

Pisciculture with pond dikes' utilization

for additional income and employment in Tripura

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Pisciculture is an important agri-allied sector in Tripura, Northeast India. Presently, more than 2.1 lakh people are associated with this sector for food and livelihood security. However, the majority of these people (94%) fall under the category of marginal and small farmers, with an average pond holding of less than 0.10 ha (locally known as 1 kani) and an income of ₹7500-37500/ha/year, which is meager compared to the actual potential of science-led pisciculture. Composite fish culture (CFC) is a proven technology, but it is highly capital-intensive, and poor farmers find it difficult to afford in their ponds. Further, most of the ponds are small and seasonal which is unfit for CFC. In this situation, modifying it according to farming conditions, and additionally integrating them with pond dikes for additional income, can bring about significant changes in pond-dependent livelihoods in Tripura, in general, and Northeast India, in particular. Through appropriate pisciculture interventions, it is possible to derive an annual net income of ₹40,000-510,000 from a 1-hectare pond and additionally ₹60,000-89,450 through the utilization of its dikes for different agri-horti crops, besides generating 150-200 additional man-days year-round. Hence, pisciculture with pond dike utilization techniques is highly recommended in settings where farmers have very limited resources.

Keywords: Composite fish culture, Carp, Coprophagus, Fisheries, Tripura

Fisheries sector plays a pivotal role in both the economic landscape and livelihood sustainability of Tripura, Northeast (NE) India. The fisheries domain is broadly bifurcated into culture fisheries, centred on pond or tank-based systems, and capture fisheries, exploring open water bodies such as rivers, reservoirs, lakes, and beels. While composite fish culture (CFC) has proven effective in enhancing fish productivity from culture fisheries, it remains capital-intensive and unsuitable for small and seasonal ponds, where the water retention period is only 5-6 months. Given this situation, there is a pressing need for technologies, interventions, or approaches that specifically address the improvement of fish production and productivity in small and seasonal ponds.

As the human population in Tripura experiences a rapid increase

at a rate of 45 persons per square kilometer per decade, the demand for safe, affordable, and sufficient food for everyone becomes a pressing concern. This demographic surge is further compounded by the aftermath of the COVID-19 pandemic and the influx of migrant workers, intensifying the need for proactive measures. To address this situation effectively, it is imperative to promote intensive land utilization through the application of technological innovations. Most of the ponds in Tripura and NE India exhibit an antiquated and backyard design, lacking adherence to scientific principles and engineering standards during their construction, thus possess substantial underutilized areas both within and around their dikes. The primary dikes, also known as periphery dikes, and the secondary dikes, referred to as internal dikes,

contribute to this utilization of underutilized areas. In numerous instances, the top width of these dikes, commonly termed as the 'crest,' measures between 2-3 meters or more, with side slopes exceeding a ratio of 1:3. By repurposing these areas through the cultivation of diverse agri-horticultural crops that demand minimal to zero tillage practices, and integrating fish farming with these activities, a transformative impact can be brought to both the production and productivity of pond-based farming and livelihood development of farming communities.

Composite fish culture

The composite fish culture (CFC) technology is recognized as an exceptionally productive and lucrative fish farming approach that focuses on optimizing three niches within the pond ecosystem through

strategic stocking of fish species with diverse feeding habits. Tailored to the agro-climatic conditions of Tripura, three recommended CFC species compositions are presented. The first composition consists of 40% Catla (*Catla catla*), 30% Rohu (*Labeo rohita*), and 30% Mrigal (*Cirrhinus mrigala*). The second composition involves 40% Silver carp (*Hypophthalmichthys molitrix*), 30% Grass carp (*Ctenopharyngodon idella*), and 30% Common Carp (*Cyprinus carpio*). Another recommended composition includes 20% Catla, 20% Silver Carp, 15% Rohu, 15% Grass Carp, 15% Mrigal, and 15% Common Carp, with a stocking density of 10,000 fish fingerlings per hectare. However, a notable drawback of the CFC method is its high capital requirement, requiring a substantial investment ranging from ₹400,000 to ₹450,000 per hectare. This financial barrier makes it challenging for impoverished farmers to adopt this approach.

