Rainbow Trout Farming and Extension

MANUAL

(Best Practices for Sustainable Rainbow Trout Production)

Edition I

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1. Introduction

The rainbow trout (*Oncorhynchus mykiss*), a cold-water fish species native to North America, has become one of the most important freshwater aquaculture species worldwide due to its rapid growth, adaptability, and high market value amongst trout species.

In Bhutan, rainbow trout aquaculture was introduced in 2007 to diversify freshwater aquaculture fish species, enhance livelihoods, improve rural food and nutrition security, and reduce dependence on imported fish. The country's pristine rivers, abundant freshwater resources, and cool mountain climate provide ideal conditions for sustainable trout farming.

Trout farming is particularly well-suited to Bhutan's mountainous regions, where both surface and groundwater resources can be efficiently and sustainably utilized. It offers steady employment and reliable income opportunities. The expansion of rainbow trout aquaculture also aligns with Bhutan's vision of promoting high-value livestock products as well as food and nutritional security.

1.1. The scope of this manual

- To serve as a standardized, science-based operational guide for livestock extension officials, research centres, and aquaculture development programmes
- To equip technical personnel, progressive farmers, and aspiring trout producers with essential scientific knowledge and practical management guidelines for a sustainable rainbow trout production under Bhutanese conditions
- To function as a primary technical reference for the planning, decision-making, establishment, operation, and expansion of rainbow trout farms
- To promote environmentally responsible and climate-resilient cold-water aquaculture systems in Bhutan

2. Rainbow trout

Rainbow trout (*O. mykiss*) is a commercially important cold-water fish species, highly valued both as a sport fish and as a premium food commodity (Figure 1). A

typical adult rainbow trout attains an average weight of 2-3 kg in 1-2 years. At the farmers' level, it is technically recommended to harvest at around 250 g (expected to attain within 10-16 months). The body morphology and coloration of rainbow trout exhibit considerable variation depending on habitat and diet. The species is readily distinguished by its pinkish-red lateral stripe.

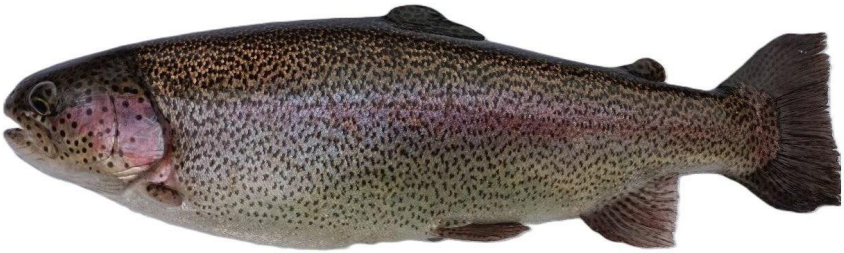

Figure 1. Rainbow trout (*O. mykiss*)

2.1. Habitat factors

The growth, survival, and overall performance of rainbow trout (*O. mykiss*) are strongly influenced by the following factors:

- **Water temperature**: Rainbow trout is a typical freshwater fish species. It grows best in water temperatures between 10-20°C. Within this range, the fish maintain optimal metabolic activity and feed conversion efficiency (FCE). Prolonged exposure to temperatures outside this range can lead to stress, reduced growth, and a higher risk of morbidity and mortality.

