Exotic trout fisheries resources and potentialities in Uttarakhand

Deepjyoti Baruah, Kishor Kunal, Ravindra Posti, N.N. Pandey, Jagdamba[1] and H.K. Purohit[2]

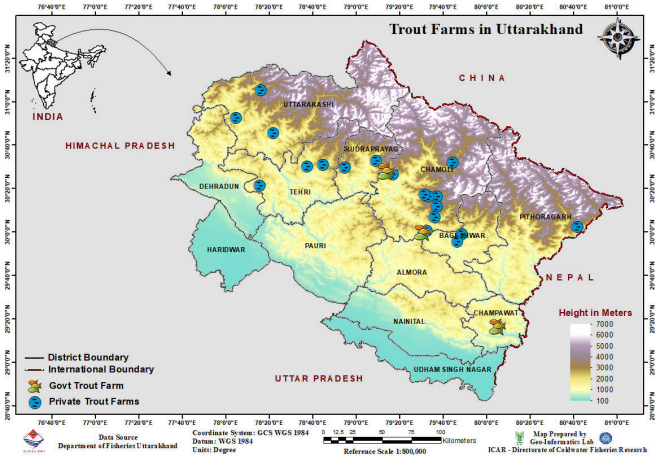
ICAR-Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand; 1. Department of Fisheries, Gopeshwar-246401, Chamoli district, Uttarakhand; 2. Directorate of Fisheries, Badasi Grant (Dhanyari), Dehradun-248008, Uttarakhand

Above, below: Government trout farm and hatchery at Bairangana, Chamoli District.

Uttarakhand is the 27th State of the Republic of India, sharing international borders with China in the north; Nepal to the east; the Indian States of Uttar Pradesh to the south and Himachal Pradesh to the west. The State is divided into two divisions, Garhwal and Kumaon, covering seven and six districts respectively. The winter capital of Uttarakhand is Dehradun and the summer capital is Gairsain in Chamoli District. The State of Uttarakhand is often denoted as Devbhumi meaning the 'Land of the Gods' due to the existence of numerous Hindu temples and sacred shrines along the banks of the rivers of the State. The rivers of Uttarakhand are also reckoned to be holy in India, especially the river Ganga and Yamuna both of which have their origins in Uttarakhand State. Other well-known rivers in the State include Bhagirathi, Alaknanda, Nandakini, Pindar, Kosi, Mandakini, Ramganga, Kali, Nayar, Dhauliganga, Saryu, Bhilangna, Tons, Saraswati and the Gomati. Each of these rivers has their own religious as well as economic significance. Apart from the religious faiths and myths, these rivers along with their tributaries impose an allurement for those seeking adrenaline rush activities such as rafting, kayaking, trekking, zorbing and bungee jumping. Angling and riverside camping are other ways one can relish the rivers of Uttarakhand at their best.

Government trout farm and hatchery at Talwari, Chamoli District.

The topography divides the State into three altitudinal regimes: the mountains, the Bhabar and the Terai. The altitudinal variation provides a rich habitat for 125 fish species in the State of which 76 species fish are distributed in Garhwal region and 96 in Kumaon region (Sondhi, 2012). The salmonids in particular are mostly valued due to their superlative nutritional quality and sporting excellence in the temperate regime (Baruah, 2019). The two most important exotic salmonids found in India are the rainbow trout *Oncorhynchus mykiss* (Walbaum 1792) and brown trout *Salmo trutta*, Linnaeus 1758 thriving well in cold freshwaters of the Indian Himalayan Region. In Uttarakhand, the history of trout farming dates to 1910 when the eyed ova of rainbow trout were transplanted in the Government trout farm at Talwari in Chamoli District. In the beginning, trout was solely regarded as a sport fish and was less considered as an aquaculture avenue. But gradually, with the advancement in technical know-how on raceway farming practices, breeding and seed production, feed preparation and disease control



Map showing the distribution of trout farms in Uttarakhand.

Table 1: Major water quality parameters of trout farms and hatcheries of Uttarakhand.