Coprophagous fish culture

Coprophagous fishes are those that consume fecal materials, demonstrating a unique dietary behaviour by feeding on waste in aquatic environments. These fishes generally dwell at the bottom of aquatic ecosystems and demand less energy compared to those dwelling in the column or surface. They are hardy and demonstrate a high survival rate. The most well-known coprophagous fishes are Common Carp and Mrigal. Besides a high survival rate, the benefit of farming these fishes is their marketability even at smaller sizes (150-200 g), fetching a price of ₹ 150-200 per kilogram, particularly in NE India,

allowing for utilization of small and seasonal ponds for their farming. Another advantage is these fish demonstrate a homogeneous growth rate throughout the culture cycle, which is otherwise heterogeneous in other fishes, particularly in backyard pond condition. Mrigal displays compensatory growth in the second year of their life; therefore, it is advisable to stock yearlings instead of fingerlings during their culture. The Common Carp is a boon, especially for impoverished fish farmers. Common Carp can be naturally induced to breed twice a year in confinements such as ponds, tanks, etc., utilizing artificial substrates or aquatic weeds like water hyacinth or water cabbage; thus, one-time stocking is sufficient for the pond. Poor farmers can reap significant benefits by cultivating Common Carp in their ponds. Rearing Common Carp is highly productive during the winter season, which is typically the most unproductive phase in pisciculture. In Tripura's climate, Common Carp breeding in the winter season, particularly in December, proves more successful than its breeding during the monsoon season (June-July).

Small indigenous species

The small indigenous species (SIS) are those fish that grow to a maximum length of 25 cm in their life phase. Considered as 'fish of no importance to fisheries' or 'trash fish' in many inland states, in Tripura and other NE states, they are in high demand and preference. Sometimes, they fetch a price similar to many big carps or even higher at the farm gate. In the CFC, after stocking fish for

three niches of the pond ecosystems with recommended ratios and stocking density, it can be assumed that 10-20% of niches still remain 'vacant.' To fulfil these 'vacant niches' and utilize food scraps generated from the application of supplemented feeds, stocking SIS like Mola (*Amblypharyngodon mola*) or Darkina (*Esomus danricus*) at 10,000-15,000 numbers/ha or Kanla (*Notopterus notopterus*) at 100-150 numbers/ha could be done. The SIS recruits automatically in the pond, and through regular thinning (at 2-3 month intervals) of their populations, fish productivity from CFC can be enhanced by 10-15%, even under low-input management. Abundant in macro- and micro-nutrients, poor farmers can use these fishes for household consumption, family nutrition, and sell large carps as 'cash crops.' SIS is a boon for poor fish farmers, allowing them to earn tremendous benefits by maintaining SIS in their pond when they missed stocking seeds of large carps in any season due to financial adversity.



Production of SIS (Kanla fish) using seasonal pond



Production of SIS (Mola fish) using seasonal pond



Silver carp production solely feeding upon plankton



Grass carp production feeding upon hybrid Napier

Utilization of ephemeral ponds

Ephemeral ponds, characterized by their small and seasonal nature, are prevalent in Tripura and NE India. These ponds retain water for 5-6 months, rendering them unsuitable for cultivating large carps that require water for a period of 8-10 months to reach marketable



Bata, a potential medium carp for farming using seasonal pond



Mono-sex Tilapia production using seasonal pond

size. Consequently, these ponds are ideal for either quality fish seed production or the cultivation of medium and minor carps or catfish, which reach marketable size in 4-5 months. Some potential medium and minor carps in the context of Tripura include Bata (*Labeo bata*), Gonia (*Labeo gonia*), or Java Puti (*Puntius gonionotus*), as well as Mola, Darkina, Punthi (*Puntius sophore*), etc. Mola and Darkina consume the same foods in the ponds, resulting in a biologically significant dietary overlapping index (≥ 0.6); in this situation, cultivating both fish together in the same pond is not advisable. Mono-sex Tilapia (*Oreochromis niloticus*) and Koi (*Anabas testudineus*) are other fish species that can be considered for ephemeral ponds. They can be raised to marketable size in 4-5 months by feeding on duckweeds or *Azolla*. With proper technological intervention and scientific management, fish productivity in ephemeral ponds, which is generally 0.5 to 1.0 MT/ha, can be increased to 1.5-2 MT fish/ha.

Utilization of pond dikes

Fodder crop cultivation on pond dikes: The dikes of ponds provide areas for cultivating fodder crops like hybrid Napier, Para grass,

Congo signal grass, perennial groundnuts, etc. This approach complements farming of fish and livestock animals by offering cost-effective feeds for both. Fodder cultivation on dikes also serves as a protective measure against common issues like erosion or breakdown of pond dikes, prevalent in Tripura. By planting hybrid Napier on dike slopes in a zigzag pattern, the pond dike breakdown or erosion can be minimized significantly. On-farm animal feed production guarantees a consistent feed supply, reducing unnecessary charges and logistics associated with feed procurement. Utilizing the crests, side slopes, and berms of a one-hectare pond can yield 500-100 kg of fodder, supporting the rearing of two small ruminant animals and meeting 20-30% of the fish feed requirement annually.

