Best Management Practices of Rainbow trout Farming

21st-23rd March, 2019

भाकृअनुप
ICAR

शीतजल मात्स्यिकी अनुसंधान निदेशालय
Directorate of Coldwater Fisheries Research

ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand-263136

Training manual

A Three (03) Days Training Programme

under

Tribal Sub Plan

on

Best Management Practices of Rainbow Trout farming

(21-23 March ,2021)

Editors

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Dr Debajit Sarma
Director

Foreword

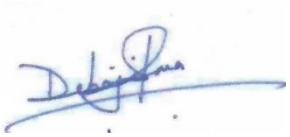
ICAR- Directorate of Coldwater Fisheries Research, Bhimtal is one of the countries premiere institutes for undertaking research, development, capacity building and extension activities in the Himalayan belt focusing especially on the Coldwater fisheries and aquatic resources. A strenuous exercise has been carried out by the directorate towards the development of coldwater fisheries and aquaculture of the country especially the trout farming. In addition to the directorate through its outreach and extension programs has contributed substantially towards the development of marginal and weaker sections of the society in the Himalayan region.

Owing to the climatic and thermal regime of the Himalayan belt, ample scope and opportunities are there for the promotion and propagation of rainbow trout farming which in turn can suffice the nutritional and livelihood needs of the population. The ICAR-DCFR, Bhimtal is dedicated to direct its efforts in developing farmer oriented, cost effective, easy to adapt and climate resilient fish farming technologies for easier adoption and maximum returns. As the Coldwater resource base of the country is huge, exploration and utilization of the same in a sustainable manner is the need of the hour.

Presently, coldwater sector contribute about 75,000 MT which is about 1.5% of total inland fish production and the intended goal is to enhance the production level up to four fold by 2050 through judicious and technological management of coldwater fishery resources, efficient production technologies and models of hill aquaculture in the context of climate change, and providing training & consultancy services for holistic growth of the sector. Morover, it has been realized that on account of population upsurge and urbanization the demand for fish has significantly increased over last decades. The coming decades are expected to pose newer and greater challenges for livelihood and nutritional security as far as hill states are concerned. Since, trout farming is in developing phase and would be a good venture of lucrative business in future. To fulfil the impending gap between supply and demand of fish, the efforts in promoting and developing rainbow trout farming in poorly utilised and underutilised areas will help in enhancing the production capacity of the region.

I strongly believe that research and development efforts taken by this directorate in the direction of developing cost effective and farmer friendly trout farming technologies in different agro-climatic zones of the Himalayan belt will encourage more and more people to take up this venture for their sustainable economic returns.

I appreciate the team of scientists of this directorate for drafting and coming up with this training manual for the benefit of the diverse stakeholders engaged in trout farming.



(Debajit Sarma)

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Rainbow trout in Kashmir: Introduction and Current status

Parvaiz Ahmad Ganie and Raja Aadil Hussain Bhat

Introduction of Trout to Kashmir valley:

Kashmir's trout fisheries history goes back to 1898 when Mr. Frank Mitchel a Scotsman introduced trout for the first time in Kashmir with the help of Pandit Sodhama Miskeen and Khwaja Gafarjoo. Mr. Mitchell, a Scot was running a carpet factory at Srinagar in nineties of the nineteenth century. Kashmir fascinated him like many others and it occurred to him that cold waters there were suitable for trout culture. He thought that if trout was introduced in the streams it would attract more tourists. So, the first batch of trout ova of 10,000 eggs arrived from U.K. in 1899 with the courtesy of Duke of Bedford, to whom the Kashmir Maharaja presented an excellent Kashmir Stag trophy through Sir Adelbert Talbot, British Resident at Srinagar. He made first attempt at culture of the brown trout in the valley in the vicinity of his factory at Bagh-e-dilwar Khan Srinagar. He also associated an intelligent young local man Sodhama Miskeen in his venture. However, half of it perished in transit because there were no airplanes those days and sea route was the only option. From Bombay the seed had to be carried first by rail upto Rawalpindi and then by bus to Srinagar in containers of water. Also the water had to be changed frequently which led to the loss of half of the stock in the transit while the other half perished on arrival. Thus, the first attempt failed but subsequent attempt in 1900 was a success. The 2nd shipment of trout ova arrived in excellent condition from Scotland in month of Dec.1900 through Mr. J.S.Macdonall which included 1800 fry. Out of this 1000 fry were transferred to Panzagam Dachigam (Harwan) about 24 km from Srinagar and rest of 800 fry were reared in the premises of a private carpet factory owner (Mr. Michel) in Baghi Dilawar Khan in the heart of city near Khank-i-Moulla. This marked the beginning of trout culture in the valley. However, in 1903 there was a devastating flood in Kashmir and Harwan hatchery lost all of its trout. Disheartened by this disaster Mitchell and Sodhama discontinued the attempt till one day, the former observed Brown trout in Ferozpur Nullah near Tangmarg jumping out of water for eating insects. Thrilled at the success of having been able to establish the trout in the Valley Mr. Mitchell was on the job once again to Harwan. He was able to convince the ruler Maharaja Pratap Singh to establish a Fisheries Department in the State and became its first Director. He appointed Mr. Sodhama as the first inspector and Gaffarjoo as the first

guard. By 1908 Brown trout (*Salmo trutta*) was well established in the valley and several beats in the streams were created for angling.

In 1912 eyed-ova of Rainbow trout (then *Salmo gairdneri*) were obtained from Briston water works and nearly one thousand alevins (advance try) hatched. In 1908 a hatchery had been built at Achabal in Anantnag District from where eyed-ova of Brown trout were sent to all over Kashmir. Following the successful transplantation of Brown and Rainbow trout, Fisheries Department of Jammu and Kashmir imported eyed-ova (seed) of eastern broom trout (*Savelinus fontinalis*) from Canada and land-locked salmon (*Salmo salar*) from the USA and splake trout, a hybrid of brook trout and lake trout from Canada but were not successful in establishing the fishery of these fish species in Kashmir waters. From time to time eyed ova consignments were procured from various European countries for strengthening the existing stock of the state but due to lack of proper infrastructure setup and technical know-how of stock management the desired results could not be achieved. The summarised introduction of trout in Kashmir waters is mentioned in the table 1.

