

Coldwater fish farming

in Indian Himalayan region: Challenges and opportunities

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*Indian Himalayan region is abounds in innumerable rivers, streams and lakes. Of these, upland aquatic resources and mid-Himalayan region laying in the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, part of West Bengal, Sikkim, Arunachal Pradesh, Nagaland and Meghalaya in the Himalayan range and Western Ghats like the Munnar high ranges in Kerala, Nilgiri hills in Tamil Nadu and Bababudang hills in Karnataka are some of the potential areas offering enough resources for coldwater fish farming in the country. Under the influence of lower temperature regime, the farming of selected cold water fast growing species i.e. rainbow trout (*Oncorhynchus mykiss*), exotic major carps i.e. grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*) and common carp (*Cyprinus carpio*) and few exotic ornamental fishes and minor carps are in practice among the people of Indian Himalayan region.*

Keywords: ICAR-DCFR, Polytask, Rainbow trout, Recirculating aquaculture system, Trout raceway

Rainbow trout farming in raceways

Among all the coldwater cultivable fish species, rainbow trout has been considered as a promising candidate species in hill fish farming and its large scale seed production and culture is being carried out in several fish farms in Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh and Sikkim (Fig. 1). The basic requirement for establishing a trout farm is availability of good quality and quantity of snow fed spring water where temperature throughout the year is below 20°C. There are about 35 small and big trout hatcheries with an estimated eyed ova production capacity of 15 million are present in the country which have been mostly established by the various state governments and also with the assistance of central government schemes. The states of Jammu and Kashmir

and Himachal Pradesh are forerunner in promoting rainbow trout farming in private sector. The highest trout producer states in India are Jammu and Kashmir with a table size trout production of 700 MT and 13.4 million trout ova production. Himachal Pradesh is the second highest producer (650 MT) in the country. DCFR is further giving technical support and conducting demonstration program for expanding trout culture activities in

Leh- Laddak, Sikkim, Arunachal Pradesh, Nagaland and also in high reaches of Uttarakhand. Seed production of trout is mainly in Jammu, Kashmir, Himachal Pradesh and Uttarakhand in central Himalaya. However, with the DCFR's tiring efforts, seed production of trout has further been extended in Sikkim and of late in Arunachal Pradesh. At present the trout production in the country is over 1,500 tonnes (2018-19). The

rainbow trout is a highly expensive fish to cultivate in the farms and as a luxury food beyond the reach of the common man is still holding well amongst the fisheries planners. Being a low volume high value commodity, the trout has good potential for domestic consumptions as well as foreign export. Presently the rainbow trout has been established in Indian water and is a

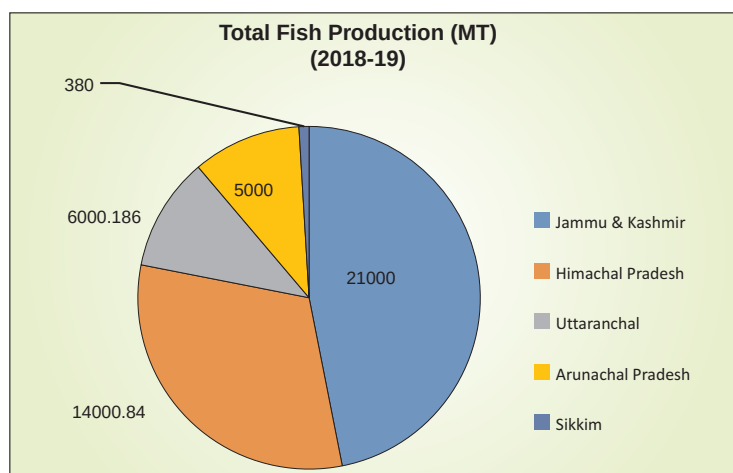


Fig. 1. Total fish production from Himalayan States is 46,381 MT



Fig. 2. Trout raceways

cultivable species with cool, clean and well oxygenated flowing water (Fig. 2). Cool, clean and well oxygenated flowing water is the prime need for the successful culture of rainbow trout. Raceways of 30-150 sq m with depth of 1 m used for the production of table sized trout fish (300-400 g). This system is feed based culture in continuous flowing water known as raceway farming. The stocking density is also dependent on quality and quantity of available water volume. Healthy seed is stocked at the rate of 5-10 fingerlings/sq m under suitable water temperature and sufficient good quality protein rich (40%) feed supply, trout attains 300-500 g size after 10-12 months with stocking of advanced fingerlings. Technology is farm based and eco-friendly to achieve production of 10-15 kg/sq m. There is ample scope for enhancement of trout production in hill states through participatory approach. The present trout production of the country is around 1500 MT which may be enhanced upto 10000 MT easily with the adoption of recent technology and with the help of best management practices. Trout has good potential for domestic consumptions as well as foreign export. It provides an excellent opportunity for utilizing the abundant aquatic upland resources and for livelihood and nutritional security to the hill community through fetching of a very good market price restaurants.

