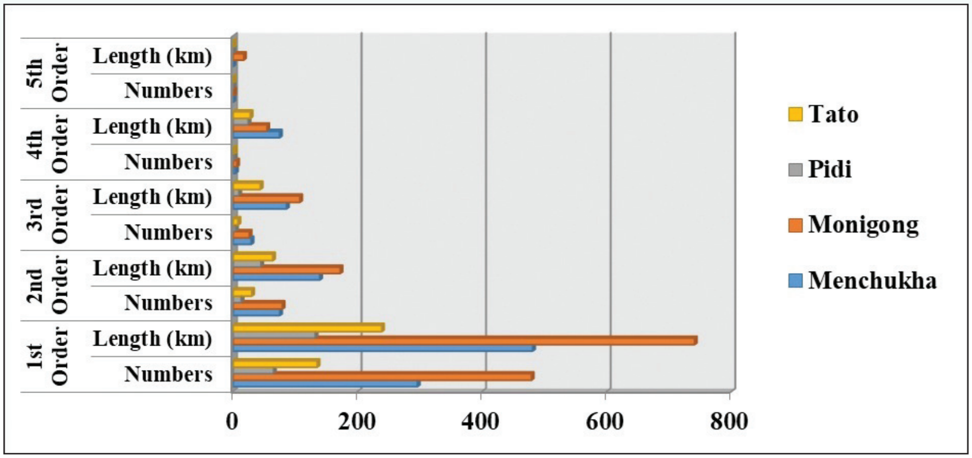

Fig. 5: Stream order of river system in Shi Yomi district

Table 1: Stream order, stream frequency and stream length of Shi Yomi district of Arunachal Pradesh

S. No	Circle Name	1st Order Number/ Length (km)		2nd Order Number/ Length (km)		3rd Order Number / Length (km)		4st Order Number / Length (km)		5th Order Number / Length (km)
1	Menchukha	296	481.03	75	139.25	29	85.95	4	74.69	
2	Monigong	479	740.97	79	172.03	26	107.26	6	54.33	1/16.95
3	Pidi	65	131.93	13	44.69	4	9.34	2	24.29	
4	Tato	135	238.58	30	63.68	8	43.72	2	27.68	
5	Shi Yomi	975	1592.51	197	419.65	67	246.27	14	180.99	1/16.95

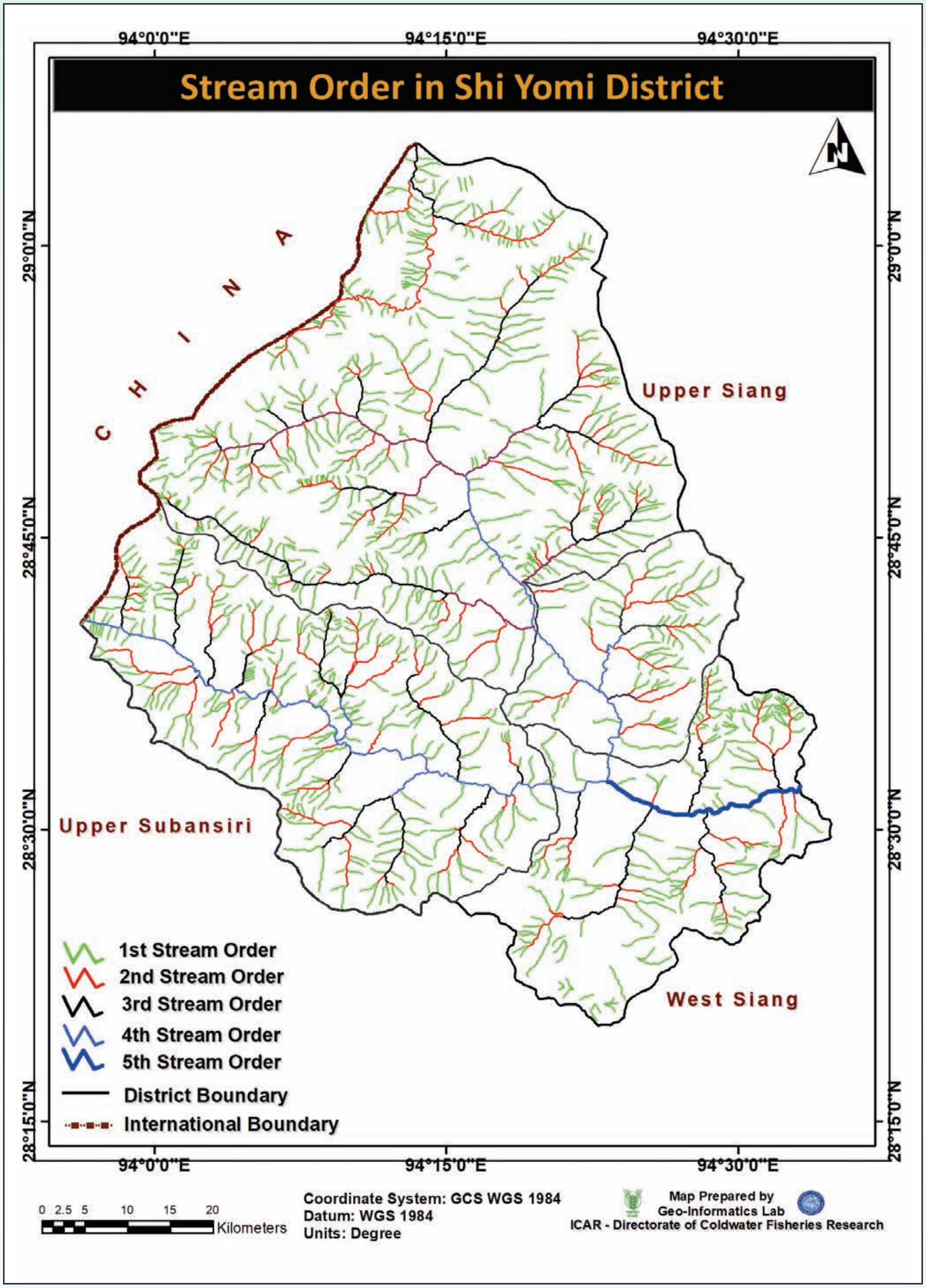

Fig. 6: Stream order of river system in Shi Yomi district

Fig. 7: Stream order of river system in Menchukha Circle

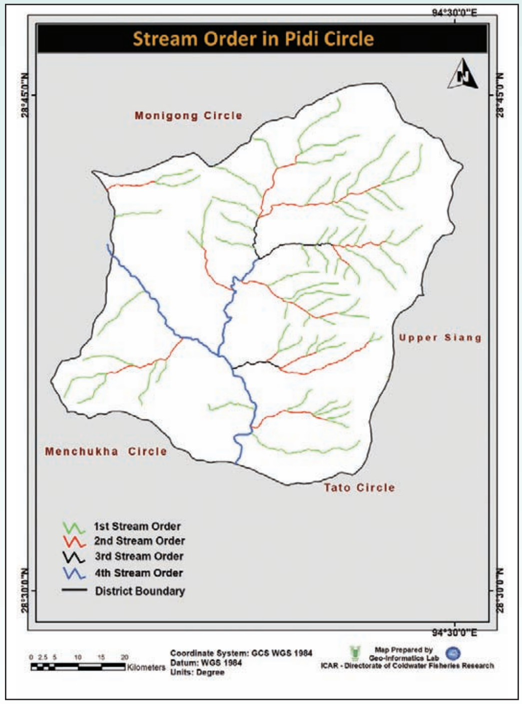

Fig. 8: Stream order of river system in Pidi Circle

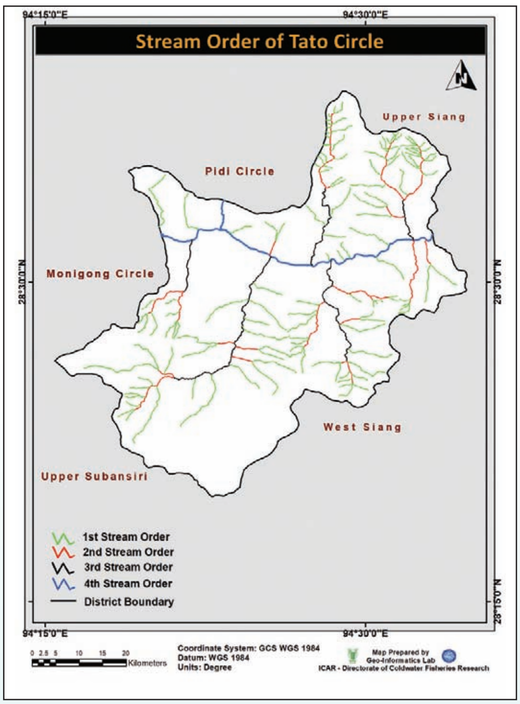

Fig. 9: Stream order of river system in Tato Circle

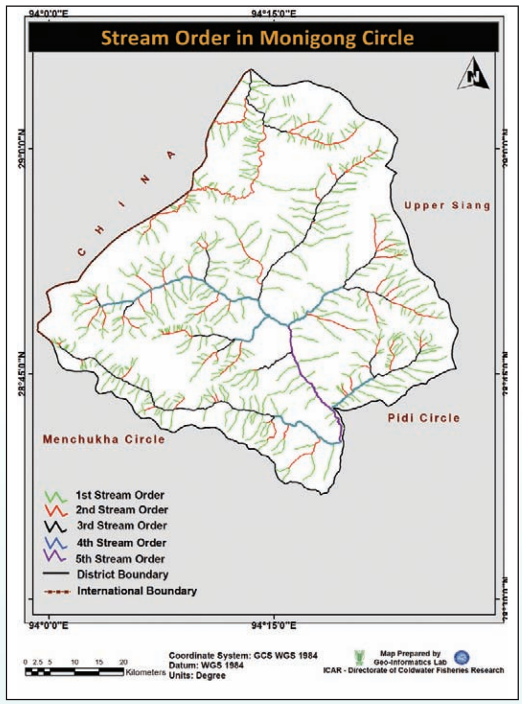

Fig. 10: Stream order of river system in Monigong Circle

4. Land use and land cover (LULC)

The knowledge of land use and land cover is important for planning and management activities as it is considered as an essential element for modelling and understanding the earth feature system. The term land use relates to the human activity or economic function associated with a specific piece of land, while the term land cover relates to the type of feature present on the surface of the earth (Lillesand and Kiefer, 2000). Information on land use or land cover provided in this bulletin allows a better understanding of the land utilization aspects (Table 3) which are vital for development planning.

