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# AQUACULTURE ASIA

Contemporary integrated fish farming

Farming seabass in freshwater impoundments

Trout fisheries resources

Mud crab farming

AQUACULTURE ASIA

**Aquaculture Asia**

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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**NACA**

An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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## Join us in Shanghai for the Global Conference on Aquaculture 2020

The Global Conference on Aquaculture 2020 will be held from 26-30 October in Shanghai, China. The objectives of the conference are to:

- Review the present status and trends in aquaculture development.
- Evaluate the progress made in the implementation of the Bangkok Declaration and Strategy on Aquaculture Development Beyond 2000 and the Phuket Consensus.
- Address emerging issues in aquaculture development.
- Assess opportunities and challenges for future aquaculture development.
- Build consensus on advancing aquaculture as a global, sustainable food production sector and contribute to the Sustainable Development Goals.

The conference is jointly organised by the Food and Agriculture Organization of the United Nations and the Network of Aquaculture Centres in Asia-Pacific, in collaboration with the Chinese Ministry of Agriculture and Rural Development.

Aquaculture 2020 will be the fourth conference in a series that began at the dawn of the industry. It succeeds the Global Conference on Aquaculture 2010 (Phuket, Thailand), the Global Conference on Aquaculture in the Third Millennium (Bangkok, 2000) and the FAO Technical Conference on Aquaculture (Kyoto, 1976).

The previous (2010) conference reviewed the changing role of aquaculture over the previous decade. Social issues including gender had come to the fore. Technological advances were surging. Disease issues were rife. Yet decades of experience allowed more informed debate on these issues. The conference adopted the *Phuket Consensus*. This was a re-affirmation of commitment to the principles of the *Bangkok Declaration*, developed at the 2000 conference, adding emphasis on gender and incorporating contemporary experiences in development.

### Things have changed

As we approach 2020 it is time to take stock of the aquaculture sector once again. Where is it heading? What have we learned? Will aquaculture be able to meet global food and nutrition needs? What role will it play in rural development? What can we do to mitigate the impact of aquaculture on climate change?

A series of plenary lectures together with six regional reviews and a global synthesis will set the scene for thematic sessions and associated expert panel discussions on key aspects of aquaculture development in the coming decades.

Detailed arrangements, programme and partner details will be announced in due course. For more information, please visit: **www.aquaculture2020.org**

Simon Wilkinson

AQUACULTURE ASIA

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# Farming of Asian seabass *Lates calcarifer* in freshwater impoundments in West Bengal, India

**Subrato Ghosh**

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*Sri R. A. Molla with a 900g Asian seabass.*

The Asian seabass *Lates calcarifer* is a highly preferred foodfish in West Bengal, with a high meat content and commercial value compared to Indian major carps. Found in estuarine systems on the north-east and south-east coasts of the Bay of Bengal, Asian seabass is a hard+y, euryhaline fish and suitable for culture in coastal marine, inland saline, brackishwater and freshwater ecosystems. Most of them are male when around 2-2.5 kg in size. They later become females as they attain more than 4 kg. Seabass feed voraciously on live fishes (young carp, mullet, gobies and prawns) coming their way in large confined water areas. The posterior edge of the pre-operculum bears sharp serrations and a spine that can cut fingers if live specimens are handled incautiously. In some parts of West Bengal, Asian seabass and mullets are cultured in brackishwater and freshwater ponds by stocking wild seed[1]. During the past decade, Asian seabass has received greater attention and has been increasingly farmed commercially in modified-extensive systems in large freshwater impoundments (termed *'mithen gheri'* in local dialect), mainly at the Canning-II, Kultali and Joynagar-I Blocks of South 24 Parganas District. It is reported to grow well[2] and faster in freshwater[3].

In these large, rain-fed, perennial, low-lying fish farming areas, paddy farming was done traditionally but the fields have been converted into fish farming regions since 2011 for better profits. Peripheral areas on four sides are deepened and embankments constructed with excavated earth. Here, farmers are either doing grow-out culture of Asian seabass, Indian major carps or a combination of both, on their own. Professional fish farmers in nearby regions have taken tracts on long-term lease to undertake Asian seabass culture in freshwater on large scale. In such *mithen gheri*, tidal influence does not persist and water from the brackish rivers of the Indian Sundarbans region does not enter. This article outlines the on-growing farming system of Asian seabass in freshwaters and is a representation of progressive seabass farmers and their vocation.

*Asian seabass cultured in a mithen gheri (freshwater impoundment).*

*Haul of Asian seabass from Sri D.Naskar's pond.*

*Displaying the pre-opercular spine.*

### Wild Asian seabass seed

In South 24 Parganas and East Midnapore districts of West Bengal, 5-7mm long of Asian seabass are caught by professional seed collectors two times a month during the spring tides from the Matla, Herobhanga and Canning rivers at Amjhara Village; Hooghly River at Nischindipur, Karanjali and Kakdwip villages; Hooghly estuary at Nandigram, Khejuri and Kukrahati villages, Nayachar Island and Agnimari Char south-east of Haldia town. Such post-larvae are reared in small freshwater earthen chambers for 10-14 days, attaining 8-12mm (early fry; dark brown with scattered yellow spots) and are supplied to farmers. Often those are reared @ 3,000 individuals / 40 $m^2$ for 15-20 days and sold at 24-30mm size. Seed caught during March-April are of superior quality and available till June; culture of Asian seabass in confined freshwater environments in South 24 Parganas is made possible by natural collection of wild fry. Advanced fry are collected in appreciable numbers from Kulpi and Rajnagar villages on Hooghly estuary, Thakuran and Matla rivers during May-October. Fins, opercular spines and mouth structure assume adult characters at around 15mm size. Asian seabass is cultured in low-lying excavated ponds whenever juveniles are available in the wild seed collection centers (April-June in West Bengal)[4].

### Stocking density and growth obtained

#### Procurement of fry

Md. Tahabur Sardar at Village Saranger Abad, Block Canning-II stocks 1000 g of spawn (around 800,000 individuals) of Indian major carps, brought from renowned carp breeding units of Bankura District, in his 1,320 $m^2$ nursery pond and rears them for 30-35 days until they attain 48-60mm (3.0-3.5 g). Finely-powdered mustard oil cake and rice polish is fed to growing spawn @ 400 g / 1,000 g spawn daily. During March-April, 1,000 seeds of Asian seabass (9-12 mm; bought @ Rs 5/- / piece) are stocked in a separate nursery pond/ chamber of 1,320 $m^2$ in area and reared for 45 days until they reach 40-60 g. Young prawns *Metapenaeus monoceros* are fed to the seabass. Subsequently seabass juveniles are stocked in his freshwater grow-out culture system 7,260 $m^2$ in area @ 160-180 individuals / 1,320 $m^2$ and at the same time, those advanced fry of Indian major carps are also stocked. Sri Sardar has experienced that in eight months of culture, out of an initial 1,000 seed, 80% of seabass attain 2-3 kg (sold @ Rs 580-600/- /kg in domestic market) and 10% attain 600-700 g, with around 10% mortality. Seabass prey upon the finger-lings of Indian major carps and also on naturally-occurring weed fishes.

During harvest of seabass, 9-10 months after spawn stage, 20% of his stocked Indian major carps survive with body weight gained accordingly: Rohu *Labeo rohita* and mrigal

*Asian seabass at 200-250g.*

*Cirrhinus mrigala* 350-450 g, *Catla catla* 800-900 g and *Labeo bata* 100 g. These are harvested along with the bigger Asian seabass and sold. In Asian seabass ponds, Indian major carps are fed mustard oil cake and by-products of wheat, pulses and gram @ 40 g / 1,000 g fishes daily. He opined that an Asian seabass consumes 14-15 kg of advanced fry and fingerlings of other fishes in its growth up to 1 kg size.

In early April, another farmer, Pinturam Mondal, at Village Miyergheri procures riverine Asian seabass seed (8-10 mm) in oxygen-packed containers @ Rs 3/- / piece. In a 1320 $m^2$ pond, 1,000 pieces are stocked and powdered mustard oil cake is used as feed @ 2,500 g / 1,000 seed / day initially and prawn *M. monoceros* (*'metha chingri'* in local dialect) later on. These attain 60-75 g in 30-45 days with near 100% survival and are further stocked in a freshwater grow-out pond 1,320 $m^2$ in area. Indian major carps 250-300 g in size (total 100 kg) and prolific breeding Mozambique tilapia *Oreochromis mossambicus* of 50-80 g size (total 5 kg) are introduced into the pond. In the next six months, Asian seabass reach 1,300-1,600 g and Indian major carps 750-1,100 g, at which size they are harvested.

Md. Safikul Sardar at Village Khagra owns a 13,200 $m^2$ *mithen gheri* for Asian seabass grow-out culture, which is rain-fed supplemented by water drawn in via deep tube-well, when required. During May, he procures Asian seabass seeds of 24-25mm from Canning Bazar (Rs 3.50/- / piece), which are stocked in a nursery chamber @ 1,000 individuals / 384 $m^2$. Young gobies *Glossogobius giuris* and prawn *M. monoceros* are their live prey and the fish reach 60 g and above in one month. This stage is stocked in the *mithen gheri* @ 400 individuals / 13,200 $m^2$. Growing Asian seabass juveniles feed upon young tilapia and major carps; 400-450 kg of Indian major carps fry (60 mm), previously reared in the nursery pond, are released in the area. After 8-9 months, Asian seabass weighed 2-2.5 kg and 800 kg of marketable-sized fish are harvested (400 x 2 kg) and sold for Rs 448,000/-. According to Sri Sardar, from 5-7mm stage, 80-90% of Asian seabass will attain 2,500-3,000 g and weigh between 2000-3,000 g with sufficient and insufficient food availability respectively in 10-11 months of culture. A 3 kg Asian seabass can devour 100-150 g of Indian major carp fingerlings. In addition to Indian major carps fry meant to feed Asian seabass, Sri Sardar co-stocks Indian major carps of 150-300 g mainly for culture (total weight 500-550kg). Every 2.5-3 kg Asian seabass fetches him Rs 1,450-1,700/-, which are sold at Champahati, Taldi, Canning and Jibontala wholesale markets. Sri Sardar invests Rs 100,000/- as cost of 1,000 kg Indian major carps fry and larger fingerlings and another Rs 100,000/- on supplementary feed of Indian major carps.

*Asian seabass at 400-450g size.*

### Procurement of Asian seabass juveniles

During August-September 2017, Sri Airaf Ali Molla at Village Parganti in Canning-II Block stocked 225 Asian seabass juveniles (25-30 g; 10-12 cm, each cost Rs 28/-) and 500 kg fry of Indian major carps and *Labeo bata* in his 9,240 $m^2$ freshwater impoundment (1.35-1.50 m deep). Asian seabass juveniles were brought from Simultala market near Amjhara village. They prey upon the early stages of finfishes or *M. monoceros* as much as available. In 6-7 months of culture, they reached 0.8-1.25 kg and were harvested in March 2018 with a total weight of 200 kg. Indian major carps fingerlings 75-100 g (*Catla catla* 250 g) stocked in January 2018 weighed 250-350 g in March (*C. catla* 0.75-1 kg). Sri Molla stocks 60-70 kg of tilapia (100-150 g size) in a 256 $m^2$ nursery chamber and within 30-45 days, fry of 36-60 mm are obtained, which breed at two months intervals. Such fry are transferred to the main impoundment once in three months to feed the seabass @ 25-30 kg each time. Bag feeding with mustard oil cake and maize dust is done for Indian major carps. He gets Rs 420/- / kg for Asian seabass at Baburhat wholesale market under Minakhan Block in North 24 Parganus District.

