THEME PAPER ON TROUT FARMING

1.0 Introduction

Trout fish is native to the Pacific drainages of North America, ranging from Alaska to Mexico. It has been introduced to waters on all continents except Antarctica, for recreational angling and aquaculture purposes. Trout fisheries are maintained, or culture practiced, in the upland catchments of many tropical and sub-tropical countries of Asia, East Africa and South America. Several local domesticated strains have been developed, while others have arisen through mass selection and cross-breeding for improved cultural qualities. Europe, Chile, Japan, North America and Australia are major production centres of trout fish in the world. As per FAO estimates the world trout production in 2013 was 8.14 lakh MT.

Brown trout and Rainbow trout are main production species in the world which can be differentiated phenotypically. Brown trout has orange spots on the body and has red tipped adipose fin edges whereas Rainbow trout has small star shaped black spots. The male adult of rainbow trout has distinctive rose coloured iridescent band on their flanks which is more reflective at the time of reproduction. The wide distribution of rainbow trout attests to its ability to adapt itself to a variety of aquatic environments including aquaculture conditions. Rainbow trout can be propagated artificially, grows fast, which makes it important as fish food production. The fish can be fed artificial feed and can withstand temperatures of up to 26.6^{o}C for short periods. It also tolerates low dissolved oxygen content of water and is resistant to some of the fish diseases.

2.0 Trout farming in India

The trout is a freshwater fish of Salmonidae family. Of the 15 trout species which are found worldwide, brown (*Salmo Trutta fario*) and rainbow trout (*Oncorhynchus mykiss (Old name Salmo gairdneri*)) are found in the country. The major trout producing states are Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Tamil Nadu and Kerala. These states have established a well developed infrastructure for trout production depending on the availability of water in required quantity and quality, i.e. from springs and snow-melt/glacier-fed streams.

British were the first to introduce trout in the country from Europe to meet their need for recreational fishing in absence of any fast-growing indigenous fish in Indian waters. Thus, trouts were introduced to encourage sport fisheries. Now apart from sport fisheries, culture of trouts is increasingly being identified as a commercial venture for table fish production. The first attempts to bring brown trout eyed-eggs from England into India were from Howeiton in Scotland and the eggs successfully hatched in a small trout hatchery at Harwan in Kashmir. In 1905, in Kashmir, the first batch of eggs were obtained from the stock which had been produced from the Scottish eggs. This was the beginning of the spread of brown trout in the Himalayas and elsewhere. From Kashmir the species was taken to Jammu, Gilgit, Himachal Pradesh, Uttar Pradesh, North Bengal, Arunachal Pradesh, Meghalaya and Nagaland In 1918 steelhead strain of rainbow trout was introduced from England. Of the two species of trout, brown has become domesticated in culture systems, streams and lakes, and has emerged as a self-sustaining population in the Himalayas. The rainbow trout, however, has remained confined to pond culture and is not very common in streams and rivers of India.

The transplantation of these fishes has provided excellent game fishing to the anglers and started attracting large number of tourists to the country. However, large scale road construction in the valleys followed by destruction of breeding and feeding grounds of the fishes, development of river-valley projects, rapid urbanization, fishing pressure and of course illegal and destructive means of fishing etc. have been posing threat to this species as sports.

3.0 Trout farming in HP

Himachal Pradesh is the country's main producer of trout in the private sector. Both brown and rainbow are found in the snow-fed Beas, Sutlej and Ravi rivers in the higher reaches of the state. Of the 3,000-km network of state fisheries, water resources, 600 km of cold water streams are conducive for trout farming. Zone II and III of Himachal Pradesh have vast potentials for the culture of highly prized fish “Rainbow Trout”. The agro climatic conditions of the area under these two zones are very congenial for cold water aquaculture. The state has over 512 trout farms, mainly in Kullu, Chamba, Shimla, Kinnaur and Mandi districts

First entry of trout fish in Himachal Pradesh has been reported to be in Kangra and Kullu Districts in 1905 from Jammu and Kashmir. Commercialisation of rainbow trout got impetus with in 1988, with launching of Norwegian project to rehabilitate the exotic trout culture as well as to commercialize trout production. The project, initiated in 1989, was executed in two phases with specific objectives for transfer of technology and boosting production. The transfer of technology stipulated construction of a modern trout farm based on the Norwegian model with a capacity to produce 10 MT of trout per year. Further activities included import of quick growing, disease resistant eggs, development of economically viable pelletised feed with locally available ingredients, training of local staff and farmers, and production of economically viable fingerlings to encourage local farmers to adopt trout farming.