Eight categories of LULC were classified for each circle of Shi Yomi district which include agriculture, settlement, forest, grazing land, wasteland, water bodies, shifting cultivation and glacial area. Forest covers 75% of the total area and occupied by hills and mountains. Snow area occupies 17% of the total area and is mostly distributed in Menchukha and Monigong circles. 41 wetlands were found scattered at an altitude ranging between 3000-5000m MSL in Shi Yomi district. Wasteland occupies 7% of the total area which may consist of marshy, swampy and unutilized water-logged areas. Human habitation is sparsely distributed in the district. Fig. 11 shows the distribution of the major land use land cover categories of the study area. The land use land cover of the district reflects the significance of land as a finite resource for human intervention for fish production coupled with economic growth (Fig. 12-16).

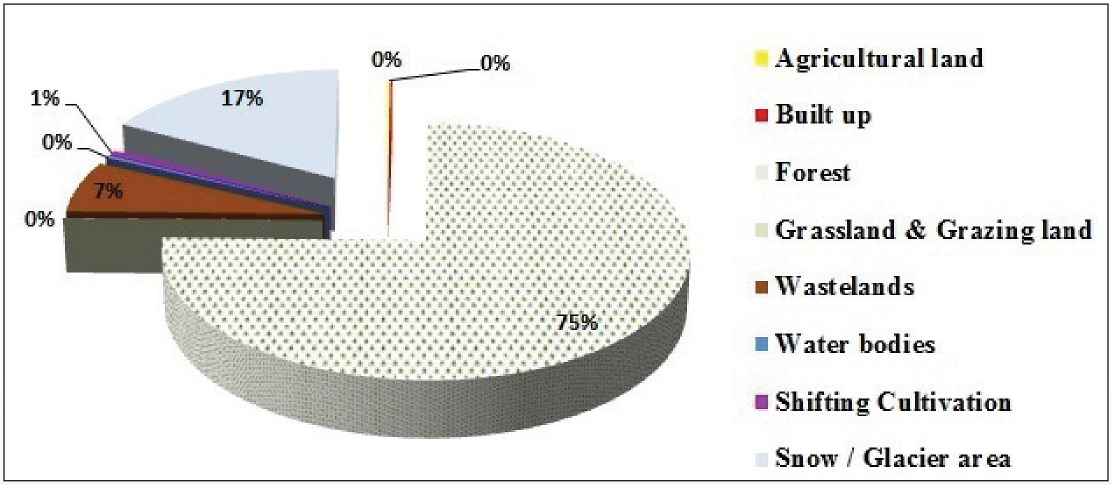

Fig. 11: Land use and land cover area of Shi Yomi District

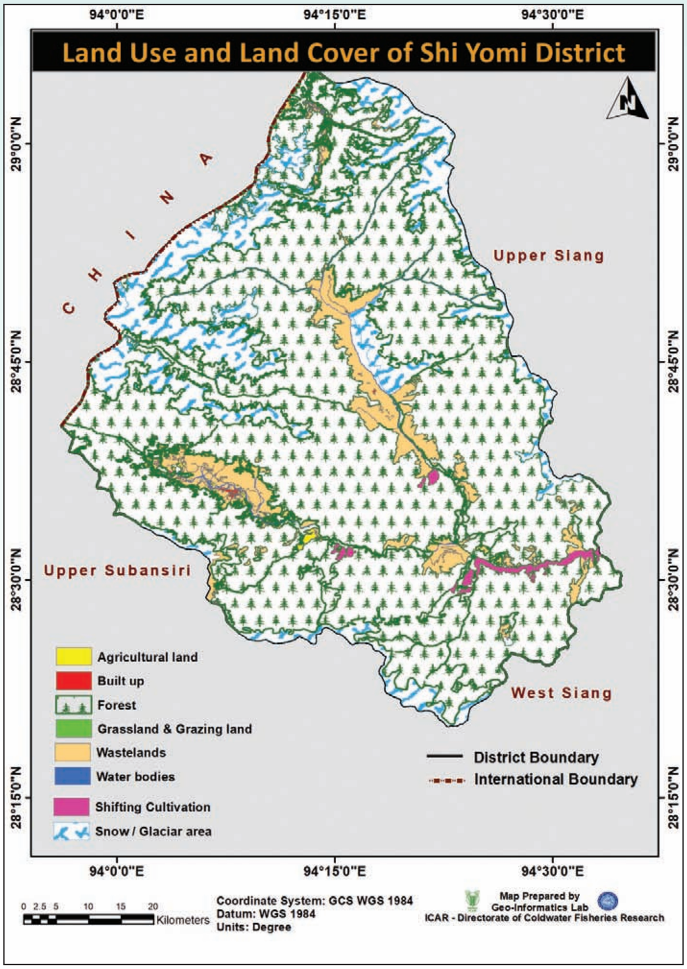

Fig. 12: Land use land cover of Shi Yomi District

Table 2: Land use land cover categorization of Shi Yomi district

S. No	Land use category (Area in hectare)	Menchukha Circle	Monigong Circle	Pidi Circle	Tato Circle	Shi Yomi District
1	Agricultural land	4.08	-	-	-	4.08
2	Built up	2.32	0.74	0.25	0.77	4.10
3	Forest	621.37	844.76	239.58	430.84	2136.56
4	Grassland & Grazing land	0.18	0.28	13.69	-	0.46
5	Wastelands	67.11	69.60	23.22	29.16	189.11
6	Water bodies	2.97	5.27	0.63	2.04	10.93
7	Shifting Cultivation	3.16	-	-	10.90	15.83
8	Snow / Glacier area	75.31	360.38	-	38.91	486.55