Krishna Ch. Sardar at Village Kaluakhali rears Asian seabass in an extended 15,840 $m^2$ freshwater plot of which 1,320 $m^2$ is a nursery chamber meant for tilapia and *Labeo bata*. During March-April, the latter, stocked at 36-48 mm length (total 50 kg) grow up to 50-60 g in three months and are released in the seabass pond. Tilapia (60 kg adults in chamber) fry are transferred to main plot at three month intervals. In June 2018, he stocked Asian seabass juveniles (12.5-15.0cm; Rs 35-40/- / piece) bought from Putimari market, Sandeshkhali Block @ 60-70nos / 1320 $m^2$. According to Sri Sardar, Asian seabass juvenile consumes rohu and mrigal of 10.0-12.5 cm in size and fry of *Liza parsia, L. macrolepis* and *L. bata* are highly preferred by the predatory fish. 450-500 kg of Indian major carp fingerlings of such a size, reared previously for three months from 24 mm stage in the nursery chamber, are released in the main plot after introduction of fry of tilapia and *L. bata*. In addition, *M. monoceros* (65-75mm) reared for 2-3 months from 7-8 mm stage is also introduced, aiming to supply sufficient food matter of different kinds for the seabass. In January 2019, beginning with 700 Asian seabass stocked, Sri Sardar harvested 650 kg of marketable sized fish (1-1.2 kg) and 500 kg of Indian major carps (400-500 g; *C. catla* 1-1.4 kg). He sold Asian seabass at Baburhat market @ Rs 500/- / kg. It grows upto 3.5 kg in 12 months if sufficient live food is available in the culture system. Unlike Indian major carps, it feeds actively even during winter season and pace of growth is kept up. He stocked larger juveniles of giant prawn *Macrobrachium rosenbergii* (10.0-12.5 cm) in his 15,840 $m^2$ plot; Asian seabass will be unable to prey upon *M. rosenbergii* if its chelate legs are developed.

*Above, below: Sri P. Mondal with a 1.25 kg Asian seabass.*

Sri Rahamat Ali Molla at Village Homra-Polta took a 29,040 $m^2$ freshwater impoundment on lease @ Rs 6,500/- / 1,320 $m^2$ / year for seven years. In early April, he stocked 100,000 Indian major carp fry in a 2,640 $m^2$ nursery chamber brought from the Naihati fish seed market, North 24 Parganas District; those attained 50-70 g (12-14 cm) in 75-80 days. He released Indian major carps fingerlings and 500 Asian seabass juveniles (25-30 g) in the main plot and on 90$^{th}$ day of stocking, he obtained 500 kg of seabass (1-1.25 kg) and sold them at Taldi market @ Rs 450/- / kg. The fish fed mainly upon naturally-occurring weed fishes brought in by water of adjoining freshwater canal and young tilapia. He bought post-larvae of riverine *M. monoceros* @ Rs 200/- / 150 g in April, reared in nursery chamber for 45 days (8-10 g; 48-60 mm size) and stocked them in the main plot. On 90$^{th}$ day, larger *M. monoceros* that survived are harvested and sold @ Rs 360/- / kg. On the 30$^{th}$ day, Indian major carps reached 150-200 g, harvested and were sold live at Chingrighata market in east Kolkata @ Rs 10-15/- / piece.

According to Dilip Naskar at Village Naliyakhali, Block Joynagar-I, Asian seabass 20-25 g size (7.5-8.0cm; Rs 9-10/- / piece) is available at Karanjali market in Kulpi Block until August. After buying 100 pieces in July 2017, he kept them in hapa cloth enclosures for a day before stocking in a 1980 $m^2$ freshwater pond. 6-8 kg of tilapia (150-200 g) and Indian major carps yearlings (150-200 g) were also stocked. He harvested 55-60 kg Asian seabass (400-600 g) at the end of January 2018 and a few of them attained 3.2-3.4 kg in December 2018. He sold the fish at Taranagar market in Joynagar-II Block @ Rs 400/- / kg. In six months, he sold Asian seabass (450 g) @ Rs 180/- / piece; juveniles of which had cost Rs 10/.

In March, for every 1,320 $m^2$ freshwater area, some farmers in Canning-II Block stock larger 5-6 month old Asian seabass juveniles 75-80 (100 g; Rs 35-40/- / piece), Indian major carps 60 g size (total weight 100 kg; 1,500-1,550 pieces), 20 kg of adult tilapia and larger *M. rosenbergii* juveniles 100 (Rs 4/- / piece). During harvest, by end of June, 68-70% of Asian seabass attain 1.5 kg each and are sold @ Rs 590/- / kg; 100-120 pieces of Indian major carps survive, attain 550-700 g each and are sold @ Rs 150/- / kg; 50-55 *M. rosenbergii* attain 100-120 g size (total weight 6.0-6.5kg) and are sold @ Rs 360/- / kg. Two crops can be raised every year, Asian seabass run after the growing Indian major carps even if they are unable to get hold of it and the growth of surviving Indian major carps is triggered due to the chasing impact of the former. Rice bran and wheat by-products are fed to Indian major carps. Growth of Asian seabass up to 0.7-1.5 kg in 12 months has been reported in perennial village ponds of 10,000-30,000 $m^2$ in the presence of Indian major carps, tilapia and freshwater prawn in Raigad district of Maharashtra[5]. According to the afore-mentioned fish farmers,

*Sri D. Naskar with a harvested 3.2 kg Asian seabass.*

polyculture of Asian seabass and major carps in freshwater is more profitable than carp culture alone in the Indian Sundarbans region.

**References**


1. Kandan, S. 2009. Commercialization of Asian seabass *Lates calcarifer* as a candidate species for cage culture in India. In Course manual: National Training on Cage Culture, ICAR-CMFRI Publication: 13-16.
2. Thirunavukkarasu, A. R., Kailasam, M., Sundaray, J. K., Subburai, R., Thiagarajan, G. and Karaiyan, K. 2008. Improved hatchery technology for Asian seabass *Lates calcarifer*. ICAR-CIBA Special Publication 34: 1-48.
3. Ghosh, A. 1971. Observations on the acclimatization and growth of *Lates calcarifer* in freshwater ponds. J. Inland. Fish. Soc. India, 3: 123-124.
4. Thirunavukkarasu, A. R., Kailasam, M. and Sundaray, J. K. 2009. Success in hatchery development of seabass and its potential for commercial cage culture in India. In Course Manual: National Training on Cage Culture, ICAR-CMFRI Publication: 71-80.
5. Vartak, V. and Belsare, S. 2004. Natural seed collection of *L. calcarifer* and its traditional culture practices in Konkan region of Maharashtra. Fishing Chimes, 24(3): 62-63.


*Juvenile Asian seabass at 25 g.*

*Nursery chamber in front and Mithen gheri of Md.T. Sardar.*

*Left: Growout impoundment. Right: Nursery chamber.*

*Sub-adult Asian seabass in R. A. Molla s pond.*

# An integrated approach to contemporary fish farming practice incorporating traditional knowledge in mid hills in India: A success story

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*Different shades of Champawat.*

Hill farming is largely characterised by low productivity, small land holdings, scarcity of agricultural land and irrigation facilities, and uneven terrain. The use of steep areas for cultivation also amplifies the chances of soil erosion together with poor retention of water. Low returns in farming and unemployment problems in hilly areas are compelling youth to move to the cities to find livelihoods.

In Uttarakhand State, agricultural activities are gradually gaining momentum, however, a lack of awareness of good practices and access to technology is a major concern, mainly because of the remote location of many farming communities.

With a growing population and gradual improvement in living conditions, the demand for nutritious food is increasing day by day. A national sample survey has revealed while hunger in the country has consistently fallen for example from 15% in 1983 to 2% in 2004-2005, nutritional deficiencies, principally protein, are becoming a major concern. These can lead to underweight and stunted growth particularly in women, and children below five years in age where 33% of individuals are affected (2015, Ministry of Health and Family Welfare). The effect of malnutrition could be more pronounced in rural and hilly areas of the country, mainly due to the prevalence of poverty, poor agriculture productivity and a lack of access to protein-rich food in general.

Harnessing diversified natural resources in a sustained manner to improve livelihoods and accessibility to protein-rich foods in hilly areas of the country is of utmost importance. Efforts in maximising sustained returns from these resources could greatly help farmers and rural communities achieve nutritional security. Adoption of integrated farming practices utilising available land, water and waste products more efficiently can improve farm productivity and income for farmers. With a view to motivate fellow farmers, the achievements of a young farmer, Shri Raghubar Datt Murari of the remote Bheti Village (Champawat) of Uttarakhand, are documented in this article.

**Detail of farming activities, area under cultivation, production, gross and net income.**

| Crop | Area (h) | Production cost | Total production | Gross income Indian Rupees (INR) | Domestic use kg | Sold kg | Net income INR/crop |
|---|---|---|---|---|---|---|---|
| Paddy | 0.5 | 2000 | 0.6-0.8 t @ 15 INR/kg | 8,000 1,000 | All | 0 | - |
| Wheat | 0.4 | 2000 | 0.5-0.5 t q @18 INR/kg | 9,000 | All | 0 | - |
| Maduwa | 0.16 | 400 | 0.2-0.25 t @12 INR/kg | 300 | 50 | 200 | 2,000 |
| Soybean | 0.5 | 1000 | 0.8-1 @20-30 INR/kg | 22,500 | 100 | 700 | 16,500 |
| Cabbage /cauliflower | 0.1 | 1000 | 0.5-0.7 t @20-25 INR/kg | 12,000 | 100 | 500 | 9,000 |
| Tomato (Hemlata, Shahlata) | 0.04 | 800-1000 | 0.1-0.15 t @15-20 INR/kg | 2,250 | 50 | 100 | 1,400 |
| Capsicum (California Wonder) | 0.08 | 3000 | 0.9-1 t @30/kg | 27,000 | 100 | 800 | 21,000 |
| Potato | 0.5 | 25,000 | 5-6 t @6-10 INR/kg | 50,000 | 600 | 44,000 | 19,000 |
| Branjal | 0.025 | 500 | 0.2- 0.25 t 10-15 INR/kg | 2,000 | 50 | 150 | 1,000 |
| Pumpkin | 0.02 | 150-200 | 0.6-0.7 t @10-15 INR/kg | 7,200 | 100 | 500 | 5,800 |
| Cow | 2 | 50,000 45-50/day | 8-10 litres @ 20 INR/kg | 180/day | 6 | 4 | 40/day |
| Poultry | 20-25 nos | Rs 1,225 50/p+ Rs 200 | 10-15 eggs/day @ 5 INR/piece, meat 250-300 INR/bird | Eggs 75/day Meat 6,000 | 3-4/day eggs 8 piece | 8-10 eggs /day 15 piece | 50/day 2,300 |
| Honey | 20 hives | 1,000 | 35-40 INR/kg @300/kg | 12,000 | 5 kg | 35 | 9,500 |
| Carp culture | 0.02 | 1,500 | 60-70 INR/kg @120/kg | 8,400 | 10 | 60 | 7,200 |

## About Uttarakhand

'Himalaya' signifies the abode of snow in Sanskrit, truly characterising the vast and enduring snow fields of the high altitudes. In the heart of these majestic mountains lies the state of Uttarakhand. With a geographical area of 53,000 km$^2$ the area was designated as a separate state from erstwhile Uttar Pradesh on 9 November, 2000, becoming the 27th state of the Republic of India.

Uttarakhand lies in the northern part of India amidst the magnificent Himalayas and bears dense forests. The state borders Himachal Pradesh in the north-west and Uttar Pradesh in the south and has international borders with Nepal and China. Most of the state, around 46,000 km$^2$ is covered in hills with the remaining 7,000 km$^2$ being plains. A major part of the state is forested, some 34,600 km$^2$ with annual average rainfall of 1,606 mm. As per 2011 the total population of the state was provisionally estimated at around 10.1 million with a literacy rate of about 79.63%. The thirteen districts can be grouped into three distinct geographical regions, the high mountain region, the mid-mountain region and the Terai (lowland) region. Dehradun is the interim capital city. Uttarakhand consists of two divisions viz. Kumoun and Garhwal, thirteen districts, 78 tehsils, 15,761 inhibited and 1,065 uninhibited villages. Temperatures range from a minimum of -1.3°C (Mukteshwar) and 41.2°C (Dehradun).

## Chanmpawat District

In the ancient times this region was the origin of the Naga, Kinnar and Khas Rajas. The available historical pillars, manuscripts, archaeological collections and folk myths described show the greatness of the area during the Mahabharata period.

The lowland Terai area is hot whereas the hilly regions are comparatively colder. In summer, Champawat District is pleasant with temperature varying from 1-35°C. The Terai area around Tanakpur consists mainly of agricultural land with a warm climate, having an average altitude of 200 to 250 meters. The Shivalik Range consists of dense forests with an altitude range of 250 to 1,200 metres and peaks averaging 1,500 metres in height. Agriculture development in the area is limited by the availability of flat land and infrastructure to support intensive farming.