The yearwise trout production in the state is presented below:

Year	Production (MT)
2010-11	75.91
2011-12	76.94
2012-13	205.44
2013-14	233.49
2014-15	351.27

The state has a well developed infrastructure for promotion and development of trout farming. Chamba Valley, Kinnaur Valley, Kullu Valley, Lahul & Spiti, Pabbar Valley and Uhl Valley have been declared as Trout Zones in the State.

3.1 Infrastructure facilities for promotion of Trout

The State has seven well established trout farms and one trout feed unit. In addition, two new trout farms are also being setup. These farms meet the requirement of technology, farming technique, seed as well as feed of the producers in the district.

3.1.1 Patlikuhl Trout Farm :

The farm is located on national highway between Kullu and Manali on 22 ha of land. The farm was setup in 1909 and has infrastructure comprising of two hatcheries, 16 raceways and feed mill. The farm has capacity to produce 10 MT of fish. Bather hatchery is located about 5 km from the farm with incubation capacity to produce 2.00 lakh. Feed mill has capacity to produce 3 Q of feed per hour and annual production is estimated to be 50 MT. The existing hatchery at Patilkuhl is being renovated and upgraded.

3.1.2 Hamni Trout Farm:

The farm was setup in 2006 on 0.64 ha of area in village Hamni in Kullu district. The farm has 20 raceways.

3.1.3 Barot trout farm:

This farm was setup in 1959 on 1 ha area and is situated on the left banks of Uhl and Lambadug rivers near the barrage of Shanon Hydro-electric power project at Barot in Jogindernagar tehsil of Mandi district. The farm has one water storage tank , three fish ponds, 19 raceways and 4 hatcheries with incubation capacity of 1.3 lakh.

3.1.4 Holi trout farm:

This farm has been constructed in Bharmaur tribal area at Holi in Chamba district in 2000 to facilitate the propagation of trout in open waters of Ravi and its tributaries besides initiation of trout farming in rural areas for the generation of employment avenues to the tribal people. The farm has a land area of 0.48 ha. The farm has six raceways, 10 nurseries and one hatchery to incubate 1.0 lakh ova

3.1.5 Dhamwari trout farm:

This farm was setup in 2005 and is located on 2 ha land in Rohru tehsil of Shimla district at Dhamwari. The farm has on 11 raceways and one hatchery to incubate 1.0 lakh ova. The farm has been recently constructed and has production capacity of 5 MT .

3.1.6 Sangla trout farm

Kinnaur district has a small trout farm at Sangla in on the left bank of river Baspa which was setup in 1956. The farm has total area of 0.6 ha. The farm has 13 raceways, 12 nurseries and one hatchery to produce 1 lakh ova.

3.1.7 Bharmaur Trout farm :

The foundation of a fish farm in Bharmaur tribal area to be developed at a cost of Rs 4 crore has been laid and this would be the seventh fish farm in the state. This run-of-the-river farm is located at Thalla village, 12 km from Bharmaur in Chamba district and would annually produce six to seven tonnes of trout. The farm would also produce around 1.5 to 2 lakh fingerlings to be supplied to fish breeders.

3.2 Status of Production of trout fish and ova in State trout farms

S.No	District	Trout Farm	Output	
			Fish Production MT/ annum	Ova Production (Lakh/annum)
1.	Kullu	Patlikuhl and Batahar Hatchery	15.0	8.5
2.	Mandi	Barot	5.0	1.0
3.	Shimla	Dhamwari	4.0	1.0
4.	Kinnaur	Sangla	5.0	1.0
5.	Chamba	Holi	2.0	1.0

	Total		31.0	12.5

3.3 Schemes for promotion of trout farming in the state

3.3.1 Schemes of National Fisheries Development Board

3.3.1.1 Promotion of Trout Farming :
Unit cost Rs. 2.30 lakh
Construction of trout raceway of size 15x2x1.5 m with investment cost of Rs. 1.00 lakh & subsidy @ 20% for General Category @ 25% for SC/ST on the approved unit construction cost.

Provision of subsidy to farmers for first year inputs (feed & seed) totaling Rs. 1.30 lakh @ 20% of cost to General Category and @ 25% of cost to SC/ST.

