RIVER RANCHING GUIDELINES

River Ranching : National Guidelines for the Conservation of Indigenous Fish Germplasm in Indian Rivers

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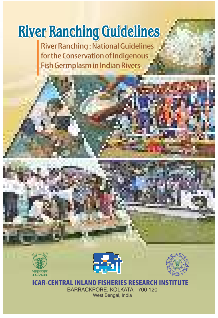

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River Ranching: National Guidelines for the Conservation of Indigenous Fish Germplasm in Indian Rivers

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सत्यमेव जयते

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जल संसाधन,
नदी विकास और गंगा संरक्षण विभाग
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MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES,
RIVER DEVELOPMENT & GANGA REJUVENATION

FOREWORD

The riverine systems of India play an important role in providing livelihood and food security to millions of people living in their basin by supporting diverse aquatic life. Ganga, India's national river, rises from the Gangotri Glacier, running approximately 2525 kilometers through the heart of India before merging with the Bay of Bengal. The '*Namami Gange*' program envisages a holistic approach towards rejuvenation, conservation, and cleaning of the river Ganga.

The rivers are known for their rich fish biodiversity, which demands protection and preservation to overcome recent anthropogenic challenges. Increasing sewage effluents, water abstraction, overexploitation of fish stocks, climate change, and other pollutants have resulted in a massive restructuring of fishery resources in recent years. The decreasing population of aquatic fish species in the riverine system is alarming. Conservation of endemic species of any natural inhabitants without contaminating the genetic pool is a serious challenge.

It is of utmost importance to restore the viable populations of all endemic and endangered biodiversity of the river and the species occupying their full historical range to fulfil their role in maintaining the integrity of the river ecosystem. River ranching is a critical conservation practice that helps species return to their natural environment. An ex-situ conservation technique works well with captive breeding and ranching to form an efficient conservation strategy. Mere governmental efforts cannot achieve the task of river rejuvenation. It requires the participation of all the stakeholders.

I am happy to note that ICAR-Central Inland Fisheries Research Institute has developed a comprehensive document on guidelines for the river ranching program under the '*Namami Gange*' program of the National Mission for Clean Ganga. This would certainly be helpful towards river rejuvenation and conservation. The present document, River Ranching: National Guidelines for the Conservation of Indigenous Fish Germplasm in Indian Rivers," would guide all stakeholders and policymakers to conduct the appropriate river ranching on a mass level nationwide. I wish all the best to ICAR-CIFRI for this excellent initiative.

(G. Asok Kumar)

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Preface

India is blessed with diverse river systems that extend 45,000 km in length and have a combined catchment area of 3.12 million km^2, which includes 113 river basins. Regarding water output rather than length or width, the Ganges ranks third globally and is one of the longest rivers to pass through India (2,525 km). One of Asia's transnational rivers originates in the western Himalayas of the Indian state of Uttarakhand, flows across North India's Gangetic Plain into Bangladesh, and then empties into the Bay of Bengal.

India has an extensive network of rivers running throughout the nation, however, due to the growing human population and numerous anthropogenic activities, the diversity of fish and fish production and productivity are steadily declining in almost all of India's rivers. One of the most crucial alternatives for reviving riverine fisheries and conserving the native threatened species is the identification of suitable species, the prioritization of appropriate species in the individual riverine systems, and the proper ranching of those species.

With the "Namami Gange" programme (NMCG), ICAR-CIFRI has initiated a river ranching programme in Indian rivers emphasising the river, Ganga. IMCs-catla *Labeo catla*, rohu *Labeo rohita*, mrigal *Cirrhinus mrigala*, calbasu *Labeo calbasu*, and other depleted stocks like hilsa *Tenualosa ilisha*, striped dwarf catfish *Mystus vittatus*, etc. are being raised in several locations along the Ganga River.

In India, ICAR-CIFRI was the organization that first popularized the idea of river ranching and has already released more than 86.97 lakh IMC seeds along the various stretches of the Ganga. A total of 90,669 hilsa brood fish were also released upstream of the Farakka barrage to revive the fish population in the Ganga River. Together with ranching, several awareness-raising campaigns were conducted among fishers to encourage the preservation of the river's fish population for long-term management. Considering this, ICAR-CIFRI has created this national guideline for the conservation of native fish germplasm in Indian rivers for the restoration of depleted stocks as well as the enhancement of fish production. This important document is being released at the G20 Summit, and it is anticipated that the planners, policymakers, line departments, and other stakeholders will find the guidelines useful in reviving the riverine fish stocks and production.

B. K. Das
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January 2024

1 Introduction

India is blessed with large numbers of river systems that run into a total length of 45,000 km with a total catchment area of 3.12 million km^2 comprising 113 river basins (Ayyappan et al., 2019). A total of 15 major (drainage basin >20,000 km^2), 45 mediums (2,000 to 20,000 km^2), and over 102 minor (<2,000 km^2) rivers are drained in the Indian mainland, besides numerous ephemeral streams in the western arid region (Fig. 1). The Indian River systems are grouped based on their origins, such as Himalayan rivers and Peninsular rivers, or according to the direction of flow into east-flowing rivers and west-flowing rivers (Table 1). The Ganga-Brahmaputra-Meghna rivers system includes the main river, the Ganga, and its tributaries (Ramganga, Gomti, Gandak, Koshi, Sone, Yamuna, etc.), eventually, flow into the Bay of Bengal through Bangladesh.