## Background information

Mr Raghubar Datt Murari, a young man in his forties from Bheti village and son of the late Shri D.N. Murari, has a post-graduate degree in history from Lucknow University. His family consists of nine members and their main occupation is agriculture. His father was employed in the State Health Department as a Health Supervisor, and frequently used to stay away from home. Hence, from his early school days, Mr Murari was attracted towards agricultural activities and helped

*Fish health examination.*

*Harvesting fish tanks.*

*Exposure visit of local fish farmers.*

his elders. He has an agricultural land holding of about 1.96 ha spread over uneven hilly terrain about 22 km away from Champawat District Headquarters. About 1 ha is irrigated and the remaining 0.96 ha is rain fed land. After completing his Masters degree, he returned to his village with a dream to carry forward his ancestral occupation. His father who retired from active service in year 2000 also extended a helping hand to his son and shared his inherited wisdom and indigenous traditional knowledge.

## Practices

In 1989-90, Mr Murari started farming a small in a 0.08 ha area, growing cabbage and cauliflower. Seed was procured from outside. With proper care a production of 5 tonnes/ha of these vegetables was achieved. Wheat, paddy, soybean and, maduwa (finger millet) were also produced. The husks and other by products are used to feed the livestock.

Farming later included cabbage, cauliflower, tomato, capsicum, potato, branjil (eggplant)and pumpkins. A poultry shed was established with 20-25 layers were reared. The nearest market is at Lohaghat, which is about 7 km away from the village.

## Fish farming

Under the Grammya scheme of water shed development programme, a 100 $m^2$ tank was constructed 2003-2004 at a cost of Rs 80,000/-. The construction cost was high as the land was uneven. Rs 62,000/- was given by the Grammya scheme as a subsidy. About 150 larger size (100-150 g) grass carp, silver carp and common carp specimens were collected from a nearby tank and stocked. These fishes attained a size of 350-600 g after around 18 months of culture. In the beginning no one in the area believed that fishes could grow in cement tanks. But seeing the success of fish farming again they collected 600 fry of rohu, grass carp, common carp and silver carp from the Krishi Vigyan Kendra (agricultural extension office, KVK) Lohagha. The average growth of these fishes ranged between 300-500 g. During winter, silver carp and rohu mortality was observed. A total of 40 kg of fish was harvested. Subsequently, another tank with an area of 100 $m^2$ was constructed, connected to the older tank. Only Rs 12,000/- was spent on constructing the second tank of which an Rs 8000/- subsidy was given by the state department to promote fish culture on a larger scale.

The nearest KVK office extending help in form of seed collected from Pantnagar. A total of about 800 rohu, grass carp, silver carp and common carp seed was stocked. With proper care fish attained a size of 300-700 g, and farmer was able to harvest 60-70 kg of fish. As demand for fish is very

high in the area they sold at a good price of @ Rs 120-140/ kg. From 2008 onwards, larger sized fishes have been kept in a separate tank and the smaller ones are reared separately. During the course of this period, help was received from fish culture experts. Mr Murari was immensely encouraged after seeing the income from the fish sales, which attracted him to this occupation.

Scientists of the ICAR-Directorate of Coldwater Fisheries (DCFR) regularly visit the fish tanks to provide valuable guidance. From time to time regular visits of many dignitaries, farmers, and students have been received by the Mr Murari. He regularly takes part in group discussions with fellow farmers regarding growth, production, disease problems, sales and other important issues. Stocking of quality, large sized seed, adoption of a scientific package of practices and regular interaction with nearby fisheries experts were key factors that boosted his farm productivity and brought all round prosperity in his family. He never hesitates in sharing his achievements and failures with fellow farmers, and to encourage them. He has become a well-known farmer in the area and district. ATMA has awarded him with best farmer's award.

### Practices which helped Mr Murari increase fish production included:

- Use of fish culture tanks water in vegetable crops enhanced vegetable productivity with reduction in incurring fertilisation cost.
- Rational stocking (2-3 fish per square metre) of ponds with proper combination of species considering the availability of water, grass and other feed ingredients.
- Collection of water from natural resources through gravitational method reduced the cost of power in pumping water.
- Multiple use of water for drinking, irrigation and fish culture.

*Above, below: Farmers learn about breeding grass carp.*

*Farmer learning grass carp breeding.*

*Below: Egg-laying poultry.*

*Participation in value addition training.*

*Polyhouse grown vegetables.*

- Stocking of larger sized exotic carp varieties (grass carp, silver carp) with weight range of 80-120 g along with an improved variety of common carp.
- Regular pond raking for reducing organic load in the pond.
- Partial water exchange.
- Fixing of feeding baskets in fish tanks to reduce the feed wastes and improve feed utilisation.
- To bring down expenditure on feed, a locally prepared fish feed was made using mustard oil cake and rice polish. These items were procured locally and given in dough form. Compared to commercial feed, farm-made feed reduced cost by up to 50%.
- Demand-driven harvesting of fish during extreme winter months, road blockages and special occasion fetched higher prices.
- Visits to nearest fisheries Institutions and regular monitoring of the ponds.

Mr Murari also applied innovations in technology, management practices and knowledge including:

- Conservation of hilly water resources and improving its productivity by implementing fish farming in water storage tanks.
- After utilisation of stored water for fish culture, which increased its nutrient content, the water was used for irrigating agricultural crops, improving their productivity.

*Routine feed application.*

*Small carp tanks laid out in series.*

- Providing cost effective transfer of technology through farmer to farmer training in local language.

Factors that led to Mr Murari's success included:

- The firm determination of the retired army Naik Mr Gahtori to serve his own villagers.
- Co-ordination and co-operation of the local farmers in conducting the work.
- Strong linkages and support by the fishery departments, ICAR-DCFR and KVK at Lohaghat.
- Networking with various organisations for diversified activities/operations in the region.

However, Mr Murari faced many constraints on his efforts. These included:

- Initially there was no water storage tank in the vicinity and villagers were procuring drinking water from far-off places with much difficulty.
- The community had a lack of awareness about water storage and the possibility of raising fish in the stored water.
- A lack of adequate infrastructure for large scale fish farming.
- Inadequate availability of flat land in the Himalayan hill region, which makes it difficult to undertake agriculture on a commercial scale.
- Small uneven land holdings and acute scarcity of water in the summer months.
- Due to the high altitude and lower thermal regime, slower growth of stocked fishes resulting to lower fish production.
- Although fish seed is produced in the foothills of the Himalayan region it is very difficult to transport due to the hilly nature of the terrain.

**Acknowledgments:** The authors are thankful to Director, ICAR-DCFR, Bhimtal for providing the opportunity to carry out the present work, and to Shri Ragubar Datt Morari, progressive fish farmer, Champawat, for providing the necessary assistance and help during the study.

*View of two cement fish tanks.*

*A water storage  tank used as a fish nursery.*

# Mud crab farming: An alternative livelihood in the Indian Sundarban

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*Mud crab grow-out pond.*

Mud crab is one of the most valuable crustaceans in both domestic and export markets. They are hardy and can survive out of water for extended periods at lower temperatures making them ideal species for live export to other countries and the domestic market. There are four commercially important species of mud crab, *Scylla serrata, S. tranquebarica, S. olivacea* and *S. paramamosain* and they are the focus of commercial fisheries and aquaculture production throughout their distribution (Keenan et al., 1998, Shelly and Lovatelli, 2011). Molecular studies conducted in India suggested that *S. serrata* (Forskal) is the most abundant mud crab species in India followed by *S. olivaceae* (Balasubramanian et al., 2016).

*S. serrata* are the largest species, commonly known as green crab whereas *S. olivaceae* has orange to reddish colouration in claws and carapace. *S. serrata* can grow to a size of over 1.5 to 2 kg while *S. olivacea* reported to have a maximum weight of 1.2 kg. Mud crab has huge demand in export and domestic market fetching a price from 8 to 25 USD depending on size and season. This report is prepared to familiarize the farmers, researchers and entrepreneurs about the current practices adopted by mud crab farmers in India with special reference to the Indian Sundarban where mud crab capture and farming constitute an important livelihood among the small holder farmers.

## Wild seed collection and traditional farming

Mud crab fattening predominates farming practices in Sundarban as opposed to grow-out culture. Locally, mud crab fattening is known as *chamber chas* and has been practiced since the late 1990s (Nandi et al., 2016) although the contribution of mud crab to fisheries is an age old practice in Sundarban. In West Bengal, three districts, namely North 24 Pargana, South 24 Pargana and Purba Midnapur have brackishwater areas (Mahapatra et al., 2014), some of which is utilised for mud crab culture and fattening. Smaller sized mud crabs from capture fisheries contribute to the domestic market whereas crab fattening or grow out systems aim for the export market.

Juvenile mud crab are generally purchased by the farmer from wild seed collectors (0.10-0.15 USD/ 20 g size). Mud crab fattening is carried out by feeding trash fish or farm-made feed at the rate of 5-8% body weight either directly in pond, pen or cage systemsfor a period of 20-30 days or until the gonad-developed animal fetches a good price in the domestic and export markets. Different types of low-cost by-catch, trash fish and molluscan meat are fed to animals of different sizes depending on season and availability. Bombay duck *(Harpadon nehereus)*, goat fish (*Upeneus* sp.), threadfin

*Above, below: Trash fish (raw and sun-dried).*


*Preparation of farm-made mud crab feed.*

bream (*Nemipterus* sp.) and grenadier anchovies (*Coila* sp.) are among the commonly available trash fish in West Bengal. Molluscan species such as *Telescopium* sp. and *Bellamya bengalensis* which are available in ponds and canals as pests are often caught and utilised as feed in nursery rearing of mud crab. The ease of farming and lower investment required in crab culture along with good return attracts small farmers to this venture.

## Improved culture practices

In an effort to circumvent the long culture period and optimise the economy, ICAR-CIBA developed a three tier modular farming system of mud crab which can readily be adopted by farmers of the Sundarbans. The long culture period of 6-8 months hinders the production efficiency, survival rate and economics resulting in farmers' reluctance towards adopting the farming practices.

## Nursery culture in hapa system

Nursery rearing is carried out using hatchery produced mud crab instar of *S. serrata*. In this system, a 20 micron mesh nylon net hapa of described dimension (eg. 3 m X 3 m X 3 m, 5 m X 5 m X 3 m) is suspended equidistantly between rows of catwalk using rope. The pre-stocking pond preparations include drying, ploughing, filling, disinfection with bleaching powder (30 ppm), liming (200kg/ha) and fertilisation using probiotics and minerals to initiate algal productivity. Hides made of shredded plastics or ropes are sufficiently placed inside the hapa to facilitate shelter and reduce cannibalism. Mud crab instars of 5-6 mm are stocked @ 90-100 / $m^3$ in a hapa. Molluscan meat, chopped to a size suitable for the crab, are fed ad libitum twice daily by lowering a feeding tray inside the hapa. Feeding trays are exclusively employed in order to avoid wastage of feed and to check contamination of water. Grading of animals is carried out 15 days after stocking and continued till harvest i.e. 25 days of culture (DOC). After 25 days, an average survival of 80-90% is achieved and the crablets are stocked in nursery ponds.

## Nursery rearing in pond system

The harvested crablets of 2.5-4 cm from hapas are stocked into nursery ponds at the rate of 3-4 individuals/$m^2$. Pond preparation includes crab fencing, disinfection, liming and fertilisation using minerals and probiotics. A specially

*Farm made pellet feed.*

*Hapa nurseries for rearing of mud crab instar.*

designed feeding tray that leaves a space between the bottom soil and tray while submerged is employed to avoid crushing of crablets present in the bottom sand while lowering the tray. The animals are fed with chopped molluscan meat ad libitum twice daily. To provide shelter and to avoid cannibalism, a large number of hides made of pipes and tiles are provided. Grading and culling of animals are carried out by carefully picking up the hideout pipes and collecting shooters of 80-100 g among the smaller size crabs (10-40 g) which were then stocked to grow-out ponds. Final harvest after completion of second tier is carried out after 45 days with an average harvest size of 80g (40-120 g) and average survival of 50%.