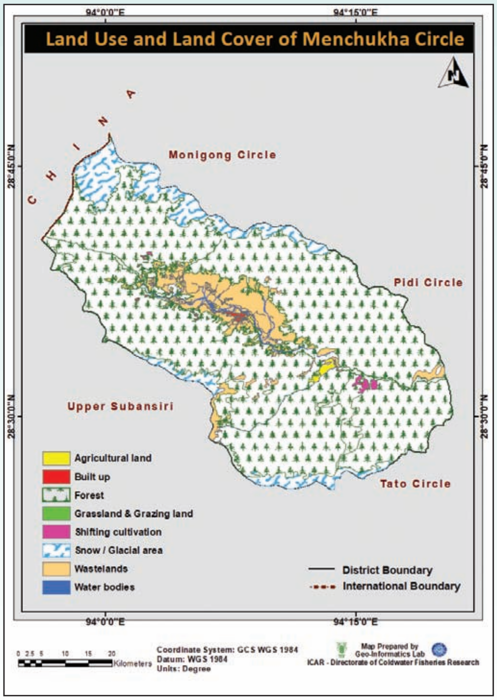

Fig. 13: Land use land cover of Menchukha Circle

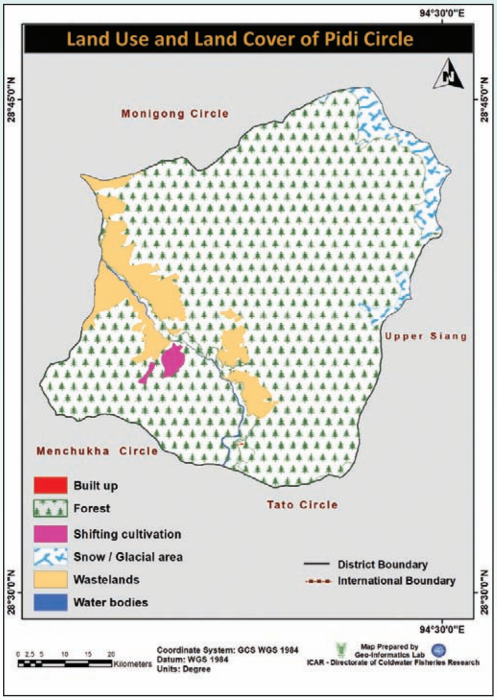

Fig. 14: Land use land cover of Pidi Circle

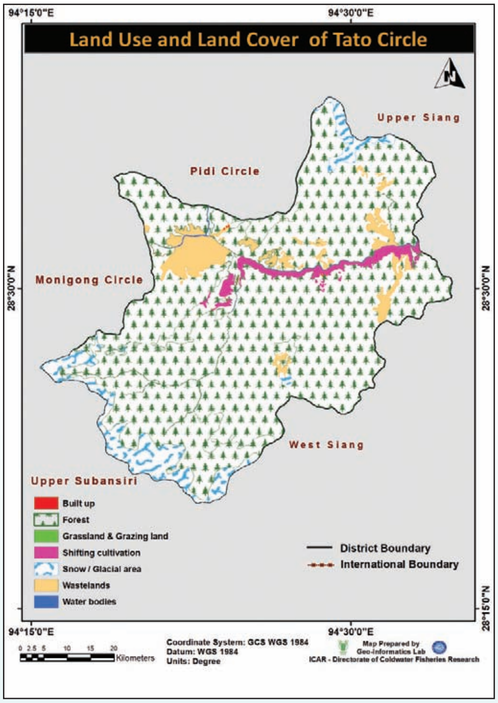

Fig. 15: Land use land cover of Tato Circle

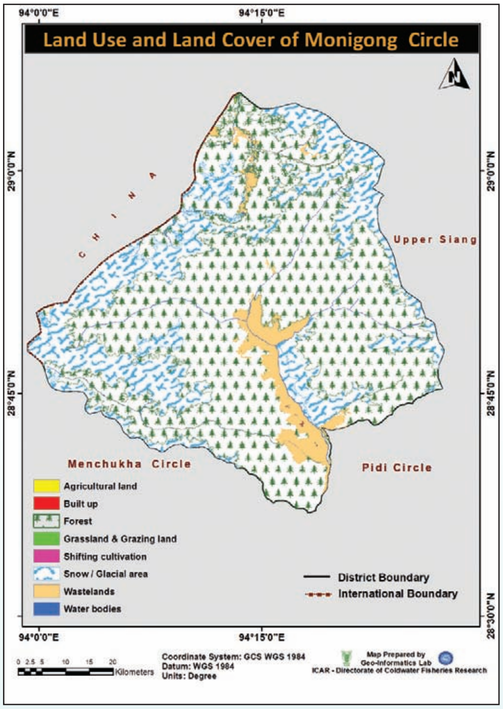

Fig. 16: Land use land cover of Monigong Circle

5. 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. In other words it can be defined as the digital representation of the land surface elevation with respect to any reference datum such as Mean Sea Level (MSL). DEMs are used to determine terrain attributes such as elevation at any point, slope and aspect. The DEM of the study area was obtained from USGS (https://www.usgs.gov.) and classified into five different elevation classes (height in meters) by employing the spatial analyst tools of the ArcGIS v 10.7 (Fig. 17).

From the DEM examination, it can be inferred that the elevation class ranging from below 1000m to 3000m (Fig.18) encompassing 69% of the total geographic area can provide suitable sites for undertaking aquaculture activities provided the other conditions are conducive. Moreover, the DEM generated for the study area can also be helpful to study the terrain stability of the region such as in identifying areas with steep slopes and little vegetation is prone to landslides and flood especially during the rainy or winter seasons. This in turn will help to identify the real potential areas for formulating fisheries developmental projects (Fig.19-22).

Development of a slope map can be generated dynamically from DEM for a particular location which is computed as the maximum rate of change of elevation between that location and its surroundings, expressed either in degrees or as a percentage (Fig. 23). Slope describes the steepness of the ground's surface and can be measured as the rise (the increase in elevation in some unit of measure) over the run (the horizontal distance measured in the same units as the rise). (Table 4) The degree of slope of the study area is represented herewith by a colour map wherein green colour represents 0- 21 degree slope, yellow colour represents the slope class ranging from 21-35 degree and the slope class ranging from 35-78 degree is represented by red colour. The percentage share of different slope degree classes in Shi Yomi district is as shown in Fig. 24. The slope class 0-21 degree in green colour comprising 41% 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 region.

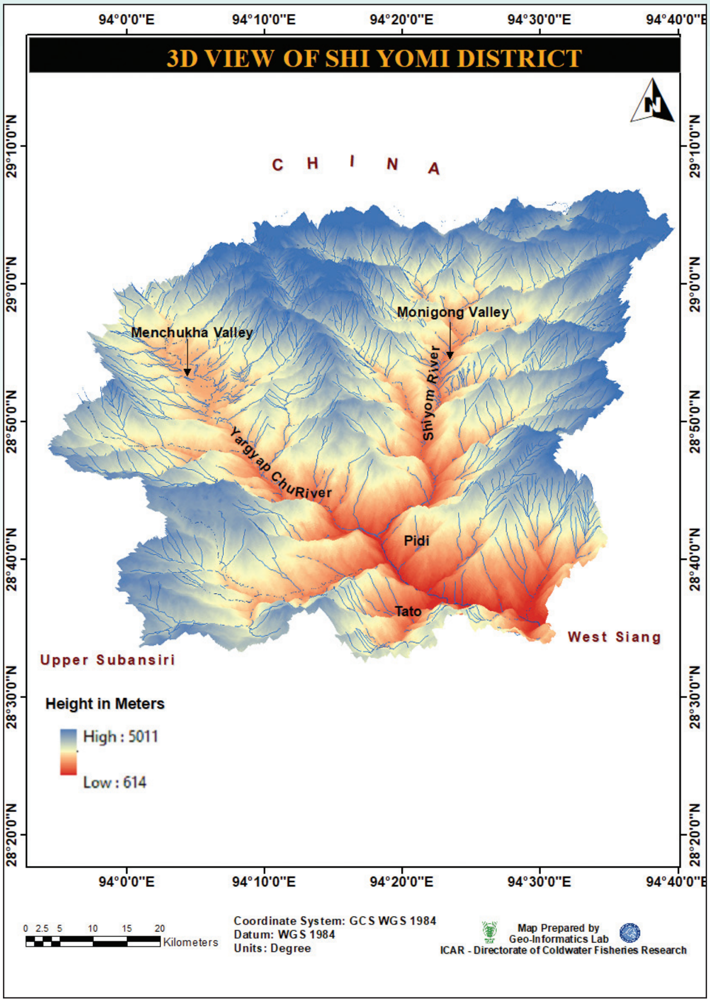

Fig. 17: 3D Digital elevation model of Shi Yomi District

Table 3: Digital elevation model categorize in meters

S. No	DEM Height in Meters	Area	%
1	Below 1000	16.27	0.58
2	1000-2000	348.93	12.45
3	2000-3000	1201.59	42.88
4	3000-4000	1045.57	37.31
5	4000 Above	190.01	6.78

