

Grassroots Aquaculture: Raceways and Rural Transformation in Jammu and Kashmir

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Introduction

Jammu and Kashmir, located in the northwestern Himalayas, possesses abundant freshwater resources that make it highly suitable for coldwater aquaculture. Among the species best adapted to these conditions, Rainbow Trout (*Oncorhynchus mykiss*) has emerged as a high-value candidate due to its adaptability to cold waters, rapid growth rate, and rising consumer demand. Raceway farming, a flow-through aquaculture system, is increasingly being adopted by farmers in the region due to its efficient water utilization, suitability for controlled management practices, alignment with the area's natural topography and hydrological conditions, and its potential to generate high economic returns. This article provides a farmer-centric overview of raceway trout farming in Jammu and Kashmir, with a focus on economic potential, practical methodologies, and its broader impact on rural livelihoods.

Why Rainbow Trout?

Rainbow Trout is increasingly favored by farmers in Jammu and Kashmir for several practical and ecological reasons. The species thrives in coldwater environments, with optimal physiological performance occurring at temperatures between 10°C and 16°C, conditions naturally sustained by the region's spring-fed streams and snowmelt-fed rivers. Rainbow Trout exhibits efficient feed conversion and steady weight gain under proper management, enabling farmers to achieve desirable harvest sizes within a defined rearing cycle. The species' responsiveness to controlled aquaculture conditions makes it well-suited for structured farming systems such as raceways. Additionally, market demand for trout remains strong, particularly in urban centers and tourism-driven areas where high-quality coldwater fish is in demand. Government support through centrally sponsored schemes like the Pradhan Mantri Matsya Sampada Yojana (PMMSY), which provides training, input subsidies, and seed supply has

further encouraged the adoption of trout farming as a sustainable and profitable livelihood strategy across the region.

Understanding Raceway Systems

Raceway systems represent a highly efficient and scientifically validated approach to coldwater aquaculture, particularly well-suited for the intensive culture of Rainbow Trout (*Oncorhynchus mykiss*) in mountainous regions like Jammu and Kashmir. These systems consist of elongated, narrow, rectangular channels, typically constructed from reinforced concrete through which a continuous, unidirectional flow of high-quality water is maintained. The hydraulic design of raceways incorporates an efficient inlet and outlet system that ensures uniform flow distribution, enhances oxygen transfer, and facilitates the effective removal of metabolic waste and uneaten feed, thereby supporting optimal water quality and fish health. Water is typically sourced from perennial springs or snowmelt-fed streams and delivered via screened inlets to prevent debris and predator entry. The raceway floor is designed with a gentle longitudinal slope, typically ranging from 1–2%, to maintain consistent water velocity that aligns with the natural swimming behavior of trout and supports self-cleaning by guiding solid waste toward the outlet. One of the primary advantages of raceway systems is their ability to maintain optimal dissolved oxygen levels, typically above 7.0 mg/L through constant water turnover, which supports the aerobic metabolism, fast growth, and overall health of trout. Moreover, raceways enable higher stocking densities, often exceeding 20–30 kg/m³ under intensive management, and promote efficient feed utilization, with feed conversion ratios (FCR) commonly ranging from 1.1 to 1.3, depending on environmental conditions and feed quality. The linear, open structure of raceways facilitates ease of daily management, allowing for real-time monitoring of fish behavior, feed intake, and health status, as well as straightforward harvesting and biomass estimation. Their design is particularly advantageous in hilly terrains, where gravity-fed flow reduces the need for mechanical pumping, thereby lowering operational energy costs. Raceway systems remain a cornerstone of modern coldwater aquaculture, offering a scalable, water-efficient, and technically robust solution for trout farming in ecologically sensitive, high-altitude regions.

Daily Operations at a Trout Farm

The daily routine of a typical Rainbow Trout farmer in Jammu and Kashmir is centered around precise feeding practices, diligent raceway maintenance, and the consistent availability of clean cold water, all essential for maintaining healthy and productive fish stock. Feeding is one of the most critical tasks, typically carried out two to three times a day using high-protein,

floating commercial feed specifically formulated for Rainbow Trout. Farmers monitor fish behavior closely during feeding to assess appetite and adjust feed quantities based on factors such as water temperature, biomass, and activity levels. Careful observation of uneaten feed allows for timely adjustments, helping to optimize feed conversion efficiency while preserving water quality. Raceway maintenance is equally important and begins early each day with inspections of the water supply, usually derived from spring-fed or snowmelt-fed sources. Farmers assess water flow, clarity, and temperature to ensure optimal conditions. Since trout are highly sensitive to fluctuations in dissolved oxygen, any reduction in water flow, particularly during lean seasons requires immediate intervention. To address this, some farmers have adopted automated siren or alarm systems that activate in the event of a sudden drop in water flow, providing a timely alert that helps prevent stress or loss of stock. Midday activities often involve cleaning the raceway channels to remove sediment, uneaten feed, and organic waste, all of which are essential to maintaining a hygienic and oxygen-rich environment. Regular inspection and maintenance of screens, inlets, and protective netting are also carried out to ensure the smooth functioning of the system. In many farms, on-site sales have become an integral part of daily operations. Freshly harvested trout are graded, weighed, and packaged directly at the farm for local customers, visitors, or small-scale buyers. This not only creates an immediate revenue stream but also strengthens the farm's presence in the local market. While the routine demands consistency and attention to detail, its structured nature, combined with emerging technologies and market integration, makes raceway trout farming a practical and rewarding agricultural activity in the region.