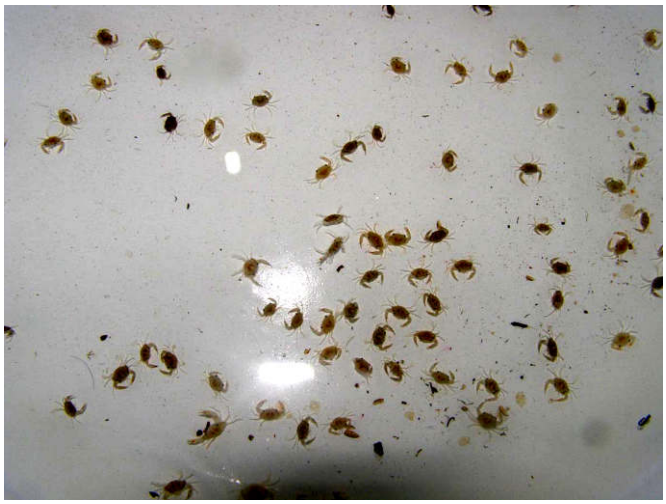
## Grow-out system in pond

The harvested crabs of 70-80 g size are stocked in grow-out culture ponds at a rate of 0.5-0.7 $m^{-2}$ and cultured for a period of 6 months. Paddle wheel aerators (2 HP) are operated in grow-out ponds for two hours daily to improve circulation of water in order to disperse the pheromones released during moulting which attract other crabs. The animals are fed with chopped trash fish or wet feed prepared by mixing trash fish with fish oil, flour, probiotics and yeast. After six months culture, the male *S. serrata* attain an average weight of 900-1000 g while females attain 600-700 g with an average survival of 60%. Partial harvest is carried out by the bamboo-line method while final harvest is done by completely draining of pond and hand-picking crabs from the bottom of the pond. In the bamboo-line method, capture of culture mud crab is usually done using a line where a rope is attached to a wood or bamboo stick, at the end of which is a weight and bait is tied to assist in sinking and luring the mud crab. Several such lines may be placed on the dyke of the water body and the catch can be made using a circular net when the line stretch indicates a pull by mud crab.

## Polyculture

In an on-station experiment, polyculture of mud crab was carried out along with different finfish and shellfish species such as milkfish *(Chanos chanos)*, mullets *(Mugil cephalus, Liza tade, Liza parsia)*, shrimp *(Penaeus indicus)*. The combination of mud crabs *(S. serrata)* and milkfish and mud crabs and mullets at 0.5:0.5:0.5 ratio) indicated a benefit–cost ratio (BCR) between 1.57 and 1.73 respectively. Growth parameters of mud crabs were similar in both (407.64 ± 105.78 g and 418.89 ± 105.24 g respectively), with no significant differences after 210 days trial (Anand et al., 2018). In another experiment, crab monoculture was compared with polyculture with *Penaeus indicus* (2/$m^2$) and *Mugil cephalus* (0.5/$m^2$). Mud crab (59.47 ± 1.77 g) stocked in all ponds at the rate of 0.5/$m^2$ uniformly, recorded no significant difference between the polyculture and monoculture ponds. These results show that there is no negative interaction between

*Crab hide used in nursery.*



*Hapa-reared crablets.*

the mud crab and other animals stocked in the polyculture pond which indicated that polyculture provide an efficient and sustainable utilisation of resources.

### Box culture

In recent years, a capital-intensive box culture method of crab growout has gained popularity among mud crab farmers. In box cage systems, fattening is largely carried out although grow-out is also done in a lesser scale. In case of grow-out culture, the nursery reared crabs are stocked in boxes at the rate of one crab per box and cultured for 4-6 months attaining 200-400 g for *S. olivacea* and 300-900 g for *S. serrata*. Box culture systems have both advantages and disadvantages. The pros of the system include lower maintenance, predictability, easy assessment etc. It can also be employed in and indoor system where there is scarcity of land and water using flow-through or recirculatory aquaculture systems (RAS). A high capital investment on boxes and related equipment is one of the drawbacks of box-culture system. The lower activity of crabs is also believed to lower the metabolism of the animals and subsequent feed intake. Therefore, the animals in boxes are fed only once daily with trash fish compared to two times in open pond culture systems. Very low activity of the animal inside the box-cage, coupled with constant exposure to sunlight, as the boxes remain at the surface, result in infestation by algae and difficulties with molting can constitute a problem during culture.

Crab fattening involves rearing of soft-shelled or immature crabs in individual boxes wherein the animals are fed until the shell is hardened or up to the development of gonads. Gravid females with full orange-red eggs fetch a high price both in domestic and export markets. A 200 g animal after 1 month gain 25-50 g and the fattening may continue for 9-10 months in a year with one fattening cycle duration of 20-30 days.

*Nursery rearing of mud crab in ponds.*

*Nursery-reared crabs.*

*Feeding tray.*

*Mud crab harvest using farm-made circular net.*

### Submersible box system

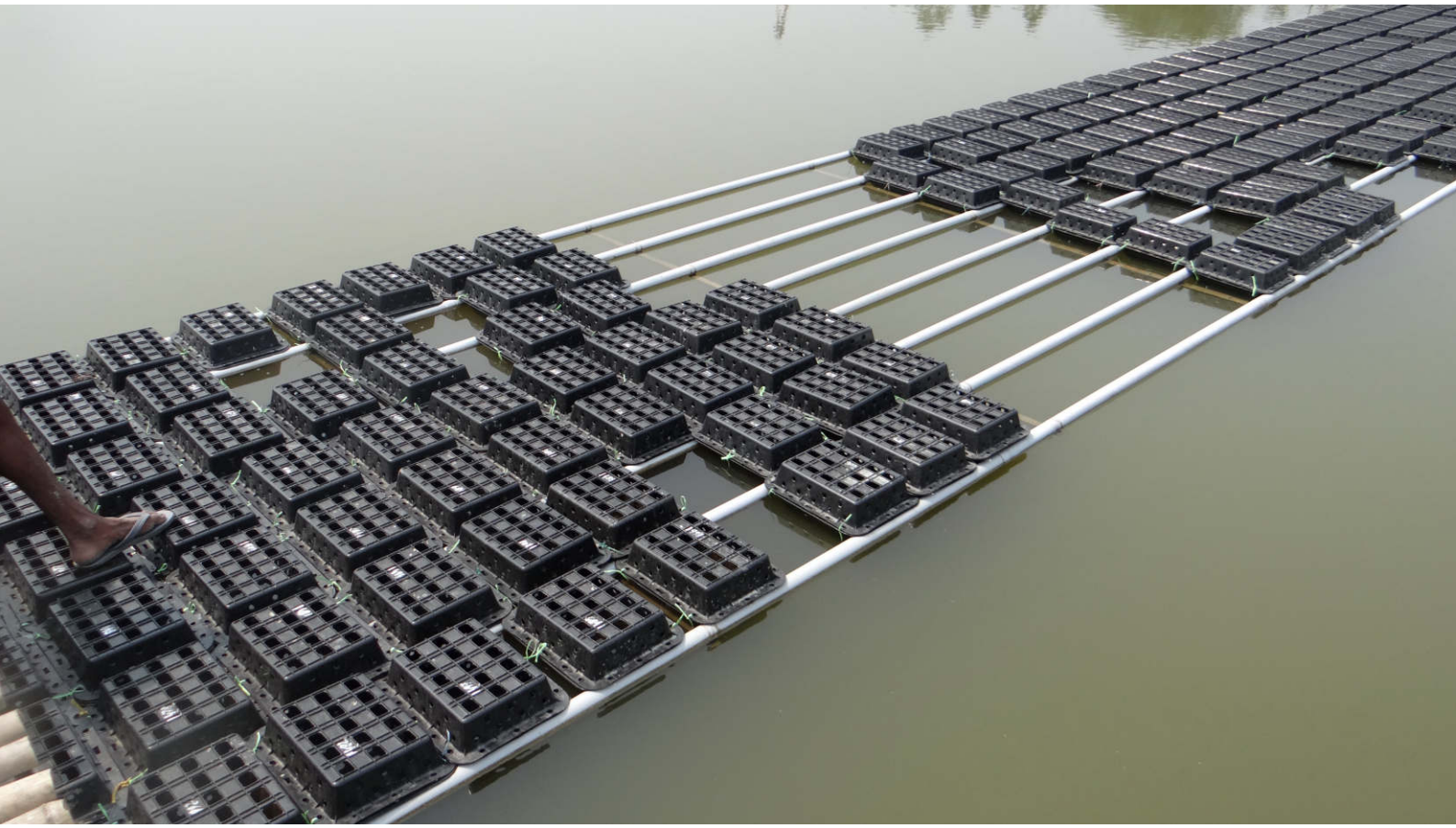
The high temperature during summer induces stress to the cultured mud crab in boxes which remain afloat at the pond surface throughout the day. Besides the stress caused by the heat, the constant exposure to sun may cause algal growth and fouling on the exoskeleton. These factors may lower the market value of the animal, hinder molting and cause death due to high temperature. A practical and innovative thinking is imperative in solving a problem faced in the farm, and has been one of the significant factors in improving the culture system. Keeping in mind these factors which adversely affect the box farming, the submersible box system was developed. This submersible box system is engineered and designed based on the function of a water pump. In this system, the PVC pipe which help float the box are interconnected and a pump is attached in one corner of the pipe. The system functions by pumping in or flushing out water from the pipe which in turn submerged or make the structure afloat. Using this technique, the cages can be submerged underwater during the hot days.

### Vertical RAS system

Another emerging technology that has entered the market in recent years is the vertical RAS which is designed principally for indoor environments. This system incorporates a sand-filter, bio-filters and U.V. filters, which are all interconnected with a specially designed and vertically stacked mud crab box. Although it is a sophisticated system with the ability to control water quality requirements and facilitate observation of the culture crabs, it may not be suitable for farmers of low means due to its high initial investment. On the other hand,

*Above, below: Box culture of mud crab.*

*Above, below: Rafts for box culture of mud crab.*



*Above, below: Different styles of boxes for crab growout.*

*Interconnecting pipes for support and floatation of box cages.*

vertically stacked mud crab boxes which can be installed in pond system with a lifting and sinking mechanism can be an innovative and less expensive alternative for farmers.

## Market

The mud crab produced through culture and fattening is generally aimed for export market. Most of the farmers directly sell their product to exporters but in some cases may also involve middlemen. The different grades of mud crab *(S. serrata and S. olivacea)* fetch different prices which are fixed by the exporter depending on prevailing export market. Mud crabs that have lost a claw or are in sub-optimal condition are often blatantly rejected by the exporter. Male mud crabs of more than 1 kg and berried females of >900 g fetch 22-24 USD $kg^{-1}$. Mud crabs of size > 700 g, >500 g, >400 g and >300 g fetch 17-18 USD, 13-14 USD, 11-12 USD and 8-9 USD respectively. Mud crab *(S. olivacea)* of size ranging from 20 g to 150 g is commonly available in the local market fetching a price of 3-6 USD.

## Constraints in mud crab farming

The mud crab farming in India overwhelmingly depends on collection of wild seed posing a threat to the wild population. Hatchery technology, although available, has limitations owing to the poor survival of larvae. Development and dissemination of mud crab hatchery technology is desirable to resolve the problems of the farmers. The lack of commercial feed mill and manufacture of dedicated mud crab feeds compel farmers to use low-cost fresh feed. Low priced feed such as trash fish and molluscs remain the major feed fed to culture mud crab. The problem with these feeds is fast spoilage and the requirement of storage facilities.

**References**


Shyne Anand, P. S., Balasubramanian, C. P., Lalramchhani, C., Panigraphi, A., Gopal, C., Ghoshal, T. K., Vijayan, K. K. 2018. Comparison of mud crab-based brackishwater polyculture systems with different finfish species combinations in Sundarban, India. Aquaculture Research, 49 (9), 2965-2976.

Shyne Anand, P. S., Balasubramanian, Panigraphi, A., Gopal, C., Kumar, S., and Ghoshal, T. K. 2015. Development of pond reared broodstock / spawners of green mud crab. Aquaculture Asia, 10 (2), 23- 25.