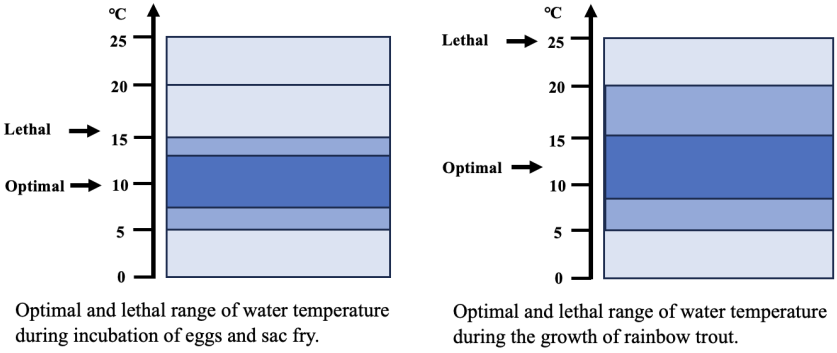

Figure 2. Temperature range for rainbow trout at different development stages

- **Dissolved Oxygen (DO):** A minimum concentration of 5-7 mg/L with a saturation level of 80-100% is essential for optimum metabolism and growth.
- **Water pH:** The pH range of 6.5-8.0 is essential for healthy growth. Clean and unpolluted water minimizes physiological stress and disease outbreaks.
- **Availability of feed:** In addition to formulated feed, the presence of natural food organisms such as aquatic insects and benthic invertebrates (bottom-dwelling organisms) supports growth, particularly during early life stages. A rich natural food base enhances nutrition, survival, and overall productivity.
- **Water supply:** A continuous supply of fresh, clean, and oxygen-rich water is essential to maintain optimal conditions in rearing systems. The volume of water required depends on the fish's developmental stage, stocking density, and metabolic activity. Water flow rates are commonly expressed as litres per second (L/s) or litres per minute (L/min).

2.2. Morphometric measurements and anatomy

Rainbow trout have a streamlined, elongated body with a slightly forked tail, soft-rayed fins, and a small adipose fin typical of salmonids. They feature a pink lateral stripe and black spots across the body and fins (Figure 3). The head is tapered with a terminal mouth and fine teeth, while internal organs include gills for respiration, a swim bladder for buoyancy, and simple digestive structures suited for carnivorous feeding (Figure 4).

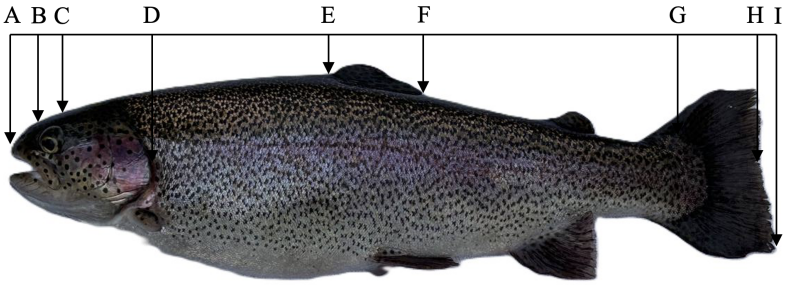

Figure 3. Morphometric measurements of rainbow trout. AB: Snout length; AG: Standard length; AC: Postorbital length; AH: Fork length; AD: Head length; AI: Total length; AE: Predorsal length; EF: Length of the dorsal fin base; DG: Trunk length; GI: Tail

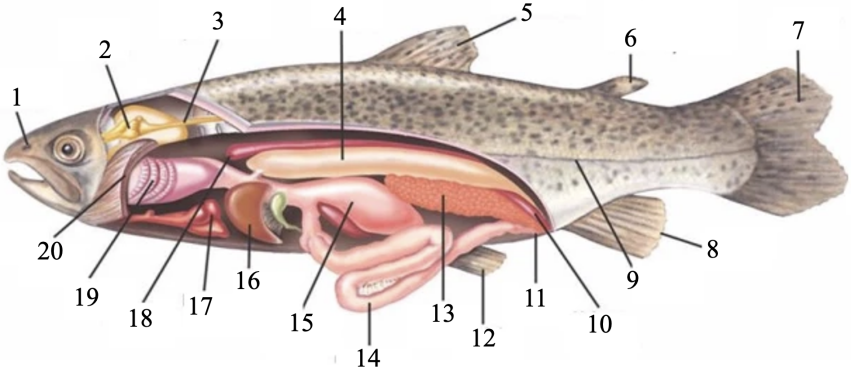

Figure 4. Anatomy of rainbow trout. 1. Nostril; 2. Brain; 3. Spinal cord; 4. Swim bladder; 5. Dorsal fin; 6. Adipose fin; 7. Caudal fin; 8. Anal fin; 9. Lateral line; 10. Urinary bladder; 11. Urogenital opening; 12. Pelvic fin; 13. Ovary in females and testis in males; 14. Intestine; 15. Stomach; 16. Liver; 17. Atrium; 18. Kidney; 19. Gills; 20. Cut edge of the operculum

2.3. Development stages

Rainbow trout undergo a series of well-defined developmental stages, from embryo to market-sized fish or adult (Table 1), each with specific growth patterns, nutritional needs, and environmental requirements.

