

Trout fisheries in the uplands of Arunachal Pradesh: Resources and opportunities

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A brief background of the region

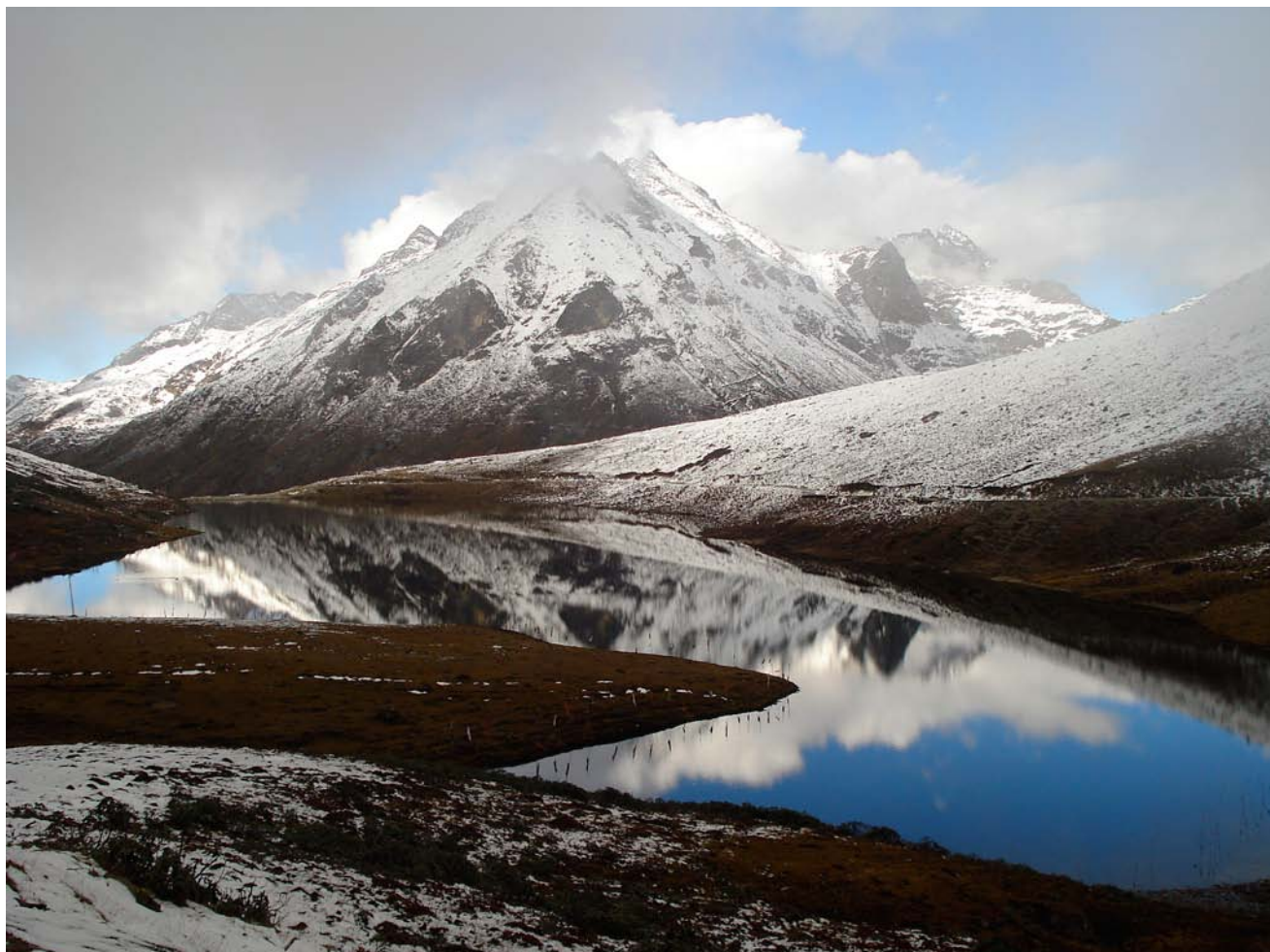
Arunachal Pradesh, the eastern most state of India is known as the land of the rising sun. This is the largest state in the north eastern region of the country, sharing international boundaries with Bhutan, China and Myanmar. The States of Assam and Nagaland flank its southern and south eastern borders. The population of Arunachal Pradesh is around 1,383,000 (2011 census) with an average population density of 17 persons per square kilometre. The state is inhabited by 28 major tribes and 110 sub-tribes and is considered to be the 12th mega-biodiversity region of the world¹.