Nandi, N. C., Pramanik, S. K., Roy, D. M. K. 2016. Mud crab culture: Relevance of species identity in production economics with reference to Sundarban coast. Journal of Fisheries Sciences 10 (4): 84-89.

Balasubramanian, C. P., Cubelio, S. S., Mohanlal, D. L., Ponniah, A. G., Kumar, R., Bineesh, K. K., Ravichandran, P., Gopalakrishnan, A., Mandal, A and Jena, J. K. 2014. DNA sequence information resolves taxonomic ambiguity of the common mud crab species (Genus *Scylla*) in Indian waters. Mitochondrial DNA, 27 (1): 270-275.

Keenan, C.P., P.J.F. Davie and D.L. Mann. 1998. A revision of the genus *Scylla* de Haan, 1833 (Crustacea: Decapoda: Brachyura: Portunidae), The Raffles Bulletin of Zoology. 46(1): 217-245.

Shelley, C., Lovatelli, A.(2011). Mud crab aquaculture, a practical manual. FAO, Fisheries and aquaculture technical paper 567. FAO, Rome, Italy.


*1.5 HP pump for suction and delivery of water into the box cage pipe, controlling flotation and submersion.*

*Several units are interconnected using the main pipe from the pump.*

*A single farm-made submersible cage.*

# Trout fisheries resources and potentialities in the Menchukha region of Arunachal Pradesh

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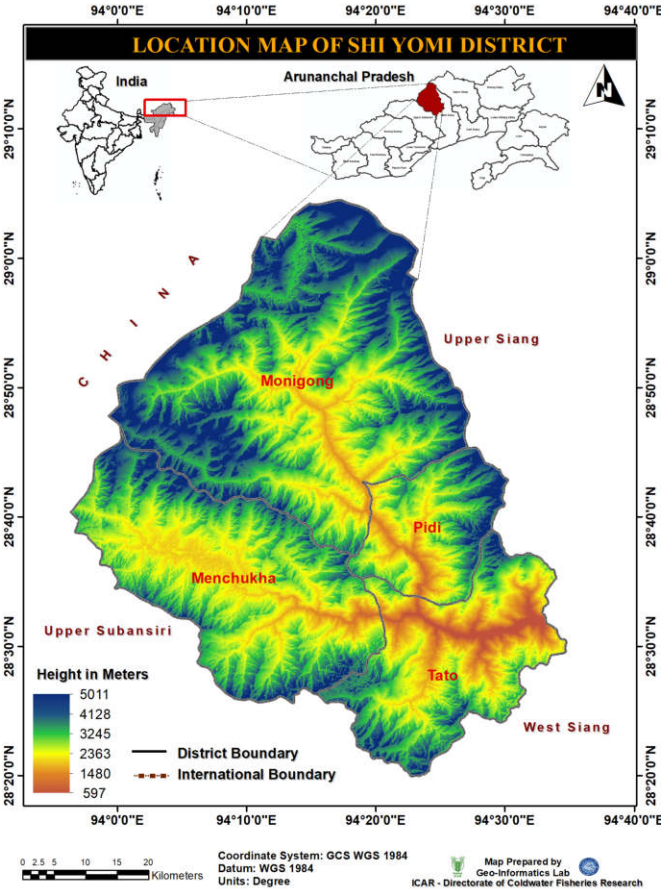
The state of Arunachal Pradesh in the eastern Himalayas is known as the land of the rising sun. This is the largest state in the north eastern region of India and home to 28 major tribes and 110 sub-tribes, with a rich heritage of arts and crafts with their own distinct and diverse culture, dialects and lifestyles.

Among the districts of Arunachal Pradesh, the district of Shi Yomi has recently been carved out of West Siang District, encompassing an area of approximately 2803 km$^2$. The major attractions of this district are its numerous perennial river drainages dissecting the mountainous terrains into deep gorges and narrow valleys. Of these, the Menchukha valley is gradually becoming a popular tourist destination on the global map due to its mesmerising beauty, gentle hills, river and snow-laden mountains. The Yargyapchu River flows through the township of Menchukha and provides a picturesque landscape to the entire valley and ample scope for recreational fisheries in the form of angling together with trekking, rafting, paragliding and camping. Together with the countryside backdrop, the Yargyapchu River has been admired as a paradise for the anglers in search of the exotic brown (*Salmo trutta fario*) and rainbow trout (*Oncorhynchus mykiss*) in this part of the eastern Himalayan belt of the country.

## The fishes and aquatic resources

The climate of the district is largely influenced by the nature of the terrain, varying from sub-tropical in the south to temperate and alpine in the north, with large areas experiencing snowfalls during winter in Shi Yomi District. The surrounding snow peaks give rise to numerous rivulets, streams, lakes and tanks. The district is bestowed with two major river systems namely Siyom and Yargyapchu. A total of 44 species of fishes belonging to four orders and nine families have been identified in the Siyom. Carps are the dominant species followed by hillstream loaches of the family Balitoridae (Bagra and Das, 2010). Similarly the fish diversity of the other major drainage, namely the Yargyapchu River, is comprised of seven species belonging to four families, with carps and hillstream loaches represented by two species each (Final Report for Menchukha Hydro Power Private Limited, 2014). The low diversity of fish species in Yargyapchu may be attributed to very cold temperatures at high altitude. However, exotic rainbow trout and brown trout were introduced to the river back in the 1990s by the Department of Fisheries, Government of Arunachal Pradesh. Since then, brown trout have settled in well and at present are reported to have a good population in the Yargyapchu as hooked by the avid anglers of the region.

**Location of Shi Yomi district in India.**




The identification and management of habitats of these fishes has been very effective with spatial assessment of the aquatic resources and understanding the range of land use patterns affecting their distribution. Therefore, an effort has been made herewith to spatially represent aquatic resources relevant to the decision context by integrating hardware, software and data for capturing, managing, and analysing blended with non-spatial information for displaying geographically referenced information. The aquatic resources in this communication have been addressed to the major rivers, their connecting channels, streams and the wetlands in the form of upland lakes. Furthermore, the integration of GIS with site suitability criteria is expected to provide a supportive database in framing strategies and developing action plans for trout fisheries improvement in this hill locked district of Arunachal Pradesh.

*Yargaypchu River giving rise to the Menchukha valley.*

## The drainages

The Siyom and Yargyapchu rivers flow for a distance of 59 km and 53 km respectively with very steep slopes in the upper section of the river valley. The Siyom River originates from Monigong Circle and joins the Siang River, the latter known as the mighty Brahmaputra of Arunachal Pradesh. The Yargyapchu joins the Siyom near the Tato District Headquarters. The present communication describes the characteristics of the Yargyapchu River, in particular from the perspectives of trout fisheries in the Menchukha valley.

The basic morphometry of the Yargyapchu River is of fourth order. Table 1 shows the frequency and length of different stream orders of rivers flowing through the Menchukha valley.

The first order streams are the majority followed by second and third order. The first order streams are snow-fed and form the major source of water supporting trout fishes in the Yargyapchu.

## Wetlands

Wetlands form an important geographical component of eastern Himalaya as a source for the development of trout aquaculture and recreational fisheries for generating avenues for livelihood, nutrition and income. From the geo-spatial analysis it can be seen that the district of Shi Yomi is covered with 17% snow (487 ha) of the total area, mostly distributed in the regions of Monigong (360 ha) and Menchukha (75 ha). 41 wetlands are found scattered at an altitude ranging between

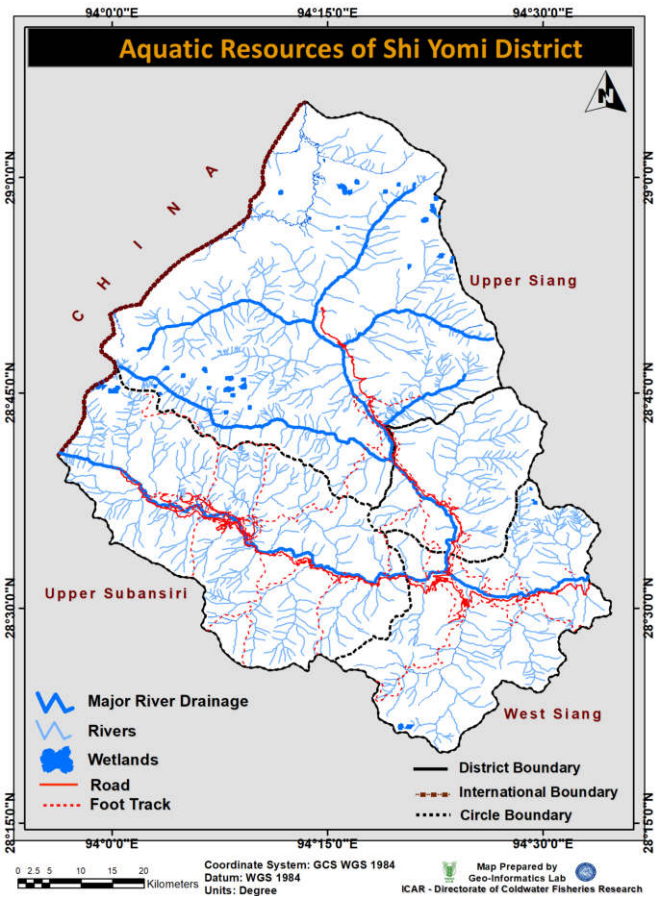
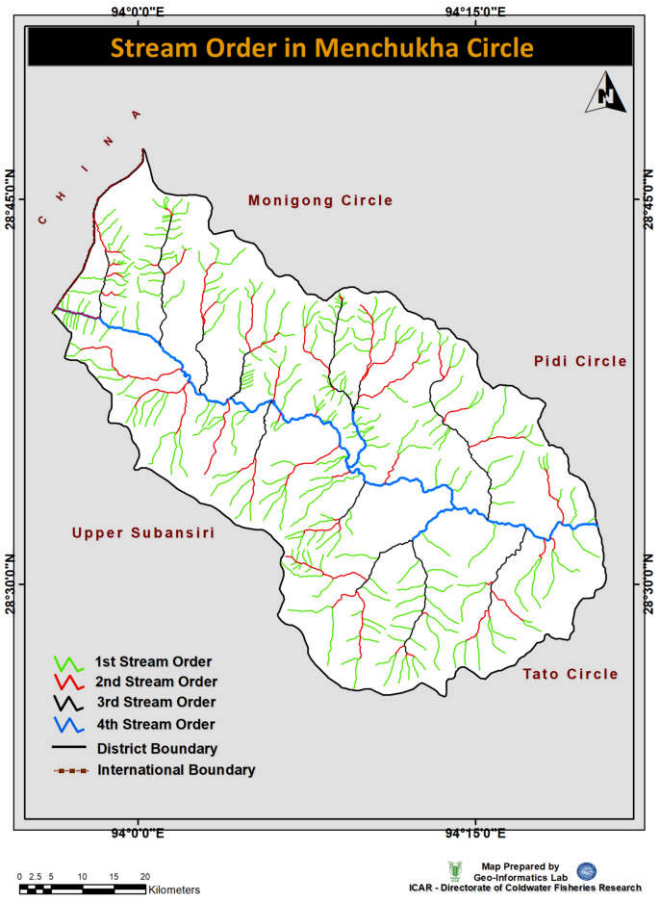
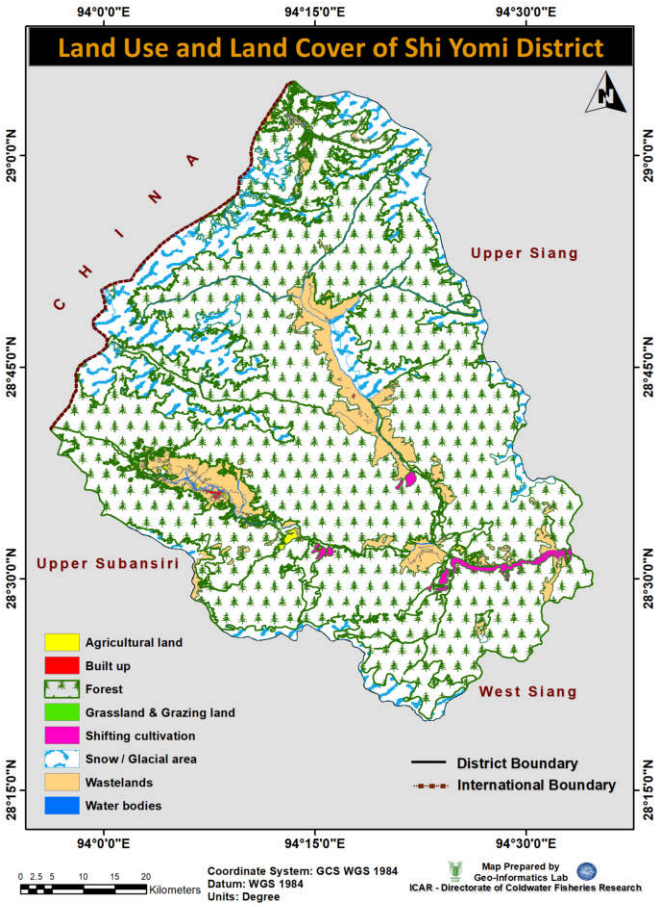