Field-crop cultivation on pond dikes: Pond dikes offer opportunities for cultivating diverse field crops such as paddy, maize, mustard, and various pulses require zero to minimal tillage. In Tripura, where rice is a staple and there is a 7% deficit in food grain production, paddy cultivation on dikes can not only supplement local rice production but also provide raw materials (rice bran) for low-cost

fish feed and paddy straws for cattle rearing or mushroom cultivation. The application of spent mushroom substrates (SMS), which is a solid waste of no use, in ponds enhances live food organism production, especially 'infusoria,' which is a preferred food for fish. Maize farming on pond dikes is highly beneficial. Maize, a flexible crop, yields green cobs and high-quality fodder. Mustard cultivation on dikes enables on-farm production of mustard oil cake (MOC), a vital fish feed ingredient with 35-40% protein, while the tender leaves serve as valuable vegetables. Selective cultivation of field crops on dikes can generate an additional annual income of ₹ 5000-9000 from pond-based pisciculture systems.



Utilization of pond dikes for Maize (HPQM 1) cultivation

Fruit-crop cultivation on pond dikes: The peripheral dikes can be utilized for cultivating various fruit crops, including mango (var. *Amrapali*), banana (var. *Sabri*), papaya (var. *Tripura papita*), and jackfruit. Dwarf or semi-dwarf varieties are preferred for mango and jackfruit. It is recommended to maintain a spacing of at least 15 to 20 feet between mango trees to ensure proper growth and access to sunlight. Jackfruit trees generally require more space, so maintaining a spacing of around 20 to 30 feet between them accommodates their



Production of hybrid Napier in and around the pond dikes

size and canopy spread. Planting lemon plants on the dikes serves as a 'bio-fence,' securing the pond and its dikes from the entry of stray animals. Additionally, cultivating coconut, areca nut, and bamboo on the primary dikes enhances compaction, consolidates dikes and drainage channels, and protects them from weathering. Approximately 20 coconut plants, 40 areca nut plants, and 10-20 bamboo stalks can be planted on the primary dikes of a one-hectare pond. Their cultivation creates shade around the pond peripheries, providing shelters for the fish during the scorching summer season. This integrated farming approach not only generates additional income and year-round employment for the farm family but also meets their fruit needs.

Vegetable cultivation on pond dikes: The secondary pond dikes offer opportunities for cultivating vegetable creepers like bottle gourd, ash gourd, country beans, pumpkin, bitter gourd, and ridge gourd by creating bamboo trellises or scaffolds on the dikes. The primary pond dikes can also be used for cultivating cruciferous crops such as cauliflower and cabbage. This not only generates additional income and employment



Utilization of pond dikes for banana (var. sabri) cultivation

but also helps maintain an ambient pond temperature, preventing a drastic decline in pond water temperature during winter and minimizing the risk of Epizootic Ulcerative Syndrome (EUS) in fish, which tends to occur during winter when water temperature declines significantly. The pond sediment is rich in nutrients, containing 1.3-1.5% organic carbon, available nitrogen 40-45 mg, and available phosphorus 20-25 mg, providing opportunities for its use as fertilizer in agricultural lands. When mixed with soil during seed bed preparation, pond sediment enhances seed germination and growth. Pond dikes further provide platforms for off-season vegetable cultivation using nutrient-rich pond water for life-saving irrigation. Cultivating cabbage, cauliflower,

knolkhol, etc., generates 10-20% residues that can be used to feed fish or livestock animals or create high-quality compost, serving as pond fertilizer. In a study at ICAR Tripura Centre, compost from cabbage and cauliflower residues was found to contain 1.2% nitrogen, 0.8% phosphorus, 0.7% organic carbon, 0.05% copper, 0.02% zinc, 0.07% iron, and 0.12% manganese, with its application effectively improving soil health status.