The potential for augmentation of fish production and fish-based eco-tourism in Arunachal Pradesh are immense. The landscape of the state is characterised by lofty mountains with snow-clad peaks, dense forests, turbulent streams, roaring rivers, deep gorges and a rich diversity of flora and fauna. The climate varies from sub-tropical in the south (foothills) to

temperate and alpine in the north (upland) with large highland areas experiencing snowfall during winter. The state is divided into five major river valleys: the Kameng, the Subansiri, the Siang, the Lohit and the Tirap. All of these valleys are drained by numerous snow-fed rivers and rivulets originating in the Himalayas.

Trout are an important species, highly regarded all over the world for recreational fishery as well as food fish. Upland water bodies provide suitable habitat for brown trout *Salmo trutta fario* and rainbow trout *Oncorhynchus mykiss* (rainbow trout). However, in Arunachal Pradesh, trout continue to remain more or less in the domain of capture fisheries.

The hilly districts of Tawang, West Kameng and West Siang have a low temperature regime and bountiful resources that offer tremendous scope for trout farming and recreational fisheries.



Snow peaks surrounding Sela lake.



Pangang Teng Tso lake in Tawang District.

Major prospective resources for trout in Arunachal Pradesh: The upland lakes

The entire terrain of the Himalayas in the State of Arunachal Pradesh is bestowed with picturesque views of the alpine mountains and numerous lakes with mesmerising backdrops. Tawang District is one such region with more than one hundred natural lakes, each offering its own attractions, situated between an altitude of approximately 3,000-4500 metres. Many of these lakes remain frozen during winter.

The local community, the *Monpas*, care for the lakes and prohibit undesirable developments, while stocking trout to promote recreational fisheries and associated livelihood opportunities.

Sela lake

Sela lake, some 14 hectares in area, is situated around 90 km from Tawang Headquarters at an altitude of 4,146 metres (27.512 N, 92.098 E), at Sela Pass, one of the highest passes in the region. The lake offers an immense natural beauty in the area attracting any tourist to witness the chill breeze blowing through these mountains all hours. The surrounding peaks remain snowy in most of the time of the year and the lake freezes on the surface during winter with temperatures falling to -10°C. The lake gives rise to Nuranang stream which is an important source of trout. Mature trout suitable for use as broodstock are caught 10 km downstream by the officials of Department of Fisheries for breeding programmes at a government trout hatchery. Brown and rainbow trout fingerlings produced at this hatchery are stocked back into Sela lake on a regular basis to maintain the population, as this is

the only fish of its kind to survive the freezing conditions. This lake has scope for development of high-altitude recreational fisheries through the provision of basic tourist amenities, facilities for angling, fish watching and other amusements.

Pangang Teng Tso Lake

Pangang Teng Tso Lake (27.637 N, 91.857 E), another traveller's paradise, encompasses an area of five hectares around 17km from Tawang Headquarters at a height of 3,845 metres. The lake is nestled among picturesque snow-capped peaks and the clear water offer a scenic reflection of these mountain peaks and the path laden with bright rhododendron flowers. This lake provides ample scope to take up recreational fisheries in terms of trout angling and fish watching as it is very popular visited by most tourists. Attempts were made to establish brown trout in this lake in 1995 and 2013 by Department of Fisheries and ICAR-Directorate of Coldwater Fisheries Research (DCFR)².

Sangestar Lake

Sangestar Lake (27.723 N, 91.826 E) is situated at an altitude of 3,672 metres and around 45 km from Tawang with an area of 18.1 hectares. This lake is formed as a result of a nearby stream that was blocked by landslides during an earthquake in the 1970's. The special attraction of the lake are the dead remains of tree trunks emerging from the surface, as this place was once said to be a grazing land with plentiful trees. Many of the tourists know this lake as Madhuri Lake, on the name of an actress of Indian cinema, for her screen shots at this lake in the movie *Koyla* where the lake was featured.

This lake neither dries up nor freezes², which makes it a very popular area for recreation of all kinds including fishing and boating.