3.3.1.2 Promotion of Trout Seed Hatchery

Setting up of private seed hatchery with a capacity of 2-3 lakh fry / year with investment cost of Rs. 12.00 lakhs/unit. Subsidy is provided @ 20% of the unit cost for all farmers/ entrepreneurs

3.3.1.3 Setting up of feed mill

Feed mill with capacity of 1.2 Q per day with investment of Rs. 7.50 lakh and subsidy @ 20% of the investment cost upto a maximum of Rs. 1.50 lakh is available.

3.3.2 Schemes of State Govt. for Promotion of Trout Farming in Tribal Areas

Unit cost Rs. 2.50 lakh

Construction of trout raceway of size 15x2x1.5 m with a cost of Rs. 1.00 lakh. Subsidy @ 40% (Rs. 40,000/-) is provided for on the construction cost.

Provision of subsidy to farmers for first year inputs (feed & seed) with a cost of Rs. 1.50 lakh @ 40% (Rs. 60,000/-) of cost.

3.4 District wise trout farmers in the state

S.No	District	No. of trout farmers	No. of Raceways	Expected stocking * (in lakh)	Expected output (MT)
1	Chamba	70	105	4.72	105
2	Mandi	60	158	7.11	158
3	Kangra	8	18	0.81	18
4	Shimla	9	15	0.67	15
5	Kinnaur	6	12	0.54	12
6	Kullu	41	172	7.74	172
	Total	194	480	21.59	480

*stocking density is considered at 4500 fry per raceway considering 10% mortality.

As against production capacity of 12.50 lakh ova from State Trout farms, a production capacity having requirement of 21.50 lakh ova/fry has been created under different schemes in the state. At present, ova/ fry are being supplied to the farmers from Patlikul, Barot and Holi trout farms. Thus there is geographical spread of farmers and seed supplying farms in the state. Further,

considering average requirement of 15 quintal of feed per raceway the total feed requirement of all the farms will be 7200 quintal. As against this production capacity of the only available fish feed mill at Patlikuhl is around 90 quintals per annum. Mainly pelletized feed is being provided from this feed mill and price of different types of feed are as under:

Starter feed I - Rs. 115/ kg

Starter feed II - Rs. 102/ kg

Production feed - Rs. 97/kg

These prices include 30% handling charges and State Govt. is providing subsidy to the tune of 15% on handling charges.

During the field survey farmers are also purchasing fish feed directly from suppliers from AP which floating feed and cheaper than presently available in the state. The price of this production feed works out to Rs. 90/ kg FOR.

However, based on the field level feedback many of these farms are not fully functional due to varies reasons such as siltation in tanks, high price of feed, temperature fluctuations, destruction of stock due to pesticide/ insecticide residues in water, theft etc. lack of insurance package for trout farming is also one of the major reasons which dissuades farmers from restarting his venture once a crop is destroyed.