Table: 1. Date wise details of Trout introduction to Kashmir

Fish Species	**Place**	**Year of Introduction**	**Source**	**Present status**
Brown Trout (*Salmo Trutta Fario*)	Kashmir	1899-1900	UK, (Howeiton, Scotland	Established
Rainbow Trout (*Onchorhynchus Mykiss*)	Kashmir	1912	England	Established
Brook trout (*Salvelinus fontinalis*)	Kashmir	1960	Canada	Disease incidence lead to total loss of stock
Splake trout (cross between the lake trout *Salmo trutta lacustris* and eastern brook trout),	Kashmir	1960	Canada	
Land-locked salmon (*Salmo salar*)	Kashmir	1960	USA	Poor results from breeding and ultimately lead to loss
Rainbow trout (*Onchorhynchus*	Kashmir	1984	Isle of Man, England	Established but mixing with

Mykiss)				previous stocks
Rainbow trout (*Onchorhynchus Mykiss*)	Kashmir	1985	Isle of Man, England	
Rainbow trout (*Onchorhynchus Mykiss*)	Kashmir	1986	Isle of Man, England	
Rainbow trout (*Onchorhynchus Mykiss*)	Kashmir	1989	Denmark	
Rainbow trout *Onchorhynchus Mykiss* (Genetically modified)	Kashmir	2019	Denmark	Hatchlings are being reared in the Beerwah hatchery premises.

In 2019 a consignment of 2.25 lacs rainbow Trout eyed ova were imported from Billud in Denmark Rever Roheamger and incubated at Beerwah trout hatchery, Budgam with the aim to boost the fish production of the state from 500 tons to 5000 tonnes in the coming five years.

Distribution within and outside the state:

Once the trout established itself in the valley it was realised that there are numerous water bodies in the valley which offer huge potential for trout propagation. To cater the needs an ambitious project was launched known as Trout Fish Farming Project Kokernag in collaboration with European Economic Community. The joint venture eventually led to the establishment of Kokernag trout farm in 1984 which now serves as mother unit for production of quality seed of Rainbow Trout and Brown Trout in the valley. Prior to establishment of this, the Maharaja of Kashmir was requested by many princely states to supply seed and expertise to them for the introduction of trout in their fast running streams-a precondition for trout to thrive. Thus Pt. Sodhama travelled to Nilgiris in the South and Himachal (then part of Punjab) and Uttarakhand (then part of Uttar Pradesh) and Muree (Now in Pakistan) to introduce trout fish there.

Since, trout being an essentially a cold water sports fish which prefers cold water of clear torrential streams and transparent high altitude lakes. There is abundance of such streams and lakes in the Himalayas and in the mountain ranges in extreme south. Such waters have a high oxygen content, low vegetation and temperature below 20^0C- conditions necessary for trout culture.

Besides, there is a sizeable population of insects which form food of trout in these water bodies. Considering this the trout were stocked in numerous water bodies of the valley of both snowfed viz, Bringhi, Lidder, Sindh etc the tributaries of river Jhelum and spring origin viz, streams of Verinag, Kokernag and Achhabal. In addition to this trout were also stocked in the high altitude lakes such as Gangabal, Vishensar, Kisenar, Satsar, Gadsar, Sheshnag and Kounsarnag. All the water bodies have a well-established trout population now.

Parallelly trout was introduced and stocked in the cold water hill streams of Jammu division with the aim of utilising the vast expanse of coldwater resources and also attract the tourists. The important waterbodies which were stocked include Dhaggar Nallah at Bani in Kathua district, in Kirchi stream at Daddu-Basantgarh in Udhampur District, Thanala in the upper reaches of Neeru nallah in Doda district in Fember nallah, Keshwan nallah, Singhpura nallah and Marwah-Wardwan nallah in Kishtwar district at Budhal in Rajouri district in Bhadora stream and Sui Devta nallah in Reasi district and Mohu-Mangat and Kheet Streams in Ramban district.

At present and in past also Kashmir has supplied trout eyed to other Himalyan states of the country including, Himachal Pradesh, Sikkim, Uttarakhand and Arunachal Pradesh. These regions have climatic conditions similar to Kashmir and possibility of propagation of trout is evident. Thus eyed ova have been supplied to both public and private trout growers of the region for establishing their stock to achieve self-sufficiency in trout farming and production.

Trout farming infrastructure in Jammu and Kashmir:

The state of Jammu and Kashmir is having nine functional seed producing hatcheries cum breeding projects. Out of these, seven units are present in the Kashmir region at Laribal (Srinagar), Kokernag (Anantnag), Shookababa (Barmulla), Mammer (Gandarbal), Khag (Budgam), Tchancer (Kulgam) and Panzeth (Anantnag). Two hatchery units are present in Jammu division with one unit each in district Rajouri and district Doda at Phailini and Bheja respectively. The seed requirement for the trout rearing units of both public and private sectors is met out from these hatcheries especially the Kokernag and Laribal trout hatcheries which together have a combined production capacity of more than 3 million eggs per year. The trout breeding and seed production at these units is carried out under modern scientific lines to ensure the better survival of the brood stock and the young ones.

In addition to this the state is also having 59 trout rearing units in government sector and 533 units in private sector. Most of these units are established in Kashmir region only owing to its

climatic, water and topographical suitability. To meet out the feed requirements of public and private sectors, the state is having three trout feed mills at Kokernag, Laribal and Manasbal centres of the Kashmir region. Kokernag and Laribal feed mills are of conventional type while as the Manasbal feed mill unit is fully modernized. It was imported from Holland with the assistance of NFDB and has the production capacity of 1 tonne per hour. With the establishment of this feed mill the Department has been able to produce quality trout feed to achieve better conversion ratio and healthy saleable stock.

Trout hatchery at Kokernag

Trout hatchery at Laribal

Trout hatchery at Mammer

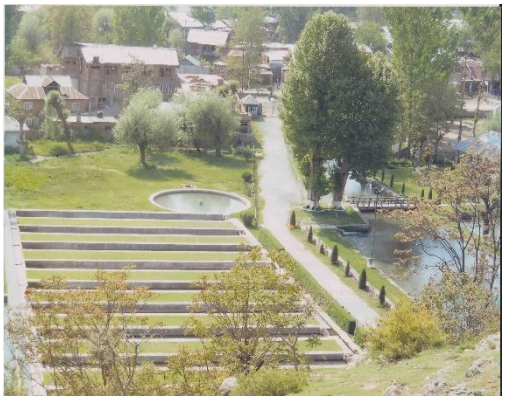
Trout hatchery at Panzath

Trout hatchery at Khag

Trout hatchery at Tchancer

(Image credits: Jammu and Kashmir State fisheries department)