The Nagula lakes

These are a cluster of lakes in close proximity and are collectively known as Nagula, ranging from 1.0-4.6 hectares in area at an elevation of 4,075-4,209 metres (27.654 N, 91.863 E). These lakes are situated 20-40 km from Tawang township and can be approached by road. The lakes remain untapped for any domestic or commercial use as the area is very thinly populated. Migratory birds are plentiful in the area which has a wide scope to take up recreational fisheries through judicious stocking with trout and provision of amenities for visitors.

Thampysum Lake

One of the lesser known lakes in this region, as spoken by Fishery Officer, Mr Kabang Kamut of the Tawan District Department of Fisheries. The lake, area unknown, (27.675 N, 91.872 E) is not visible from the approach road and can be approached only by trekking uphill for 500 metres. The unique beauty of this lake can be experienced only by witnessing the immense peace and satisfaction on reaching it. The lake lies in a bowl, surrounded by mountains. Trout stocked by the Fisheries Department and ICAR-DCFR can be seen to thrive in this lake as they move around the banks. The remoteness

of this lake and freedom from human meddling and together with an organized exertion can make this location a suitable spot for trout angling, boating and trekking point for the visitors all around the world.

The lakes at Bangajang

Bangajang is basically considered as a sacred place in Tawang District. This place can be reached by road, approximately 20 km from Sela pass, a route diverted on the way to Tawang Headquarters. Bangajang place is bestowed with a cluster of small sized lakes. These are mainly visited by pilgrims of the nearby districts to offer prayers as well as tourists across the country and the world. The road for this place remains open for a couple of months per year (August-September) and remains closed in other times due to heavy snow. No effort has been made to stock trout in these lakes to date. They offer tremendous potential for the development of trout fisheries for fish watchers, but fishing may not be permitted by local communities for religious reasons.

Omaling Lake

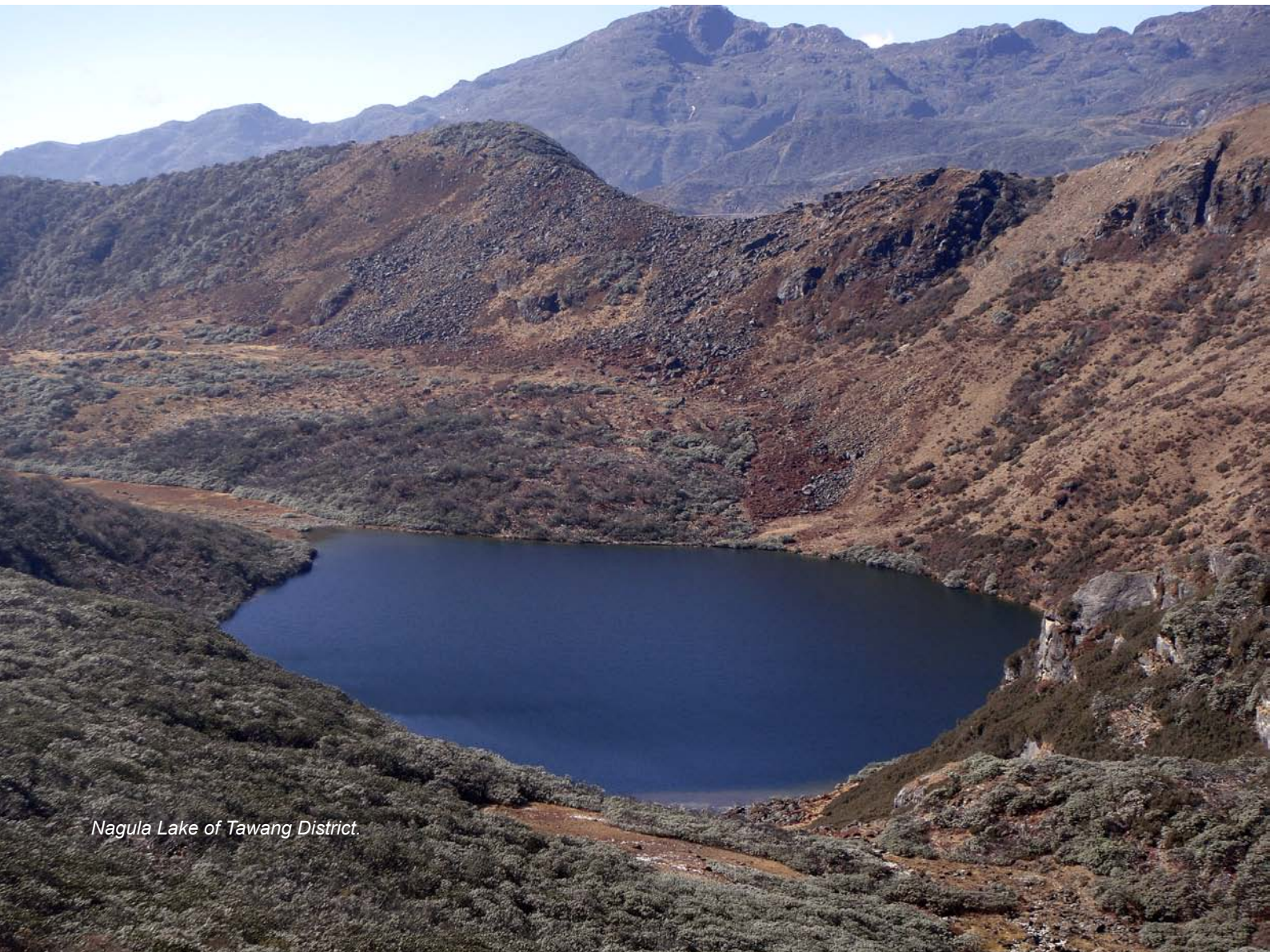
Around 2-3 hectares in area, Omaling Lake is another little-known upland lake situated in the neighbouring district of West Kameng, to the south of Tawang District. The lake is located between Shergaon and Nagajiji townships near Bhutan. The lake can be approached only by trekking on foot for 3-4 hours walking on snow-covered ground from the



