Reaching out to the unreached through diversified aquaculture in Nagaland

R.N. Mandal[1]*, S. Adhikari[1], Vimezo Kere[2], S.K. Swain[3], P.P. Chakrabarti[1], G.S. Saha[3], B.N. Paul[1], C.K. Misra[3], Ezung Tsutsamo[2], A. Hussan[1], A. Das[1], and P.K. Sahoo[3]

1. Regional Research centre, ICAR-CIFA, Rahara, West Bengal, India; 2. Department of Fisheries and Aquatic Resources, Kohima, Govt. of Nagaland, India; 3. ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, Odisha, India. Corresponding author: rnmandal2003@yahoo.com

Nagaland is one of the eight sister states in northeast India. It is a mountainous region, home to diverse indigenous tribes with distinct cultures celebrated through various festivals. The most famous of these is the Hornbill Festival, held in December each year. Nagaland is a land shrouded in mystery, characterised by its mountains, valleys, forests, water bodies, and streams. These natural features form the backdrop for the vibrant people who live there—dancers, warriors, and former head-hunters who zealously protect their heritage. The mere mention of Nagaland evokes images of these unique cultures.

However, with changing times, Nagaland is also evolving. Modernity is slowly making its way into tribal cultures, particularly in urban and peri-urban areas, though it has yet to fully reach the more remote villages where traditional ways of life are still fiercely maintained. The people of Nagaland are believed to be embracing this subtle modernity while preserving their cultural traditions, creating a unique blend of unity in diversity.

Nagaland, with a geographical area of 16,579 km² (Bhattacharya et al., 2018), has a population of 2.28 million, and Kohima is its capital. The total potential area for aquaculture is estimated to be around 30,000 hectares, but only 10.45% of this has been effectively utilised, leaving nearly 90%

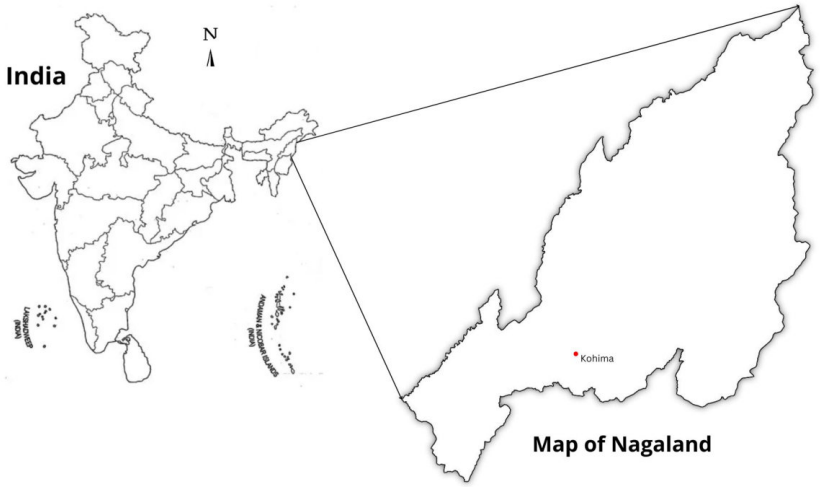
Scattered narrow trenches with water lying in the field after crop harvest.

untapped (Paul et al., 2021). Water is a crucial natural resource in Nagaland, essential for ensuring food security, maintaining ecosystem integrity and health, and supporting the religious and cultural life of the Naga people. It will continue to play inclusive and multifaceted roles in the developmental planning of the state.

Nagaland receives an average annual rainfall of 1,715 mm, with 80% of it occurring during the pre-monsoon and monsoon months (June-August). The heavy rain, combined with the state's hilly topography, results in high surface runoff. Despite the abundance of water bodies such as ponds, lakes, reservoirs, canals, rivers, and seasonal water bodies, the potential for exploiting these resources for commercial fish farming to support the livelihood of the common people remains largely unfulfilled.