Trout rearing unit at Kokernag



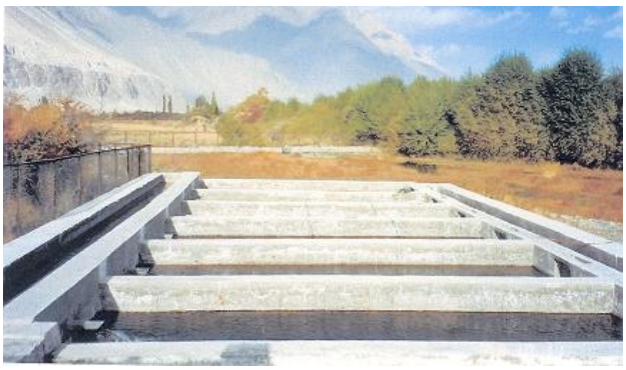
Trout rearing unit at Acchabal

Trout rearing unit at Pahalgam

Trout rearing unit at Verinag

Trout rearing unit at Krungsoo

Trout rearing unit at Akad



Trout rearing unit at Nubra, Ladakh

Trout rearing unit at Phailini, Doda

Trout rearing unit at Bhaiji

Trout rearing unit at Drass

Trout rearing unit at Bani

Trout rearing unit at Laribal

(Image credits: Jammu and Kashmir State fisheries department)

Computerised feed mill at Manasbal

(Image credits: Jammu and Kashmir State fisheries department)

Trout production:

Trout culture and farming has shown a gradual but steady increase in the state of Jammu and Kashmir from its inception till today with rapid increase especially in the last decade. As a result the trout production (saleable stock) of the state has elevated from a mere production of 12 tonnes during 1956-57 to 698 tonnes in 2018-19 with a percentage increase of 5716.67 % in last 60 years(Annual reports, Fisheries department, J&K). On the other hand the production from wild sector is almost negligible as there is no proper documentation of the records of fish caught. Moreover, the prime aim of wild stock is to attract and suffice the angling needs of the local and foreign fish enthusiasts.

Table: 2. Trout biomass production and percentage increase in different years

Year	Trout production (in tonnes)	Percentage increase
2014-15	262	69.03
2015-16	298	13.74

2016-17	302	1.34
2017-18	482	59.60
2018-19	598	24.06
2019-20	650	

Out of the three geographic zones of the state much of the trout production comes from Kashmir region while the share form Jammu and Leh regions is almost negligible. This is because of the climatic suitability of the region for breeding, stocking, feeding, rearing, production and marketing of trout fishes plus timely access and availability of quality seed and feed and technical assistance cum guidance for farming the trout from fisheries department officials. Besides this, the trout growers of the state are mostly concentrated in the Kashmir region only (more than 40 in govt. sector and more than 500 in private sector).

A total of 9 trout hatchery cum breeding projects are currently operational in the state with estimated eyed ova production capacity of more than 14 million per year. This has been achieved because of maintenance of high quality brood stock and their management is being carried out in modern scientific manner which ensures better survival of the different stages of the fish. The breeding season of trout fish starts in November. The breeding operations are carried out in controlled conditions. For this, Department of Fisheries has parent stock as healthy brooders. By the method of striping eggs of trout fish are obtained artificially after segregating male and female brooders. From the eggs fingerling are raised at selected hatcheries. Then these fingerlings are supplied to big and small trout rearing units of state. These hatcheries function on scientific and technological grounds with assistance from European countries. As a result of this the trout seed production of the state has increased upto13.7 million eggs per annum (Annual report of J&K Fisheries Department). The year wise details of eyed ova production and percentage increase are given in the table 3.

Table: 3. Trout eyed ova production in last 5 years

Year	Trout eyed ova production (In lakhs)	Percentage increase
2014-15	90	

2015-16	120	33.33
2016-17	130	8.33
2017-18	132	1.53
2018-19	137	3.78
2018-19	145	

The eyed ova produced in these hatchery units cater the need of farmers, private entrepreneurs and are also supplied to different government agencies within and outside the state for building their stocks. The supply is provided both free of cost through different centrally sponsored schemes and on sale at nominal rates to the different stakeholders.

Table 4: Rainbow trout farming infrastructure in Jammu and Kashmir

State	**No of govt. hatcheries**	**No of govt. trout farms**	**No of private trout farms**	**No of govt feed mills**	**Total eyed ova production (lakhs)**	**Total trout production (tonnes)**	**Revenue generated (rupees in lakhs)**
Jammu and Kashmir	14	44	534	03	145.00	650	360.16 (from govt farms only)

Water supply and its importance in management of Rainbow trout farming

Raja Aadil Hussain Bhat, Parvaiz Ahmad Ganie, R. S. Tandel and Abhay Kumar Giri

Water quality and water management ensure the optimal aquaculture production without impairing environment. Availability of quality water determines the success or failure of trout farming to a greater extent. Water quality is a combination of chemical, physical and biological parameters that affect the growth and prosperity of growing trout fish. The success of trout farming depends on the optimal environmental conditions for accelerated growth at the lowest cost of resources. Water quality affects the general condition as it determines the conditions of health and growth of the trout. The water quality is therefore, an essential factor to consider when planning for rainbow trout farming. Although the environment of fish culture is a complex system, consisting of some water quality variables, only few of them play a crucial role. Trout farming is an intensive type of aquaculture practice and critical parameters are temperature, dissolved oxygen, ammonia and pH. However, water temperature is the most important parameter, requiring continuous monitoring in trout farming. The ideal water temperature for production of trout is one that does not rise too high beyond 18^0C nor fall too low (4^0C) in winter. The best possible water supply is one in which the temperature remains in the range of 10-15^0C for as long as possible (Boyd and Tucker, 1998). The temperature of water supply should never exceed 20^0C. There are cumulative effects of synergistic interactions between and among different variables, which influence the growth and survival of growing trout at any moment in rearing practice. For example, increasing water temperature directly affects to trout as well as reduces the dissolved oxygen content in pond water. This synergistic situation results in improper swimming and mortality (Pandey and Ali. 2017).

Water supply by gravity to a trout farm is an economic method as it saves energy and, consequently, large amounts in terms of production costs. Water can be supplied either in parallel (separately) or in series raceways. In series connected raceways, water should be used first in raceway having younger trout, from where water flows into the raceway having trout of older age. Although arranging raceways in series is rather frequent, construction of parallel raceways with individual water supply is better practice. Construction of a water reservoir at the highest point of the trout farm facilitates easy and efficient water management. The elevated central

water reservoir serves as a buffer, where water also settles. The water from the reservoir is channelled to the raceways through open canals or pipes. Recirculation system can also be used if all the important criteria have been met satisfactorily such as optimum water flow rate, dissolved oxygen, turbidity and other physico-chemical parameters. (FAO, 2011)

Trout culture requires a flow-through system. An abundant and continuous water supply is required to sustain this flow-through system. In a conventional flow-through system, the oxygen requirement of the fish is supplied by the inflow water. The quantity of water required in a trout farm depends on the age and actual quantity of the developing fish. The quantity of eggs, fry and growing fish per unit area of raceway is determined by the oxygen content of supplied water. In colder water, the metabolism and respiration remain slow and require comparatively less water quantity, while it remains more at higher temperature. Water supply is expressed by the flow rate, which is the quantity of water needed for 1000 specimens of eggs, fry or fish. It is expressed either in liters per second (LPS) or liters per minute (LPM). Water supply may also be expressed by the exchange rate of water per hour or day. To hold one ton of fish nearly 3 -5 L/second (180-300LPM) of water flow is sufficient at an average temperature of 15^0C (Nepal et al., 2002). Some of the estimated water requirement for trout culture is 1.0 L/min/kg of trout without aeration or 0.3 L/min/kg of trout with aeration. The water supply in concrete raceways or lined tanks remains high than in earthen ponds, hence the density of fish can also be higher in concrete raceways. In earthen ponds, water can be exchanged a maximum of 4–5 times/day, but typically it is done only 1–2 times/day (FAO, 2011). In general, requirement of rainbow trout for the chemical composition of the water environment is summarized in table 1.