Table 1. Life cycle of rainbow trout

Life Stage	Description	Average Duration	Size / Weight	Influencing Factors
Embryo (Fertilization to Hatching)	Temperature controls metabolic activity; embryos rely on yolk and absorb oxygen through body surface	0-28 days	3-5 mm/ 0.1-0.3 mg	Water temperature, DO, egg quality
Hatched Fry (Yolk-sac fry to Swim-up)	Still depend on yolk sac; development increases with temperature	28-37 days	1.5-3 cm/ ≥ 1 g	Water temperature, DO
Swim-up Fry to Fry	Begin external feeding; still highly	38-87 days	5 cm/ 2 g	Water temperature,

	sensitive to DO and temperature			DO, feed quality
Fry to Fingerling	Rapid growth begins; active feeding; metabolic rate increases	88-120 days	12.5 cm/ 25 g	Temperature, DO, feed quality and quantity
Fingerling to Table Fish	Growth to minimum market size; influenced heavily by nutrition quality	121-285 days	25 cm/ 250 g	Temperature, DO, feed quality and quantity
Table Fish to Adult	Final grow-out period; feed conversion rate becomes important	285 days+	42 cm/ ≥500 g	Temperature, feed quality and quantity, stocking density

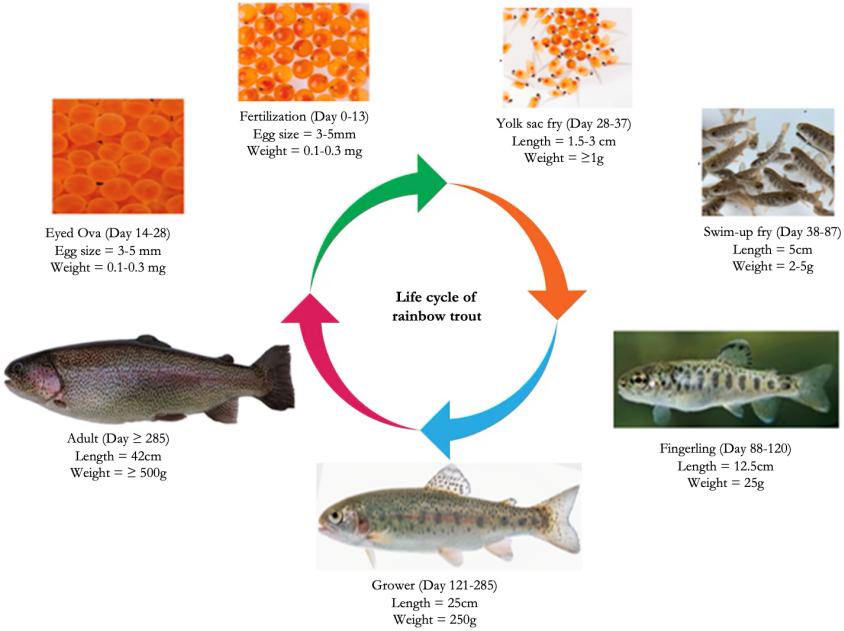

Figure 5. Life cycle of rainbow trout

3. Production types

Rainbow trout (*O. mykiss*) can be produced under several production systems depending on the farmer's skill level, resources, and target market, as outlined below:

- Eyed ova production (currently done at the government input farm)
- Fry production (currently done at the government input farm)
- Fingerling rearing (undertaken by the farmers)

3.1. Fingerling rearing

Fingerling production bridges the gap between hatchery fry and grow-out fish. It is important when fry are too small to be stocked directly into grow-out systems. Fingerling units may operate as stand-alone facilities or as integrated components of larger farms producing both fingerling and table fish.