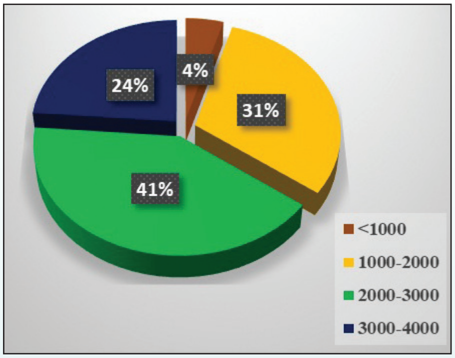

Fig. 18: Percentage share of different elevation gradients of Menchukha

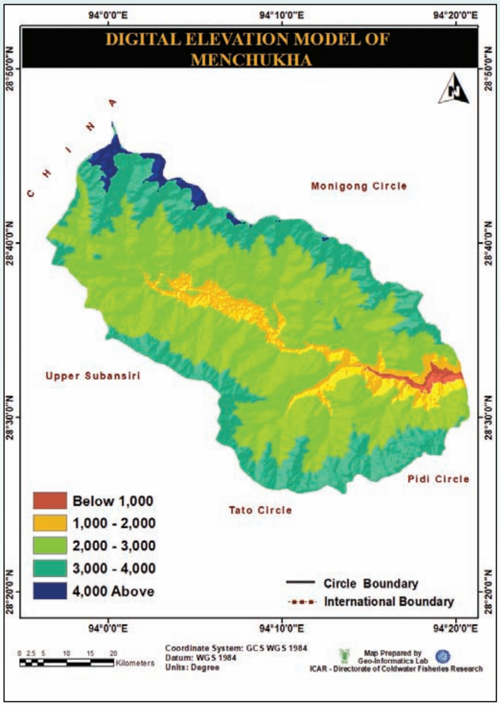

Fig. 19: Digital elevation model of Menchukha Circle

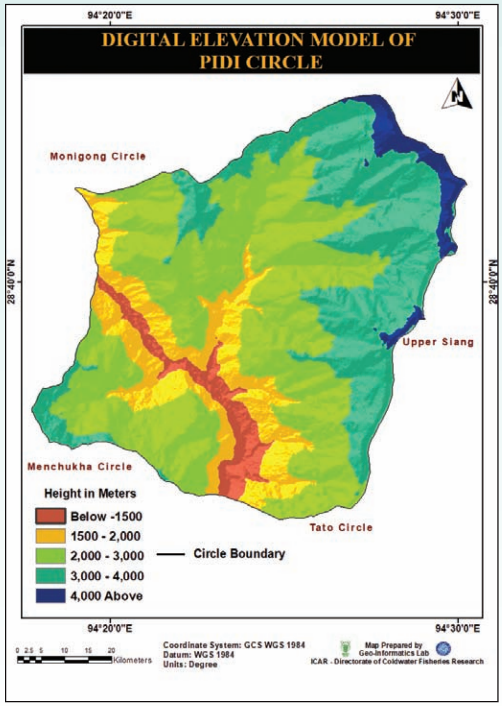

Fig. 20: Digital elevation model of Pidi Circle

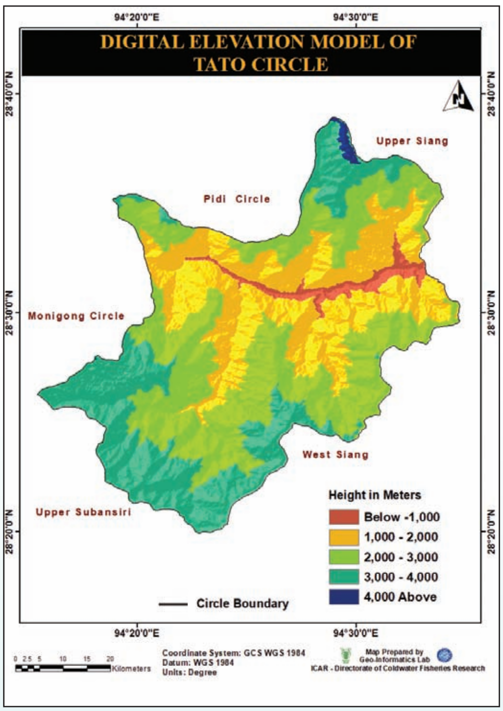

Fig. 21: Digital elevation model of Tato Circle

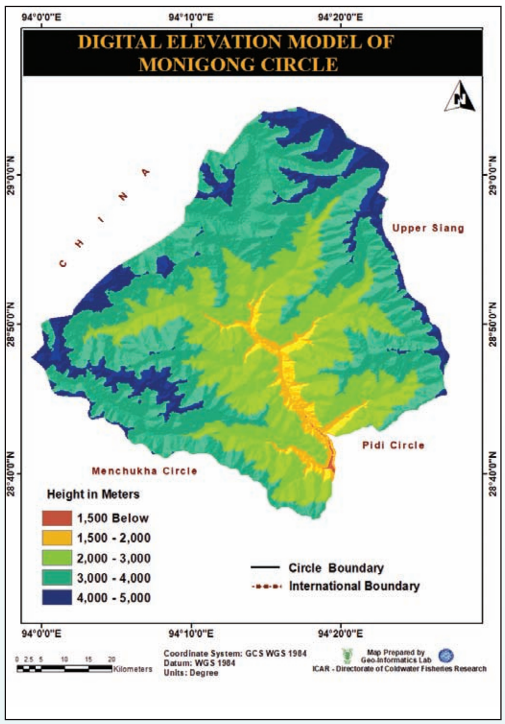

Fig. 22: Digital elevation model of Monigong Circle

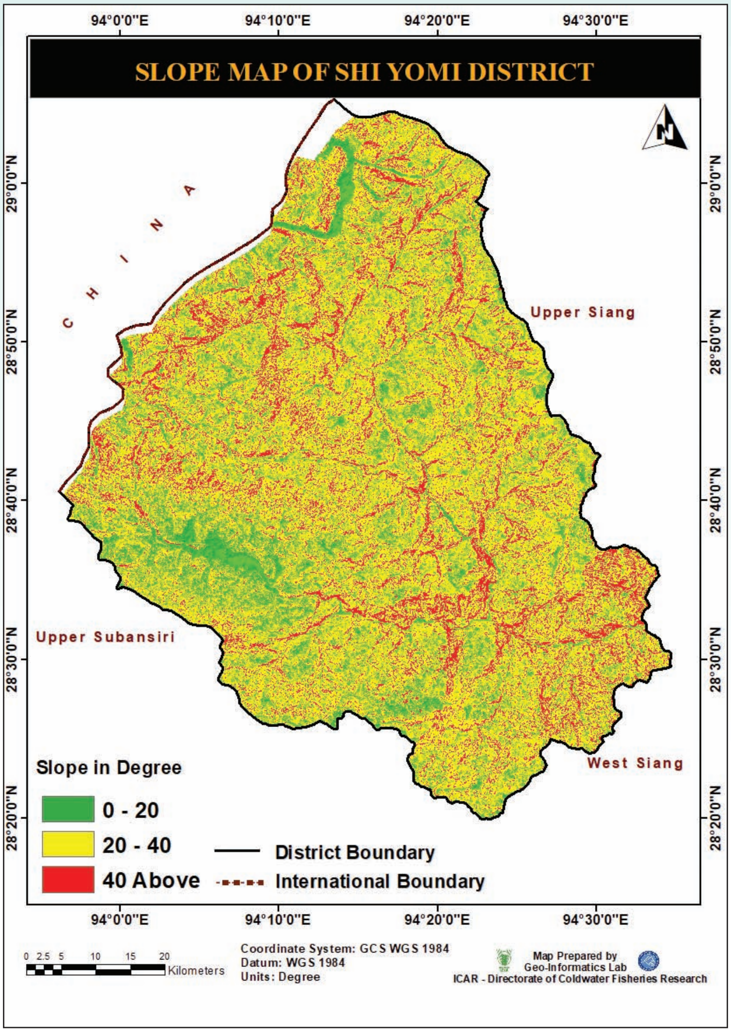

Fig. 23: Digital elevation model of Shi Yomi District

Table 4: Slope Categorize in degree

S. No	Slope in Degree	Area in (Sq.km)	%
1	0-20	643.41	22.96
2	20-40	1658.43	59.18
3	40 Above	500.35	17.86

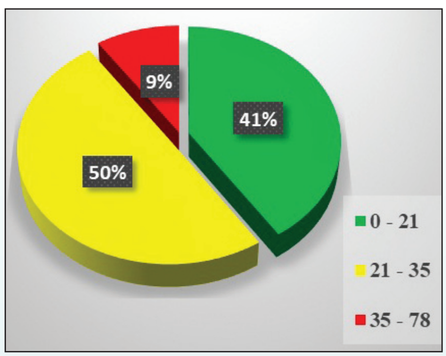

Fig. 24: Percentage share of different slope degree classes of Menchukha Circle

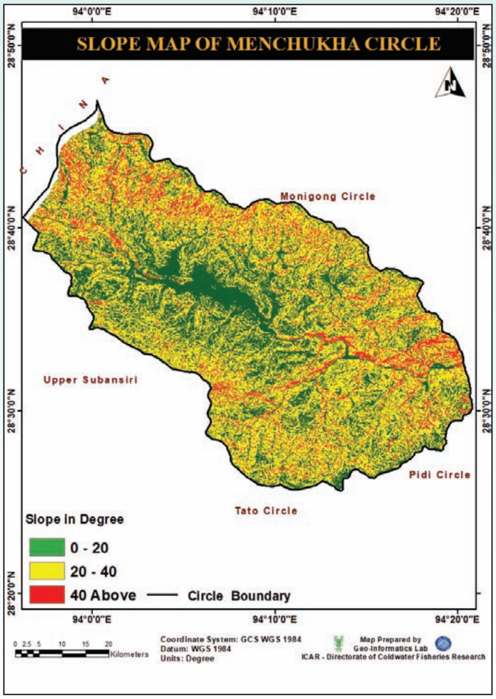

Fig. 25: Digital elevation model of Menchukha Circle

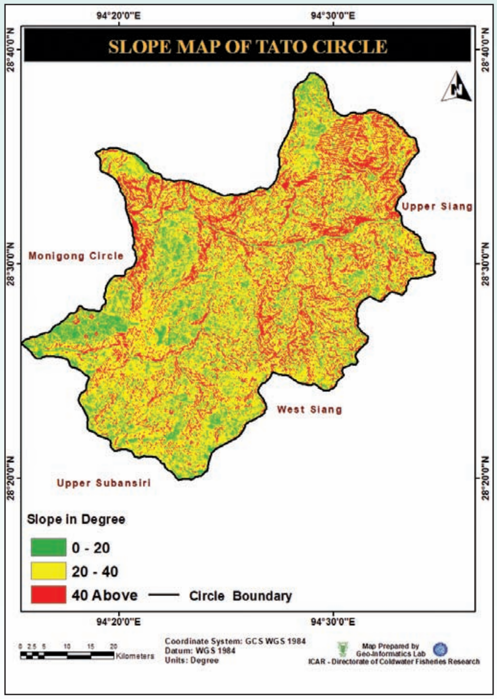

Fig. 26: Digital elevation model of Tato Circle

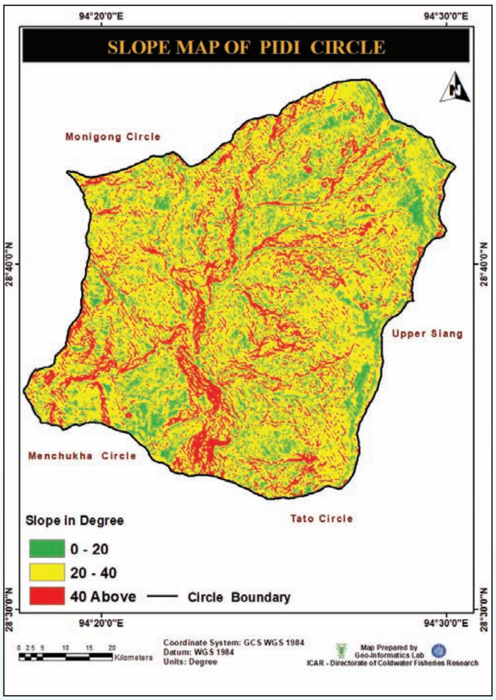

Fig. 27: Digital elevation model of Pidi Circle

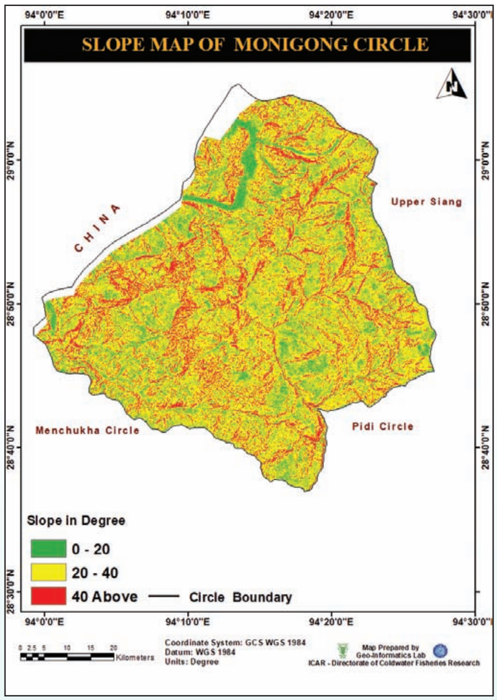

Fig. 28: Digital elevation model of Monigong Circle

6. Trout farms and hatcheries in Arunachal Pradesh

Three numbers of trout hatcheries (Table 5) has been established in the State of Arunachal Pradesh based on the favourable water temperature for trouts ranging below freezing point to as high as 20° C. The first trout hatchery was established along Nuranang stream (27° 32'20.4" N, 92°2'51.0" E) at 3,674 m MSL in Tawang district (Fig. 29), initially importing a consignment of brown trout seeds from Jammu and Kashmir. The Sela lake connected upstream is the source of trout brooders for breeding and to produce young ones in the Government trout hatchery. However, construction of a weir across the lake-river connectivity has cause to a sharp decline in trout catch downstream as spoken by the caretakers and fishermen of the hatchery. This has lead to lesser seed production in the hatchery due to unavailability of desired numbers of trout brooders in the stream. Another hatchery with a production capacity of 50,000 to 1, 00,000 numbers of eyed ova has also been established at Shergaon (27°7'23.03"N, 92°16'31.30" E) in West Kameng district during 1979, located at an altitude of about 2,085m MSL. However, trout seeds are produced at an average of 25,000-30,000 numbers in the past three years from both the hatcheries (Fig. 30) and these seeds are either procured by local trout growers or released in nearby streams for rehabilitation of the stock. The third trout seed production unit has recently been established at Tawang at ChujeGG by the Department of Fisheries.

Fig. 29 (a) & (b): Trout seed production at Nuranang (Tawang district)

Fig. 30 (a) & (b) : Trout seed production at Shergaon (West Kameng district)

Table 5: List of fish farms and fish hatcheries under Department of Fisheries, GoAP

S .No	District Name	Name of The Farm
1	Tawang	Chuje GG Trout Farm
		Nuranang Trout Farm
		Seru Trout Farm
2	West Kameng	Govt. M Trout Farm, Shergaon

7. Prerequisites in a trout farm and seed production unit

The fundamental criteria that need to be followed while constructing or establishing a trout farm are (i) a perennial source of quality water (ii) the slope of the terrain (iii) the road connectivity (iv) the built up and infrastructure facilities and (v) river buffer zones with its soil characteristics. Among the trout species in India, rainbow trout (*Oncorhynchus mykiss*) is the most promising cultivable fish species in coldwater and has considerable scope for its expansion due to its high consumer preference. Farming of rainbow trout has grown up since early nineties both in government and private sector and trout farming and seed production technologies are now available for intensifying farming practices for nutrition in hilly regime of India. ICAR-DCFR, Bhimtal has been constantly encouraging the trout growers and entrepreneurs across the country by disseminating the technology of breeding and culture practices of rainbow trout and the species is presently being cultivated in Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Sikkim and recently Nagaland. Trout farming has progressed steadily in last few decades in India and the production has increased over fivefold from 147 tonnes (2004-05) to 842 tonnes (2017-18). Trout ova production also increased from 1.85 million (2004-05) to 10.17 million (2013-14). In this context, Himachal Pradesh and Jammu and Kashmir remained the major contributor (> 80%) of rainbow trout. In addition, Sikkim has shown significant increase in trout production in recent years followed by other states such as Uttarakhand, Arunachal Pradesh and states of Tamil Nadu and Kerala in south (Pandey and Ali, 2015).