Table: 1. Water requirements in different life stages of trout.

Stages/age in months	**Stocking density nos. per m^3**	**Water flow per m^3**		**Water flow in raceway ($30\ m^3$)**
		at 5°C	at 20°C	at 12-18°C
Egg incubation/swim up fry	1000	0.5 LPM*	1.0 LPM	-

Fry (1-5g), 0.5-2 month	1000-2500	3-6 LPM	4-8 LPM	110-180 LPM
Fingerlings (5-25g), 2-4 months	100-250	3-8 LPM	5-11 LPM	120-270 LPM
Growing fish (25-250g), 4-10 months	60-100	3-6 LPM	5-8 LPM	120- 210 LPM
Table fish (250-350g) 10-12 months	50-60	2-3 LPM	3-5 LPM	90-120 LPM
Adult fish (>350g) 14 months	30-50	2-3 LPM	3-5 LPM	90-120 LPM

*LPM- Liters per minute

Table 2: Temperature ranges and incubation period in rainbow trout.

Stage	**Incubation period (days) against different water Temperature Range in °C**	
	7.0-11.0^{0}C	11.0-13.0^{0}C
Green egg to eyed ova stage	21-29 days	10-15days
Eyed-egg to alevin	20-27days	8-12days
Alevin to swim-up fry	10-12days	10-12days

Table 3: Physico-chemical parameters for trout culture.

Parameters	**Range**
Dissolved oxygen	near saturation (≥ 9 mg/l)

Temperature:	7-20 ºC
Transparency	1.5-1.8 m
Free CO2	<1.5 mg/l
pH	7.0-7.5
Suspended solids	< 10 mg/l
Alkalinity (as $CaCO_3$) Hardness	50-150 mg/l
Ammonia (NH_3)	< 0.05 mg/l
Nitrites ($NO2^-$)	< 0.05 mg/l
Nitrates ($NO3^-$)	< 1.0 mg/l
Phosphates ($PO4^-$)	< 0.03 mg/l

Breeding and seed production of Rainbow trout

Suresh Chandra, Parvaiz Ahmad Ganie, Raja Aadil Hussain Bhat, Abhay Kumar Giri, Kishor Kunal, and N N Pandey

Introduction

Among the freshwater salmonids, *Onchorhynchus mykiss* popularly known as rainbow trout is one of the promising cultivable fish species in coldwater and has considerable scope for its expansion in uplands region. Being a low volume high value commodity, the trout has good potential for domestic consumptions as well as foreign export. Inspite of having excellent positive traits, the development and expansion of trout farming has yet to be done on large scale.

Breeding and Hatchery management

Rainbow trout requires cold, clean and highly oxygenated water for ripening of brooder, successful breeding and hatchery activities. Rainbow trout breed during November to February and attains maturity after completion of 3rd year. The whole process of breeding includes brood stock rearing, stripping of males & females, mixing of eggs and milt, incubation of eggs in trays fitted in the troughs with continuous flowing water, rearing of sac fry and swim up fry in FRP tanks

Brood stock rearing

Males and females are segregated prior to 2 months of spawning and reared at density of 5-10kg/m3. Trout will not spawn naturally in captivity. Generally, two males to one female are deemed a satisfactory sex ratio for brood stock. Brood stock may be reared at density 5-10 kg/m3. During breeding season, female has round body appearance, bloat and soft belly and swollen and reddened vent, while male has dark and dull in appearance, large pointed snout with hooked lower jaw and oozing of milt. Feeding condition notably influences the fecundity. The larger the brooder size, larger the egg size, larger the alevin and more resistant young one.

Spawning and egg incubation

Dry stripping method is applied for spawning. Fertilized eggs remain lemon yellow or light green in colour with the size of 4-5 mm. 1500-1800 mature eggs can be achieved by a mature female trout of 1kg weight. Following are the steps of dry striping operation.

1. Weighing selected brooder
2. Wiped with soft and dry cloth
3. Stripping of female with thumb and index finger of the right hand
4. Fish is then immediately released in the aerated water
5. Check fecundity- nos. of eggs in 5g.
6. Stripping of male for milt
7. Mixing eggs and milt with the help of feather
8. Adding of 100 ml of saline water (0.9 % NaCl) and keep for 5 minutes
9. Washing of eggs with the fresh water
10. Placing of eggs in hatching trays
11. Transfer of trays in trough
12. Fixed 2 litre per minute of water flow for 10,000 eggs
13. Dead eggs are segregated
14. Hatched in 40-60 days at 9-14 0C

Eggs are incubated undisturbed until the eyed stage in hatchery. Hatchery of the trout with flowing water system is known as Ova house, where incubation and hatching of eggs takes place.

An ova house is comprised of an indoor structure having troughs, trays, nursery tanks and rearing tanks with continuous water flow.

- Rectangular trough-220×50×40 cm (to hold 10000-15000 fertilized eggs)

- Trays- 50×30×10 cm (Capacity-2000-3000 eggs)
- Nursery tanks- 2.0×0.5×0.6cm (for raising 10000 fry)
- Rearing tanks- 2.0×1.5×0.75 m.

Eggs are placed in meshed trays (mesh size- 1.5-2.5 mm in dia). A tray can hold a layer of 2000 eggs. Trays are placed 5 cm above the bottom, and water passes through the tray from bottom to top across the tray. Trout have prolonged incubation period extending to several days (40-60 days). Duration of incubation depends on water temperature. There are 4 distinct stages of eggs during incubation-

- Green egg (fertilized eggs)
- Eyed egg
- Alevin or sac fry
- Swim up fry

Table 1: Temperature range and incubation period of rainbow trout ova

Species/Stage	Incubation Period in Days at different temperature range	
	Temp. 7.0-11.0 0C	Temp. 11.0-13.0 0C
Green egg to eyed ova stage	0-29 days	0-15 days
Eyed-egg to alevin	29-49 days	15-30 days
Alevin to swim-up fry	49-60 days	30-40 days

As the eggs hatch, the fry drop through the mesh to a bottom trough. Sac fry can remain in trays until swim-up at about 10 to 14 days after hatching. Initially hatchlings of trout feed on reserve yolk material up to 2-4 weeks and called alevin (size 1.5-1.8 cm, weight 45-50 mg). Hatching of the batch of eggs usually takes 2-3 days, during which time all eggshells are regularly removed, as well as dead and deformed fry. Transportation of eggs can be done at eyed ova stage prior to 5 days of hatching. Sac fry are carefully removed from the trays into the mesh caged arranged into rectangular troughs where running water is maintained @0.3 -0.5 litre per minute for 1000 larvae. The sac fry are protected from bright light and remained in the tray until the absorption of the yolk sac and the fry become able to swim. Free swimming fry are fed 10 times a day @5-10%

with starter feed. After one week, feeding frequency is reduced to 3 -4 times a day and fry are transferred into fry rearing tanks.