Rainbow trout farming in re-circulating aquaculture system

Rainbow trout farming has been a

promising and remunerating livelihood opportunity in Indian uplands due to the abundance of cold freshwater sources. Nevertheless, with changes in the demographic pattern and competition for resources, huge amount of water required in conventional flow-through raceway system trout farms (FTRS), makes the activity unsustainable in the long-term. To illustrate, to maintain 1000 kg of trout at a stocking density of 25 Kg/m³ in an FTRS, a water flow rate of 600L/minute is required. As such, 50-200 m³ of water (depending on the different methods of calculation) is required to produce 1 kg of rainbow trout in FTRS, which is apparently not sustainable with diminishing water resources and limits rainbow trout farming activities to an only specific region of Indian uplands. Therefore, it is time to adopt climate-resilient and intensive farming practices, which involves maximum utilization (reuse) of available land and water resources, to facilitate the blue revolution fish production targets by 2030. It is important to note that scientific advances in Recirculating Aquaculture Systems (RAS) have reduced the water requirement in trout culture by several folds (less than 1 m³ of water per kg fish production), with stocking densities as high as 100 Kg/m³. Comparison of the environmental impact of FTS and RAS suggests that RAS reduces water dependency by 93%, eutrophication potential by 26-38%, and improves food conversion ratio by 27%. Even the bottom side of

high energy requirement in RAS (16 kWh per kg fish) can be overcome by strategically reducing energy usage to a significant extent by optimizing water re-circulation and oxygenation requirements. Besides, clean energy sources (e.g. solar energy which is adequately available in hilly regions) and biogas produced from fish waste sludge can be utilized to make RAS based rainbow trout farming more sustainable. Further, by controlling water temperature in RAS, it is possible to reduce crop duration to 5-6 months (as compared to the 12-14 months cycle in FTS) and augment production per unit time.

In this regard, ICAR-Directorate of Coldwater Fisheries Research, Bhimtal has initiated a study for the feasibility of RAS for rainbow trout in the Indian context. ICAR-DCFR designed and installed a RAS, consisting of four 7 m³ large culture tanks for grow-out production and 18 (0.5 m³ each) juvenile rearing and experimental tanks with available rearing volume of 33 m³ (Fig. 3). The system consists of radial flow separators and mesh screen drum filter to remove settleable and suspended solids and two moving-bed biological filter to remove ammonia and nitrite, and a UV filter for disinfection. The water is re-circulated with the help of water pumps continuously. With the current pilot-scale RAS set up, it is possible to produce 1.2 MT of trout per crop cycle (2.4 MT per year, at the stocking density 40 kg per m³). The production can be increased to ~5.0 MT per year with the help of pure oxygen for oxygenation and



A pilot scale rainbow trout Recirculating Aquaculture System



Harvesting rainbow trout from RAS

Fig. 3. Rainbow trout farming at ICAR-DCFR, Bhimtal

addition of CO₂ stripper and protein skimmer to system. In the trial, ~ 250kg of rainbow trout are harvested and sold from two of the grow-out tanks, and observation indicates that growth rates are much faster in RAS compared to FTRS (100 g to 800 g in four months) due to controlled water parameters. Currently, we are testing the system for complete production cycles and economic feasibility of the RAS system for rainbow trout farming in the Indian scenario. RAS system can significantly contribute to increase in trout production due to the fact that the RAS farming practices can be done from nearly anywhere in the Indian upland region with limited water availability and lower land footprints which otherwise impossible with current farming practices in flow through raceways. Moreover, ICAR-DCFR is also working on development of affordable and economically viable prototypes for small scale RAS trout production systems which can be operated by small scale farmers and will be disseminating soon to the Indian hill fish farmers.

Polyculture of exotic carps

In the upland waters, Chinese carps are commonly cultured in the mid-Himalayan region as the candidate species for polyculture. The culture of Chinese carps were introduced in the polytanks/irrigation tanks in the mid altitude regions. The technology provided opportunities for conservation of water for irrigation and fish culture. The use of polytanks has shown

enhanced growth of fish. Around 76 farmers in the Champawat and Almora districts of Uttarakhand have already adopted the technology. Recently, DCFR imported improved Hungarian strain of scale carp and mirror carp and the farm raised improved strain of common carp was propagated for aquaculture promotion in hill states which gave very promising results having 35-40% better growth over the existing old stock of introduced common carp. In the upland waters the Indian major carps do not grow well, due to the low thermal regime. Therefore, Chinese carps were taken as the candidate species for polyculture. Seed in the form of fry is being used for stocking grow-out ponds, which require 12 months to get the table size fish (>1 kg). The average fish production in the existing system is 2.6 t/ha which can be doubled through technological support, quality seed, feed and improved management practices. Crop duration may be reduced to half with the practice of stocking of stunted fish of 50-80 g. However, provision of seed banks is required for round the year availability of stocking material to the farmers. The carp culture practice may also be integrated with dairy, poultry and horticulture keeping the fish pond as nucleus in view of increasing productivity, reducing risk and production cost.