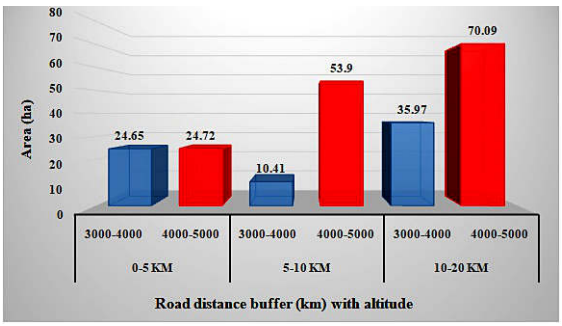
**Table 1. Stream order, stream frequency and stream length of the Yargyapchu River in Shi Yomi District.**

| Stream order | Yargyapchu River | | Shi Yomi District | |
|---|---|---|---|---|
| | Number | Length (km) | Number | Length (km) |
| 1st order | 296 | 481 | 975 | 1592 |
| 2nd order | 75 | 139 | 197 | 419 |
| 3rd order | 29 | 85 | 67 | 246 |
| 4th order | 4 | 74 | 14 | 180 |
| 5th order | 0 | 0 | 1 | 16 |
| **Total** | **404** | **779** | **1254** | **2453** |




**Distribution of wetlands (area wise) at different altitudinal regimes and accessible distance in Shi Yomi District.**




3,000-5,000 m in Shi Yomi District in the form of upland lakes covering an area of 220 hectares. The average size of the wetlands (in area) at an altitude of 4,000-5,000 m is 7.1±12.2 hectares and between 3,000-4,000 m it is 3.6±4.4 hectares. The minimum and maximum size of these wetlands between 4,000-5,000 m altitude is 0.1 and 52 hectares whereas the minimum and maximum size of wetlands between 3,000-4,000 m altitude is 0.03 and 18.7 hectares respectively. The developmental drift of these water bodies are mainly determined by their location and connectivity with the road transport lines, especially in a hill locked areas where railway and air connectivity is not prevalent. The buffer analysis showed that about 70.1% of the wetlands are scattered within the range of 10-20 km from their nearest road transport lines followed with 53.9% within 5-10 km.In both the cases the wetlands lay at an altitude regime of 4,000-5,000 m. As roads are considered the best mode of transportation for supply of critical inputs in the form of fish seed and feed in this hilly terrain, the buffer analysis provides information for designing strategic plans and programmes for development of trout fisheries in wetlands of the district.

Furthermore, the digital elevation model (DEM) examination of the district infers that the elevation class ranging from 1,000 m to 3,000 m encompassing 59% of the total geographic area can provide suitable sites for undertaking trout aquaculture activities provided the other climatic conditions are conducive. Development of a slope map generated dynamically from DEM for the district shows that the slopes in the class ranging from 0-21 degrees accounts for 28% of the total geographic area, which are more likely to include suitable sites for undertaking trout farming as compared to slopes in the class from 21-36 degrees (47% of the area) and 36-78 degrees (25% area) of the region.

## Trout fisheries development in Arunachal Pradesh: Initiatives taken

The most sought after trout species for aquaculture avenues is rainbow trout whereas the brown trout is preferred for sport fishing in natural water bodies. The Yargyapchu River is a hub for angling as this drainage contains many snow-fed streams harbouring trout. However, trout aquaculture is still in its infant stage in the Menchukha valley and much more effort has to be carried forward to expand trout farming in this beautiful region. Seeing the potential of trout farming and angling, initiatives have been taken by the Department of Fisheries (DoF), Government of Arunachal Pradesh, in establishing trout hatcheries and a couple of trout farms in different districts of the state. A list of fish farms and fish hatcheries under the DoF has been depicted in Table 2. The fish farms and hatcheries established in the districts of Tawang and West Kameng only produce trout seed and fingerlings as these two districts have favourable habitat for trout. The trout hatcheries established for seed production and rearing have encouraged stakeholders to gradually commercialise their trout farms in recent times. The ICAR-Directorate of Coldwater Fisheries Research (ICAR-DCFR), Bhimtal, has been providing technical guidance in selection of suitable sites, analysing the quality and quantity of water flow and the source of inputs in establishing these hatcheries. ICAR-DCFR has provided support through trout seed consignments and assistance with hatchery facilities, together with building technical capacity of state officials and entrepreneurs through training and skill development programmes. A similar effort has been made to train and develop skills among prospective trout growers and entrepreneurs visiting ICAR-DCFR from the Menchukha region during December 2018. Visitors gained experience in trout seed production, trout rearing and subsistence utilisation of natural resources for rehabilitation of trout population for recreation and angling.

**Table 2: List of fish farms and fish hatcheries under the Department of Fisheries, Arunachal Pradesh.**

| District / place | Name of farm |
|---|---|
| Tawang | Chuje GG Trout Farm |
| | Nuranang Trout Farm |
| | Seru Trout Farm |
| West Kameng | Govt. Fish Farm, Bhalukpong |
| | Govt. Fish Farm, Salari |
| | Govt. M Trout Farm, Shergaon |
| East Kameng | Govt. Fish Farm, Seppa |
| | Govt. Fish Farm, Veo |
| Upper Subansiri | Govt. Fish Seed Farm, Daporijo |
| | Govt. Fish Seed Farm, Dumporijo |
| Lower Subansiri | RHA Fish Seed Farm, Tarin |
| | Govt. Fish Farm, Yachuli |
| Kurung Kumey | Govt. Fish Farm, Nyapin |
| Papum Pare | Govt. Fish Farm, Emchi |
| | Govt. Fish Farm, Gumto |
| West Siang | Govt. Fish Farm, Jirdin/Kambo |
| East Siang | Govt. Fish Seed Farm, Pasighat |
| | Govt. Fish Farm, Panekorong |
| Upper Siang | Govt. Fish Farm, Yingkiong |
| Lower Dibang Valley | Govt. Fish Seed Farm, Iduli |
| | Govt. Fish Seed Farm, Bolung |
| | Govt. Fish Seed Farm, Komponath |
| Anjaw | Govt. Fish Seed Farm, Hawai |
| Lohit | Govt. MFF,TR Camp, Tezu |
| Namsai | Govt. Fish Seed Farm, Lathao |
| Changlang | Govt. Fish Farm, Diyun |
| | Govt. Fish Farm, Bordumsa |
| | RWFF, Rangkatu |
| | Govt. TN, Miao |
| | Govt. TN, Changlang |
| Longding | Govt. Fish Farm, Tissa |
| | Govt. Fish Farm, Kanubari |
| Tirap | Govt. Fish Farm, Deomali |
| | Govt. Fish Farm, Khonsa |
| Capital Complex, Itanagar | Experimental Fish Pond Headquarters |
| Dibang Valley | Nil |
| Siang | Nil |
| Kra Daadi | Nil |
| Pakke – Kessang | Nil |
| Lepa Rada | Nil |
| Shi Yomi | Nil |
| Kamle | Nil |

*Source: Directorate of Fisheries, Government of Arunachal Pradesh.*

## A visit to Menchukha

A February 2019 visit by a team of scientists from ICAR-DCFR and fisheries officers from the Arunachal Pradesh DoF had the objective to select suitable sites for establishing trout raceways and a trout seed production unit for development of livelihoods and nutritional support to the local communities of the valley. Effort was also made to evaluate the possibilities to establish and restore trout fisheries in the streams of the valley to create recreational fishing opportunities. During the visit, an awareness programme was initially conducted on 12th February 2019 on the topic “Coldwater fish culture in Menchukha region”, which was witnessed by more than 110 participants from different villages of Menchukha, along withofficers and staff representing various associated departments. The scientists from ICAR-DCFR deliberated on the subject “Promotion of trout farming and fish based eco-tourism in upland regions of IHR”. Presentations were made to the participants on:

- The fundamentals of starting of a rainbow trout farm.
- Site selection criteria for establishing concrete raceways in high altitudinal regimes.
- Undertaking trout-based eco-tourism in the Yargyapchu River and its adjoining snow-fed streams.

*Trout farm at Nuranang, Tawang District under Department of Fisheries, Arunachal Pradesh.*

*Exposure visit of trout entrepreneurs from Menchukha at ICAR-DCFR experimental fish farm.*

*Skill development on trout seed production at ICAR-DCFR experimental fish farm.*

- Seed production technology and hatchery management practices for raising trout in the Menchukha region.

- Determining aquaculture suitability sites through GIS mapping and ground surveys in the Shi Yomi District for promotion of trout farming.

The awareness programme was followed by an extensive field survey of the Menchukha region during 13-14 February 2019, looking for selecting suitable sites for start-up of trout farming in concrete raceways and establishing a seed production unit, both in the government and private sectors. Many potential sites were visited by the team with the help of local villagers and residents. The basic selection criteria were to have a site with a good source of quality water together with sloping terrain and road connectivity. The water quality of the Yargyapchu River along with its adjoining streams was examined by the scientists at each site and was found to be very conducive for trout farming and egg production (Table 3). The temperature, pH, dissolved oxygen, total hardness, alkalinity and other nutrient parameters of the water were found to lie within the optimum range for trout growth and propagation. Furthermore, a certain stretch of Yargyapchu was selected by the scientists and DoF officials, in consultation with local anglers and fishers, to consider as a “protected area” with angling restricted to a few specific points. Destructive methods of fishing such as use of explosives, electricity, poisons and small meshed nets will be considered illegal in the river and streams. The entire site selected for trout aquaculture was within the slope range of 0-21 degrees, has road connectivity and was located away from agriculture and other forms of human interference. It is expected that this visit by the team of fisheries experts has benefited the entrepreneurs of Menchukha in understanding trout farming and trout based eco-tourism as a true vocation for their livelihood and income source.

*Above, below: Earthen and concrete raceways at Shergaon, West Kameng District under DoF, Arunachal Pradesh.*


*Participants in the awareness programme, which include scientists, fisheries officers and local entrepreneurs.*

**Table 3: Major water quality parameters of the Yargyapchu River and its adjoining streams.**

| Parameters | Dorjeeling Village | Sekar Village | Lhalung Village | Nangso Village | Pemashelphu |
|---|---|---|---|---|---|
| Temperature (°C) | 8.90±0.42 | 12.70±0.20 | 8.43±0.12 | 13.40±0.26 | 8.50±2.26 |
| Air temperature (°C) | 12.33±0.58 | 13.67±1.53 | 13.00±0.00 | 14.67±0.58 | 13.00±1.00 |
| pH | 8.53±0.12 | 8.00±0.20 | 7.57±0.06 | 7.30±0.10 | 8.07±0.42 |
| DO (mg/l) | 6.70±0.41 | 6.70±0.10 | 7.06±0.04 | 7.71±0.07 | 7.09±0.13 |
| Total hardness (mg/l) | 75.00 | 75.00 | 75.00 | 75.00 | 75.00 |
| TDS (ppm) | 25.33±1.15 | 24.67±1.15 | 12.00±0.00 | 37.33±1.15 | 30.00±2.00 |
| Turbidity (NTU) | <10.00 | <10.00 | <10.00 | <10.00 | <10.00 |
| Conductivity | 010 | 011 | 00 | 020 | 001 |
| Nitrate (mg/l) | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Iron (mg/l) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| Fluoride (mg/l) | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| Chloride (mg/l) | 10.00 | 10.00 | 20.00 | 20.00 | 10.00 |
| Altitude (m) | 1,967 | 1,931 | 2,030 | 1,957 | 1,934 |

## Trout angling in the Menchukha valley

The Yargyapchu River flows through the Menchukha valley at around 1,830 m altitude and for around 29 km preceding the border with the Tibet Autonomous Region (China), offering an excellent site for adventure tourism for outdoor enthusiasts with a picturesque backdrop. Government attention to the tourism and fisheries sectors in organising recreational events such as angling competitions has encouraged tourists and explorers from all over the world in recent times. Angling for brown trout in the Yargyapchu River has remained quite a fascinating adventure for anglers. A good number of sizable brown trout of 8-12 kg by weight have been hooked from this water, which is an implausible catch elsewhere in the state. This signifies a considerable population of trout in the Menchukha area. Trout thrive in this river and provide an excellent opportunity for game fishing, generating huge income for local communities.