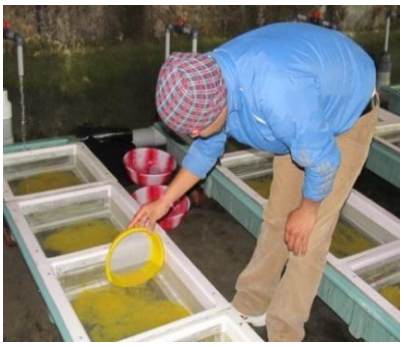
Fry and fingerlings rearing

Fry are traditionally reared in fiberglass or concrete tanks, preferably circular in shape, to maintain a regular water current and uniform distribution of the fry. Fry can be stocked at density of 1000 numbers/m^2 and provided starter feed. Growth is about 8-12 cm (3-5 inches) in length at the end of 3 months of rearing. These 3 months old fingerlings can be stocked in raceways. For the production of 1 lakh fingerlings, 400kg brooder are required, which produced 2 lakh fertilized eggs, 1.5 lakh fry with cumulative survival of 50% from eggs to fingerlings. Two production cycle (60 days each) can be achieved during breeding season.

Brood stock

Trout raceway

Stripping



Egg incubation

Eyed ova

Fry

Culture of Rainbow trout

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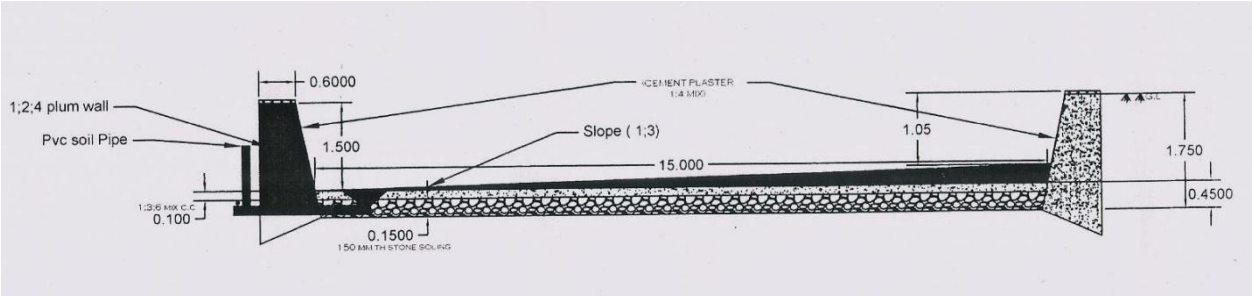
Rainbow trout is one of the best coldwater fish species for the culture in coldwater region of India. It is fast growing, tolerate wide range of environmental conditions and accomplished of occupying different habitats.

Site selection for trout culture:

A sloppy terrain with a perennial water source free from heavy metals and silt is suitable for trout farming. Water supply should have higher dissolved Oxygen level of above 7 mg/l, and pH 6.5-8.0. Thermal regime of 13-18^{0}C is suitable for better feeding and growth, however, trout can survive with water temperature range of 0-20^{0}C. Lower thermal regimes (9-14°C) are required for breeding activities. Water temperature above 18^{0}C for longer duration creates environmental stress and mortality in growing stock.

A flow-through system is essential for trout farming with continuous flowing cool, clean and highly oxygenated water. A cement concrete raceway is constructed with an area of 30-45m^2 (15m length, 2m or 3m width) and 1m depth towards inlet and 1.5m depth near the outlet. A minimum 3% bottom slope is required for proper cleaning and to flush out metabolic wastes. One or a battery of parallel raceways may be constructed in trout farm with individual inlet and outlet.

Raceway is a rectangular linear pond (length: width; 10-5:1) to facilitate flowing water current towards the outlet. This species is sensitive to lower dissolved oxygen, excess ammonia and unhygienic conditions, therefore, adequate water flow from an inlet, regular cleaning and proper outlet design is essential. Bottom pit L shaped pipe or 3 shutters outlet may be constructed in deeper zone of raceway. Raceway should be properly cleaned, washed with 1mg/l potassium permanganate solution and filled with fresh water up to 80 cm level before seed stocking. In case of silt and clay in incoming water, a settling tank may be constructed adjacent to raceway along the inlets.



Layout design of a raceway

Sluice gate

Bottom pit

Stocking density and growth potential

Quality and quantity of water source and scale of operation determine the stocking density per cubic meter in culture raceways. Generally, rainbow trout takes 12-14 months to attain marketable size (250-260 g) in Jammu & Kashmir, Himachal Pradesh and Garhwal region of Uttarakhand. However, comparatively better growth of 500-600 g was observed in 12 months at state govt. farm and private farms in West Sikkim. This is due to favourable thermal range of water (14-18^{0}C for 8 months in a year) and availability of sufficient water volume. In central Himalaya, average growth was recorded as 300 g (range 260-400 g) at thermal regime of 5.0-22^{0}C (Vass et, al. 2010) which indicates good prospects of trout production at marginally higher water temperature range of 10.0-20.0^{0}C in Central Himalayas.

In Nepal marketable size of 200-300 g reach at 14-16 months of culture period with the stocking density of 50 fish/m^3 (Rai et al. 2008). Whereas the fish takes approximately 8 months

to reach a market size of 300-350 g in trout farms of Idaho, U.S.A after being stocked in the raceways as a 4 inch long fingerling (Gempesaw et al.,1995).