4.0 Habitat

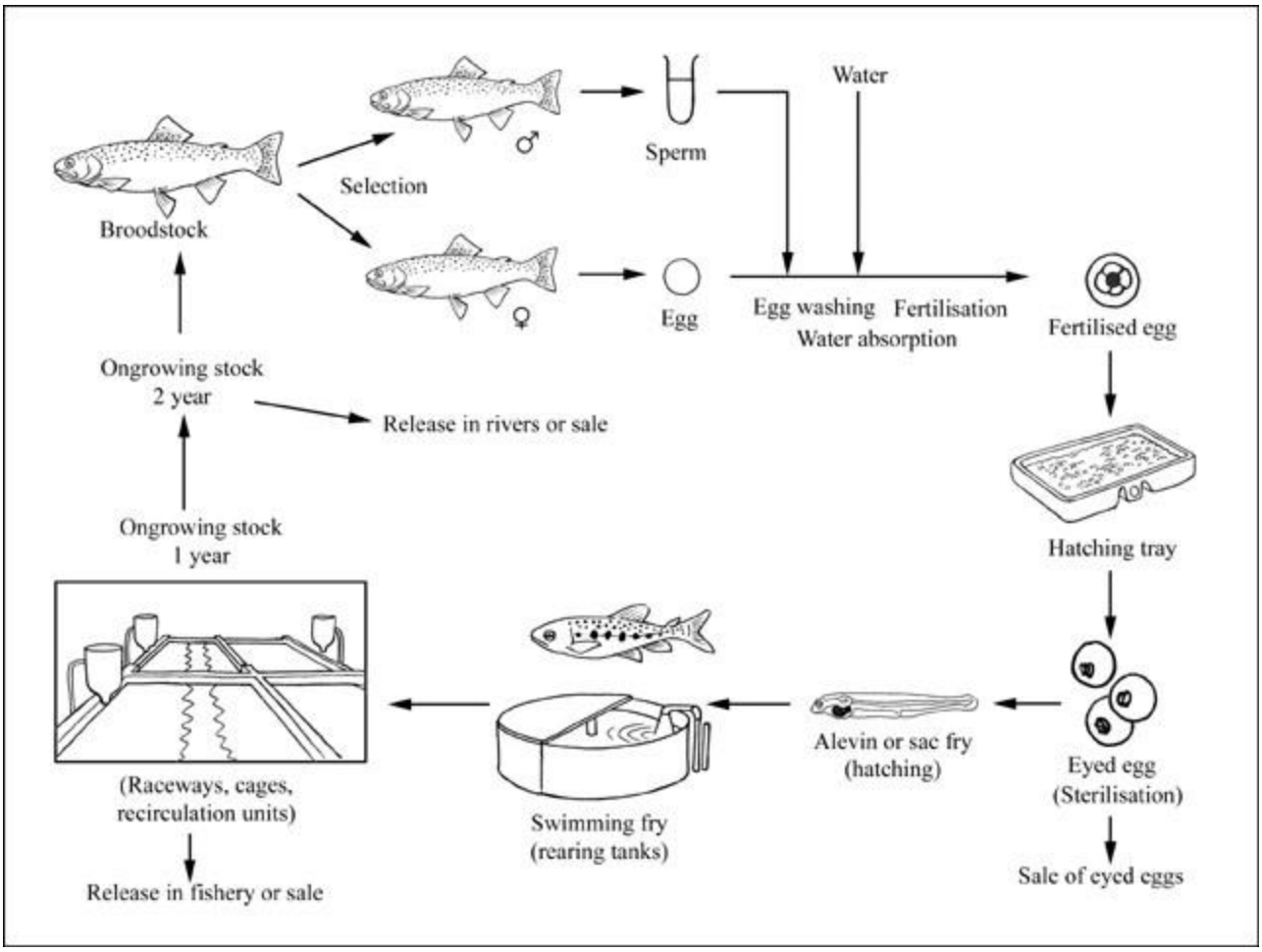
The rainbow trout is a hardy fish that is easy to spawn, fast growing, tolerant to a wide range of environments and handling, and the large fry can be easily weaned on to an artificial diet (usually feeding on zooplankton). Capable of occupying many different habitats, ranging from an anadromous life history [strain known as steelhead] (living in the ocean but spawning in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams) to stagnant lakes. The anadromous strain is known for its rapid growth, achieving 7-10 kg within 3 years, whereas the freshwater strain can only attain 4.5 kg in the same time span. The species can withstand vast ranges of temperature variation (0-27 °C), but spawning and growth occurs in a narrower range (9-14 °C). The optimum water temperature for rainbow trout culture is below 21 °C. As a result, temperature and food availability influence growth and maturation, causing age at maturity to vary; though it is usually 3-4 years. Females are able to produce up to 2 000 eggs/kg of body weight. Eggs are relatively large in diameter (3-7 mm). Most fish only spawn once, in spring (January-May), although selective breeding and photoperiod adjustment has developed hatchery

strains that can mature earlier and spawn all year round. Superior characteristic selection is also achieved by cross breeding, increasing growth rates, resistance to disease, and prolificacy, and improving meat quality and taste. Genetic manipulation of the embryo sex chromosomes producing sterile, triploid females, hence avoiding the 'hook-like' jaw that does not appeal to the customer, and ensuring that introduced / escaped individuals cannot breed.

Trout will not spawn naturally in culture systems; thus juveniles must be obtained either by artificial spawning in a hatchery or by collecting eggs from wild stocks. Larvae are well developed at hatching. In the wild, adult trout feed on aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, minnows, and other small fishes, but the most important food is freshwater shrimp, containing the carotenoid pigments responsible for the orange-pink colour in the flesh. In aquaculture, inclusion of synthetic pigments astaxanthin and canthaxanthin in aquafeeds causes this pink colouration(where desired).

5.0 Production cycle of rainbow trout

Monoculture is the most common practice in rainbow trout culture, and intensive systems are considered necessary in most situations to make the operation economically attractive.