Composite culture of rohu, catla, mrigal, grass carp, silver carp and common carp in earthen ponds of the size of 0.1-0.4 ha is advisable for the foot hill region (800-1000 msl). Raw cow dung (RCD) @ 9000 kg/ha/yr is

applied to ensure consistent growth of plankton. Stunted fish of the size of 50-80 g are stocked at the rate of 5000-6000 fish/ha with species ratio of 40:30:30 for catla and silver carp (surface feeder), rohu and grass carp (column feeder) and mrigal and common carp (bottom feeder), respectively. Supplementary feed, prepared from locally available ingredients such as oil cake, rice polish/bran is given @ 2-3% of the body weight. Vegetable waste/terrestrial grass is used for grass carp feeding. Two crops of 6 months each can be achieved with average production of 2.5-3 t/ha (total annual production- 5-6 MT/ha). With an expenditure of ₹ 2,700/100m², a gross income of ₹ 7,200/100m² has been achieved with a net return of 167%. Profitability (₹ 4,500/100m²). There is great scope for disseminating this promising technology in sub to mid Himalayan belt in order to upgrade the socio-economic conditions of the inhabitants. There is a need of introduction of large scale farming to bring the country on International scenario. The linkage of public and private sector is mandatory in order to further development of this technique. The farmers in the hill region have integrated type of farming pattern. Fish can serve as an additional source of income if integrated with the hill agriculture.

Polyculture in polyline tanks

The Chinese carp based mixed culture have shown positive results fetching average 340 g/m² in an extended culture period of over one

year. However, this limited production can further be raised up to 700 g/m² by adopting multi-tier model for integrated fish farming using polytanks. These plastic (silpaulin) film lined ponds are suitable for rainwater harvesting in uplands where scarcity of water becomes major bottleneck in agricultural production or diversification from poorly remunerative production to scientifically recommended production considering local climatic and soil advantages. In Himalayan hilly tracts, such ponds are being used for rainwater harvesting or storing the water from low discharge springs which otherwise cannot be directly used for irrigation purposes.

The following steps are involved in the preparation of polytank

Digging of the pond (100 m³ from 80 to 100 m² land area), removing sharp edge material (stone pieces) embedded on the walls and the bottom of the pond. Plastering the inside wall and bottom by using a mixture of fine soil and water mixture to smooth them. Lining the pond's walls and bottom with polythene/silpaulin (200-250 g per meter). Advanced Fingerlings (20-25 g) of silver carp, grass carp, improved common carp and minor carp are stocked at the rate of 3-4 fish/m³. Vegetable waste/terrestrial grass is used for grass carp feeding @ 20% of total fish biomass daily. Waste of grass carp in the form of faecal matter acts as manure in pond water and enrich the plankton production which is the natural feed for silver carp. Some part of the faecal matter is directly eaten by common carp. Stored water in the poly tanks also acts as buffer stock and is used for the irrigation of horticulture crops. This water remains rich in nitrogen content and also acts as manure for horticulture plot. In hills, the agriculture is mainstay of the inhabitants but the average land holding is 700-900 m² compared to national average 1370 m². The soil productivity is less due to marked water shortage during the summer in the streams of hills, soil is gravelly and porous that has low water

holding capacity which limits the production cycle and farm activities. This is the main cause of migration of the young people to the plains for earning their livelihood. In this context, this model has a lot of scope to intensify in the mid hills for increasing the productivity of the land that can help in ensuring nutritional and livelihood security in the hills which ultimately, would decrease the pressure on the metropolitan cities since this would check the migration from hills to plains. There is great scope for disseminating this promising technology in sub to mid Himalayan belt in order to upgrade the socio-economic conditions of the inhabitants. With an expenditure of ₹ 3,000/100m³ a gross income of ₹ 11,200/100m³ was achieved with net return of 273%.

Ornamental fish farming in hills

The demand of ornamental fishes is increasing remarkably due to their important role in the world trade for fish and fishery production. The export of ornamental fishes from India is worth only US\$ 0.2 million, which is not sufficient with regard to the rising demand of these beautiful coloured species in the world ornamental fish market. The Potential ornamental fishes of the coldwater resources are *Barilius* species, *Namacheilus* species, *Botia* species, *Puntius* species *Garra* species and also few exotic species are unique for aqua gardening. This diversity is yet to be explored for breeding and culture practice which may have great coldwater ornamental fish value.