The Ganges is the world's third largest river, measured in water output rather than length or width, and one of the longest rivers to flow through India. The Ganges, which flows through India and Bangladesh, is a transboundary river of Asia. The 2,525 km river rising in the western Himalayas in the Indian state of Uttarakhand flows south and east through the Gangetic Plain of North India into Bangladesh and drains into the Bay of Bengal. The Brahmaputra has a combined length, with its 41 main tributaries, in India is about 4,000 km with a catchment area of approximately 580,000 km^2 (195,000 km^2 in India) and an average water discharge of 510,450 m^3.

The Indus system includes the river Indus and its tributaries, such as Jhelum, Chenab, Beas, Sutlej, and Ravi originated in the north and generally flow in the west or southwest direction into the Arabian Sea through Pakistan. The east coast flowing rivers, such as Mahanadi, Brahmani, Baitarni, Subernarekha, Damodar, Krishna, Godavari, Cauvery, etc., flow into the Bay of Bengal along the eastern coast. Narmada and Tapti rivers originate in the central peninsular and flow western into the Arabian Sea at Gujarat. Other west-flowing rivers usually carry relatively little flow, such as Mahi, Sabarmati, and Luni are flowing through Rajasthan and Gujarat flow into the Arabian Sea at Gujarat, and some are lost through internal drainage.

The rich biodiversity in a river ecosystem is the ultimate indicator of the river's health. The ever-increasing demand for development has resulted in water scarcity and water quality degradation throughout the river basin. In the last several decades, many of the rivers have been highly perturbed due to different anthropocene such as water abstraction for agricultural and industrial water supply, deforestation, pollution, and fragmentation of river systems by various barriers and diversions, due to which steady decline seen in the population of several indigenous fish stock and biodiversity (Poff et al., 1997; Sarkar et al, 2012; Dastagir, 2015). Since the riverine catch of fishes solely depends on their natural recruitments, priced riverine fishes, including carps, featherbacks, catfishes, etc., have been affected due to habitat alterations along the river stretch. Climate change is a critical factor affecting the world's fisheries. The differences in temperature and rainfall patterns caused the breeding failure of the Indian major carp and a consequent decline in fish spawn availability in the river Ganga. Fish production showed a distinct change in the last two decades in the middle stretch of river Ganga where the contribution of IMCs has decreased from 41.4% to 8.3%, and that of various catfish species increased. Fish production showed a distinct change in the last few decades in the middle stretch of river Ganga. The average contribution of IMC to total landing was 38.09% during 1956–1967, which reduced to 15.00 % during 2005–2018 in the Allahabad stretch, and that of various catfish species increased (Jha et al., 2020). Other issues like the rising stock of exotic fishes and habitat destruction have also added to the decline of valuable native major carp (Jha et al., 2020). Additionally, obligatory aquatic species like water birds and island nesting birds are greatly impacted due to the change in the system.

Promoting the sustainable use and conservation of fishery resources in an economically and environmentally responsible manner has become the need of the hour. The river ranching program is one such activity that can achieve sustainable fisheries, reduce habitat degradation, conserve biodiversity, maximize socioeconomic benefits, and assess ecosystem services. Nevertheless, river ranching also ensures the upgradation of the traditional fishing, ecosystem sustainability, trade, and social protection of inland communities.

Table 1. Details profile of important river systems of India

River system	Name of the main river	Approx. length (in km)	State(s) covered
Himalayan Ganga	Ganga	2525	Uttarakhand, Uttar Pradesh, Madhya Pradesh, Jharkhand, Bihar, West Bengal
	Ramganga	569	Uttar Pradesh
	Gomti	940	Uttar Pradesh
	Ghagra	1080	Uttar Pradesh, Bihar
	Gandak	300	Bihar
	Kosi	492	Bihar
	Subernarekha	395	Bihar, Odisha, West Bengal
	Yamuna	1376	Uttarakhand, Haryana, Delhi, Uttar Pradesh
	Chambal	1080	Madhya Pradesh, Uttar Pradesh, Rajasthan
	Tons	264	Uttarakhand
	Sone	784	Uttar Pradesh
	Ken	360	Madhya Pradesh, Uttar Pradesh
	Damodar	592	Jharkhand, West Bengal
Brahmaputra	Brahmaputra	4000	Arunachal Pradesh, Assam
	Dibang, Siang		Assam
	Lohit, Manas		Nagaland
	Duri Dihang		Sikkim
	Dhansiri, Koppili		Manipur