Water quality parameters	Talwari	Bairangana	EFF Champawat	Private farms
Temperature (C)	6.2-6.5	6.4-7.7	11.2-14.3	8.5-14.6
pH	7.8-8.4	7.1-8.1	6.5-7.3	7.7-8.2
Dissolved oxygen (mg/l)	8.56-9.85	8.58-10.32	6.42-8.64	8.10-8.80
Total alkalinity (mg/l)	42-44	40-42	20-22	48-50
Total hardness (mg/l)	120-130	110-130	100-110	130-140
Ammonia (mg/l)	0.00	0.04	0.10	0.14
Nitrite (mg/l)	0.00	0.03	0.10	0.10
Nitrate (mg/l)	0.01	0.06	0.30	0.60

mitigations led to a transformation of the commercial trout farming scenario in the country. At present, the leading trout producing States in India are Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Tamil Nadu and Kerala. The States of Sikkim, Arunachal Pradesh and Nagaland have also gained momentum in trout rearing in pursuance to meet the ever-increasing demand of trout by tourists. Commercial trout farming in Uttarakhand has advanced progressively during the last decade and has become a profitable occupation among the rural masses especially in the colder regimes where no other fish farming has possibilities. The rainbow trout here plays the most dominant role as a commercially important candidate species for culture in this hill locked Himalayan state of India. The present annual rainbow trout production in Uttarakhand is nearly 4 tonnes from the Government sector and 5 tonnes from the private sector as spoken by the fisheries officers of Govt. of Uttarakhand. Altogether, there are 27 trout farms and 336 raceways established in the State. The most trout farms are in Chamoli District accounting six that are privately owned and two operated by the Government sector.

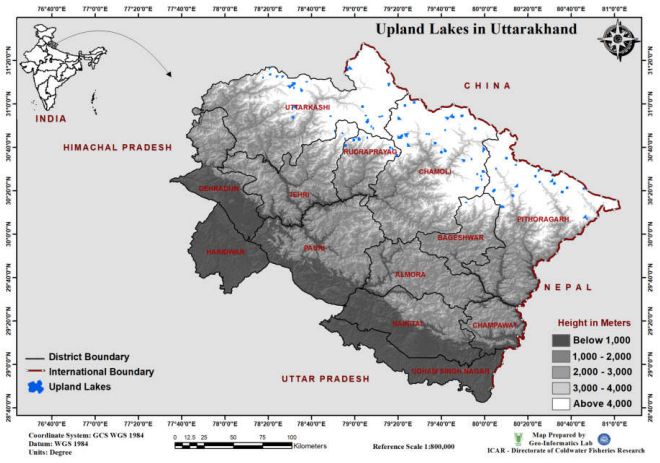
The major mode of distribution of this fish around the State is by eyed-egg transfer or fingerlings. The State has two well-equipped trout hatcheries under the Government sector located at Talwari and Bairangana in Chamoli District. The trout hatchery at Talwari is situated along the banks of a sub tributary of the Pindar River and has 28 rearing raceway units for rearing the brooders and seed production facilities with the capacity to produce 100,000 eyed eggs. The young ones are marketed to the growers of Dewal, Taal and Wan regions of the State. The trout hatchery at Bairangana is situated 15 km from Gopeshwar Township on the bank of snow fed Balkhila Gad. The hatchery has 700 brooders and produces approximately one million eyed ova each year. Altogether, 34 raceways are operational for the rearing of broodstock and alevins in the hatchery. The private farms seldom produce their own seed and therefore transport trout fingerlings from government hatcheries each year to stock in their raceways. The seeds are transported to places like Sutol, Urgam, Lwani and Ghat. Another trout seed production unit is situated at Experimental fish farm (EFF) at Champawat District along the banks of Chirapani Gad under the aegis of the ICAR-Directorate of Coldwater Fisheries Research. The Centre at present produces around 100,000 eyed ova and has a target to produce one million in the coming years. 2,800 brooders are maintained in four concrete raceways. The seeds are either used for their own research purpose or are distributed to the nearby villages such as Patti, Lohaghat, Reetha Sahib, Kathar and Madyoli for rearing as an avenue. In all the above hatcheries, the fertilised eggs are incubated in hatching troughs and remained undisturbed until the eyed stage is reached. The young ones are reared in fibreglass reinforced plastic (FRP) tanks of various dimensions based on the utility. However, young ones are also raised in concrete parallel channels along the rearing raceways at Bairangana and these have shown equal success compared to the FRP tanks. After hatching, the young pass through a series of morphological changes from sac fries or alevins to swim-up stage up to the fry stage when they are moved to outdoor grow-out facilities.

Rainbow trout is favoured in colder climatic conditions and are reared in concrete raceways on commercial lines. Access to qualitative and quantitative freshwater is the most important initial factor in deciding the suitability of a site for trout farming in order to achieve sound productivity and to mitigate disease.

Experimental Fish Farm at Champawat District.

Concrete channels for trout seed rearing at Bairangana.

Trout fry at Experimental Fish Farm, Champawat in FRP trays.