The top view of Sangetsar Lake in Tawang District.



Sangetsar Lake of Tawang visited by tourists for recreation.



Nagula Lake of Tawang District.



Thampysum Lake in Tawang District.



Lesser known Omaling Lake in West Kameng District.

approach road. This lake is also visited by pilgrims of the nearby villages and is preserved by religious devotees. The lake has a great potential for the development of a recreational catch-and-release trout fishery as local communities will prohibit the taking of fish for food. The lake freezes during winter. The water is clear and transparent.



An unnamed lake in Tawang District with picturesque landscape.

Other upland lakes

As per recent records, trout have now been well established in a few of the upland catchments of Tawang District under the aegis of the Department of Fisheries, Government of Arunachal Pradesh and ICAR-Directorate of Coldwater Fisheries Research², commencing in 1994-1995. Some of the larger lakes in Tawang District with greater potential for the establishment of trout fisheries include Klemta (4.5 hectares), Khamakar (4.4 hectares), Chochong (20 hectares) and Tapiumche (27 hectares). Many more lakes could not be



8.5kg brown trout from Yargyap Chu River, Arunachal Pradesh



The trout hatchery at Nuranang.



Alevins of trout at Shergaon Hatchery.



Young ones of trout at Shergaon Hatchery.



A haul of rainbow trout from a trout farm.



A Government trout farm at Nuranang of Tawang District.

known by name and many others could not be approached due to inaccessible terrain and absence of road connectivity. But overall, we felt that the natural grandeur of these lakes make them attractive to visitors and their suitability as habitat for trout provides many options for both recreational fisheries and as a source for nutritional security to the mountain dwellers living in these remote areas of the country.

The upland trout streams

We have observed that the upper reaches of the rivers and streams especially in the districts of West Kameng, Tawang and West Siang, have established trout stocks. These fishes also serve as a source of protein for the mountain communities living along these rivers. Effort has been made by the Department of Fisheries and ICAR-DCFR for rehabilitation of trout populations in these streams, especially the Nuranang stream and Choskorong Kho River, adjoining the two Government established trout hatcheries at Nuranang and Shergaon villages, respectively. Both these rivers offer an excellent scope to invite anglers from around the globe for trout fishing, generating income for the local villages.

River Siyom (locally known as Yargyap Chu) is another major river in West Siang district flowing through the township of Menchukha. This river provides a picturesque landscape to the valley and is known as a home to exotic brown and rainbow trout. Together with the countryside backdrop, the river Siyom has been admired as another paradise for the anglers in search of trout in the State of Arunachal Pradesh.