Spice-crops and flower cultivation on pond dikes: The primary dikes offer versatile opportunities for spice crop cultivation, including chilli, ginger, turmeric, and black pepper. Areca nut and coconut plants can serve as supportive substrates for black pepper growth. Cultivating flowers like marigold,

Table 1. Economic appraisal of scientific fish farming technologies under different pond systems (fish stocking density: 10,000 fingerlings/ha; survival rate: 80%; avg. marketing size: 400 to 600 g)

Pond type	Existing fish production (kg/ha)	CFC system	Fish production following CFC (kg/ha)	Price (₹)	Total benefit (₹)	Total cost (₹)	Net benefit (₹)	Impact (Yield/Economic returns)
Perennial pond (10-12 months culture period)	2000-2500	Indian major carps (fish composition: 40% Catla, 30% Rohu, 30% Mrigal)	3600-4000	150-200	540000-800000	400000-450000	140000-400000	Increased fish yield by 1.8-2.0 times compared to existing production; net income of ₹1.4-4.0 lakhs/ha/year
		Chinese carps (fish composition: 40% Silver carp, 30% Grass carp, 30% Common carp)	4800-5200	100-150	480000-780000	400000-450000	80000-330000	Increased fish yield by 2.4-2.6 times compared to existing production; net income of ₹0.8-3.3 lakhs/ha/year
		Indian major carps + Chinese carps (fish composition: 20% Catla, 20% Silver carp, 15% Rohu, 15% Grass carp, 15% Mrigal, 15% Common carp)	4400-4800	100-200	440000-960000	400000-450000	40000-510000	Increased fish yield by 2.2-2.4 times compared to existing production; net income of ₹0.4-5.1 lakhs/ha/year
Seasonal pond (5-6 months culture period)	500-1000	Medium carps (40% Java puti, 30% Bata) + minor carp (10% Mola) + Tilapia (20%)	1500-2000	100-300	150000-600000	100000-150000	50000-450000	Increased fish yield by 1.5-4.0 times compared to existing production; net income of ₹0.5-4.5 lakhs/ha/year



Utilization of pond dikes for creeper crop (Bottle gourd) cultivation

rose, and gladiolus around the dikes provides additional income and employment year-round. In Tripura markets, a gladiolus stick sells for ₹5, and a marigold flower costs ₹0.25. Leveraging the spaces available with pond dikes not only diversifies income sources for farmers but also contributes to the ornamental and spice markets, enhancing overall agricultural sustainability and livelihoods.

Table 2. Economic benefit from the utilization of pond dikes for various agri-horticultural crops

Crop	Variety	Production	Price	Gross return (₹)	Net return (₹)	Employment generation (Man-days)	Season
Field crops (50 sq. m area)	Paddy	40-50 kg (paddy)	15.00	600-750	500-650	10-15	Kharif
		150-200 kg (straw)	2.00	300-600	250-550		
	Maize	50-100 kg (cobs)	30.00	1500-3000	1200-2500	15-20	Kharif
		200-300 kg (fodder)	2.00	400-600	300-500		
	Mustard	10-20 kg (mustard)	50.00	500-1000	400-900	10-12	Rabi
Fruit crops (5 plants each)		40-50 kg (leaves)	5.00	200-250	150-200		
	Pulses	40-50 kg	50.00	2000-2500	1500-2000	15-20	Rabi
	Mango	150-200 kg	25.00	3750-5000	3000-4000	25-30	Summer
	Guava	80-100 kg	30.00	2400-3000	1800-2300	20-25	Winter
	Papaya	100-200 kg	30.00	3000-6000	2200-4800	20-25	All seasons
	Jackfruit	200-300 kg	20.00	4000-6000	3000-4800	25-30	Summer
	Lemon	40-50 kg	20.00	800-1000	600-800	15-20	All seasons
Seasonal vegetables (50 sq. m area)	Banana	10-20 bunches	500.00	5000-10000	3500-7000	30-40	All seasons
	Creepers	50-100 kg	30.00	1500-3000	1000-2400	25-30	Kharif
	Leafy	50-100 kg	20.00	1000-2000	800-1600	20-25	Rabi
	Cruciferous crops	80-100 kg	30.00	2400-3000	1800-2400	25-30	Rabi
	Tomato	40-50 kg	30.00	1200-1500	900-1200	20-25	Rabi
	Eggplant	40-50 kg	30.00	1200-1500	900-1200	20-25	Kharif
Tuber crops (50 sq. m area)	Elephant foot yam	80-100 kg	50.00	4000-5000	3000-4000	30-35	Kharif
	Dioscorea	40-50 kg	50.00	2000-2500	1500-2000	25-30	Kharif
	Colocasia	40-50 kg	50.00	2000-2500	1500-2000	25-30	Kharif
Spice crops (50 sq. m area)	Turmeric	40-50 kg	50.00	2000-2500	1500-2000	25-30	Kharif
	Chilli	40-50 kg	80.00	3200-4000	2400-3200	30-35	Kharif
	Ginger	40-50 kg	50.00	2000-2500	1500-2000	25-30	Kharif
	Black pepper	10-20 kg	100.00	1000-2000	700-1600	20-25	All seasons
Plantation crops	Coconut (5 plants)	200-300 nos.	30.00	6000-9000	4500-6750	30-35	All seasons
	Areca nut (20 plants)	800-1000 nos.	1.00	800-1000	600-750	25-30	All seasons
	Bamboo (10 stalks)	40-50 nos.	15.00	450-750	300-600	20-25	All seasons
Flower crops (50 sq. m area)	Marigold	10-20 kg	50.00	500-1000	400-800	25-30	Winter
	Rose	5-10 kg	100.00	500-1000	400-800	25-30	Winter
Fodders (100 sq. m area)	Hybrid Napier	400-500 kg	5.00	2000-2500	1500-2000	25-30	All seasons
	Paragrass	200-300 kg	5.00	1000-1500	800-1200	20-25	All seasons
Duckweed (10 sq. m area)	Azolla	80-100 kg	10.00	800-1000	600-800	15-20	All seasons
Total				60000-89450	45000-67088	150-200	