The ICAR-Central Institute of Freshwater Aquaculture (CIFA) has made significant efforts to establish aquaculture as a viable livelihood option for the people of Nagaland through the following programmes:

- Paddy and amur carp farming, utilising the extensive water resources available during paddy cultivation.
- The establishment of a large aquarium unit to familiarise people with ornamental fish and the distribution of aquariums to schools to develop an interest in ornamental fish species and farming among school children.



A paddy field landscape, water-filled trenches can be seen in the mid field.

Paddy and amur carp farming – a challenging task in Nagaland

Introducing aquaculture as a livelihood option in Nagaland poses several challenges. The people of Nagaland traditionally prefer pork as their primary protein source, followed by poultry. Fish does not typically feature in their daily meals, but it is gradually being accepted as a substitute protein food. Despite the substantial water resources available, these resources are scattered across the uneven terrain of farming land surrounded by hills. Water from hilly terrain flows down to the plains, where it is stored in shallow tracks of paddy fields with an average depth of 0.3 m. Farmers primarily use these water resources for paddy cultivation.

In this context, the ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), with the help of the Department of Fisheries and Aquatic Resources, Government of Nagaland, has implemented a project on amur carp farming as a diversified aquaculture practice under the Northeast Program. The project initially surveyed the possibilities of aquaculture in Nagaland and selected suitable fish species for this agro-climatic region, where temperatures can drop to around 2°C in peak winter. Amur carp (*Cyprinus carpio haematopterus*), a subspecies of the common carp, was selected based on the following criteria: (i) tolerance to low temperatures below 5°C, (ii) fast growth, averaging 500 g within 6-8 months, and (iii) omnivorous feeding habits, consuming all types of food available in water bodies.

With this backdrop, the project selected 140 farmers from different hilly terrains who own paddy fields and are interested in integrating amur carp farming with paddy cultivation. This method is referred to as integrated paddy and amur carp farming. Each farmer was given 1,000 fry, each measuring an average of 1.5 cm in length and weighing 1.25 g. The peculiarity of amur carp rearing lies in its practice as a three-tier culture system.

1st tier cultivation practice: Amur carp fry released into paddy fields

The amur carp fry given to the farmers in August were sampled in the last week of November, showing promising results with an average length of 5.0 cm and a weight of 6.0 g per fish, and a survival rate of 50%. This survival rate highlights the potential for aquaculture in Nagaland due to several factors: (i) the farmers' enthusiasm and care for amur carp farming, (ii) their eagerness to learn more about the practice, and (iii) the utilisation of previously untapped water resources for amur carp farming.

Scientists with farmers during field survey.

A scientific approach was used for stocking the amur fry at a density of 1,000 per hectare when releasing them into the paddy fields. The presence of amur carp fry in the fields coincided with the healthy growth of paddy saplings and a substantial amount of periphyton growth on the paddy tillering. The water depth in these paddy fields ranged from 0.2 to 0.45 meters.

2nd tier cultivation practice: Amur carp fingerlings released into shallow water bodies in the paddy fields

During the peak winter, after the paddy has been harvested, scattered shallow water bodies filled with water remain in the dry paddy fields. The water recedes from the paddy fields and is stored in these scattered low-lying areas connected to each field. These water bodies, continuously fed by falling water from the hilly terrains, provide a perennial water resource for both refuge and rearing of amur carp fingerlings. The fingerlings migrate to these shallow water bodies, reaching an average weight of 20 g. The staddles of paddy, which remain submerged after harvest, act as suitable substrata for periphyton growth, providing a grazing and feeding surface for the amur fry.

3rd tier cultivation practice: Growing amur carp to 'table size' in ponds and their harvest

The fingerlings that grow in shallow water within paddy fields are mostly transferred to ponds for further growth in larger water areas. However, many of these ponds have a maximum water depth of only 0.5 m with uneven bottom beds. The plankton populations in these ponds appear suitable for feeding amur fingerlings. The amur fingerlings, which grow to an average of 150 g from an initial average of 20 g, are reared to 'table size' before harvest.

In Nagaland, harvesting amur carp is different from ponds on flat land where fish are typically caught using drag nets. Instead, Nagaland fish farmers are accustomed to draining water from one outlet of the pond through a narrow canal. They use locally made bamboo contraptions placed at the outlet mouth to trap fish as they flow out with the water stream. This method presents challenges in catching a desired quantity of fish effectively.