7.1. Trout culture in raceways

- Trout farming in cemented raceways of rectangular shape measuring 15m length, 3m breadth and height of 1m (45m^2area) are mostly recommended. However, the raceway sizes may vary according to the landscape and land availability (Fig. 31).
- Earthen raceways are the traditional structures for trout production (Fig. 32). With the intensification of trout farming with higher feed inputs and stocking densities, the earthen raceways are either polylined or paved with stone or concrete. In earthen raceways, the flow of water is limited causing higher deposition of organic loads. Also the cleaning becomes difficult due to earthen bottom.
- A continuous flow of fresh and clean water is essential. The water supply by gravity to the trout raceways and trout hatchery is preferred as this saves energy and recurring production costs. A rule of thumb is that about 10 litres/sec (600 litres/min) of water source should be calculated for each 1 tonne of rainbow trout produced (Edwards, 1989 and 1990).
- The source of water to the farm and hatchery unit can be stream inflow in hilly terrains. The

farm should not be constructed very near to the rivers and reservoirs so as to avoid high flood situations.

- The raceways can be supplied with water either in parallel (Fig. 33) or in series.
- The optimum temperature of water for rainbow trout culture is advised between 12-18°C. The water must be clean, rich in oxygen, pH ranged between 6.5-8.0.
- Stocking density of 45-50 trout fishes/m^2 can be stocked in cemented raceways. This stocking density may be increased by following better management practices.
- The fishes must be graded at regular intervals according to the size attained in order to prevent cannibalism and achieving a uniform growth.
- Care must be taken to ensure that the outlet and inlets in raceways are properly guarded with mesh screens with adequate size so as to prevent entry of fish from outside and exit from inside.
- Trout are fed with high protein (40-45%) diet when nursery reared and 35-40% protein diet in grow out culture.
- Trout may be considered as marketable on attaining a size of 200-300gm in weight after 12-14 months of rearing.
- Planning for a new trout farm is usually done in a reverse direction. The number and size of different rearing units of a production house is calculated on the final targeted quantity and the expected individual grown up size of fish.

Fig. 31: Cemented raceways for trout farming

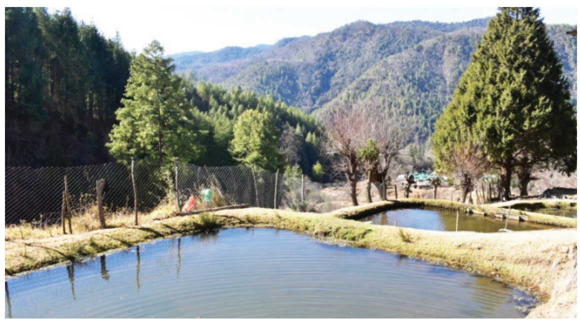

Fig. 32: Earthen raceways for trout farming

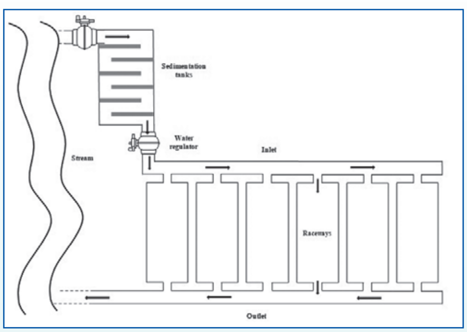

Fig. 33: Parallel type of raceways for trout culture

7.2 Trout seed production

- An ova house (Fig. 34) containing hatching troughs and trays made offibreglass or polypropylene, concrete tanks, lined and unlined earth tanks are the requisites for production of eyed ova and alevins.
- The hatching trays are square or rectangle in shape and are required to incubate the trout eggs and sac fry. The bottom of the trays is a sieve material, on which the eggs and sac fry rest. The trays receive freshwater through the sieve and flow out through one of the side walls. The quantities of eggs and sac fry are maintained in a manner that the tray can hold just a single layer of them. The eggs must not be placed layer over another.
- It is crucial to ensure appropriate water supply and maintain the appropriate water flow to bring enough oxygen and carry away wastes from the trough and trays.
- The troughs and tanks are used for rearing fry and fingerlings. Shallow troughs are usually used for rearing fry while deeper ones serve for rearing fingerlings. These tanks are mounted on iron framed stands. Their sizes may vary according to the requirement.
- Before the actual placement of eggs the trough and trays must be cleaned and disinfected.
- The different stages of trout eggs and larvae needs to be handled with extreme care during rearing, transferring and size grading.
- The dead eggs and larvae from the hatching and rearing units must be removed with special egg-pincers and siphons on a daily basis. The number of mortality and weight of the dead eggs and larvae from each rearing units should be registered in a diary.
- The faeces and the leftover feed particles must be frequently removed with a siphon.
- The hatchery owner and the workers require specialized skills and extensive practice through hands on training.
- Availability of fish feeds, chemical shops, fish markets and skilled labourers need to be ascertained near to the farm complex.