The trout hatcheries

Two trout hatcheries have been established in the State of Arunachal Pradesh based on the favourable water temperature for trout ranging around freezing point to as high as 20°C. The first trout hatchery was established along Nuranang stream (27.535 N, 92.050 E) at 3,674 metres in Tawang District, initially importing a consignment of brown trout seed from Jammu and Kashmir. The Sela Lake connected upstream is now the source of trout broodstock in the Government trout hatchery. However, construction of a weir across the lake-river connectivity has caused a sharp decline in trout catch downstream as spoken by the caretakers of the hatchery. This has led to lesser seed production in the hatchery due unavailability of desired pairs of trout broodstock in the stream.

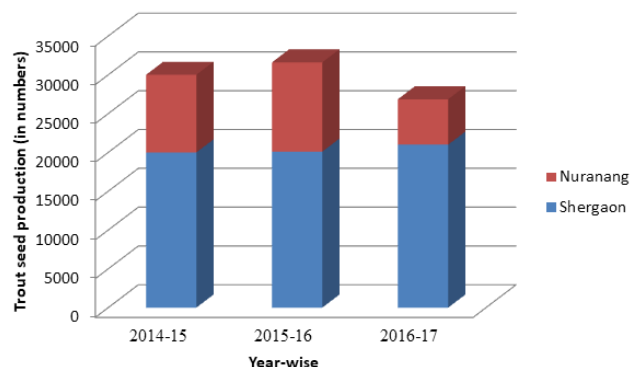
Another hatchery with a production capacity of 50,000 to 100,000 eyed ova was also established at Shergaon (27.133 N, 92.277 E) in West Kameng District during 1979, located at an altitude of about 2,085 metres. However, trout seed are produced at an average rate of 25,000-30,000 in the past three years from both the hatcheries and these seed are either procured by local trout growers or released in nearby streams for rehabilitation of the stock.

Considering the encouraging results in trout seed production, the Department of Fisheries has established a Regional coldwater hatchery and a farm complex at Samtheng, situated 8 km from the hatchery, encompassing an area of 300 hectares, for successful rearing of the trout. ICAR-DCFR has been providing technical guidance and inputs in establishing these hatcheries through up gradation of human resource development, providing technical advice, trout seed consignments and hatching facilities.

The trout farms

The trout hatcheries established for seed production and rearing of fingerlings has encouraged stakeholders to gradually commercialise their trout farms in this region. Privatisation of trout farms by entrepreneurs are mostly supported financially by the Department of Fisheries and technically by research institutes especially the ICAR-Directorate of Coldwater Fisheries Research. This concerted effort has resulted in horizontal expansion of trout farming in the region. It is expected that in the days to come, the scarce supplies of trout feeds and seeds will be made available on a regular basis, which will strengthen trout farming to rise at par in these high altitudinal remote areas. Rainbow trout is the most preferred fish for culture in the region due its ability to adapt in variable aquatic environments with substantial growth performance. On the other hand, brown trout is highly valued as sport fish for angling in trout waters. The other districts of Arunachal Pradesh with potentiality for dispersal and propagation for trout farming and recreational fishing are Lower Subansiri, Upper Subansiri and Anjaw.

Fig. 14: Quantative seed production of trout in Arunachal Pradesh



Source: Department of Fisheries, West Kameng & Tawang districts, Govt. of Arunachal Pradesh

Trout angling

Trout is regarded as the best sporting fish of the coldwater in the country. A considerable population of trout has been reported in upland waters of Menchukha region of West Siang District by an avid angler Mr Dorjee Sona from the area. The river Siyom (locally known as 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 organising 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. A good number of sizable brown trout of 8-12 kg by weight has been reported from these waters which is an implausible catch among the water bodies of the entire State. Trout thrives well in this river, although the source of the fish remains unknown. The adaptation of the trout in these cold waters provides an excellent opportunity for game fishing in this mesmerising part of the country.



Private trout farms in West Kameng District.



A haul of snow trout by noose and line method at Dirang area.