Introducing the concept of fee fishing in the upland lakes, ponds and tanks, together with trekking expeditions, river side camping and rafting can be an excellent way of generating income. The fish must be hooked on the basis of 'catch and release' by the anglers to preserve the existing fish stock. Furthermore, the Department of the Fisheries must be entrusted in issuing fishing licenses to anglers visiting Menchukha in order to protect the fishes from destruction. Declaration of a protected area/zone along a certain stretch

of the Yargyapchu River by the local administration will be an added advantage in allowing trout to propagate through self-recruitment. Establishment of a trout hatchery at Menchukha will help the local community and officials to ranch hatchery produced brown trout seed in the river to enhance the trout population in the valley.

## GIS mapping of potential sites for trout fisheries development

The success of any aquaculture project or fish farm depends to a large extent on selection of a suitable site for establishment of a fish farm or hatchery. Site selection using the conventional method, based on very limited data, can result in inaccurate information and cause discrepancies among the implementing agencies. The utilisation of remote sensing and geographic information systems can provide a useful source of additional information. An attempt has been made herewith to identify and select potential areas where fisheries developmental activities such as culture and seed production can be carried out by employing different input feature classes.

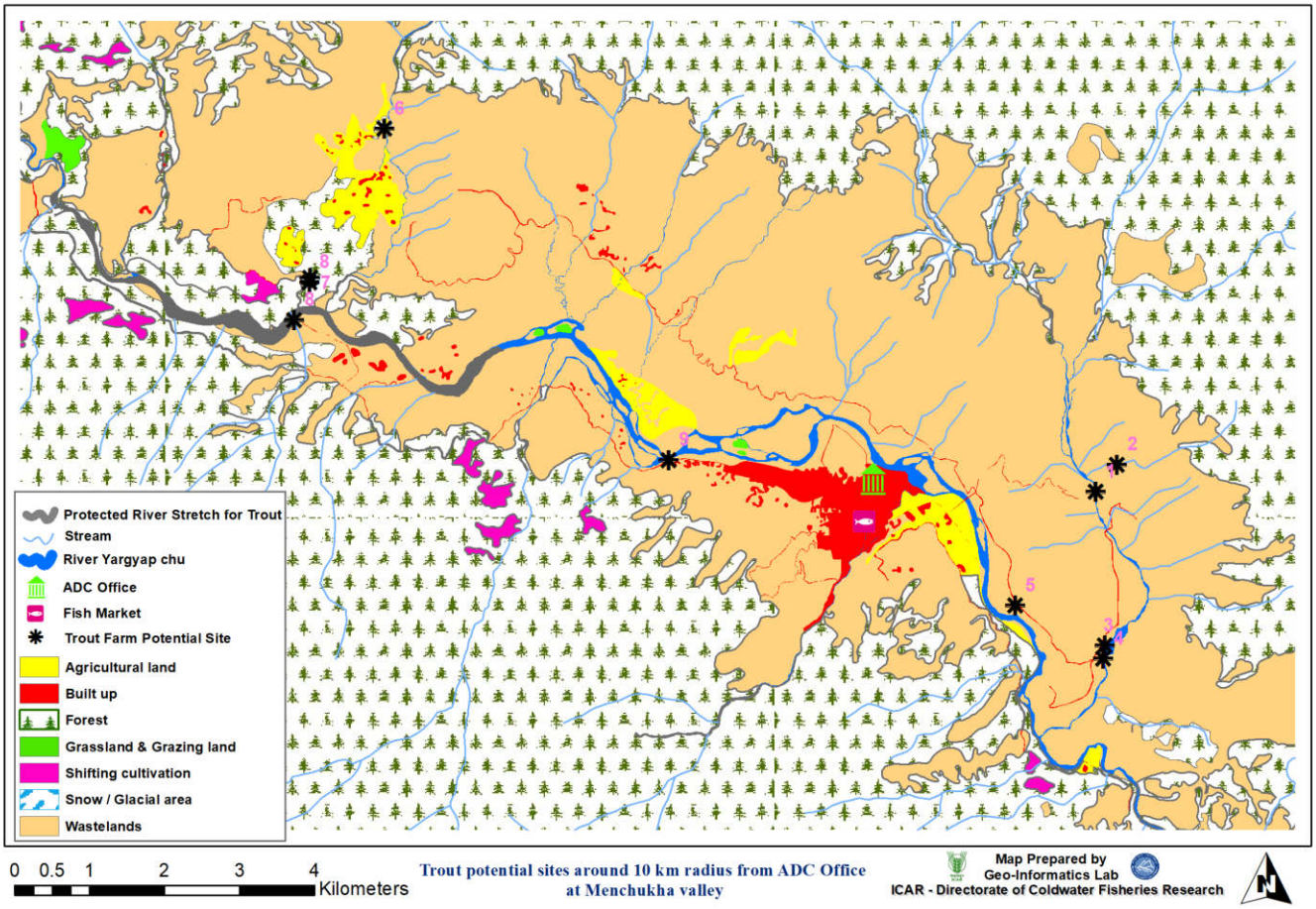
Since the region is at over 3,000 m altitude with hilly terrain and little habitation or human population, it is presumed that the water of the region is pollution free and of the quality as desired for aquaculture operations. Thus, water quality and quantity as input criteria for site selection was considered to be optimum. Other feature classes that were taken as selection criteria were:

*Analysing physicochemical parameters of river water to assess site suitability for trout farming.*

- Drainage network, as water being the essential element for trout farming, its location and extension/spread is essential in selection process.
- Road network, due to its importance in mobilising materials from one place to another and the accessibility for supplying inputs and market the farm produce.
- Slope of the region, as it is of prime importance in hilly terrain.
- Land use land cover, to reflect the significance of land as a finite resource for human intervention for fish production coupled with economic growth.

*Visit to farmers field to analyse site suitability for trout farming.*

**Map of the protected area on the Yargyapchu River and potential trout aquaculture sites in the Menchukha valley.**




*Angling of trout in the Yargyapchu River by local anglers.*

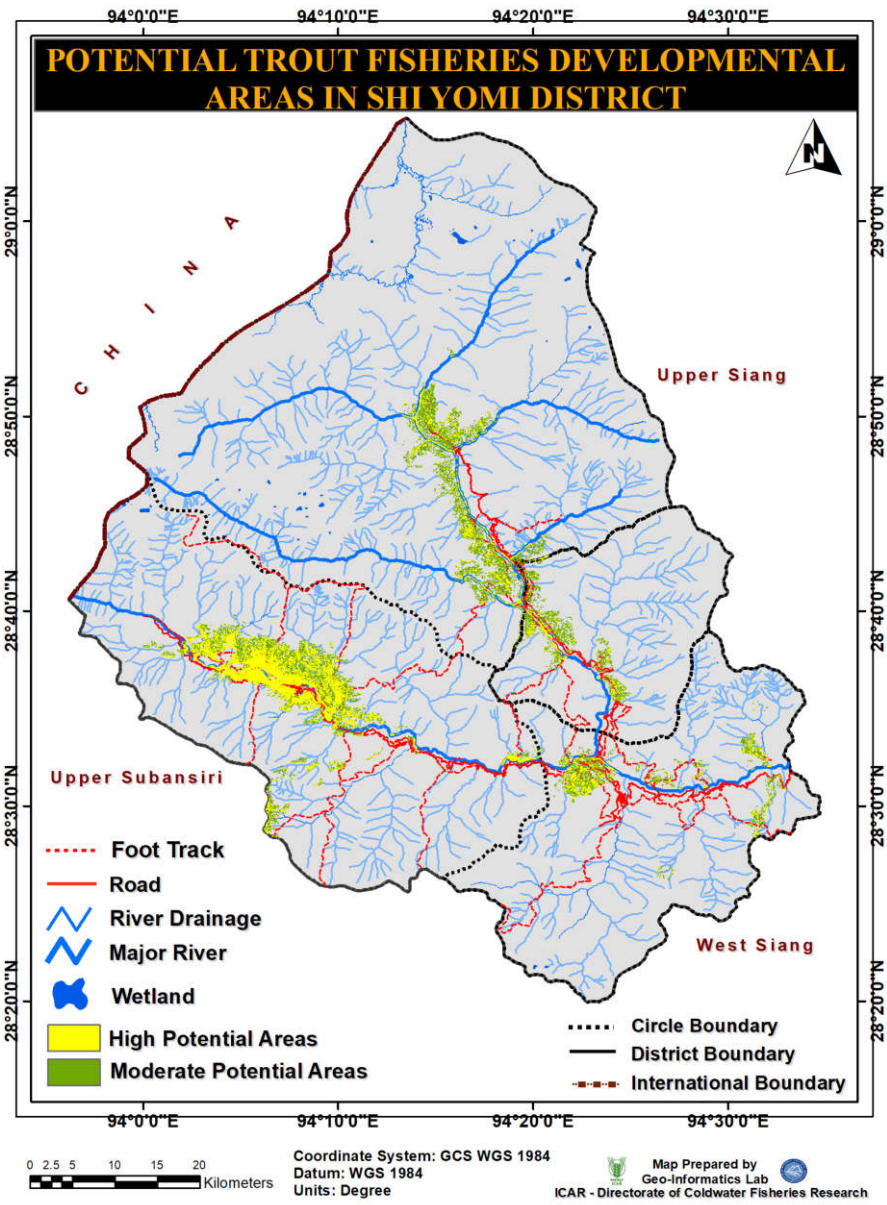
*Estimating the morphometric count of brown trout caught in the Yargyapchu River by local anglers.*

To select a suitable area for trout farming, these input feature classes were subjected to spatial analysis using the different tools of the spatial analyst extension of the ArcGIS v 10.6.1. A buffer was drawn over the river network of the region with a spread of 100m up to the third order streams and a spread of 200m on fourth and fifth order streams with a purpose to limit the extension stretch over which trout farming operations may be initiated. In a similar way, a buffer layer of 5 km was drawn over the digitised road network input feature class of the region so as to set the distance limit under which trout farming operations are feasible and conducive. Topographic constraints are imperative in such areas hence the limit. In case of the slope input feature class only the slope ranges of 0-10 degrees and 10-20 degrees were considered for selection, as higher slopes will be too steep for trout fish farming. Based on this, the selected input feature classes were superimposed in the GIS environment and probable trout farming areas were identified. An area of 34.77 $km^2$ in the slope range of 0-10 degrees and an area of 51.34$km^2$ in the slope range of 10-20 degrees was found suitable in the entire Shi Yomi District for undertaking trout farming provided the other requirement criteria are optimum and as per the

requirement for trout farming. It is noteworthy to mention here that these are only the probable areas and not the exact areas. For delineating actual suitability, a thorough and careful field examination was made during the first visit by the team to the Menchukha region.

## Conclusion

Financial assistance to the trout growers by the DoF, Arunachal Pradesh, together with technical guidance by ICAR-DCFR has resulted into horizontal expansion of trout farming in the state. It is expected that this concerted effort by the department and research institutes together with participation of stakeholders will further mitigate the scarcity of trout seeds and feeds in the days to come. Establishment of concrete raceways and an ova house will further strengthen production of rainbow trout, which is the most preferred fish for culture in the region due its suitability for local habitats and substantial growth performance. On the other hand, establishment of brown trout in natural water bodies through seed ranching and preventing illegal methods of fishing, restricting anglers to follow catch and release practices and declaring a protected zone in the Yargapchu River will further enhance populations of this highly valued sport fish. Therefore Shi Yomi District has great potentiality for dissemination and uptake of trout farming and recreational fishing activities.