River system	Name of the main river	Approx. length (in km)	State(s) covered
Indus	Jhelum	400	Jammu and Kashmir
	Chenab	330	Jammu and Kashmir, Himachal Pradesh
	Beas	460	Himachal Pradesh, Punjab
	Sutlej	1450	Himachal Pradesh, Punjab
	Ravi	725	Jammu and Kashmir, Himachal Pradesh, Punjab
Peninsular Rivers East Coast	Mahanadi	857	Chhattisgarh, Madhya Pradesh, Odisha,
	Brahmani	799	Bihar
	Baitarani	360	Odisha
	Godavari	1465	Maharashtra, Andhra Pradesh
	Krishna	1401	Maharashtra, Andhra Pradesh, Karnataka
	Cauvery	800	Tamil Nadu, Karnataka
	Pennar	597	Karnataka, Andhra Pradesh
	Bhima	861	Karnataka
West Coast	Narmada	1312	Madhya Pradesh, Maharashtra, Gujarat
	Tapti	720	Madhya Pradesh, Maharashtra, Gujarat
	Mahi	583	Gujarat
	Sabarmati	371	Rajasthan, Gujarat

Source: Handbook of Fisheries and Aquaculture

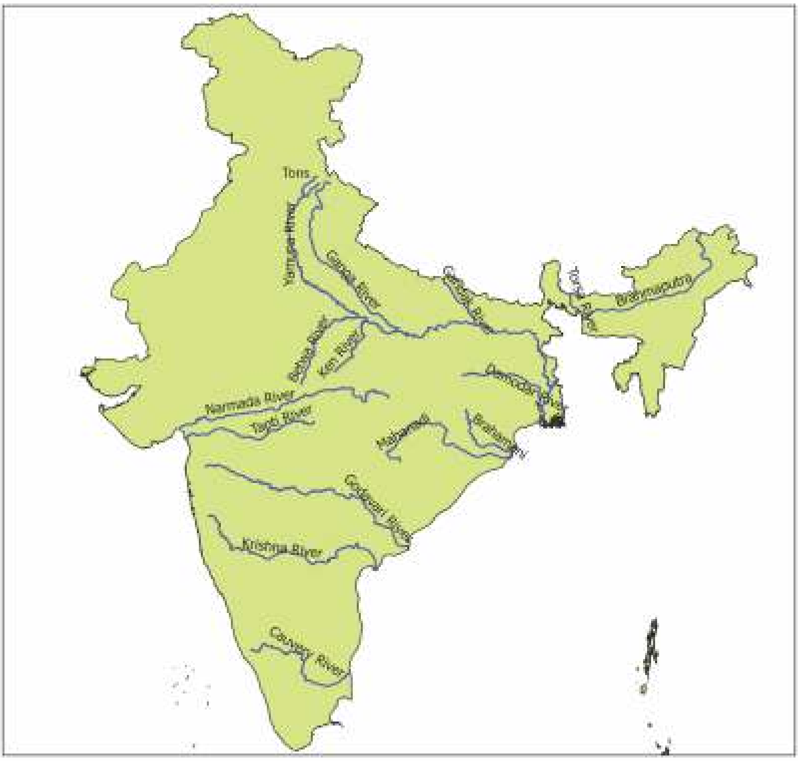

Fig. 1. Map showing the important river systems in India (Map not in scale)

Objectives

The prime objective of conservation is not only to revive the fish stocks but also entrust in maintaining genetically diverse sustainable fisheries.

The key objectives of the component are:

1. To conserve, sustain, and replenish the fish biodiversity of the river system.
2. To felicitate regular stocking of desired indigenous carp and other fish species of river system by using riverine germplasm.
3. To increase overall fish production by ranching desired fish species.
4. To enhance income and livelihood securities to the fishers communities directly or indirectly dependent on the riverine resources.

2 Purpose and scope for ex-situ conservation and river ranching

Fishery resources are increasingly threatened by environmental pollution and human activities, dominating the natural ecosystem, and this impact has accelerated irreversible damage to the habitat, ecosystem functioning, biodiversity, and the traditional fishery and artificial-culture industries. River ranching helps achieve sustainable fisheries, reduce habitat degradation, conserve biodiversity, maximise social-economic benefits, and assess ecosystem services.

Ecological degradation of the river is caused by anthropogenic loading and manmade hindrances thus resulting in a noticeable decline in overall fish production, as the impact is more visible on the indigenous fish fauna of the river like IMCs which have been reduced to a large extent. Conservation of endemic species of any natural inhabitants without contaminating the genetic pool is a serious challenge. It is of utmost importance to restore the viable populations of all endemic and endangered biodiversity of the river and the species occupying their full historical range to fulfil their role in maintaining the integrity of the river ecosystem. Among several managerial methods to conserve and enhance the native fish or germplasm in the river, ex-situ conservation is one of the most effective. As per Convention on Biological Diversity (CBD) Article 2, ex-situ conservation is defined as ***"means the conservation of components of biological diversity outside their natural habitats"*** (Jena and Gopalakrishnana, 2012). Fish ranching can also play a pivotal role in the ex-situ mode of aquatic life conservation. Ranching can be defined as the process through which economically important fish are stocked in the river for future harvest (Das et al., 2020). Therefore, the combined application of these methods would certainly pave the way for conserving germplasm. Realizing the importance of the declining indigenous fish species in the river and the importance of ex-situ conservation, an effort is made to standardize ranching protocol in the river keeping the Indian Major Carp (IMC), viz., *Labeo rohita, L. catla*, *Cirrhinus mrigala*, and *L. calbasu* as the targeted species. The protocol may also be helpful for river ranching of other indigenous fish species and other inland open-water bodies with suitable, need-based modifications.