3.2. Table fish production

There are two practical approaches to table fish (rainbow trout) production in Bhutan:

- Rearing from fry
- Rearing from fingerlings

4. Rainbow trout rearing facilities

The rearing devices consists of:

- Hatching tray
- Fry rearing device
- Fingerling and table fish tanks

4.1. Fingerling and table fish tanks

Concrete raceways or tanks are the most preferred systems for intensive rainbow trout culture. Small tanks are used for young fish, while larger tanks (100-300 m^3) are designed for table fish. Typical tank dimensions are 20 m (length) × 2-3 m (width) × 1-1.5 m (depth), along with a stocking rate of 10 kg fingerlings per cubic meter. A typical raceway tank structure can be classified into parallel and series systems.

Although earthen ponds were traditionally used, their role has diminished with the shift toward intensive farming. In Bhutan, lined or stone-paved ponds are still used in some areas but require good drainage and regular cleaning.

The recommended water flow for a rectangular pond is 0.7-1.4 L/minute per m^3, ensuring a complete water exchange once or twice daily.

4.2. Farming system

In trout farming, two main systems are used: series and parallel (Figure 6), depending on the landscape and farm priorities.

In a series system, water flows from one raceway or pond to the next. It is simple and cost-effective but can reduce water quality downstream as oxygen decreases and waste builds up. This system works best with low stocking densities or when water treatment is applied between units.

In a parallel system, each raceway or pond receives a separate supply of fresh water. This ensures consistent water quality, temperature, and oxygen levels, reduces disease risk, and supports higher stocking densities and growth. It requires more water and higher infrastructure costs.

For most trout farms, especially where water quality and biosecurity are important, a parallel system is recommended. The series system should be used only when water is limited, and water quality is closely monitored with aeration or treatment between units.

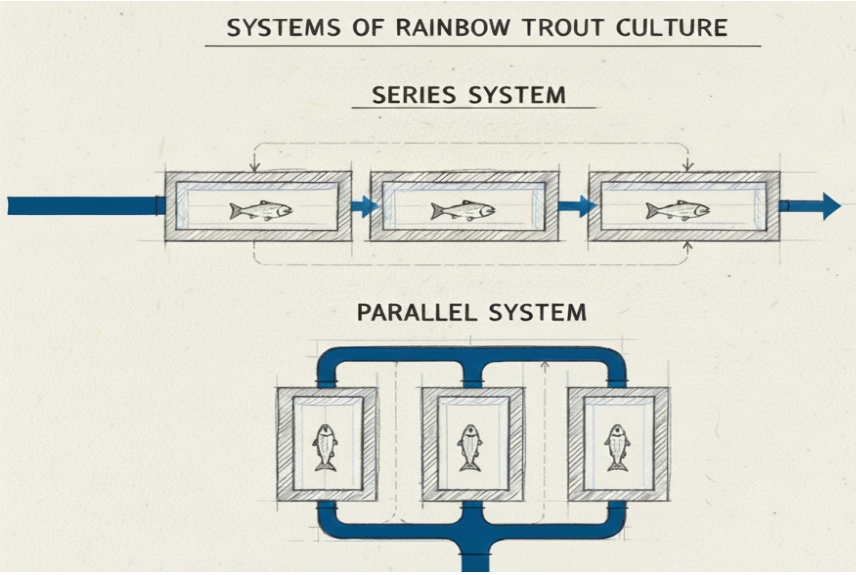

Figure 6. Rainbow trout farming system

5. Feasibility and site selection

For the establishment of a new rainbow trout (*O. mykiss*) farm, the most critical factors to consider are:

5.1. Preliminary decisions

- Should have a clear idea of the type of trout farm you wish to establish
- Level of production you plan to reach: Subsistence or commercial?
- Production plan: Seasonal or year-round
- Production options: Should I buy fingerlings or produce them at my farm?
- Aqua-tourism: Should I try to integrate my trout farming with other economic activities?