Fig. 34: A ova house along with trout raceways

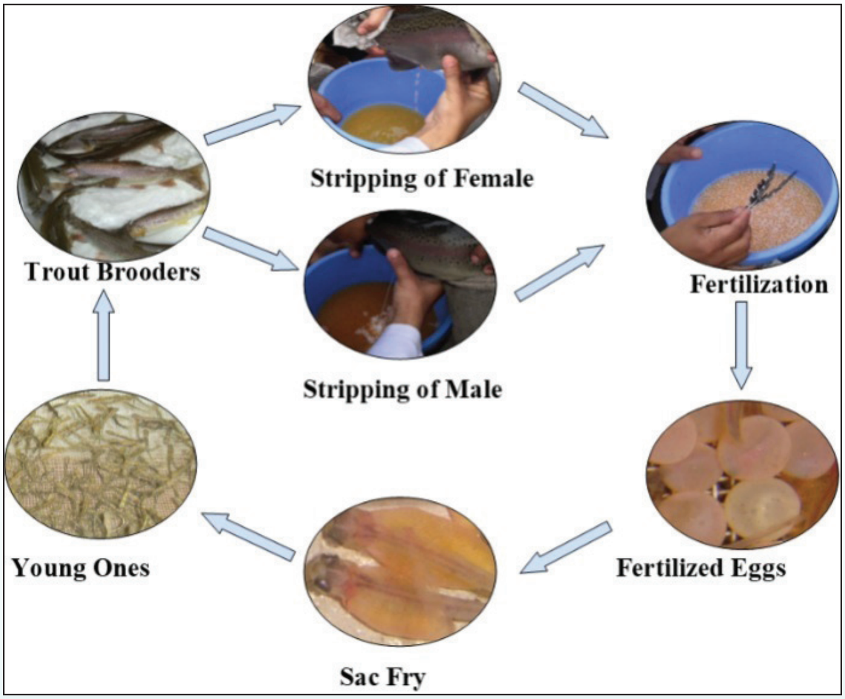

Fig. 35: Cycle of rainbow trout breeding

8. HRD programme for entrepreneurs of Shi Yomi district at ICAR-DCFR

A collaborative approach was decided to be undertaken between the ICAR-DCFR and Department of Fisheries, Govt. of Arunachal Pradesh to promote the trout fisheries in the Menchukha valley in the year 2018. Initiating this approach, seven numbers of perspective fish farmers and entrepreneurs from Menchukha region of newly declared district Shi-Yomi of Arunachal Pradesh along with Mr. Kenbom Chisi, District Fishery Development Officer and Mr. Sange Dere Diri, Fishery Demonstrator of Department of Fisheries, Govt. of Arunachal Pradesh visited ICAR-DCFR, Bhimtal and Experimental Fish Farm, Champawat during 06-10 December 2018, with an objective to gain knowledge and to develop skill in trout farming practices in different culture systems, techniques in trout seed production and subsistence utilization of natural resources for rehabilitation of trout population for recreation, angling and trout fisheries. In order to fulfil these objectives, a 5-days training programme cum exposure visit was jointly organized by ICAR-DCFR, Bhimtal and Department of Fisheries, Govt. of Arunachal Pradesh on the topic "Coldwater Fisheries and Aquaculture Practices in Indian Himalayan Region" at ICAR-DCFR Headquarter, Bhimtal and EFF, Champawat (Fig. 36-47). The farmers were trained on the subjects in understanding the important coldwater fishes of India having economic importance for food and recreation, site selection criteria for designing and developing different infrastructure including raceways for trout culture in hill region based on topography and water availability through implication of GIS based tools, construction and design of trout ova house, techniques of seed production and raising other coldwater fish species viz., mahseer, snow trout, exotic trout and carps in various conditions and culture practices etc. Emphasis was also given to monitoring the water quality parameters, feed preparation and application and prevention and remedial measures to control the occurrence of diseases in coldwater fisheries during fish larval development and growth period. Presentations, practical demonstrations, interactive sessions and scientific fish based film shows were imparted to the visitors during the 5 days programme, both at ICAR-DCFR Headquarter and EFF, Champawat for their easy understanding (Fig. 38-49). Reading materials in the form of pamphlets, leaflets and technical bulletins were distributed to the farmers for further reference. Feedback received from the visiting farmers and entrepreneurs were quite satisfactory as revealed from the interactive meet during the valedictory function. The farmers welcomed the team of scientists of ICAR-DCFR to visit Menchukha region to render further technical guidance in site selection, seed rising and culture. Certificates of their participation were distributed in the presence of the Director and scientists of ICAR-DCFR, Bhimtal. Concluding remarks were made by the Director Dr. Debajit Sarma, stating that the institute will take a positive note to develop trout fisheries for culture and recreation in the Menchukha region through technical support, building linkages and network among various stakeholders in coldwater fisheries. The programme ended with a vote of thanks from Dr. Deepjyoti Baruah, Senior Scientist and Coordinator of the programme.

Fig. 36: A group photograph with the participants

Fig. 37: Interactive session with the participants

Fig. 38& 39: Presentation on recent advances in coldwater fish farming and seed production at ICAR-DCFR Hq, Bhimtal and EFF, Champawat

Fig. 40 & 41 Exposure of participants on various systems for culture and seed raising at ICAR-DCFR, Bhimtal

Fig. 42: Skill development on feed preparation

Fig. 43: Visit Himani Aquarium of ICAR-DCFR

Fig. 44: Management practices in raceway culture at EFF, Champawat

Fig. 45: Trout seed production at EFF, Champawat

Fig. 46: Water quality analysis at Laboratory

Fig. 47: Exposure on RAS for trout culture in the hill region

8.1. Awareness Programme for Entrepreneurs at Menchukha of Shi Yomi District

An awareness programme was organized for the very first time by Department of Fisheries, Government of Arunachal Pradesh in collaboration with ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Nainital, and Uttarakhand at Menchukha of newly declared Shi Yomi district of Arunachal Pradesh. The programme was conducted on 12th February 2019 on the topic "Coldwater fish culture in Menchukha region" which was witnessed by more than 110 participants from different villages of Menchukha region, officers and staffs representing various line departments, fisheries officers and scientists from ICAR-DCFR. The programme was chaired by Mr. Ngilyang Pussang, Deputy Director of Fisheries, Govt. of A.P., who briefed the participants on the objectives of the programme. The other officers present were Mr. Tagi Yonggam, Deputy Director Fisheries, Govt. of A.P. and Mr. A. Rahman, Assistant Director Fisheries, Govt. of A.P. The officers of the department highlighted on the recent advances being made and targets achieved by the state fisheries department in pursuance to promotion of fisheries in the coldwater sector of Arunachal Pradesh. Mr. Yonggam further stressed on the protection of the existing brown trout fishes (*Salmo trutta fario*) at river Yargyap chu by declaring a "Protected Area" in a certain stretch of the river, which will provide a healthy home to the fishes to propagate and breed freely. The resource persons invited from ICAR-DCFR, Bhimtal for deliberations during the programme were Dr. Deepjyoti Baruah, Senior Scientist; Mr. Parvaiz A. Ganie, Scientist and Mr. Ravindra Posti, Young Professional. Dr. Baruah elaborated on the fundamentals in starting of a trout farm as an avenue by raising rainbow trout (*Onchorhynchus mykiss*), the site selection criteria for establishing concrete raceways in high altitudinal regimes and in undertaking trout based eco-tourism at river Yargyap chu and its adjoining snow-fed streams. Mr. Ganie spoke on the seed production technology and hatchery management practices for raising trout in the Menchukha region. Mr. Posti briefed on the aquaculture site suitability possibilities through GIS mapping and ground survey in the Shi Yomi district for promotion of trout farming. The programme was coordinated by Mr. Kenbom Chisi, District Fisheries Development Officer, West Siang district, Aalo and he assured the participants to provide his best assistance in undertaking trout farming and ova house development through the developmental schemes and programmes of the Department. He further offered his vote of thanks to all the participants and the invitees in making the programme a successful one during the valedictory function. The participants expressed their great satisfaction on the programme and received a certificate of participation. (Fig. 48 - 57).

The awareness programme was followed with an extensive field survey during 13-14 February 2019 in the Menchukha region for selecting a suitable site for start of trout farming by establishing concrete raceways and a seed production unit (ova house), both in the Government and private sector. The local villagers and residents of Menchukha region showed many potential sites to the invitees and officers, having a good source of quality and quantity water. The water quality of the streams and river Yargyap chu was examined by the invited scientists of ICAR-DCFR, Bhimtal with the assistance of the Fisheries Officials and local residents and was found very conducive for trout farming and ova production. The temperature, pH, total hardness, alkalinity and other nutrient parameters of the water was found within the optimum range for trout growth and propagation. Furthermore, a certain stretch of river Yargyap chu was selected by the Fisheries officials and visiting scientists in consultation with local anglers and fishermen to consider as Protected Area and to restrict angling only in a few specific points. The other methods of fishing by using dynamites, electrifying, poisons, small meshed nets will be considered illegal. It was felt that this visit by the team of fisheries experts is going to benefit the residents of Menchukha in taking trout farming and trout based eco-tourism as a true vocation of their livelihood and income in a concerted approach between all the stakeholders. (Fig. 58 - 61).