Aquatic ecology of the upland water resources

The climate of the river valleys and upland lakes varies from severe cold to mild depending upon the altitude of the area and extent of exposure to sun. The temperature in upper reaches in winter falls below 0°C due to heavy snow fall. The normal annual temperature for the upland water bodies is less than 20°C. Dissolved oxygen concentrations increase wherever the water flow becomes turbulent, such as in a riffle area, cascade or a waterfall. The pH values ranged from slight acidic to slight alkaline and medium alkalinity. The total hardness in various water bodies has soft to moderately hard water. Table 1 generalises the water quality parameters of important upland trout water bodies of Arunachal Pradesh. The important species of phytoplankton in lotic water are comprised of *Fragilaria* (30%), *Stigeoclonium* (30%), *Pinnularia* (20%) followed by others viz., *Navicula*, *Nitzschia*, *Oscillatoria*, *Chlamydomonas* etc. Zooplankton are mostly dominated by rotiferans and cladocerans. There are no major sources of organic pollution loading in the rivers and lakes as their vicinities are thinly populated by humans. The low cropping intensity coupled with low agro-chemical dosing and absence of industries also means that the pollution load due to chemicals is quite low. None of the lakes and streams are infested with emergent type of aquatic plants and have clear water.

Table 1: Physico-chemical parameters of major trout water of Arunachal Pradesh

Parameters	Upland lakes	Upland streams and rivers	Upland trout farms and hatcheries
Temperature (°C)	5.37-8.36	11.42-14.09	6.0-14.0
pH	5.04-7.35	6.86-7.90	6.82-8.05
D.O (ppm)	6.20-8.30	8.06-8.13	5.00-6.18
Resistivity (mΩ.cm)	0.043-1.000	0.008-0.060	0.0039-0.064
Conductivity (µS/cm)	0.00-23.00	16.0-124.0	2.0
Actual Conductivity (µS/cm)	0.00-16.00	13.0-96.0	1.00
TDS (ppm)	0.00-12.00	8.0-62.0	1.00
Salinity (ppt)	0.00-0.01	0.01-0.06	0.00
ORP	-80.30-59.70	-42.2-47.50	-15.1-(-62.1)
Ammonium (mg/L)	<0.01	<0.01	<0.02
Nitrate (mg/L)	1.4-5.3	4.0-5.8	4.0-4.5
Nitrite (µg/L)	<5.0-6.6	8.0-10.0	5.0-5.3
Phosphate (mg/L)	<0.01-0.02	0.14-0.90	0.31-0.34
Sulphate (mg/L)	<0.02-0.11	<0.02-0.55	<0.02
Chloride (mg/L)	<2.5	<2.5	<2.5
Iron (mg/L)	0.29-0.56	<0.01-0.12	0.37-0.42
Magnesium (mg/L)	<5.0-23.5	<5.0	<5.0
Calcium (µg/L)	7.0-26.0	17.0-70.0	8.0-8.5
Cadmium (µg/L)	<5.0	<5.0	<5.0
Zinc (µg/L)	<0.20	<0.20	<0.20
Copper (µg/L)	<0.05	<0.05	<0.05
Turbidity (NTU)	0.27-1.72	0.31-0.48	0.37-0.42
Alkalinity (NTU)	4.0-22.0	16.0-52.0	12.0-16.0
Hardness (NTU)	6.0-22.0	14.0-64.0	10.0-12.0

Fish diversity in the trout streams of Arunachal Pradesh

The distribution and diversification of fish species in Arunachal Pradesh can be mainly attributed to altitude and topography. The higher elevations have specific coldwater forms mostly dominated by *Schizothorax* species (snow trout), *Garra* species and *Glyptothorax* species. These Schizothoracine fishes are the important indigenous trout from these upland water resources for capture and are not commercially stocked in ponds and tanks for culture in view of their slow growth rate. Recreational fishing with these snow trout involves a specially designed noose on line method developed indigenously by the local fishers of Dirang region in West Kameng district³. These snow fed streams and rivers converge into a common drainage downstream in the foothills and plains, and here the fish composition are mostly comprised of the mighty mahseers, catfishes, featherbacks, eels, carps, barbs and minnows. Altogether, 258 fish species belonging to 21 families and 76 genera have been reported from the coldwater resources and utilised for sports, ornamental value and as food fish⁴.

Fisheries development strategies in upland resources

The proposed strategies of fishery development are aimed towards upland resource utilisation by means of propagation and conservation of indigenous and commercially important species of trout. Some of the strategies may be worked out by: i) resource mapping of unutilised upland water bodies for framing developmental policies, ii) establishment of location-specific hatchery units for facilitating seed production and propagation, iii) habitat rehabilitation for trout conservation, iv) awareness and capacity building among mountain dwellers for adopting trout farming to ensure food security, v) promo-

tion of eco-tourism and angling for recreation and income generation, and v) strengthening of human resource development in the public sector to implement these strategies in remote hilly terrains.

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