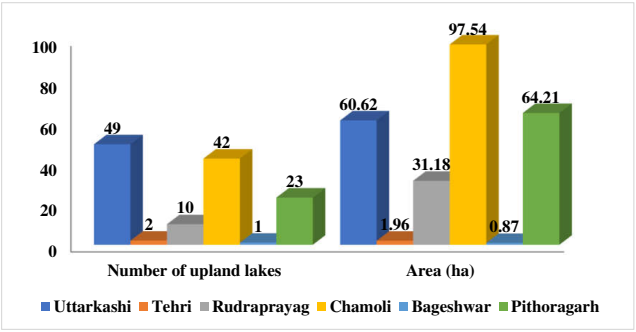


Distribution of high altitude lakes in Uttarakhand.

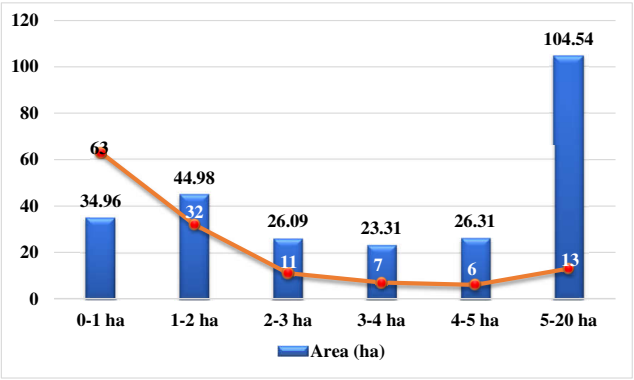
Therefore, the trout farms and hatcheries in Uttarakhand are located in a topography which ensures a perennial source of high-quality stream water year-round. The units of the trout farms and hatcheries are designed to have the best use of gravity for a convenient supply of water across the landscape. The water is mostly silt free except during the monsoon flow. Therefore, sedimentation tanks with buffers are provided in the government trout farms to retain the silt before water passes into the rearing and hatchery units. The other important factors for success of a trout farm in becoming a revenue generating centre are optimum temperature, pH, adequate dissolved oxygen, total alkalinity, hardness, and low ammonia, nitrite and nitrate levels in water (Table 1). The soil is not a major factor as the trout are cultivated in concrete raceways. The raceways are rectangular in shape

Raceway.

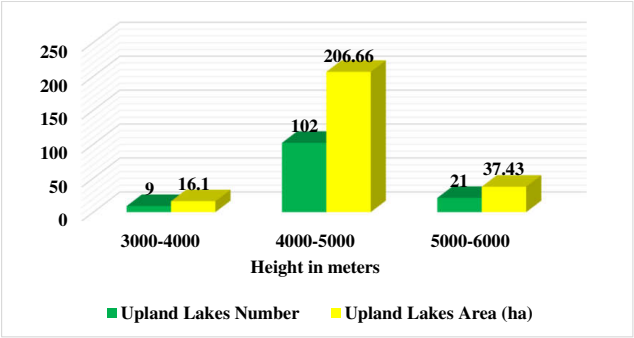
District-wise distribution of upland lakes in Uttarakhand.



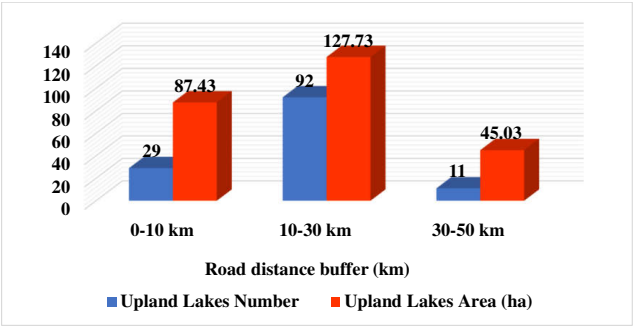
Size-wise classification of upland lakes in Uttarakhand.



Altitudinal-wise distribution of upland lakes in Uttarakhand.



Distribution of upland lakes according to the nearest road connectivity.



Trout raceways.

having an inlet pipe or channel at one end and an outlet at the opposite end fixed with wire mesh for overflow of water. A drainpipe or a drain channel is also provided at the bottom of the pond to facilitate the harvesting as well as in cleaning of the tank periodically. Both the parallel and serial type of raceways were observed which measured 15 x 3 x 1 m as standard dimensions maintaining a continuous water flow through them. The raceways are stocked with 45-50 fishes m^{-2} at Uttarakhand. Rainbow trout reaches a marketable size of 250-260 g usually in 12 months of rearing (Pandey and Ali, 2015). The stock is essentially graded four times during the rearing period in the initial year viz., at 2-5 g, 10-20 g, 50-60 g and >100 g, so as to ensure uniformity in growth. Periodical size grading and estimation of fish biomass determines the specific growth rates, feed conversion ratios and the production costs which are an essential requirement under better farm management practices.