Economic Benefits and Livelihood Impact

Economically, raceway trout farming has proven transformative for rural households in Jammu and Kashmir. A single raceway can yield approximately 750 kilograms of trout per production cycle. Thus, a small unit consisting of three to five raceways can produce between 2,250 to 3,750 kilograms per cycle. At a market price of ₹500 per kilogram, this translates to a total revenue of ₹11.25 to ₹18.75 lakhs per cycle. With an average profit margin of around 50%, farmers can expect net earnings between ₹5.6 to ₹10 lakhs per cycle, depending on factors such as feed conversion efficiency, mortality rates, and water availability. In addition to selling market-size trout, many farmers are diversifying their income by producing fingerlings, developing value-added products like grilled, fried, and ready-to-cook items of rainbow trout. This diversification has enabled some farmers to integrate trout farming with tourism-based services, especially in popular tourist areas like Akad, Pahalgam in the Anantnag district of

Jammu & Kashmir. The sector has also seen strong participation from youth, many of whom are launching aquaculture-based microenterprises and startups. Women are increasingly contributing to the value chain as well, engaging in feeding, maintenance, record-keeping, and local marketing, thereby playing a crucial role in enhancing household incomes and driving rural economic development.

Key Challenges Faced by Farmers

Despite its numerous advantages, farmers engaged in trout farming encounter several challenges in maintaining and scaling up their operations. A significant constraint is the seasonal reduction in water availability, particularly during the late autumn and early winter months. During this period, natural water sources experience a marked decline in flow, which directly impacts the functioning of flow-through raceway systems that rely on a steady and sufficient water supply. As a result, farmers are often compelled to minimize their operations during these lean months by reducing stock density and keeping only a limited number of raceways functional. This seasonal adjustment, while necessary, restricts continuous production and limits the overall output and profitability during lean time period. One of the most pressing challenges in raceway trout farming is the availability and cost of high-quality commercial feed, which remains the largest recurring input in the production process. Supplies of trout feed are often limited within the region, compelling farmers to source it from distant locations outside Jammu and Kashmir. This dependence on external suppliers not only inflates costs due to transportation and handling but also leads to delays and inconsistency in availability, especially during peak farming seasons. The absence of local feed manufacturing facilities further exacerbates the issue, leaving farmers vulnerable to market fluctuations and supply chain disruptions. As a result, feed supply constraints directly affect growth performance, production planning, and profit margins. Ensuring a steady, affordable, and regionally accessible feed supply is therefore crucial for the long-term viability and expansion of trout farming in the area. In many cases, farmers lack technical knowledge on feed conversion ratios, dietary requirements at different growth stages, and the impact of nutrition on overall fish health and productivity. Addressing these gaps through technical training and expert support is essential to improve feed utilization, reduce costs, and enhance the economic sustainability of trout farming in the region. Outbreaks of bacterial or fungal infections can spread rapidly in raceway systems if not managed properly, requiring vigilance and sometimes technical support. Marketing remains a significant challenge for trout farmers, especially those operating in remote villages with limited access to well-connected markets. Poor road

infrastructure hampers timely transportation of fresh produce to urban centers where demand is higher. Additionally, the lack of nearby marketplaces or organized distribution channels often forces farmers to rely on intermediaries, reducing their profit margins. Without direct access to reliable markets, many farmers struggle to sell their harvest at fair prices, making it difficult to scale operations or invest in improvements. Strengthening local market linkages and establishing collection centers or cooperative marketing models could play a critical role in addressing this barrier.

Local Success Stories

Nevertheless, numerous success stories highlight the resilience, innovation, and adaptability of local farmers in advancing trout aquaculture. A prominent example is Mr. Raja Amir Usman from Kishtwar district, a postgraduate student in Fisheries Resource Management, who embarked on trout farming in 2022 with support from the Department of Fisheries. By adopting scientifically recommended practices and implementing a well-designed raceway system, Mr. Amir Usman has successfully established a profitable trout farming enterprise, generating an annual income exceeding ₹5 lakhs. In 2024, Mr. Amir Usman further advanced his farm operations by initiating the breeding of rainbow trout at his unit, Alpine Trout Kishtwar. This strategic step aimed to make his farm self-sufficient in seed production, reducing reliance on external hatcheries and ensuring a consistent supply of high-quality fingerlings. The breeding initiative proved successful, enhancing both the sustainability and productivity of Mr. Amir Usman's farm. Beyond his technical achievements, Mr. Amir Usman has also contributed to local employment by incorporating three local youth into the day-to-day operations of his raceway system. Through his efforts, the farm has become a model unit in the Kishtwar region, attracting interest from visiting farmers, researchers, and aspiring entrepreneurs. Mr. Amir Usman's journey exemplifies the transformative potential of science-backed aquaculture, particularly when driven by youth leadership, and underscores the importance of self-reliant, community-integrated models for the sustainable development of trout farming in Jammu and Kashmir.