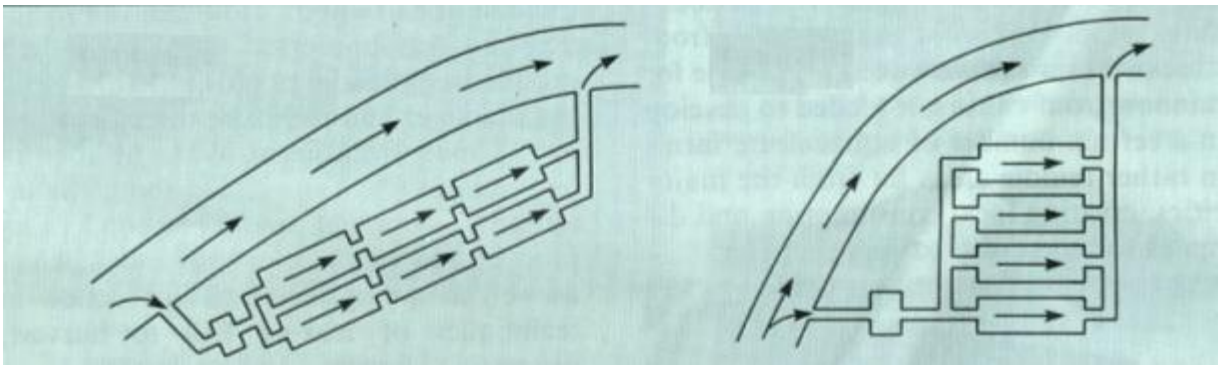
6.0 Infrastructure requirements of trout farm

6.1 Site Selection

Water is the most crucial deciding parameter for selection of site for setting up of trout farm. Site for commercial trout production must have a year-round supply of high quality water. The water to the farm can be from spring or from snow fed stream and must be free from silt.

6.2 Construction of ponds/ raceways

The cemented ponds/ raceways are required for the culture of trout fish. The rectangular tanks are better than the circular cisterns. The economical size of a trout race way should be 12-15 m x 2-3 m x 1.2 - 0.5 m with an inlet and an outlet for overflow of water fixed with wire mesh screws to prevent the exit of stocked species. There should be a drain pipe at the bottom of the pond to facilitate the harvesting as well as the cleaning of tank from time to time.



6.3 Water supply in the farm

The water supply in trout farm should be through a filter bed/sedimentation tank. There is a problem of silt particularly during monsoon season when the water is turbid which is not good for trout farming. The quantity of water required for a trout farm is related with the stocking density, size of fish as well as the water temperature. Therefore, it is necessary to regulate the flow of water very carefully. For example, 30,000 fries need water flow of about 15 litres/minute, the fish below 250 g needs a water flow of 0.5 litres/kg/minute at 10-12 ^{o}C. The water flow of above mentioned economical size of tank should be 52 m^3/hour for stocking of fingerlings of 5-

50 g at 15^{o}C. Thus, the water flow is regulated in such a way that fishes should not assemble at one place and also do not move fast. Temperature and flow of water also plays important role in the production of trout. The pH of the water should be in the range of 7-8 with temperature in the range of 10-12 ^{o}C.

6.4 Physico-chemical requirements of water for a trout farm

The physico-chemical parameters for the successful culture of trout are temperature, dissolved oxygen, pH and turbidity.

6.4.1 Temperature: The fish thrives well within the temperature range of 5 to 18^{o}C, but it has been found to tolerate the water temperature upto 25^{o}C without any mortality. However, the maximum growth is obtained within the temperature range of 10 to 18^{o}C.

6.4.2 Dissolved oxygen: The oxygen concentration range is from 5.8 to 9.5 mg/l. If the oxygen concentration is 5 mg/l, it is better to increase the flow of water.

6.4.3 pH: A neutral or slightly alkaline pH is best for the trout. The tolerable minimum and maximum pH values are 4.5 and 9.2, respectively. However, pH range of 7-8 is ideal for the growth of this fish.

6.4.4 Turbidity: The crystal clear water is required and there should not be any contamination. The turbidity should not be more than 25 cm of Secchi disc transparency.

6.4.5 Stocking density: It is related with the water supply, water temperature, quality/water and types of feed. If water temperature is above 20^{o}C, the stocking density should be less than the recommended density. The fry fingerlings (5 to 50 g) are stocked at the rate of 20 kg fish per cubic meter of water surface area.