Many of the aquatic resources with fisheries significance in Uttarakhand are still unexplored due to their remoteness in location and poor road connectivity. An effort has been made through application of GIS in determining potential sites suitable for trout farming and angling. Non-spatial data has further enhanced the development of suitability maps for understanding the actual land availability for cold water fisheries development in the State. Enumerating river resources reveals a total combined length of 10,928 km of river network in the State of which around 3,150 km has the potential to sustain suitable habitat for brown trout based on the criteria of elevation and the existing thermal conditions. These river resources have a temperature range below 16°C, delivered with clear and oxygenated freshwater (6.0-9.5 mg/l) and are surrounded by sparsely populated human habitation. Some of the important stretches of river and their upstream reaches harbouring brown trout have been reported

Interactive meet among scientists, officers and 300 fish farmers of Pauri Garhwal region of Uttarakhand.

Sedimentation tanks at Bairangana.

to include Nandakini, Pranmati Gad, Dhauli Ganga, Laisar Gad, Bhilangna River, Har Ki Dun, Pinder (Singh et al., 1983); Asiganga, Lake Dodi Tal, Balkhila Gad, and Madhu Ganga (Rawat et al., 2011). Applying the tools of GIS in the present communication showed the rivers Nandakini, Dhauli Ganga West, Laisar Gad, Bhagirathi, Bhilangna, Asiganga, Pranmati Gad, Bal Ganga, Badiyar Gad, Gomati, Balasuti, Pinder situated in the northern part of Uttarakhand can form potential grounds for brown trout. These river stretches may further be considered for establishing angling beats which can offer potential fishing spots for capturing brown trout on a catch and release basis. Although the seed production of brown trout in the state is very meagre, attempts has been made at the Bairangana hatchery to produce seed from 200 brown trout broodstock in recent years.

In addition, the State is also bestowed with 132 upland lakes covering an area of 260 ha and situated at an altitudinal regime ranging from 3,000-6,000 m MSL. The highest number of lakes is in the district of Uttarkashi whereas the largest area covered by these lakes is in Chamoli District. The minimum and maximum size of these lakes are 0.22 ha and 19.71 ha area respectively with an average size of 1.97 ± 2.54 ha area. There are 63 smaller sized lakes of 0-1 ha in the State whereas there are 13 of the largest sized lakes within the range 5-20 ha area. The largest number of lakes is situated at an altitudinal regime from 4,000-5,000 m MSL. 121 lakes cover 215.16 ha area are within the range of 0-30 km from road connectivity. The roads are considered as the major transport lines for carrying the basic inputs to the farm sites especially in the mountain regions. All these facts indicate the potentiality of the State in developing promotional based trout livelihoods among the rural folk dwelling amid the high mountains.

Overall, rainbow trout is a highly commercial food fish in the upland region of Uttarakhand and its farming has progressed steadily during the last decade and it has become the most profitable cold-water fish. Application of the tools of GIS has shown that the upland regions of the State situated above 2,000 m MSL with high potentialities for promotion of trout fisheries cover a land area of 1955 km^2; moderate potentialities cover 2,705 km^2 area and least potentialities cover 457 km^2 area. Altogether eleven districts have been found to have potentialities of which the districts of Almora (19.35%) and Pauri (19.26%) have shown the maximum potentialities followed with the districts of Dehradun (12.62%), Uttarakashi (12.09%), Chamoli (9.89%) and Pithoragarh (8.52%). Furthermore, the state being a tourist destination for many can be an added advantage for an easy access to the market, restaurants, riverside camps and homestays. The fish can be relished and prepared in many different forms such as boiled, smoked, steamed, and fried and their good taste and flavour can fetch higher market returns upon transport to nearby cities in frozen conditions. At the same time, brown trout has all the superlative qualities to become one of the most important sport fish and the seeds are being produced primarily to release them in the upland streams and lakes. A concerted effort from the researchers, anglers, hatchery managers and entrepreneurs can develop certain trout angling points together with other ancillary services and adventure sports inviting tourist worldwide to the State.

Diagnostic visit by scientists to evaluate a potential trout farming site, Chamoli.

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