3 Methodology for River ranching

To retain genetic integrity, a captive breeding plan of wild IMCs for the river ranching program is developed following standard protocols (Figs. 2 and 3).

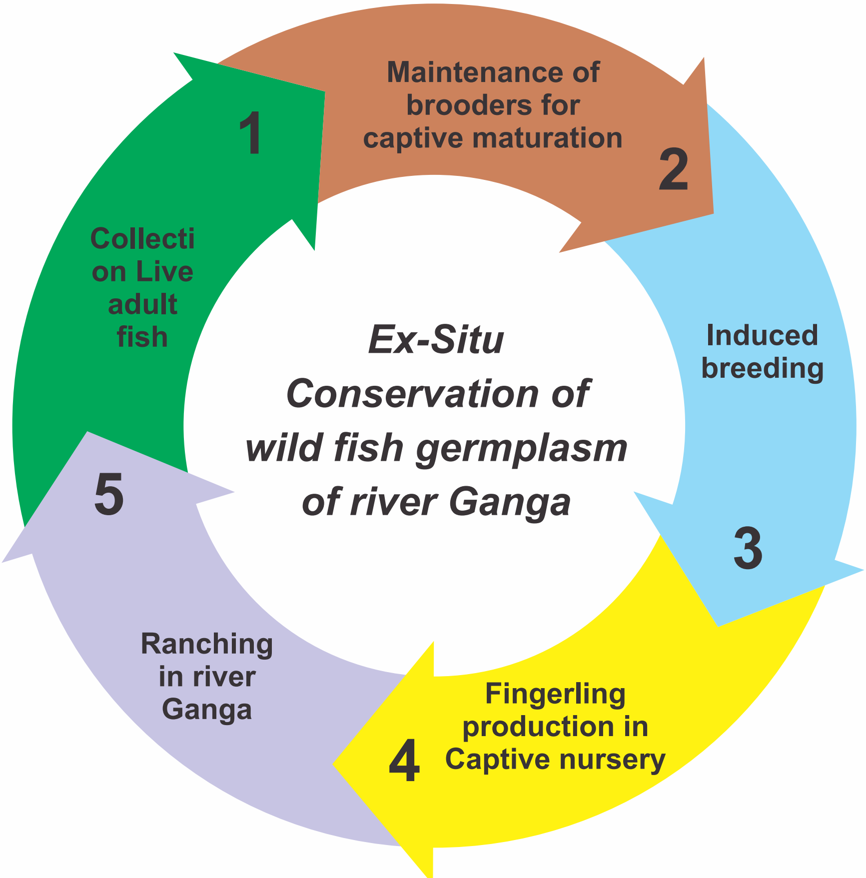

Fig. 2. Steps followed for ex-situ conservation of wild fish germplasm

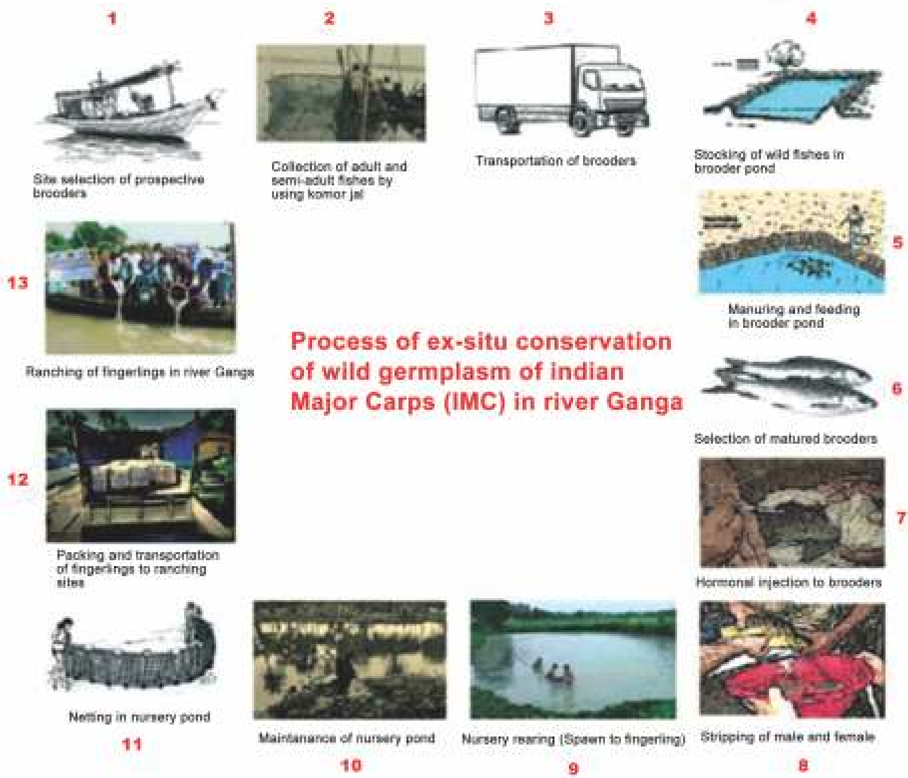

Fig. 3. Processes followed for ex-situ conservation of Indian major carps in river Ganga

3.1 Brood stock collection and transportation

A group of adult individuals employed specifically in aquaculture for breeding purposes is known as brood stock or broodfish. Brood stock sources for the river ranching program are always obtained from the wild populations in which they naturally breed. After being harvested and reared in a confined space, they are artificially bred to provide stocking materials.