7.0 Economics of trout farm

7.1 Investment cost

S.no	Particulars	Qty	Unit cost	Total Cost (Rs.)
1	Raceways - 15 x2 x 1.5 m	1	100000	100000
2	Equipment (Dragnet, hand net, bucket, tubs, thermocol box etc.)		LS	6000
3	Capitalisation of recurring expdt.			

	Seed	4500	5	22500
	Feed (Q)	15	9700	145500
	Interest cost for 1 st Yr			26715
	Total			3,00,715

7.2 Techno-economic parameters and assumptions

S.No	Particulars	Unit/Amt
1	Raceway size	15x2x1.5 m
2	No. of raceways	1
3	Seed rate/ stocking density	4500 nos
4	Mortality	10%
5	Seed cost (Rs./ piece)	5
6	Feed consumption per raceway (Q)	15
7	Feed cost (Rs. per Q)	9700
8	Water flow rate in raceway (lps)	10-15
9	Culture Period (year)	1.5
10	Av. Wt. of fish at harvesting (kg)	0.25
11	Sale price of fish (Rs.) / kg	350
12	Miscellaneous cost / year (Rs.)	6000
13	Labour (man days)	90
14	Labour Rate (per man day)	200

7.3 Cash flow analysis

S.No	Particulars	I	II	III	IV	V	VI	VII	VIII	IX	
a	Capital Cost	300710									
b	Expenditure										
	Feed	0	145500	145500	145500	145500	145500	145500	145500	145500	
	Fingerling cost	0	22500	22500	22500	22500	22500	22500	22500	22500	

	Labour	18000	18000	18000	18000	18000	18000	18000	18000	18000	
	Misc. expenses	5000	5000	5000	5000	5000	5000	5000	5000	5000	
	Total expenditure	23000	191000	191000	191000	191000	191000	191000	191000	191000	
	Total costs	323715	191000	191000	191000	191000	191000	191000	191000	191000	
c	Income										
	Sale of fish		354375	354375		354375	354375		354375	354375	
	Total income	0	354375	354375	0	354375	354375	0	354375	354375	
d	Gross surplus	-323715	163375	163375	-191000	163375	163375	-191000	163375	163375	
e	Net benefit	-323715	163375	163375	-191000	163375	163375	-191000	163375	163375	
f	DF @ 15%	0.870	0.756	0.658	0.572	0.497	0.432	0.376	0.376	0.376	
g	Discounted Costs	499217	138783	138783	138783	138783	138783	138783	138783	138783	160947 8
h	Discounted benefits	0	292174	292174	292174	292174	292174	292174	292174	292174	233739 1
i	NPV	727913									
j	BCR	1.45									
k	IRR	17%									

7.4 Repayment

	Loan	225536.25					
	ROI	13.00%					

Year	loan o/s		Gross surplus	Repayments			Surplus with farmer
	at beg.	at end		Principal	Interest	Total	
I	225536.25	225536.25	0.00	0.00	0.00	0.00	0.00
II	225536.25	189505.96	163375.00	36030.29	29319.71	65350.00	98025.00
III	189505.96	148791.74	163375.00	40714.22	24635.78	65350.00	98025.00
IV	148791.74	109581.74	0.00	39210.00	19342.93	58552.93	0.00
V	109581.74	58477.36	163375.00	51104.37	14245.63	65350.00	98025.00
VI	58477.36	0.00	163375.00	58477.36	7602.06	66079.42	97295.58
			DSCR	2.04			

8.0 Feed

The quantity of feed mainly depends on the water temperature and size of fish. If the water temperature is above 18^{o}C, the recommended feed should be reduced to just half of the required amount and above 20^{o}C, better to stop the feeding. The feeding should also be suspended on a cloudy day and when the water is turbid. A general feed formula is given below :

Ingredients	Percentage of ingredients	Quantity for preparing 10 kg of feed(kg)
Fish meal	50	5
Soyaflakes	10	1
Groundnut cake	20	2
Wheat flour	10	1

Linseed oil	9	0.9
Supplevit-M	1	0.1
Choline chloride	0.1	0.01

Feeding @ 4-6 % is necessary for the fingerlings for better growth but due consideration should also be given to the water temperature for following the feeding schedule. At the water temperature range of 10-12^{o}C, feeding schedule of 6% is optimum but when it increases to 15^{o}C, the feeding schedule to be lowered to 4% and beyond 19^{o}C, it should be just 50% of the optimum schedule. The optimum growth rate per month is 80 g.