In general, the production level of rainbow trout in Indian conditions is 300-500 kg per raceway of the size of 15m×3m×1m (45 m^3) in 12 months. However, productivity of 1 tonnes or more has been achieved at state govt. farms and at private trout farms of J & K, Kullu valley of Himachal Pradesh and West Sikkim. This trend of production reflects the inherent better potential of productivity having conducive environment and sufficient water volume. In present practice, stocking density of 45-50 fish/m^3 has been adopted by the trout growers, which can be increased up to 100 fish/m^3 with better management practices and sufficient water flow in the raceways. Based on their size attainment in culture facilities, grading of smaller and bigger ones is essential at regular intervals to avoid cannibalism and for achieving uniform growth. The fish is sensitive to lower DO and unhygienic conditions, it is therefore, always advisable to ensure the cleanliness of culture raceways on regular basis. Under suitable water and sufficient supply of good quality of feed, better growth may be achieved in10 months after stocking of 10-20 g sized fingerlings. Cost of rainbow trout production has been analyzed which shows that nearly Rs. 240/-cost is required to produce 1 kg of marketable size (200-300 g each) of trout. (Pandey and Ali., 2015)

Culture management

Trout culture is intensive type of farming which requires more input resource s compared to other species for survival and growth. The feasibility of achieving required production naturally depends on a number of factors including seed, feed, health management and environmental consideration.

Water supply and water quality management

The success of trout culture mainly depends on the water quality and quantity supplied to the farm. Availability of year-round supply of cool, clean, oxygen rich, pollutant free and suspended matter free water is one of the most important prerequisite for successful trout farming. Optimal or near to optimal conditions of water supply depends on the age of fish and its biomass. The source of water may be an irrigation canal, river, creek, lake or spring which can be supplied via feeder channel, storage tank or pipeline by gravity. Water supply by gravity to a trout

farm is an economic method as it save energy and production cost. This synergistic situation results in improper swimming and mortality. Thus, any abnormal responses by trout may be due to temperature, or dissolved oxygen levels, or the synergistic response due to both variables, and another, unknown variable.

Table 1: Physico-chemical parameters for trout culture

Parameters	Range
Dissolved Oxygen	near saturation (≥ 9 ppm)
Temperature:	7-18 ºC
Transparency	1.5-1.8 m
Free CO2	>1.5 mg/l
pH	6.5-8
Suspended solids	< 10 mg/l
Alkalinity	50-150 mg/l
Ammonia (NH3)	< 0.05 mg/l
Nitrites (NO2-)	< 0.05 mg/l
Nitrates (NO3-)	< 1.0 mg/l
Phosphates (PO4-)	< 0.03 mg/l

The ideal water temperature for production of trout is one that does not rise too high beyond 18^0C nor fall too low (7^0C) in winter. The best possible water supply is one in which the temperature remains in the range of 13-18^0C for as long as possible. The temperature of water supply should never exceed 18^0C. There are cumulative effects of synergistic interactions between and among different variables, which influence the growth and survival of growing trout at any moment in rearing practice. For example, increasing water temperature directly affects to trout as well as reduces the dissolved oxygen content in pond water.

An abundant and continuous water supply is required to sustain the flow-through system. Adequate water flow is required to sustain optimum fish biomass and to get better growth and optimum production. Water flow is expressed by the quantity of water needed for 1000 specimens of eggs, fry or fish. It is expressed either in litre per second (LPS) or litres per minute (LPM). To hold one tone of fish nearly 3-5 LPS (180-300 LPM) of water flow is required at an average temperature of 15^0C. Some of the estimated water requirement for trout culture is 0.3 LPM for 1 kg of trout with aeration.

Table 2: Water requirements in different life stages of trout

Stages/age in months	**Stocking density per m^3**	**Water flow per m3**		**Water flow in raceway (30 m^3)**
		at 5^0C	at 18^0C	at 12-18^0C
Egg incubation/swim up fry	For 1000 unit	0.2 LPM	0.5 LPM	Not applicable
Fry (1-2g), 0.5-2 month	1000-2500	3-6 LPM	4-8 LPM	110-180 LPM
Fingerlings (2-20g),2-4 months	100-250	3-8 LPM	5-11	120-270 LPM
Young fish (20-300g), 4-10 months	60-100	3-6 LPM	5-8 LPM	120- 210 LPM
Marketable fish (300-400g) 10-12 months	50-60	2-3 LPM	3-5 LPM	90-120 LPM

LPM- Liters per minute.

Feed and Feeding:

Trout accepts artificial pelleted feed easily and its dietary protein requirement is in the range of 30-50% on dry matter basis. Trout has an exclusive requirement of n-3 or ω-3 PUFA in their diet. 10-14% lipid is included in the trout diet. Sterilized fish meal (60% protein), solvent extracted soybean meal, mustard oil cake, wheat flour, Starch, fish oil, Brewer's yeast powder, Linseed oil cake and Vitamin and minerals mixture may be used for formulation of trout diet. In

general, 50% protein and 14 % lipid for starter feed, 45% protein and 16 % lipid for fingerlings feed and 35% protein and 14 % lipid for grow out feed is required for proper growth. Requirement of Arginine (6.427%) is comparatively higher than the other essential amino acids. Feed alone comprises 76% of total variable cost and 40% of the total production cost of trout farming. A major issue for trout feeding is the high cost of manufactured pelleted feed due to the use of largely imported fish meal. The increasingly scarce supply of fish meal and its high market price had made the trout feeding more expensive. One of the promising alternate seems to be soybean which is rich in plant protein and generally low in phosphorous. Solvent extracted soybean meal (SESM) contain 48% protein and has best amino acid profile and is highly palatable, digestible to trout (Digestion coefficient 80%). It also contains Arginine (3.91% of dry basis) but is not a complete substitute of fish meal. Fish oil is also an expensive feed ingredient of trout feeding. Trout feed is available at state trout farms and in the market in the form of starter feed, fingerling feed, and grow out feed (FCR-1.4) which are used for different life stages of the fish. Due to high content of animal protein and fish oil, trout feed has low shelf life and cannot be stored more than 3 months. In order to avoid the wastage, it is advisable to broadcast the feed or feed dispenser can be used.

Table 3: Feeding rate for different size of growing trout:

Size of the Fish	Protein Content	% of body weight	Feeding frequency (times in a day)
< 10 g	40 %	5-10 %	7-8
<50 g	35 %	5- 6 %	3-4
> 50 g	35 %	2-3 %	2-3

Health monitoring

Regular health monitoring in trout hatchery and raceways is essential to recognize clinical signs of both infectious and non-infectious health problems in order to prevent and control them. Commonly occurring health problems of rainbow trout are eye infection, fungal infestation, dermal head necrosis, mortality of un-striped trout brooders. Most of the health

disorders originate from the poor management and stocking of infested seed. Fungal infestations are common in all life stages of trout. Bath treatment in 3% common salt solution for 5 minutes or in 1mg/l solution for 1-2 minutes may be adopted at monthly interval. Regular cleaning of raceway, proper feeding, stocking of disease free seed and disinfection of farm accessories with potassium permanganate solution are prophylactic measures.