Site selection for potential brooder collection is mainly driven by observations of fish availability through experimental fishing, catch information, and fishermen's feedback. To prevent genetic contamination, live and healthy fish (brooders, subadults, etc.) should be obtained from rivers or water bodies that are actively connected to rivers (open wetlands). Live fish can be captured with harmless fishing gear, such as encircling gear (locally known as "Komor Jal" in West Bengal). One of the most important and challenging tasks is transporting the brood fish from the collection site into the well-maintained brood stock pond. The appropriate procedures must be followed to transport adult and subadult fish that remain healthy while maintaining the optimum stocking density and water quality.

3.2 Conditioning of brood fish before transportation

Brood fish for long transportation need to be conditioned properly. Brood fish are usually kept starving in a cloth 'hapa' in relatively quiet water in a canal or river before transferring them.

The advantages of conditioning:

- The brood fish become used to confined conditions.
- The brood fish are less excited and thus restrained in energy expenditure.
- The brood fish recover from the handling effect of capture - increased blood lactate level and decreased blood pH becomes normal.
- The brood fish recover from minor injury - mucus loss, etc. - Ion-osmotic balance upset by handling becomes normal.
- During conditioning, gut evacuation, the medium is not further contaminated by faecal matter during transportation.

3.3 Method of brood fish transportation

Transport carriers are of two types:

(a) Open system comprising open carriers, with or without artificial aeration/oxygenation/ water circulation.

(b) Closed system having sealed airtight carriers with oxygen.

(a) Open system

The brooders may be transported in large open containers for short distances and large metallic rectangular open tanks fitted in the vehicle with proper aeration facility for longer distances to maintain the dissolved oxygen in the tank water (Berka, 1986). Water is continuously agitated during transportation, and foul water is bailed out periodically.

Collection site

Brooder collection

Transportation in an open container

Transportation in an open metallic tank

Fig. 4. Collection and transportation of wild brooders

(b) Closed system

This technique provides compressed air or pure oxygen to fill the space over the water surface in the airtight containers, exposing the water surface to it. Large closed-system carrier tanks have been designed to transport larger brooders. Splashes of water in the tank are beneficial because the fish sustain less damage (Das et al., 2015).

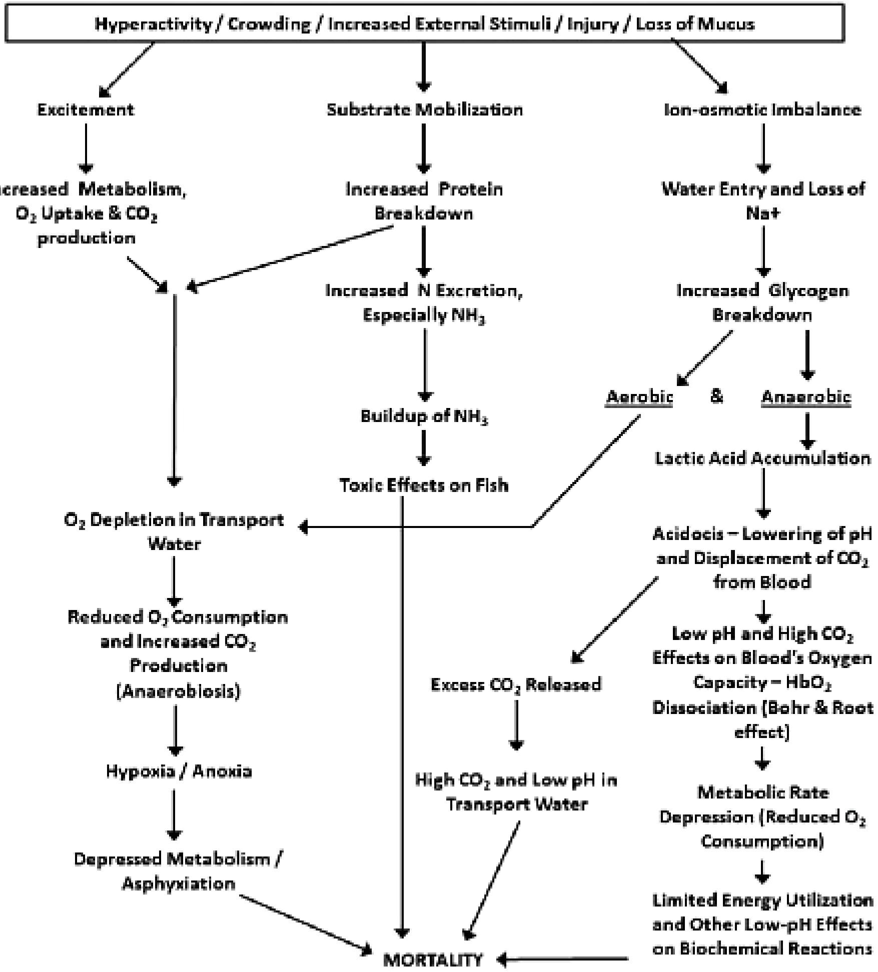

Fig. 5. Flowchart showing the potential effects of handling and transport of fish (After Delince, Cambel, Janssen and Kutty, 1987)

Points to be considered for brood stock transportation:

- The brooders must be in good health and be capable of being transported.
- The travel time must be as short as possible.
- Once the brooders are packed, the transportation process shouldn't take excessively long.
- Overstocking ought to be minimized.
- To prevent metabolite buildup in the water, the brooders should have low metabolic activity while transported.
- Care must be taken for safer transport.