9.0 Production of Table size fish and trout products

The fish after gaining the weight of 250 g is advisable to be harvested because beyond this size the growth is slow and rearing is uneconomical. Apart from fresh consumption, various types of products from the trouts are smoked, whole, filleted, canned, and frozen trout that are eaten steamed, fried, broiled, boiled, or micro-waved and baked. Trout processing wastes can be used for fish meal production or as fertiliser. The fresh fish market is large because the flesh is soft and delicate, white to pink in colour with a mild flavour. Food market fish size can be reached in 9 months but 'pan-sized' fish, generally 280-400 g, are harvested after 12-18 months. Strict guidelines are in place for the regulation of rainbow trout for consumption with respect to food safety. Hygiene and safe transportation of fresh fish are of paramount importance, to ensure that fish are uncontaminated by bacteria, in accordance with food agency directives.

10.0 Hygiene

The cleanliness is a very important factor in trout farming. The trout should be cleaned and disinfected either with 10% formalin or 4 ppm $KMno_4$ solution periodically. The infected fish should be immediately removed from the tank and due care should be taken to consult some fishery expert regarding the disease, if any.

11.0 Issues

Farmers from as far as Kinnaur, Shimla, Chamba, Kangra have to bear the cost of transportation from their farms and feed unit. There is a need to introduce transport subsidy to reduce the production cost for these farmers and make the venture more profitable.

Feed which is major production cost in trout farming is presently available mainly from existing Govt. feed unit in the state i.e. at State feed Unit, Patlikuhl. At present 30% handling/ Departmental charges are being levied on the feed. Department provides 15%

subsidy on handling charges. There is a need to relook into the levy of handling charges and offer feed to farmers at no profit no loss basis.

State Scheme for promotion of trout farming in tribal area which offers 40% subsidy need to be extended to NFDB scheme for trout farming which offers 20%/25% subsidy. Further, disparities in unit cost and subsidy among two schemes also need to be addressed.

NFDB scheme for promotion of hatchery with capacity of 2-3 lakh fry by private entrepreneurs needs to be revised by lowering the capacity to 0.50-1.00 lakh since the capacity and capability of private entrepreneurs is limited. This would help the progressive farmers located at far off places to have captive production of trout seed. Training component on hatchery management also need to be included in the scheme.

Development or provision of floating feed instead of pellet feed will prevent feed loss during feeding and reduce production costs. At presently, some farmers in Kullu district are purchasing floating feed from Andhra Pradesh to meet their requirements.

At present insurance companies are not insuring the trout farms since higher risks are involved. There is need to liaise with insurance companies to develop a product for meeting the high risks at higher premium. Alternatively, risk fund can be established under various schemes to help the farmer to meet his working capital requirements partially to restart his venture in case of any eventually.

Of the 500 plus trout units which have availed assistance under different schemes for promotion of trout farming, many of these have stopped rearing trout due to varied reasons such as disease, contaminated water, theft, higher production cost, lack of adequate knowledge about trout husbandry practices, marketing, etc. There is need for in depth study on the issues related to these farmers and redress the same.

Required hydrological conditions for the construction of raceways or circular ponds limit the number of sites where a farm could be constructed. Therefore, locations of trout farms are generally away from the house of farmers and theft of the stock is one of the major threat. Farmer's suggestion for inclusion of fencing of raceway in the unit cost trout promoting schemes as a measure to prevent theft of the stock need to be looked into.

Keeping in view the geographical spread of farmers and state farms and occasional requirements for feed and seed, there is also a need to promote district level institutions such as cooperatives of farmers, producer's organizations and contract farming that link producers to markets and reduce marketing and production costs.

There is a need to intensify holding district level camps at regular intervals that will help in improving capacities of the farmers locally as also provide an interface for redressal of different issues related to trout husbandry.

12. Conclusion

Rainbow trout farming has developed into a vibrant model in Himachal Pradesh due to continuing efforts of the Department and State. Govt. However, it is observed many farmers have suffered losses due to various reasons, which need to be addressed so that the production capacity of State is augmented. Further, research and development to increase production efficiency and reduction of production cost is required. Developing better marketing avenues especially for those farmers in the district which do not have tourist inflow will further auger development of this breed.