Harvesting

Fish takes approximately 10-12 months to reach a marketable size of 300-400 g. In general, the production level of rainbow trout in Indian conditions is 500-700 kg per raceway in 12 months. However, productivity up to1 tonne/raceway has been achieved in Himachal Pradesh by some progressive trout growers. Fish can be partially harvested by drag netting or complete harvesting can be done by complete draining of water from raceway. Before harvesting, fish should be starved for 24-48 hrs. Harvested fish is degutted, washed with fresh water and packed with ice and salt. Grading of size before packing is also required. Fish can be sold in local markets in fresh condition. Ice packed fish can be sent to fish markets and restaurants of metropolitan cities however the bulk of the produce can be exported.

Constraints-pitfalls; precautions

- Require continuous supply of cool, clean and well oxygenated water.
- Culture is purely based on artificial diet even from first feeding.
- High capital cost and initial investment for raceways construction.
- Intensive production results in the release of organic wastes and soluble inorganic nutrients such as nitrogen and phosphorus.
- Phosphorous present in the discharged water of the trout farm is subject to regulatory restrictions.
- Requires high animal protein content in diet.
- High cost of manufactured pelleted feed due to the use of costly and scare fish meal.
- Non-availability of adequate seed round the year
- Less genetic variability, slow growth.
- Highly perishable, seasonal, bulky, small scale and scattered production.
- Poor market infrastructure and high cost of transportation.

- Dead eggs remain more susceptible to the fungal attack during incubation
- Lack of readily available financial resources to prospective rainbow trout farms

DOs and DONTs

S.no.	Dos	DONTs
1.	Cleaning of raceway and washing with 1 mg/l potassium permanganate solution before stocking.	Stocking in unhygienic pond
2.	Adequate water supply into raceway.	Irregular water supply
3.	Stocking of healthy seed of uniform size in appropriate density.	Stocking of undersized seed, over /under stocking of seed
4.	Periodic grading of growing stock.	Improper feed storage for longer duration (not more than 3 months)
5.	Regular feeding at fixed scheduled time with protein rich diet. Limited feed during increased water temperature.	Over feeding and under feeding
6.	Use of pelleted grow out feed.	Use of raw slaughter house waste
7.	Thinning of stock if water temperature is in higher side (> 18^{o} C)	Use of rancid feed
8.	Bath treatment with 10% Common salt solution for 5 minutes at monthly interval	Mishandling the fish
9.	Prophylactic measures for health	Ignorance for health monitoring
10.	Degutting and ice packing after harvesting	Improper packing and unhygienic storage

A. Economics of rainbow trout farming (raceway area-30m^3)

Capital Cost	**Water area 30 m^3 (Rs.)**
1. Construction of Raceway	2,00,000/-
2. Water channel	50,000/-
Total Capital Cost	**2,50,000/-**
Running Cost	
1. Cost of Fingerlings (2000 nos.)	20,000/-
2. Cost of Feed 1 tonn @ 100/- per kg.	1,00,000/-
3. Depreciation @ 10% of Capital Costs	25,000/-
4. Labour cost, 40 man- days	12,000/-
5. Farm accessories & miscellaneous expenditure	15,000/-
Total Running Cost	**1,72,000/-**
Total Cost (Capital+ running cost)	4,22,000/-
1. Interest on fixed & working capital @ 12% P.A.	50,600/-
Total Annual Cost (running cost+ interest)	2,22,600/-
Sale of fish of 700kg @ Rs. 500/- per kg	3,50,000/-
Net Profit	**1,27,400/-**

Rs. 318/- is required to produce 1 kg of marketable trout. The annual rate of return in trout farming is nearly 57% of the total annual investment.

B. Economics for 1 Lakh fingerlings production of rainbow trout

Capital Cost	**Amount (Rs.)**
1. Construction of ova house (5m×10m)	10,00,000/-

2. Brooder raceways-2, nursery raceway-1	6,00000/-
3. Water channel & storage tank	2,00,000/-
4. Trough-15, trays-60, FRP tanks-4	6,00,000/-
Total Capital Cost	**24,00,000/-**
Running Cost	
1. Cost of 400 kg brooder @ Rs. 600/ kg	2,40,000/-
2. Cost of Feed 1 tonn @ 100/- per kg.	1,00,000/-
3. Depreciation @ 10% of Capital Cost	2,40,000/-
4. Labour Cost, 100 man- days	30,000/-
5.Hatchery accessories & miscellaneous expenditure	40,000/-
Total Running Cost	**6,50,000/-**
Total Cost (Capital+ running cost)	30,50,000/-
1. Interest on fixed & working capital @ 12% P.A.	3,66,000/-
Total Annual Cost (running cost+ interest)	10,16,000/-
1. Sale of 1 lakh fingerlings @ Rs. 10/ piece	10,00,00/-
2. Sale of spent brood fish 600kg @ Rs. 600/- per kg	3,60,000/-
Net Profit	**3,44,000/-**

Health management of Rainbow trout

Raja Aadil Hussain Bhat, R. S. Tandel, S. Chandra and Parvaiz Ahmad Ganie

Fish disease pathogens are ubiquitous, present in the water, soil, air, or fish. In nature fish are often resistant to these pathogens and they are able to seek the best living conditions available. Food fish reared under commercial aquaculture conditions are confined to the production unit and are weakened by stress conditions including high stocking & poor water quality, poor nutrition, handling injury. Physiological stress and physical injury may cause poor health or death of fish.

In cold water aquaculture virus (though not detected in India), parasite, bacteria and fungus are potential disease causing pathogen which may adversely affect growth and health status of fish.

A. Parasitic Diseases

Disease	Causative agent	Etiology/Sign/symptom	Management/Treatment
White spot (Ich) Disease	*Ichthyophthirius multifiliis*	Adult parasite is 1mm long round hairy often brown colored parasite, oval with "C" or horse shoe shaped nucleus, moves very slowly.	• Bath treatment in 150 ppm formalin for 60 minutes • Dip treatment in 2-3% salt solution for 1-2 minute • Dip treatment with $KMnO_4$ @ 2 ppm

Whirling diseases	*Myxobolous cerebralis*	Fishes show circular or whirling movement due to imbalance and loss of equilibrium, erratic swimming, darkening of tail region, deformity of skeleton and mortality.	• Feed 5 mg Fumagillin/Kg of body/day for 42 days. • Dip treatment in 2-3% salt solution for 1-2 minute • Dip treatment with $KMnO_4$ @ 2 ppm

B. Bacterial diseases

Disease	**Causative agent**	**Sign**	**Treatment**
Fin rot and gill rot	*Aeromonas hydrophila* *Psudomonas fluroscence*	Tail and fin erosion	Oxytetracycline with feed @ 70 mg /kg body weight for 10 days
Dropsy	*Aeromonas hydrophila*	Body cavity filled with fluid Scale protrusion	Oxytetracycline with feed @ 70 mg /kg body weight for 10 days
Eye disease	*Aeromonas liquifaciens*	Eye get vascularized or protruded eye	Oxytetracycline with feed @ 70 mg /kg body weight for
Lactococcosis	*Lactococcus garvieae*	Unilateral exophthalma Swollen vent and swollen liver	Oxytetracycline with feed @ 70 mg /kg body weight for 10 days