3.4 Brood stock management

Brood stock management involves manipulating environmental factors surrounding the brood stock to ensure maximum survival, enhance gonadal development and increase fecundity (Izquierdo et al., 2003). Such conditioning is necessary to ensure the sustainability of aquaculture production, improve the number and quality of eggs produced, and control the timing of maturation and spawning (Mylonas et al., 2010).

For captive maturation and preserving wild germplasms, maintain the potential brood fish in the brood stock pond. Before stocking, fish should acclimatize and undergo a prophylactic treatment with a 3% $KMnO_4$ solution. Rectangular ponds with an area of 0.2-0.5 ha and an average water depth of 1.5 m are preferred for brood fish raising. The fish should be maintained at the stocking density of 1500 kg/ha to avoid overcrowding.

Proper monitoring of stocked fish health and maintaining the best possible water quality are crucial to brood stock management. Brooders can consume traditional supplementary feed such as rice bran and groundnut oil cake (1:1) at 2% of their body weight. However, it is preferred to feed the brood fish a farm-made, specially formulated diet with crude protein at 33.0%, crude fat at 10.0%, and gross energy at 4,000 Kcal/kg of feed (Gupta et al., 1995, Table 2).

Table 2. Formulated feed for Indian major carp (IMC) brood stock

Ingredients	Quantity
Groundnut oil cake (kg)	70.0
Rice bran (kg)	28.4
Common salt (kg)	1.5
Trace elements (kg)	0.1
Vitamin C (g)	10.0
Vitamin E (g)	3.0

(Trace elements: ferrous sulphate 50.0 g, copper sulphate 8.0 g, zinc oxide 6.7 g, manganese sulphate 15.4 g, potassium iodide 4.2 g, cobalt chloride 2.0 g, calcium carbonate 13.7 g)

A diet for carp named "CIFABROOD" is developed for the intensive brood-rearing program. This feed includes groundnut oilcake, rice bran, fish meal, soya meal, vegetable oil, and vitamin-mineral premix (Table 3).

The condition of the brood fishes' gonads and their general health must be monitored frequently. Brooders may be tagged to maintain accurate records of each fish's origin, location, date of collection, sex, length, weight, etc.

Table 3. Nutrient level of CIFABROOD on dry matter basis

Nutrient level	% Share
Crude protein	21.3
Crude lipid	11.7
Gross energy	3.9 kcal/g

3.5 Selection of mature brooder and captive breeding

Selecting the right brood fish is one of the most crucial steps to gaining good breeding and growth results. Male and female fish must be removed from the tank at least three months before the breeding season to prevent unwanted breeding. Stress management while netting is vital during segregation. Secondary sexual morphological traits that develop throughout the breeding season can distinguish males from females (Table 4). When the abdomen is gently pressed, the sperm freely flows in males, and the development of the ovaries creates a swollen abdomen in females. The fish must be kept in adequate space and fed a protein-rich diet to promote healthy gonadal development and high-quality egg production.

Fully matured, healthy, and non-deformed gravid brooders may be selected for breeding operations. Selected brooders artificially breed through injection of inducing agents such as carp crude pituitary extract (CPE) or synthetic hormone (SH) (Table 5) by following the standard hatchery operational procedures like injection, spawning, hatching, etc. In breeding operations, if the breeding pool is used, then brooders of single species need to be put in the breeding pool for spawning to avoid

Fig. 6. Checking the maturity status of the carp brooders

cross-breeding. In the case of stripping, the male and female of the same species need to be used for the stripping.

Fig. 7. Injection of CPE to the IMC brooders of river Ganga

Fig. 8. Stripping of matured eggs for fertilization

Fig. 9. Fertilized eggs shifting in hatching pool

Table 4. Secondary external morphological features of Indian major carps

Characteristics	Male	Female
Scale, operculum, and pectoral fins	Rough to touch, particularly the dorsal surface of pectoral	Pectoral smooth to slippery
Abdomen	Round and firm	Swollen and soft
Genital opening swollen	Elongated slit, white in colour, not swollen	Round and pink
When pressure applied to abdomen opening	Milky white fluid oozes through genital opening	A few ova may ooze through genital
Shape of body and size	Body linear, swollen	stouter, slightly large

Table 5. Dose of different inducing agents for the brooders

Inducing agents	Male	Female	
	Single dose	**First dose**	**Second dose**
Carp Pituitary extract (CPE)	2-3 mg/kg	2-4 mg/kg	8-10 mg/kg

* Whenever carp pituitary extract is not available, synthetic hormone may be used, and doses should be given as per the manufacturer's instructions.