5.2. Major considerations

The major factors to be considered when selecting a site for the construction of a rainbow trout farm are:

- Water quality and quantity: Fresh and abundant water supply
- Soil quality: Clayey or loamy soils are preferred for structural stability and water retainability
- Topography: Gently sloping terrain supports efficient farm layout and drainage
- Vegetation cover: Thin forest cover is preferred for easier clearing
- Road Accessibility: Easier transportation of goods and inputs
- Proximity to your home: To protect from poachers and for easy management
- Market Nature/Accessibility: To market the product
- Availability of inputs: For the regular functioning of the farm

6. Production work

On many new trout farms, production begins when eyed ova, fry, fingerlings, or advanced fingerlings arrive from another farm or a government hatchery. Before their arrival, all rearing devices should be thoroughly cleaned and disinfected, and the water supply to the devices checked. The production activities include:

6.1. Receiving eyed ova, fry, fingerlings, or adult rainbow trout

- Fill the bag with water and oxygen at a ratio of 1:2 volume
- Pack the fish in a polythene bag with water and oxygen (1kg fish/polythene bag) (Figure 7)

- Tie the opening of the bag with the jute thread to prevent leakage during transportation
- Maintain and adjust the water temperature slowly, at steps of 0.5 °C per minute, to ensure acclimatization (Freezer van is recommended for constant temperature regulation)
- After reaching the site, the acclimatization procedure is done by placing the polythene bag in the pond for 15 minutes, before the fish is released into the water

Figure 7. Advanced fry and fingerling selection, and packaging for transportation

6.2. Grading of fish

Grading is the process of segregating different sizes of fish. It is mainly done to:

- Prevent cannibalism
- For partial harvesting and marketing
- To prevent the competition for feed and space, and ensure uniform growth
- Monthly grading of fish is recommended in the field

6.3. Signs of water shortage

- In fry, fingerlings, and older fish, oxygen shortage is evident when fish gather near the water inlet (Figure 8)
- Acute shortages can cause mortality, while chronic shortages result in reduced feeding and poor growth

Figure 8. Fish concentrated at the inlet due to insufficient water supply in the rearing trough

6.4. Signs of excess water flow

- Whirlpools forming in tanks are a clear indication of excessively strong currents
- Fish struggle to swim against the water currents
- In circular-flow tanks, fish concentrate in the middle rather than dispersing evenly
- In large raceways or ponds, fish seek shelter along sidewalls

Figure 9. Fish were swept away towards the outlet by excess water flow

6.5. Feeding

Feeding constitutes around 60-70% of the total cost in trout production. Conventional trout diets like trash fish, slaughterhouse remnants, and offal are replaced by high-protein formulated feeds (FCR 0.6-1.1) due to operational convenience and high nutritional value.

Additionally, where commercial feeds are scarce, farm-based or homemade feed formulations may still be an option. However, considering the nutritional value and the FCR, commercial pellet feed is recommended for higher growth.

6.5.1. Nutritional formulation trends

Rainbow trout requires a balanced formulated feed to ensure strong immunity and growth. In Bhutan, the centre uses commercial pellet feed sourced externally. Nutritional composition is shown in Table 2.

Table 2. Nutritional content of different groups of rainbow trout feed

Analyses (%)	Feed Size (mm)					
	1	1.5	2	3	4.5	6
	Advance	Pre-grower		Grower	Grower with Astax	
Protein	54	54	45	40	41.5	43
Fat	15	15	18	20	32	31.5
Crude fiber	0.3	0.3	1.2	1.5	1.5	1.5
Ash	11.3	11.3	8.8	6	7	7
Total Phosphorus	1.72	1.72	1.49	0.75	0.87	0.87
Astaxanthin (mg/kg)	0	0	0	0	60	60
Vitamin A (IU/Kg)	13333	13333	11667	8936	9067	9067
Gross Energy (MJ/kg)	21	21	21.3	22	22.4	24
Digestible Energy (kcal/kg)	19.3	19.3	19.1	19	19.4	19.4

(Source: Trout, Alltech Coppens, The Netherlands, 2022-2023)

6.5.2. Feeding and feeding rates

Feeding rates should be adjusted depending on the water temperature, body size and the metabolism of the fish (Tables 3 and 4). Additionally, the feeding rate is inversely proportional to the size of the fish. This is to ensure optimal utilization of the feed, fish growth, prevent diseases and maintain a healthy tank environment.