The concept of 'farm-made feed' involves preparing feed using locally available ingredients such as Tapioca powder, rice bran, *Azolla* powder, maize powder, etc., supplemented with Mustard oil cake sourced externally. The feed preparation follows various ratios of ingredients to meet the nutritional needs of the fish:

- Mustard oil cake: Rice bran (60:40).
- Mustard oil cake: Tapioca powder : Rice bran (60:10:30).
- Mustard oil cake: Rice bran : *Azolla* powder : Maize powder (50:25:15:10).
- Mustard oil cake: Broken rice : Tapioca powder : *Azolla* powder : Rice bran (50:10:10:15:15).
- Mustard oil cake: Maize powder : Tapioca powder : Rice bran (50:15:10:25).

A total of 140 cartons each having 1,000 amur carp fry.

Scientists handing over carton to farmer.

Farmers transport cartons to their respective fields by car

These formulations can be adjusted based on the availability of feed ingredients at different times and locations. Farmers are encouraged to use cost-effective farm-made feeds to promote profitable and sustainable aquaculture practices (Paul et al., 2021).

CIFA's contribution to aquaculture development in Nagaland

Prior to CIFA's intervention, seasonal water bodies in paddy fields were left unused, dedicated solely to paddy cultivation. Water resources in the narrow trenches of paddy fields remained idle without significant use. Ponds also lay fallow, devoid of cultivable fish species.

CIFA has effectively utilised these underutilised water resources for fish rearing, encouraging fish farmers and promoting aquaculture. Amur carp has proven to be a suitable species capable of tolerating temperatures below 5°C during peak winter months. Farmers are now able to cultivate two crops—paddy and amur carp—simultaneously on the same cultivable area, thereby increasing overall yield per unit area. Amur carp farming aims to supplement the protein source in the aquatic food available to the people of Nagaland.

Dissemination of knowledge on aquarium-based farming and ornamental fish species

ICAR-CIFA has initiated efforts to promote aquarium farming of ornamental fish species, aiming to engage and educate the public about fish species and their cultivation in confined environments. This initiative includes two key initiatives:

A farmer displays amur fry after receipt.

Establishment of a 'capacity building program'– an attractive display for the public

One large aquarium unit, housing 42 aquariums displaying both indigenous and imported ornamental fish species, was established by ICAR-CIFA in a department-owned building at Brooders Fish Farm, Half Nagarjan Dimapur, Nagaland, for students, research scholars, and the public. The establishment of this ornamental unit aims to achieve the following objectives: (i) fostering curiosity about ornamental fish species and their farming as household activities among common people, (ii) promoting the trading of ornamental fish

A pair of amur fingerlings.

A view of pond used for amur carp farming.

species as a livelihood option, and (iii) inspiring common people to collect indigenous ornamental species from natural water bodies for farming or hobby purposes, considering Nagaland's status as a hotspot for a variety of indigenous ornamental fish species (Box 1).

Distribution of aquariums along with ornamental fish species to high schools

ICAR-CIFA has adopted an innovative approach to promote aquarium farming and educate school students about ornamental fish species. Initially, 20 high schools were selected, and each school received a modular glass aquarium made of crystal-clear glass with a thickness of 1.2 cm, measuring 120 cm in length, 45 cm in width, and 45 cm in height. The aquariums were stocked with a variety of ornamental fish species, including indigenous ones. This initiative aimed to spark interest among young minds in ornamental fish farming and its potential as a source of revenue in the future. School representatives, mainly comprising teaching staff, were trained on aquarium maintenance and care within the school premises. This approach has proven effective, as students and their guardians have shown keen interest in promoting ornamental fish farming in their own homes.