Injection methods

- Pituitary, ovaprim, or ovatide are intramuscularly injected into the muscle on the caudal peduncle, which is located between the dorsal fins posterior end and the lateral line. It is the most secure and efficient, and widely used technique.
- A soft body area, such as the pectoral fin or pelvic floor, is injected intraperitoneally. This technique could harm the gonad or liver.
- On the skull, an intracranial injection is delivered. The brain is harmed by this procedure, which is quite hazardous.

4 Breeding and seed production techniques of IMCs

4.1 Catla (*Labeo catla*)

- ✓ Catla, the fastest-growing major carp in India (grows to 1.0-1.5 kg/yr), is an important component of the country's carp polyculture system.
- ✓ Matures in its second year of life and only propagates during the monsoon season in flowing rivers and streams (May to September).
- ✓ Together with other Indian major carp, two- to three-year-old class brooders are produced in the earthen pond(s) at a 1,500–2,000 kg/ha biomass.
- ✓ Pituitary extract or synthetic hormones such Ovaprim, Ovatide, Ova FH, etc., are injected to induce brooding.
- ✓ Pituitary extract is administered to females in two dosages of 2-3 mg/kg and 4-6 mg/kg at 6–8 hours intervals, whereas males get a single dose of 2-3 mg/kg. However, a single dose of 0.4–0.5 ml/kg for females and 0.2–0.3 ml/kg for males is administered when using synthetic hormones.
- ✓ The current method of induced breeding in circular echo hatcheries maintains a 1:1 female to male ratio. In the breeding pool, the injected broods are released. Spawning occurs 6 to 8 hours after injection.

- ✓ Typically, 1.0-1.5 lakh eggs per kg of the female are produced, and the fertilization rate exceeds 90%. The eggs are moved to a tank for hatching, where they are maintained in a floating condition with proper water circulation.
- ✓ Hatching occurs satisfactorily 80–95% of the frequency in 18–22 hours at 27–28 °C. While their yolk sac can last up to 72 hours, the hatchlings are kept in the same hatching tank for two additional days without being fed.
- ✓ When transferred to the nursery, these free-swimming hatchlings, commonly known as spawn, reach a size of approximately 5–6 mm. The spawn is raised in earthen nursery ponds and concrete tanks for 15-20 days, growing to an average fry size of 25 mm with survival rates of 30-35% and 50-60%, respectively, at stocking densities of 3-5 million/ha and 8-10 million/ha.

Fig. 10. A matured catla from river Ganga

4.2 Rohu (*Labeo rohita*)

- ✓ The most significant Indian major carp in the Indian Subcontinent is rohu (*Labeo rohita*). It attains maturity in the second year of life and only spawns during the monsoon in riverine environments.

- ✓ Brooders of the 2+ year class are raised in earthen ponds with a 1,500–2,000 kg/ha biomass for captive breeding.
- ✓ During the spawning season, the sexes are differentiated, with females having protruding abdomens and softer pectoral fins. The male has a narrow body and rough pectoral fins, and when the belly is pressed, milky-white milt pours from the vent.
- ✓ Hatcheries or hapas are used for captive spawning. In hapa breeding, a female-to-male sex ratio of 1:2 is maintained. In contrast, the female-to-male ratio in circular hatcheries is maintained stable at 1:1.
- ✓ Either synthetic hormones or pituitary extract are injected into the brooders. The pituitary extract is administered intravenously in two doses to females along with one to males. However, when the synthetic hormone is used, a single dose of 0.4–0.5 ml/kg for females and 0.2–0.3 ml/kg for males is administered.
- ✓ Spawning happens 6–8 hours after the injection. Round, clear, semi-buoyant eggs, around 2.0 lakh, are hatched by a female weighing one kilogram.

Fig. 11. A matured rohu from river Ganga

- ✓ In a hatchery's spawning tanks or hatching hapa, eggs are kept for 8–22 hours at 27-28 °C. The hatchlings are kept in the hatching tank for an additional two days.
- ✓ The 5- to 6-mm-sized spawn, which is 3 days old, is now ready for additional nursery care. The spawn is raised in earthen nursery ponds at stocking densities of 5–10 million/ha or even more densely at 10–20 million/ha in concrete nurseries.

4.3 Mrigal (*Cirrhinus mrigala*)

- ✓ Mrigal is one of the three major carp in India and is a key component of the carp polyculture system.
- ✓ In confined water, it does not reproduce. It propagates naturally during the monsoon in fluviatile riverine conditions.
- ✓ The brooders are raised in ponds alongside other Indian major carp for captive breeding at a 1,500–2,000 kg/ha biomass. It takes a second year to reach maturity.
- ✓ When the fish are fully matured, from May to August, which coincides with monsoon season, successful induced breeding is performed.
- ✓ At mature, the sexes are separate and distinct, with females having a protruding belly and soft, smooth pectoral fins, while males are thin, have stout, rough pectoral fins, and have milt that oozes when the belly is pressed.
- ✓ In hapa systems, brooders are selected and paired in a 2:1 female-to-male sex ratio, while this is 1:1 in hatchery systems. They undergo induced breeding with synthetic hormones (CH) like Ovaprim/Ovatide/Gonopro FH or pituitary extract (PE).
- ✓ While a single CH injection is quite effective for both males and females at 0.3-0.4 ml and 0.15-0.20 ml/kg body weight,

respectively, the PE requires two doses at 2-3 and 6-8 mg/kg and @ 2-3 mg/kg body weight at 6 h intervals for female and @ 2-3 mg/kg for male at the time of second injection to female.