Fig.48 Inauguration session during the awareness programme

Fig.49 Presentation on starting of a trout farm as an avenue by raising rainbow trout by Dr. D. Baruah

Fig.50 Presentation on aquaculture site suitability possibilities through GIS mapping by Mr. R. Posti

Fig.51Presentation on seed production technology and hatchery management practices for raising trout by Mr. P.A. Ganie

Fig.52 Interactions session local entrepreneurs with DCFR Team and State fisheries officers

Fig.53 Interactions session local women fish farmer with DCFR Team and State fisheries officers

Fig.54 & 55 Distribution of certificates to the participants on completion of the programme

Fig.56 Participants of the awareness programme including scientists, state fisheries officers and local entrepreneurs

Fig.57 A group photograph with the participants & ICAR-DCFR team, state fisheries officers and local entrepreneurs

Fig. 58 Analysing physicochemical parameters of river water for site suitability for trout farming in Dorjeeling village Site 1

Fig.59 Analysing physicochemical parameters of river water for site suitability for trout farming in Sekar Village Site 2

Fig.60 Analysing physicochemical parameters of river water for determining site suitability for trout farming in Lhalung village

Fig.61 Analysing physicochemical parameters of river water for selection of site suitability for trout farming in Nangso village

9. GIS based mapping of potential suitability sites for trout fisheries development

9.1 Trout farming potentialities at Menchukha valley

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. Since aquaculture site selection using the conventional method, based on very limited data will result in inaccurate information and cause discrepancy among the implementing agencies, the utilization of Remote Sensing and Geographic Information Systems (GIS) is considered to be the most favorable option. An attempt has been made herewith to identify and select potential areas where fisheries developmental activities (Fig. 62) such as culture and seed production can be carried out by employing different input feature classes. Since the region being at above and over 3000m MSL with hilly terrains and little habitation cum population, it is presumed that the water of the region is pollution free and of the quality as desired for aquaculture operations. Thus, water quality and quantity as input criteria for site selection was considered to be optimum. The other feature classes which were taken as input criteria to designate the probable potential areas for trout farming were - Drainage network, as water is the essential element for trout farming (Fig. 63), its location and extension/spread is essential in the selection process. Road network, due to its importance in mobilising the stuffs from one place to another and the accessibility for supplying inputs and market the farm produce; Slope of the region, it is of prime importance in site selection especially in hilly terrains where most of the land surface is undulated with varying slopes. To select the probable area for trout fish farming, these input feature classes were subjected to spatial analysis using the different tools of spatial analyst extension of the ArcGIS v 10.7. A buffer was drawn over the river network of the region with a spread of 100m up to the third order streams and a spread of 200m on fourth and fifth order streams with a purpose to limit the extension stretch over which trout farming operations may be initiated. In a similar way, a buffer layer of 5 km was drawn over the digitised road network input feature class of the region so as to set the distance limit under which the torut farming operations can be feasible and conducive. Since the topographic constraints are imperative in such areas hence the limit. In case of slope input feature class only the slope ranges of 0-10 degrees and 10-20 degrees were considered for selection. As the slope degrees beyond the selected classes will be too steep for conducting any torut fish farming. Based on this, the selected input feature classes were superimposed in the GIS environment and probable trout fish farming areas were identified (Fig. 64). An area of 34.77 km^2 in the slope range of 0-10 degree and an area of 57.34 km^2 in the slope range of 10-20 degree range was found suitable in the entire (Table. 6) Shi Yomi district for undertaking trout farming provided the other requirement criteria are optimum and as per the requirement for trout farming. It is noteworthy to mention herewith that this area in both the slope range classes is only the probable area and not the exact area. For delineating that a thorough and careful field examination is needed. A field analysis conducted by a team of scientists of ICAR-DCFR, Bhimtal on the abiotic and biotic components of water and fish habitat reveals that the river Yargyap chu alongwith its adjoining streams are extremely conducive for trout survival and recreation (Table.7).

Table 6: Area of trout potential suitability sites using GIS at Menchukha

SI. No.	Potential Fisheries Area	Area in (sq. km)
1	High Potential Areas	34.77
2	Moderate Potential Areas	57.34

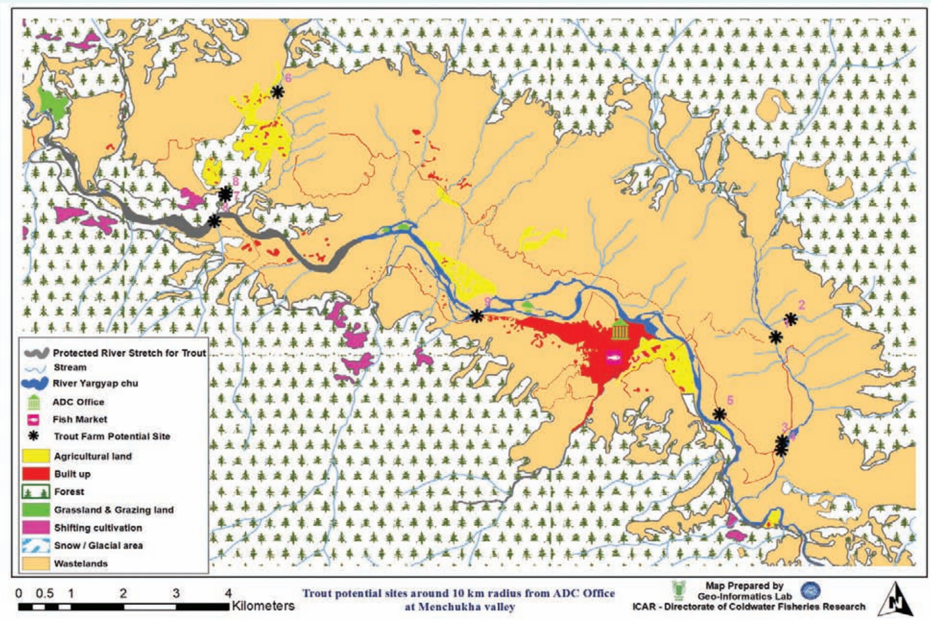

Fig. 62: Potential trout fisheries developmental areas in Menchukha region

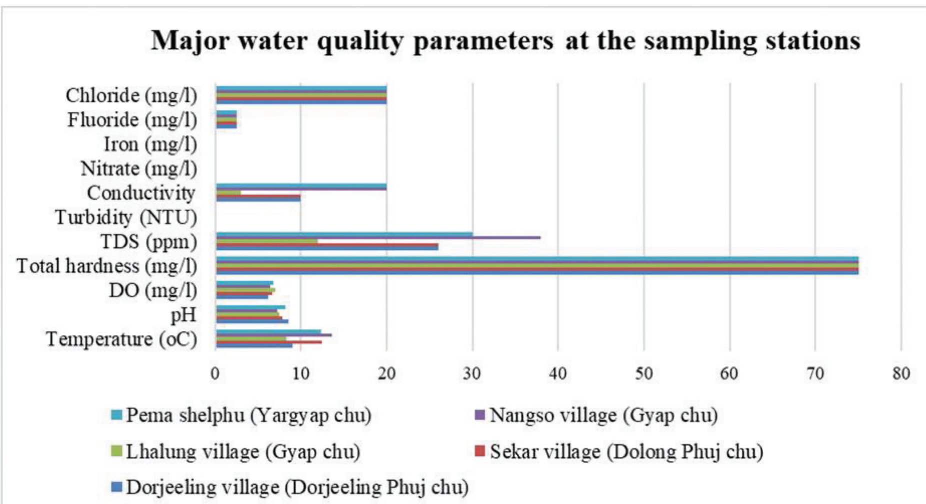

Fig. 63: Major water quality parameters at the sampling stations

Table 7: Visit to farmers field to analyse water quality parameters for determining site suitability for trout farming

Water quality parameters	Dorjeeling village (Dorjeeling Phuj chu)	Sekar village (Dolong Phuj chu)	Lhalung village (Gyap chu)	Nangso village (Gyap chu)	Pema shelphu (Yargyap chu)
Temperature ($^{\circ}$C)	8.90±0.42	12.70±0.20	8.43±0.12	13.40±0.26	8.50±2.26
Air temperature ($^{\circ}$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	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
Suitable sites at Menchukha					