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### References


Bagra K. and Das D.N. (2018). Fish diversity of river Siyom of Arunachal Pradesh India: A case study. Our Nature 8: 164-169.

Gurumayum S.D. and Tamang L. (2017). Coldwater fish and fishery of Arunachal Pradesh, India, Bulletin of Arunachal Forest Research, 32, 1&2: 17-26.

Pandey N.N. and Ali S. (2015). Rainbow trout farming in India: R&D perspectives. ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Bulletin No. 23.

Link Technologies Pvt. Ltd. (2014). Environmental Impact Assessment for Pemashelpu HE Project (81 MW). West Siang District, Arunachal Pradesh, Final Report.

Sarma D, Singh AK and Baruah D (2018). Checklist of endemic Ichthyofauna of North-east India, Indian J. Fish., 65(3): 1-15.



*Brown trout, Yargyap Chu River.*

# NACA Newsletter

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Food and Agriculture Organization of the United Nations

MINISTRY OF AGRICULTURE AND RURAL AFFAIRS OF THE PEOPLE'S REPUBLIC OF CHINA

## First Announcement

In 1976 FAO held its first global conference on aquaculture in Kyoto, Japan, triggering the recognition of aquaculture as a significant food production sector and exploring opportunities for the development of the sector. This was followed by global conferences on “Aquaculture in the Third Millennium” in Bangkok, Thailand, in 2000 and on “Farming the Waters for People and Food” in Phuket, Thailand, in 2010.

With aquaculture now providing more than half of the global aquatic food supplies, and increasingly contributing to the sustainability of agrofood systems, FAO in partnership with NACA and the Chinese Government, are organising the fourth Global Conference on Aquaculture to review the achievements and challenges in world aquaculture development and build consensus on a way forward for sustainable development of the sector.

The objectives of the Global Conference on Aquaculture 2020 are to:

- Review the present status and trends in aquaculture development.
- Evaluate the progress made in the implementation of the Bangkok Declaration and Strategy on Aquaculture Development Beyond 2000 and the Phuket Consensus.
- Address opportunities, challenges and emerging issues in aquaculture development.
- Build consensus on advancing aquaculture as a sustainable and competitive food production sector.

The Global conference on Aquaculture 2020 will bring together a wide range of stakeholders, i.e. government, academia, education, research, industry and many others, to join the conference. You are cordially invited to attend the conference and share your innovative contributions. More information about the Global Conference on Aquaculture 2020 can be found at: **www.aquaculture2020.org**

# Bangladesh delegation visits Thailand to study shrimp aquaculture

NACA and the Bangladesh Shrimp and Fish Foundation collaborated to organise a study tour programme focused on shrimp operations in Thailand for fourteen Bangladesh officers during 29 April to 2 May 2019. The study tour was supported by the Winrock Foundation and coordinated by Dr Cherdsak Virapat, the outgoing Director General of NACA.

The group had a meeting with CP Executives at CP Headquarters on 29 April to discuss CP SPF shrimp management systems, as well as freshwater fish production. On 30 April, they visited a CP SPF shrimp hatchery in Ranode, Songkhla Province.

The Bangladesh delegation had a meeting with DOF-Thailand on 1 May, chaired by Mr. Thaworn Jirasophonrak, Deputy Director General and staff from related divisions to discuss policy and regulations, as well as shrimp farming practices and information. The new Director General of NACA, Dr Jie Huang, attended the meeting and gave a presentation on the role of NACA as a mechanism for sharing experience and bridging needs with resources in sustainable aquaculture development. Dr Huang appreciated the efforts of the Thai Government, scientists, and private sector in development of shrimp aquaculture in the region.

*Bangladesh Shrimp and Fish Foundation study tour participants visit the Thai Department of Fisheries.*

The delegation went on to visit the Banjong Farm in Chachoengsao Province. The farm operates SPF hatcheries for *P. monodon*, *P. vannamei* and giant freshwater prawn. The delegates returned to Bangladesh on 2 May 2019.

# Expert Consultation on Development of Sustainable Aquaculture Guidelines, Rome

The increasing importance of aquaculture for food security and nutrition, improved livelihoods, poverty alleviation, income generation, as well as job creation and trade, and its potential to meet the growing global demand for fish, was highlighted by the FAO Committee on Fisheries (COFI) during its last session.

It was also noted that there is a growing need for implementation of best practices in aquaculture in many countries and regions. COFI thus recommended that FAO develop global guidelines for sustainable aquaculture development.

In addition, the last Sub-Committee on Aquaculture (COFI-SCA) called for identification of existing strategies and experiences in aquaculture development worldwide in order to document lessons learned. These could be included in new guidance with the objective to help governments achieve a better implementation of the Code of Conduct for Responsible Fisheries (CCRF), while engaging and enabling their aquaculture sector to effectively participate in the implementation of the 2030 Agenda for Sustainable Development.


*Participants in the expert consultation. NACA was represented by Dr Yuan Derun.*

An expert consultation was convened in Rome, from 15-22 June, to prepare a roadmap and methodology that will be submitted to the COFI-SCA at its tenth session in Trondheim (Norway), in August 2019. The consultation addressed preparation of:

- A proposed methodology and criteria for selecting strategies and experiences of aquaculture developments worldwide and for identifying the lessons learned from them.

- A methodology for documenting and analysing the lessons learned.
- A list of thematic modules.
- A gap analysis between existing guidelines and needs for new ones.
- An updated roadmap

Seventeen experts from different countries representing governments, organisations and networks participated in the consultation, along with ten FAO fisheries/aquaculture officers and a consultant.

The workshop participants made the recommendation to be submitted to COFI-SCA that pathways be developed to transform aquaculture to better achieve the Sustainable Development Goals.

The group examined and revised various thematic "modules" describing the rationale and attributes for approaches and practices on each specific topic, the existing guidelines and the key recommendations for successful implementation and capacity development, based on the achievements and difficulties highlighted by case studies.

The group proposed methods, approaches and criteria to identify, research and document a series of case studies that would describe the process, the accomplishment and the constraints, to illustrate the possible pathways and thematic factsheets.

The outcomes will be presented at the next meeting of COFI-SCA. The consultation was supported by the Norwegian Government and the Government of the Republic of Korea.

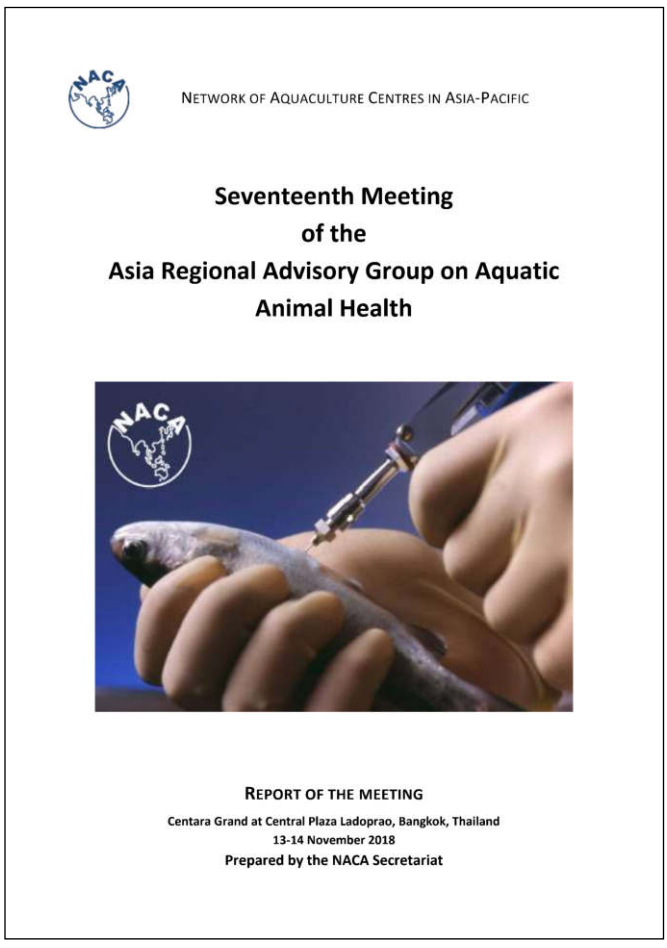
## Report of the Seventeenth Meeting of the Asia Regional Advisory Group on Aquatic Animal Health

This report summarises the proceedings of the 17th meeting of the Advisory Group, held 13-14 November 2018 in Bangkok, Thailand. The group discussed:

- Progress in NACA's Regional Aquatic Animal Health Programme.
- OIE standards and global issues.
- Updates on FAO initiatives in the Asia-Pacific in support of aquatic animal health.
- Review of regional disease status, including for diseases of fish, crustaceans, molluscs and amphibians.
- Reports on the aquatic animal health programmes of partner agencies.
- Aquatic animal health activities of the private sector (PHARMAQ, Fish Vet Group Asia).
- Quarterly disease reporting status and updates.
- New OIE Disease List and revisions to the Regional Quarterly Aquatic Animal Disease Report for 2018.

The Advisory Group meets annually to provide advice to NACA member governments on aquatic animal health management. The group's role includes reviewing disease trends and emerging threats in the region, identifying developments in global aquatic disease issues and standards, evaluating the Quarterly Aquatic Animal Disease Reporting Programme and providing guidance on regional strategies to improve aquatic animal health management.

The report can be downloaded from:
https://enaca.org/?id=1053



## Quarterly Aquatic Animal Disease Report, October-December 2018

The 80th edition of the Quarterly Aquatic Animal Disease report contains information from twelve governments. The foreword discusses revisions to the regional reporting system for 2019.

Download the report from:

https://enaca.org/?id=1052

## Tuskfish 2 Alpha: Testers wanted

The alpha release of Tuskfish 2 will be available for testing from Github in a few weeks. Tuskfish 2 is a rewrite of Tuskfish CMS, the software that runs the NACA website. It is distributed for free under the GNU General Public License V2. Tuskfish 2 builds on the experience gained in the first version to produce a faster, leaner and more efficient code base.

Tuskfish 2 adopts a strict model-view-viewmodel (+ controller) architecture (MVVMC). You can think of it as traditional model-view-controller (MVC) except the view is split into a view and a viewModel to abstract the relationship between the view and model, which improves flexibility and allows reuse of components. A front end controller and static router have been added.

### So what's new?

- Strict MVVMC architecture.
- Front end controller with static routing for seo-friendly, customisable URLs.
- Inheritance completely removed in favour of composition and dependency injection.
- Namespaces implemented.
- Content objects simplified down to a single class.
- Simplified theme and template system.
- Data validator class split into a series of smaller traits that are used as required.
- Added admin-side search for locating content to edit.
- A lot of methods have been refactored and simplified.

This means that:

- It's even faster than before; the MVVMC architecture greatly improves code separation, which means less code is read on each page load.
- With adoption of namespaces the code is better organised and easier to work with.
- Easier to extend. Add a new route and your own MVVMC components to create new functionality or add a microservice without disturbing the existing system.

### System requirements

- Apache webserver.
- PHP 7.2 or higher (the installer will not run without it).
- sqlite3 extension.
- PDO and pdo_sqlite extensions.
- gd extension.

### What about Tuskfish 1?

Tuskfish 1 won't be developed any further (although security patches will be provided, if issues arise). However, it remains fast, reliable and easier to customise, as it has a simpler architecture, and has full documentation on installation, use, development and on the API. Tuskfish 1 is available from: https://github.com/crushdepth/tuskfish

### Testers wanted

If you're interested in helping to test Tuskfish 2 in a voluntary capacity please send an email to simon@enaca.org.

You will need to have your own infrastructure and previous experience in operating a content management system (eg. Wordpress, Joomla, Drupal etc).

However, Tuskfish can also be set up locally on a PC with XAMPP or equivalent in a couple of minutes. I would also be interested to hear from people interested in trying to install it on alternative webservers such as NGINX.

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