Utilization of pond dikes for cole crop (cabbage) cultivation

Recommendations for farmers

The fish farmers with perennial ponds can adopt a modified composite fish culture system with a combination of Indian major carps (Catla, Rohu, Mrigal) and Chinese carps (Silver Carp, Grass Carp, Common Carp) to achieve a net income of ₹40,000-5,10,000 per ha annually. This system can increase their fish yield by 2.2-2.4 times compared to existing production levels. For farmers with small and seasonal ponds (5-6 months water retention period), adopting a polyculture system with medium carps (Java Puti, Bata), minor carps (Mola), and Tilapia is recommended. This system can yield a net income of ₹50,000-4,50,000 per ha annually while increasing their fish yield by 1.5-4.0 times compared to existing production levels. Additionally, the utilization of pond dikes for various agri-horticultural crops can generate an additional ₹60,000-89,450 in yearly

income and 150-200 additional man-days of employment.

SUMMARY

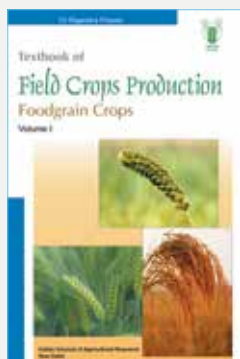
The piscicultural landscape in Tripura predominantly comprises small and marginal farmers grappling with resource constraints, rendering the adoption of capital-intensive composite fish culture unfeasible. The prevalence of small and seasonal ponds, with a mere 5-6 month water retention period, further exacerbates the challenge, hindering the application of scientific fish culture techniques. This predicament yields meager incomes and poses significant hardships for the pond-dependent populace. However, a transformative solution emerges through the strategic adaptation of fish culture approaches, tailored to the resource capacities of farmers. The integration of pond dikes with diversified agricultural and horticultural endeavours, coupled

with the implementation of modified composite fish culture, presents an avenue for substantial year-round food production and livelihood enhancement. In Tripura's context, a prudent deployment of low-cost composite fish culture can yield a net income ranging from ₹40,000 to ₹510,000 per ha annually. Moreover, harnessing the potential of pond dikes holds the promise of an additional ₹60,000-89,450 in yearly income and 150-200 additional man-days of employment. Consequently, embracing pisciculture coupled with pond dike utilization emerges as a highly recommended strategy, ensuring optimal resource utilization and fostering enhanced year-round income and employment opportunities for the upliftment of fish farmers in NE India in general and Tripura in particular.

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Textbook of *Field Crops Production* – Foodgrain Crops

(Volume I)



The first edition of Textbook of Field Crops Production was published in 2002 and there has been a heavy demand for the book. This book is now being brought out in two volumes. The chapters cover emerging trends in crop production such as System of Rice Intensification (SRI), export quality assurance in the production technology of commodities like Basmati rice, organic farming, resource conservation technologies, herbicide management etc. Good agronomic practices must judiciously inter-mix the applications of soil and plant sciences to produce food, feed, fuel, fibre, and of late nutraceuticals while ensuring sustainability of the system in as much possible environment and eco-friendly manner. The advent of hydroponics, precision farming, bio-sensors, fertigation, landscaping, application of ICT, GPS and GIS tools, micro-irrigation etc. is in the horizon. The textbook covers both the fundamentals of the subject and at the same time inspire and prepare both teachers and students for the emerging frontiers.

TECHNICAL SPECIFICATIONS

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