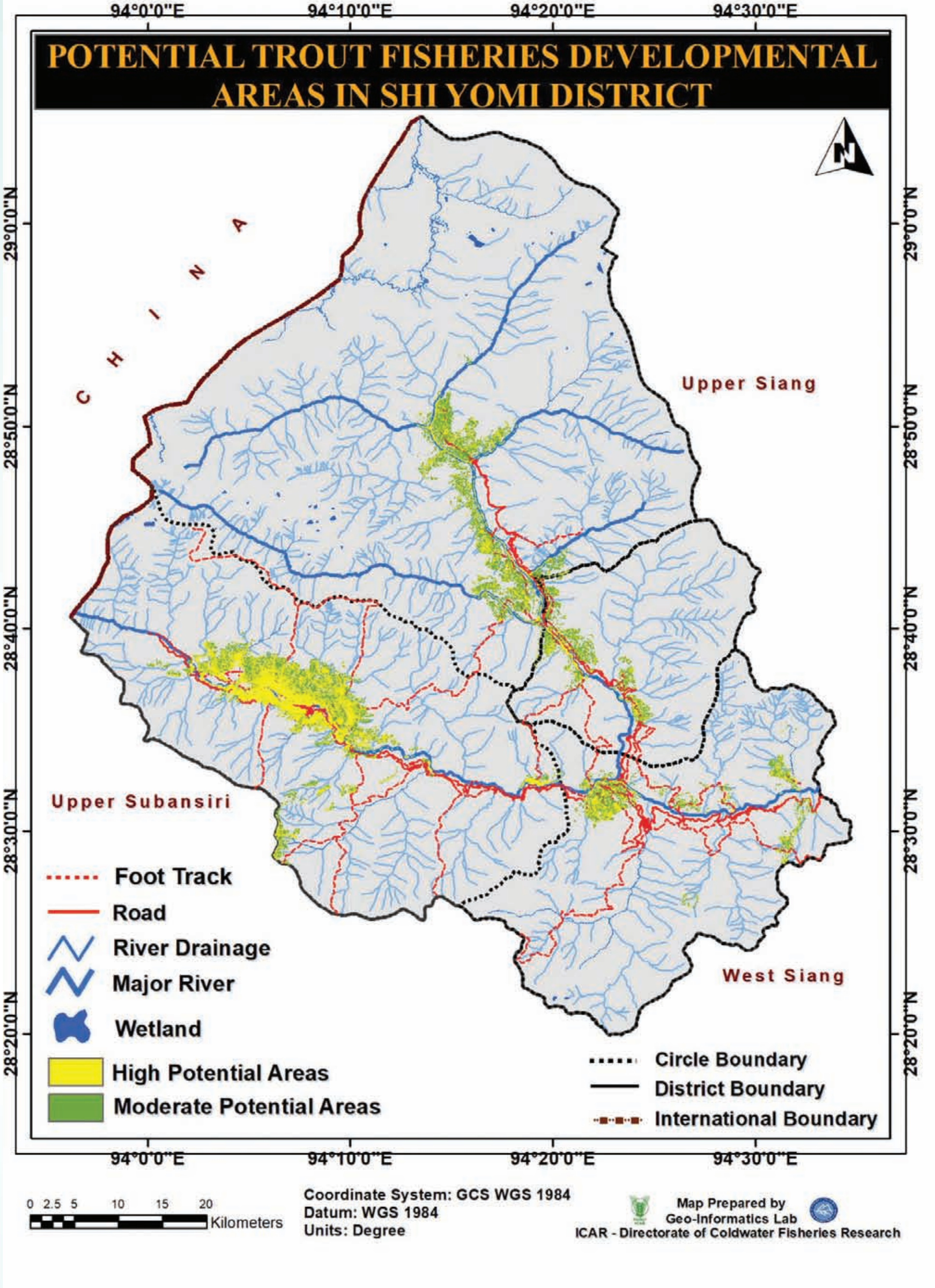

Fig. 64: Map showing potentiality of trout developmental areas in Shi Yomi District

Fig. 65: (a) & (b) Trout raceways under construction at selected sites, Menchukha

9.2 The Trout Angling

The trout is regarded as the best sporting fish of the coldwater in the country. A considerable population of these trout has been reported in upland waters of Menchukha region of Shi Yomi district by an avid anglers of the area (Fig. 66). Menchukha township is situated at 1,829m msl and is just 29 kms preceding the Indo-Tibet border. The river Yargyap chu) flows through Menchukha region and offers an excellent site for adventure tourism for outdoor enthusiasts with a picturesque backdrop. But very few know about the beauty of this unexplored place as reaching Menchukha by road is quite tiresome. However, a little attention by the Government in tourism and fisheries sectors in organizing recreational events may invite tourists and explorers all over the world. At present, angling of trout in river Yargyap chu has remained within the domain of the local anglers (Fig. 67). A good number of sizable brown trout of 8-12 kg by weight has been reported from this water which is an implausible catch among the water bodies of the entire State. Trout thrives well in this river, whereof the source of trout in this water mass has been reported by the State fisheries officials to have introduced in 2009-10. The adaptation of the trout fishes in these coldwater provides an excellent opportunity for game fishing in this mesmerizing part of the country in generating huge income for local communities. Introducing the concept of fee fishing from the upland lakes, ponds and tanks can be an excellent way of generating income. The trout necessarily be hooked on the basis of "catch and release", by the anglers for causing no harm to the existing fish stock and helping them in their auto-stocking in the river. The visiting scientists further proposed the local residents to restrict angling on river Yargyap chu to a few specific points and to consider a 10 km stretch of the river (Fig. 68) as "Protected Area" as a means of conservation. Furthermore, issuing license by the Department of the Fisheries to the anglers to hook trout out of the water will further maintain the regulatory measures to protect the fishes from destruction.

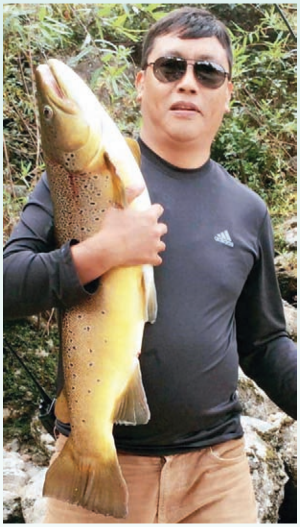

Fig. 66: A prize catch of brown trout by an avid angler Mr. Dorjee Sona from Menchukha

Fig. 67: Angling of trout in river Yargyap chu by local anglers

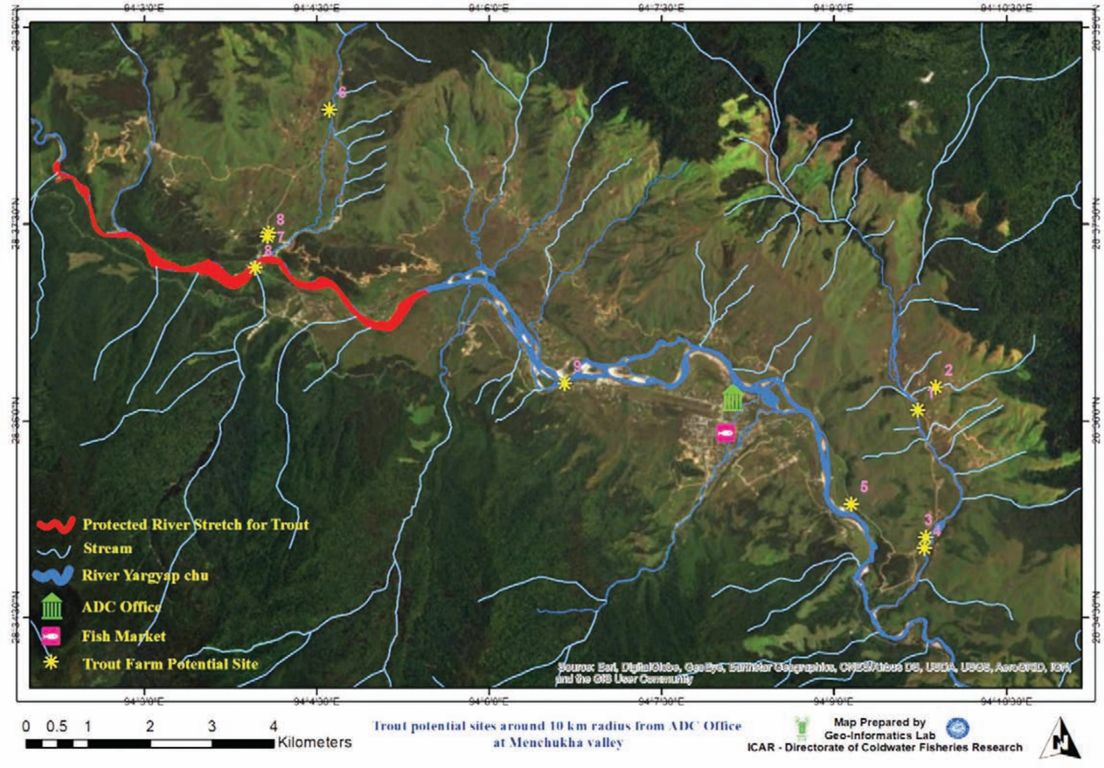

Fig. 68: Protected stretch at river Yargap chu for trout conservation

10. Trout fisheries development strategies in upland aquatic resources of Shi Yomi

The proposed strategies of fishery development are aimed towards upland resource utilization by means of propagation and conserving indigenous and commercially important species of trout. Some of the strategies may be worked out by:

(i) Resource mapping of unutilized upland water bodies for framing developmental policies,

(ii) Establishment of location-specific hatchery units for facilitating seed production and propagation,

(iii) Holistic approach for establishment and promotion of trout sanctuaries, eco-parks and reserves in different aquatic resources with the convergence of the Department of Fisheries, Department of Tourism, Department of Forest and Wildlife for trout habitat rehabilitation and conservation,

(iv) Organizing awareness and capacity building among mountain dwellers for adopting trout farming to ensure food security,

(v) Encouraging community participation for promotion of eco-tourism and angling (catch and release) for recreation and income generation,

(vi) Strengthening of Human Resource Development in Government sector to implement these strategies in remote hilly terrains,

(vii) Introduction of better genetic strains from abroad for improvement of the existing stocks of trout for enhancing aquaculture productivity in coldwater regions.

Acknowledgement

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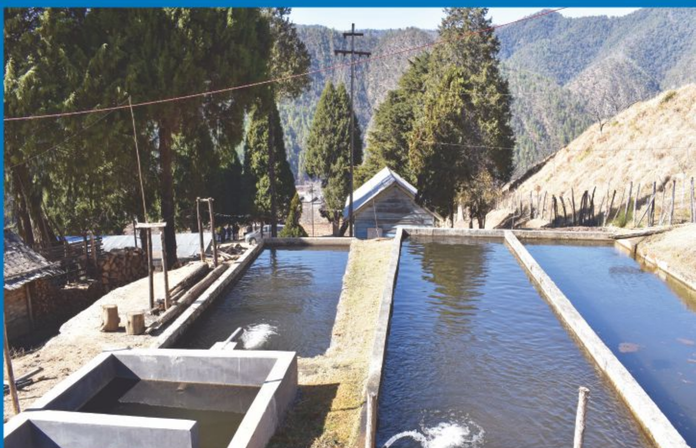
River Siang

Brown trout of river Yargyap chu



Trout raceways in Aruranchal Pradesh

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