Box 1. List of indigenous ornamental fish species available in Nagaland (Anonymous, 2005)

1. *Amblyceps mangois*, 2. *Badis badis*, 3. *Balitora brucei*, 4. *B. burmanica*, 5. *Barilius barna*, 6. *B. bendelisis*, 7. *B. vagra*, 8. *Batasio batasio*, 9. *Danio aequipinnatus*, 10. *D. dangila*, 11. *D. devario*, 12. *D. nagaensis*, 13. *Gagata cenia*, 14. *Glyptothorax cavia*, 15. *G. indicus*, 16. *G. manipurensis*, 17. *G. platypogonoides*, 18. *G. siaisii*, 19. *G. telchitta*, 20. *G. triliniatus*, 21. *Nemacheilus beavani*, 22. *N. botia*, 23. *N. manipurensis*, 24. *N. multifasciatus*, 25. *N. reticulofasciatus*, 26. *Psilorhynchus balitora*, 27. *P. homaloptera*, 28. *Puntius clavatus*, 29. *Sisor rabdophorous*, 30. *Xenentodon cancila*

Farmer showing advanced amur carp fingerling.

Training for scientific aquaculture

The training's aim is to enhance skills and knowledge among stakeholders involved in fish farming. ICAR-CIFA has organised several sessions for officials and farmers to impart knowledge essential for the sustainable management of fish farming practices.

Training at Kohima: Ornamental fish farming

A one-day workshop titled 'Species Diversification in Freshwater Aquaculture in Nagaland' was jointly organised in Kohima, Nagaland by ICAR-CIFA and the Directorate of Fisheries & Aquatic Resources, Nagaland. The event drew more than 50 participants, including officials. Scientists from ICAR-CIFA conducted training sessions focused on ornamental fish culture and farming aimed at generating revenue. They highlighted the importance of collecting indigenous ornamental fish from natural water bodies in Nagaland and emphasised their domestication. ICAR-CIFA reaffirmed its commitment to the development of fisheries in Nagaland and reviewed past aquaculture practices in the state. The workshop also included interactive sessions between scientists and farmers.

Training at the Directorate of Fisheries, Nagaland: Paddy and fish farming

In this training, two major subjects were discussed: (i) paddy cum amur carp farming, and (ii) water quality management in paddy fields to sustain amur carp. Scientists with expertise in paddy cum carp farming shared their experiences on how carps are reared in paddy fields. They discussed carp feeding strategies, including the application of exogenous feeds

Director of ICAR-CIFA, Dr Pramoda Kumar Sahoo, flanked with principal scientists inside the aquarium unit.

School showing one aquarium supplied by CIFA.

Training programme for capacity building of fish farmers.

alongside natural foods available in paddy fields. Participants were encouraged to adopt these practices for amur carp rearing in paddy fields. Additionally, water quality management was addressed to ensure sustainable farming practices that promote the growth of both amur fish and paddy saplings without disturbance.

Training at Dimapur: A way of revenue generation

The discussion on how ornamental fish farming contributes to revenue generation was a key issue during the interactive training session. State fisheries officials actively participated in both the training and discussions. The training covered various aspects such as the morphology and identification of different ornamental fish species, feeding practices, breeding techniques, management strategies, and the isolation of juveniles from brooders. These discussions aimed to rejuvenate fishery officials and encourage them to promote ornamental fish farming as a small-scale industry within

Participants in a training programme on paddy and amur carp farming.

households. Ornamental fish farming is in high demand due to its trade value, making it a lucrative opportunity for small-scale farmers.

Conclusion

The efforts of ICAR-CIFA are poised to diversify livelihood options for economically disadvantaged small-holder farmers in the region and enhance revenue through profitable aquaculture practices. With abundant fisheries resources, there is potential for aquaculture to significantly contribute to the economic balance of the state. This initiative holds promise for improving livelihoods and generating employment. However, a significant challenge lies in the lack of familiarity among local people with fish farming, necessitating continuous training in scientific aquaculture practices, particularly in paddy cum amur farming. Amur carp, well-suited to the region's agro-climatic conditions, offers the opportunity to integrate fish farming with paddy cultivation, enabling dual crop harvests within the same cultivable area. Additionally, promoting small-scale fish farming of ornamental fish species in enclosed environments could provide another avenue for livelihood improvement among local communities.

Participants in a training programme on ornamental fish farming.

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