A germplasm repository of seven cold water ornamental fish species

like *Barilius*, *Tor chilinoides*, *Garra*, *Schistura*, *Nemacheilus* including exotic gold and koi carp have been established in DCFR, Bhimtal campus. The focus of the technology is to establish culture and breeding of ornamental fishes in the backyard or Kitchen garden in upland rural areas. Depending upon the space and available resource, the unit is established. For establishing a 30 sq feet with 5 feet deep UV resistant polylined tank including labour and input cost is about ₹ 2,500. Total about 350 fishes can be stocked with a survival of 300 with a sale value @ ₹ 25/piece in hills is about ₹ 7,500 with an approximate net income of ₹ 5,000 per year. The small landholding in the hills with marginal agricultural and allied activities is directly affecting the economic status of the population (Fig. 4). The intervention of ornamental fish culture in the tribal regions will help in upbringing the livelihood opportunities. Ornamental fish keeping in house, hotels, offices are the general practices by much reason (fascination/recreation/aesthetic value) which will create livelihood opportunities in the hill areas.

Upland rice-fish culture

The rice-fish wetlands are important resources in the state of Arunachal Pradesh, Nagaland, Meghalaya, Manipur and parts of Assam. A large area in Apatani plateau in Ziro valley of Lower Subansiri district of Arunachal Pradesh, several districts of Nagaland and other Northeastern states is being cultivated under rice-fish culture (Fig. 5 and 6). The fish production in these fields is at present



Fig. 4. Ornamental fish farming in hills



Fig. 5. Upland rice-fish culture

is low (215-290 kg/ha) and scientific intervention is required to enhance the productivity. Higher productivity from rice-fish plots can be achieved by stocking bigger size (3-4") of quality fingerlings at appropriate density of fish (1-2 fish/m²) and redesigning proper sized trenches in the field for providing shelter to the fishes. Of course, nutrient and natural fish food available have to be taken into account to decide the practices of organic fertilizers and supplementary feed. There are possibilities to enhance the productivity to 3-4 times. Never the less, large sections of upland population including women are dependent of rice fish culture in NE region and it gives livelihood and nutritional security to the particular tribes of Indian Himalayan region.

Challenges in coldwater fisheries development

The constraints of coldwater fish farming are low productivity of upland waters due to comparatively slow growth rate in almost all fish species except rainbow trout, coupled with low fecundity in fishes. Further, poor landing and marketing facility

are also obstacles in the development and expansion of coldwater fish production.

The major constraints are cost intensive activity, slow growth rate leading to less output, lack of infrastructure (e.g. Raceways, Hatcheries, and Transport *etc.*), costly inputs (less availability of seed, feed for culture), habitat destruction, lack of commercial/cluster approach for farming, non-adaption of fisheries as main stream profession by local population and lack of organised market for selling high value fish like trout.

The key strategies to be adopted to address the challenges and tap the opportunities are:

- Promotion of trout farming in areas above 1,500 msl having temperature range of 4-12.
- Poly culture in hill regions between 700 and 1,500 msl with suitable land and water resources for carp culture.
- The eco-climatic conditions of the foothills and river valleys located up to 500 MSL are suitable for composite culture of carps. Such sites are available in the

catchments of the Himalayan and peninsular rivers, streams and their tributaries. The carp farming would be, therefore successful in the valleys and peripheral regions located in the temperature range between 15 to 25°C.



Fig. 6. Traditional rice fish culture in Ziro valley, Arunachal Pradesh

Future Scope

Under scientific management and through application of modern techniques, significant scope exists for promoting trout farming, which in long run, will have both domestic and export demand. There is also a great potential for sport fishery development and ecotourism in hill regions. Ornamental fish culture for small scale enterprises in the hills can provide an alternative source of employment. Presently DCFR has different available technologies for the hill aquaculture, resource management and conservation. Three ponged fish farming has been standardized and also disseminated to the farmers of different hill states of the country. Chinese carp based polyculture technology has been popularized and also adopted by farmers in Arunachal Pradesh, Manipur and Uttarakhand. Trout farming and seed production technology has also been introduced in the state of Sikkim and Arunachal Pradesh. Aquaculture diversification is the key of fish production enhancement in the hill states and also one of the most important needs of the hour. It is believed that the introduction of Recirculatory Aquaculture System for rainbow trout farming will definitely be a game changer for improving the status of coldwater fish production in the country and will play a significant role in improving the livelihood and nutritional security of the upland population of Indian Himalayan region.

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