Similar successful models have emerged in the Anantnag district, where several prominent trout farmers have demonstrated exceptional achievements in aquaculture. Notable among them are Mr. Shakeel Ahmad Teli and Mr. Mohd. Amin Khanday, both operating in the Sallar Bhagwani area of Pahalgam—an ecologically favorable region for trout farming due to the perennial flow of the Lidder River.

Mr. Mohd. Amin Khanday, the proprietor of the Royal Rainbow Trout Fish Unit, has established a highly productive farm that utilizes the clean, cold waters of the Lidder River. His enterprise consistently yields substantial profits, and he is widely recognized for his extensive hands-on experience and in-depth knowledge of trout husbandry. His farm serves as a benchmark for quality and operational efficiency in the region.

Mr. Shakeel Ahmad Teli is regarded as one of the pioneering figures in Kashmir's trout farming sector. With decades of experience, he has made significant contributions to the growth and development of trout aquaculture in the region. His early adoption of raceway systems and continued commitment to scientific fish farming practices have inspired many emerging farmers and helped lay the foundation for the expansion of the industry in south Kashmir. These exemplary cases underscore the role of experienced and innovative individuals in shaping the



Water siren system installed at Royal Rainbow Trout Fish Unit, Sallar Bhagwani, to monitor and alert for consistent inlet water flow into the raceway, ensuring uninterrupted aquaculture operations.



Glacial waters of the Lidder River sparkle near Sallar Bhagwani, tracing a timeless journey from Kolahoi Glacier through the heart of Pahalgam's serene landscapes.

trajectory of trout farming in Jammu and Kashmir. They reflect the potential for combining traditional knowledge with modern aquaculture practices to create sustainable, high-yield models in ecologically suitable regions.

Strengthening the Future of Raceway Farming

To further enhance the impact of raceway trout farming on rural livelihoods, a combination of policy, technical, and institutional interventions is essential. Structured training programs and farmer field schools can play a crucial role in bridging knowledge gaps and building technical capacity among trout farmers. A key area requiring urgent attention is the involvement of qualified fish nutrition and feed technology experts. Despite the expanding scale of trout production, the sector remains heavily dependent on expensive commercial feeds, often used without customized guidance on feed formulation, feeding regimes, or stage-specific nutritional requirements. The expertise of trained professionals in fish nutrition is vital for developing region-specific, cost-effective feeding strategies that improve feed conversion efficiency and reduce operational costs. Their input would significantly contribute to enhancing both productivity and long-term sustainability. In parallel, increased research support from specialized fisheries institutions is critical for driving innovation across the value chain. The Faculty of Fisheries, Rangil Ganderbal, under SKUAST-Kashmir, is uniquely positioned to lead these efforts. Through focused research, field trials, and farmer-centric extension programs, the faculty can contribute to the development of improved broodstock, enhanced disease resistance, and optimized production practices. Strengthening partnerships between trout farmers and the Faculty of Fisheries would accelerate the adoption of scientific advancements at the grassroots level, boosting resilience and profitability across the sector. Furthermore, strategic marketing initiatives such as eco-labeling and branding of Rainbow Trout from Jammu and Kashmir as a premium, Himalayan-origin product could unlock access to high-value domestic and export markets. Integrating digital tools, such as mobile-based advisory applications and online trading platforms could also help bridge critical gaps in information dissemination, market access, and value realization. Together, these interventions can create a more inclusive, efficient, and sustainable ecosystem for trout aquaculture in the region.

Conclusion

Raceway trout farming in Jammu and Kashmir has emerged as a transformative livelihood strategy, particularly for rural communities situated in the region's ecologically favorable coldwater zones. Leveraging abundant spring-fed and snowmelt-fed water resources, this scientifically grounded system has enabled efficient and high-yield aquaculture of Rainbow Trout, a species with strong market demand and excellent biological performance under controlled conditions. The model aligns well with the natural topography of the

Himalayan region and provides opportunities for income diversification, youth entrepreneurship, and localized economic development. While farmers have demonstrated remarkable adaptability in adopting raceway technology, several systemic challenges, such as seasonal water variability, limited local feed availability, and insufficient technical guidance still constrain the sector's full potential. Addressing these issues through collaborative efforts involving research institutions like the Faculty of Fisheries at SKUAST-Kashmir, targeted policy support, and innovations in feed, marketing, and extension services will be the key to scaling up operations sustainably. Moreover, enhancing access to training, integrating women in aquaculture value chains, and promoting local success stories can further deepen grassroots participation and resilience. With the right investments and institutional backing, raceway trout farming stands poised to become a cornerstone of rural transformation and coldwater aquaculture development in Jammu and Kashmir.