Table 3. Feeding rate for advanced fry to fingerling

Fish Weight (g)	Feed Size (mm)	Feeding rates based on water temperature								
		Below 6°C	6°C	8°C	10°C	12°C	14°C	16°C	18°C	Above 18°C
5-12	1.5	Based on fish's appetite	1.18	1.43	1.72	2.09	2.52	3.05	2.47	Based to fish's appetite
10-20	2		1.03	1.24	1.5	1.81	2.19	2.39	1.94	
20-30	2		0.93	1.12	1.35	1.64	1.98	2.39	1.94	

(Source: Trout, Alltech Coppens, The Netherlands, 2022-2023)

Table 4. Feeding rate for fingerlings and grower

Fish Weight (g)	Feed Size (mm)	Feeding rates-based water temperature								
		Below 6℃	6℃	8℃	10℃	12℃	14℃	16℃	18℃	Above 18℃
35-100	3	Based on fish's appetite	1.1	1.33	1.61	1.94	2.35	2.84	2.3	Based on fish's appetite
100-200	3, 4.5		0.88	1.07	1.29	1.56	1.89	2.28	1.85	
200-300	4.5		0.8	0.96	1.16	1.41	1.7	2.06	1.67	
300-400	4.5		0.74	0.9	1.09	1.32	1.59	1.92	1.56	
400-500	4.5/6		0.71	0.86	1.04	1.25	1.51	1.83	1.48	
500-750	6		0.67	0.81	0.98	1.18	1.43	1.73	1.4	
750-1000	6		0.62	0.75	0.91	1.1	1.33	1.61	1.31	
1000-1500	6		0.58	0.7	0.84	1.02	1.23	1.49	1.13	

(Source: Trout, Alltech Coppens, The Netherlands, 2022-2023)

6.5.3. Feeding frequency and method

Feeding frequency, like feeding rate, decreases as fish grow. Advanced fry may need 4-5 or more feedings per day. As they reach the fingerling stage and above, this can be reduced to two feedings per day.

Hand feeding is a common feeding method practiced for rainbow trout farming. It is important to ensure uniform distribution of feed across the raceway.

6.5.4. Storage of rainbow trout feed

Feeds should be kept in a dry and well-ventilated store to:

- Prevent insects and rodents
- Moisture or mold
- Preserve palatability and nutritional value
- Prevent health risk from toxins and pathogens

A "**first in, first out**" principle should be followed to ensure older feed is used before newer stock.

7. Rainbow trout health management

Disease prevention is the most economical way to maintain fish health. This can be achieved by consistently providing optimal water quality, nutrition, handling, hygiene, and biosecurity. The clinical signs and symptoms of rainbow trout diseases are in Table 5.

Table 5. Rainbow trout health quick diagnostic chart

Observed Signs	Possible Cause(s)*	Immediate Action
Fish stop eating; gather at inflow; sluggish swimming	Low dissolved oxygen; poor water circulation; disease onset	Check water parameters and flow rate; increase aeration
Gasping at surface; crowding near inflow	Oxygen deficiency; gill parasites; nitrite poisoning	Measure DO & nitrite; add aeration; salt bath (if parasites suspected)
Erratic swimming (whirling, spiralling, trembling)	Viral (IHN, IPN, VHS); parasites (whirling disease); gas bubble disease	Check water gas levels; send samples for lab diagnosis
Skin ulcers, haemorrhages, frayed fins	Bacterial diseases (furunculosis, ERM, columnaris)	Isolate affected tanks; improve hygiene; consult for treatment
Cotton-like growths on skin, gills, or eggs	Fungal infection (*Saprolegnia*)	Improve water quality; treat with hydrogen peroxide or iodophor
White spots on skin or gills; flashing against tank walls	Parasitic disease (*Ich*, *Trichodina*, *Costia*)	Confirm using a microscope; and salt or formalin bath.
Swollen abdomen; exophthalmia (pop-eye); pale gills	Bacterial Kidney Disease (BKD); dropsy; nutritional deficiency	Isolate affected fish; lab confirmation; check and adjust feed quality
Uneven fish sizes in the same tank; increased cannibalism	Underfeeding or poor feed distribution	Review feeding rate; increase feeding frequency
Spine deformities; slow growth; poor coloration	Scoliosis; Vitamin/mineral deficiency; poor-quality feed	Check and adjust feed quality