Furunculosis	*Aeromonas salmonicida*	Boil like lesions and blood clot on fins	• Oxytetracycline with feed @ 70 mg /kg body weight for 10 days • Feed Sulphadimethoxine/ Ormetoprim @ 50 mg/ kg of fish per day for 5 days
Bacterial Kidney disease	*Renibacterium salmonarium*	Focal, White nodules in spleen, kidney, small vesicles on the flanks filled with fluid	Feed 100mg erythromycin thiocyanate / Kg of body weight for 21 days
Red mouth disease	*Yersinia ruckeri*	Haemorrhages in the mouth and eyes, swollen abdomen	Feed Sulphadimethoxine/ Ormetoprim @ 50 mg/ kg of fish per day for 5 days

C. Fungal like Diseases

Saprolegniosis

Saprolegniosis disease is characterized by white or grey cotton like patches/hyphae on skin and fins of infected fish. Among several strains of Saprolegnia, *Saprolegnia parasitica* and *S. diclina* are responsible for significant infections in fish and eggs, particularly in aquaculture facilities.

Sign/symptom

- Initially the disease appears as white mats over the skin that gradually spreads and invades in deeper tissues causing mortality in acute cases.
- As the infection progresses the fish becomes increasingly lethargic due to overgrown mycelium

Control measures

- Formalin, a solution of 37% formaldehyde, Hydrogen peroxide, and Sodium chloride at high concentrations has also been recommended for the cure of fungal infected fish. Add 1-2 ml formalin/L and treat eggs for up to 15 minutes.
- Bath/flush treatment daily with Bronopol(Pycez) @ 30 mg l^{-1}.
- Bath treatment with Peracetic acid @ 7 mg l^{-1} .
- Water flush treatment with 2-3% of common salt, weekly, for 3 weeks can be given to the infected stock.

Fish Health management in coldwater aquaculture

In addition to practicing good fish husbandry, a fish disease contro l plan includes proactive health management, judicial use of appropriate and approved chemotherapeutics when disease occur or the application of selected chemicals after handling, and the use of vaccines when available. Management procedures that help reduce stress as it relates to increased disease susceptibility are (1) fish handling and stocking, (2) feed management, (3) water flow and temperature management, (4) aeration management, (5) controlling other environmental problems, and (6) waste management.

Water quality

- Maintenance of proper stocking density not exceeding carrying capacity
- Routine monitoring of water quality parameters
- Prevent the accumulation of organic debris, nitrogenous wastes (ammonia and nitrite)
- Maintenance of appropriate pH, alkalinity, and temperature for the species

Handling and transporting

- While handling try to minimize physical injury and stress.
- Transport and holding tanks should be large enough to allow free movement of fish
- Slowly changing water temperature from one environment into another (tempering) is advisable while transferring fish

- Sodium chloride or potassium permanganate (KMnO4) may be used after holding fish as prophylactic to help prevent secondary bacterial infections

Feed management

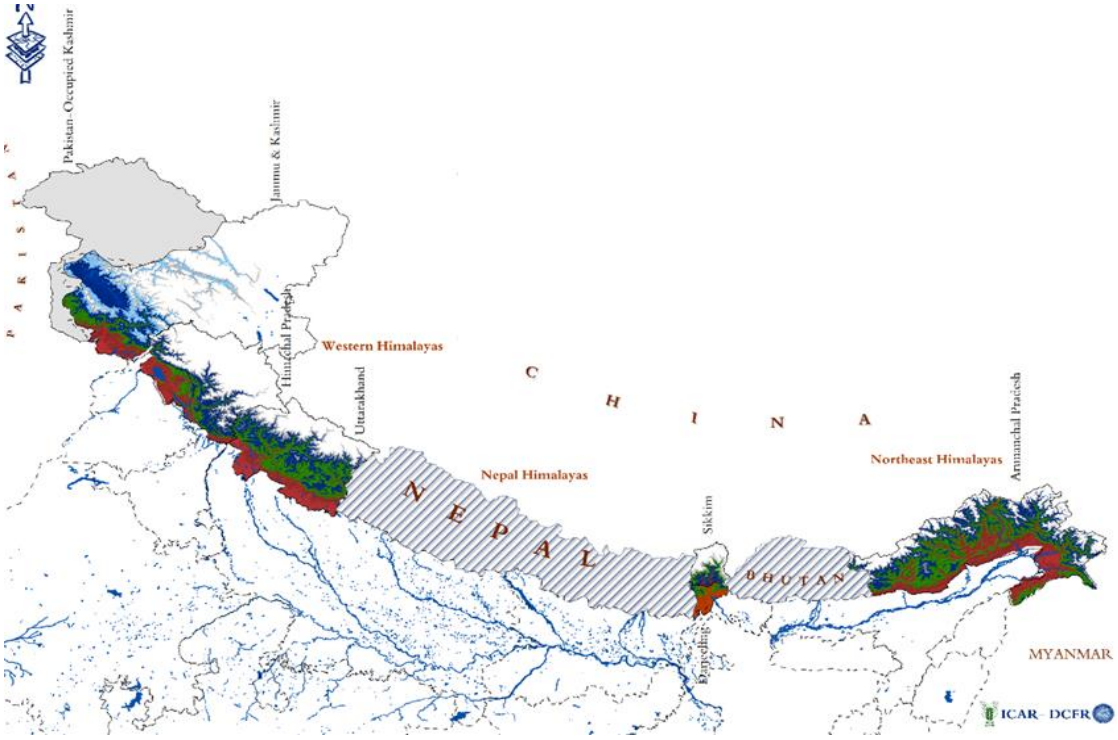
- Accumulated metabolic waste in water creates oxygen demand as it decomposes and serves as a source of nutrients for phytoplankton, which in turn exert an oxygen demand.
- Good quality feed should be provided with optimum frequency.

Proximate composition of pelleted feed

Fish stage (Trouts)	**Recommended level (%)**	
	Protein	fat
Starter diet (Fry)	45-50	16-18
Grower diet (Fingerlings)	42-48	20-24
Bloodstock diet (maturing fish)	35-40	14-16

Pellet and Ration size

Life stage	**Fish size (g)**	**Feed type**	**Feed size (mm)**	**Feeding rate (% body weight)**	**Feeding frequency (no./day)**
Fry	0.3–1.0	Crumble	0.3–0.7	5	10
Fingerling	1.0–25.0	Pellet	0.7–2.0	3	4
Grower	25–1 500	Pellet	2.0–4.5	2	2
Broodstock	>1500	Pellet	5		2



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