Fish mortality after heavy rain or sudden weather change	Environmental shock (pH, temperature, ammonia spike)	Test water parameters

**IHN: Infectious Hematopoietic Necrosis; IPN: Infectious Pancreatic Necrosis; VHS: Viral Hemorrhagic Septicemia; ERM: Enteric Red Mouth Disease.*

7.1. Commonly used cleaning agents

Cleaning and disinfection are essential for maintaining a healthy environment and preventing disease outbreaks. For details, refer Table 6.

Table 6. Cleaning agents and their applications, dosages and precautions

Cleaning Agent	Uses / Applications	Recommended Rates	Precautions
Salt (Sodium chloride)	• Cleaning fry troughs and tanks • Scrubbing tank walls to remove dirt and biofilm	Use coarse or kitchen salt; no fixed concentration required	Remove dead fish and siphon faeces before scrubbing
Formalin (Formaldehyde solution)	• Disinfecting tanks, equipment, and water supply pipes between cycles	• 1% solution: washing tanks and rearing devices • 2-3% solution: disinfecting water supply pipes (fill and hold 15-30 min)	Flush thoroughly with clean freshwater until no odor remains; handle with caution
Lime (Quicklime or chlorinated lime)	• Disinfection of concrete tanks	• Quicklime: 0.25 kg/m² • Chlorinated lime: 0.03–0.05 kg/m²	Avoid quicklime; use chlorinated lime instead
Domestic cleaning agents (powders or liquid detergents)	• Cleaning equipment, troughs, and tanks	No specific rate; use small amounts as needed	Must be thoroughly rinsed to avoid harmful residues

Iodophors (iodine-based disinfectants)	• Egg disinfection • Equipment cleaning	Varies by product; typically used at low concentrations	More safer alternative to formalin

7.2. Best practice notes for rainbow trout farmers

- Check water first: 80% of fish health issues are linked to water quality
- Observe during feeding: appetite is the quickest indicator of health
- Isolate sick fish: reduces spread before lab confirmation
- Report to fish experts if symptoms persist or spread
- Early detection is critical. Behavioural monitoring during feeding sessions often provides the first warning signs
- When abnormal signs are observed, farmers should immediately check water quality parameters (DO, temperature, pH, ammonia, nitrite)
- For disease confirmation, report to the animal health authority

8. Farm records

Record keeping is an important component of successful farm management. Good records support traceability, enable timely decision-making, and allow for continuous evaluation of farm performance, helping identify trends, address problems early, and plan for improvements in future production cycles. The recommended recording formats are provided in Annexure 1-6.

Annexure 1: Fish stock record

Sl. No.	Date	Pond ID	Pond Area (m^3)	Type	Quantity (Nos.)	Unit Cost	Total Cost (Nu.)	Remarks

Annexure 2: General input record

Sl. No.	Date	Input Type	Unit	Quantity	Unit Cost (Nu.)	Total Cost (Nu.)	Remarks

Annexure 3: Harvest record

Sl. No.	Date	Pond ID	Number Harvested	Quantity (Kg)	Average Weight at Harvest (Kg)	Farm Gate Price (Nu./Kg)	Total Amount (Nu.)

Annexure 4: Daily feeding record

Sl. No.	Date	Pond ID	Number of Fish	Type of Feed	Quantity Fed	Feeding Schedule

Annexure 5: Disease treatment record

Sl. No.	Date	Pond ID	Diseases	Treatment	Cost of Treatment	Mortality (%)	Method of Dead Fish Disposal

Annexure 6: Water quality parameters record

Sl. No.	Date	Pond ID	Temperature (°C)	pH	DO (mg/l)	Nitrate (mg/l)	Ammonia (mg/l)