- ✓ Spawning happens after 6-8 hours, and hatching occurs after 14–16 hours. In general, 75–90% of eggs are fertilized. Hatchlings grow to spawn size in another 55–60 hours with an 80–90% survival rate.
- ✓ Spawn is raised at a density of 500–1,000/m^2 for 15–20 days in well-maintained earthen ponds to produce fry that is 20–25 mm in size and have a survival rate of 30–50% or at a density of 1,000–2,000/m^2 for 60–70% survival in cement tanks.

Fig. 12. A matured mrigal from river Ganga

4.4 Kalbasu (*Labeo calbasu*)

- ✓ In a polyculture system, a substantial carp species with a high consumer preference and a moderate growth rate are farmed alongside Indian major carp at a relatively low proportion of about 5%.
- ✓ In pond conditions, the fish reaches maturity in two years. Typically, the breeding season lasts from May until July. The ponds are used to breed brooders and other major carp. Selected brooders are kept in the hatchery's spawning tank in a 1:2 female-to-male ratio to induce breeding.

- ✓ Breeding is carried out by single injection of hormonal formulations such as Ovaprim/Ovatide/Gonopro FH at 0.4-0.5 ml/kg and 0.2-0.3 ml/kg body weight to females and males, respectively. Within 6-8 hours, spawning takes place.
- ✓ Fecundity is 1.5 to 2.0 lakh eggs per kg of female weight. Eggs are clear, demersal, and 3.0-3.5 mm in diameter.
- ✓ The hydrated eggs are shifted to hatching tanks, where they are kept in floating condition with mild water circulation. Hatching takes place in 15–18 hours. The hatchlings are kept in a similar environment with water circulation for an additional two days.
- ✓ These hatchlings' yolk sacs, which provide the necessary nutrients throughout their three days of incubation, are absorbed within 72 hours; at that stage, the spawn is prepared for feeding and shift to the nursery.
- ✓ In earthen nursery ponds and concrete tanks, spawn is raised to an average fry size of about 20 mm in 15-20 days at stocking densities of 5 million/ha and 10 million/ha with 30 and 50% survival rates, respectively.

Fig. 13. A mature kalbasu from river Ganga

5 Carp seed rearing

The success of the river ranching program depends mainly on the availability of the desired size and quantity of seed. It can be achieved through the proper rearing of the seed in seed rearing facilities such as nurseries and rearing ponds as a desired stocking material for river ranching. Seeds of Indian major carps are generally reared in small earthen ponds of 0.02-0.10 ha with a depth of 1.0-1.5 m, though ponds up to 0.5 ha can also be used for large-scale production. Nursery pond preparation begins before breeding by following standard aquaculture practices like drying of the pond, weed clearance, eradication of predatory fish, manuring, insect control, etc. to ensure a high rate of survival and good growth and thereby yields. Nursery rearing involves nurturing 72-96-hour-old spawn for a period of 15-20 days, during which they grow to a fry stage of about 25-30 mm. The fry was further reared in another pond for a period of 2–3 months to raise fingerlings of about 100 mm in size. Newly hatched larvae nourish themselves for 3 days, after which they depend on the natural feed from the environment. The availability of natural feed is most critical during the phase when it changes from the yolk sac nourishment to the commencement of natural feed, besides a suitable ecology to obtain a greater survival percentage. Adequate care is to be taken before initial stocking. Phased manuring with a mixture of groundnut oil cake at 750 kg, cow dung at 200 kg, and single superphosphate at 50 kg/ha is found to be very effective in the production of desired plankton. A thick paste of one third to half the total dose is prepared and applied as a basal dose 2-3 days prior to spawn stocking. The remaining amount is applied later in 2-

Fig. 14. Cleaning of aquatic weed

Fig. 15. Feeding in nursey pond

Fig. 16. Periodical netting in ponds

3 split doses, depending on the plankton levels of the pond during the nursery phase.

The ideal range of spawn stocking density recommended for IMC is 3-5 million/ha (300–500/m^2), with an outcome of 30–40% survival. The most used supplementary feed during the nursery phase has been the powdered mixture of rice bran or wheat bran mixed with groundnut oil cake, mustard oil cake, or cotton seed oilcake in a 1:1 ratio. To achieve greater growth, extra ingredients such as soy flour, fishmeal, vitamins, and minerals can also be included. The dry feed mixture is added in nurseries normally at 0.4 kg/lakh/day from the second day of the release of spawn in a prepared nursery pond. Daily feed quantity is increased roughly by 50-75 g/lakh/day, depending on the consumption pattern. A minimum of two-time feeding or two rations per day is desired.

After 21 days, the fry is to be shifted to the rearing pond for further rearing. The seasonal ponds are preferred over the perennial ponds; also, small ponds have greater scope in terms of effective utilization than larger-sized ponds.

The rearing ponds also need all the pond preparation practices like those followed for nursery ponds, except the insect control practices, for good survival and the production of healthy fingerlings. Cow dung at 3-4 tons/ha and single superphosphate at 30-40 kg/ha are to be added to the rearing pond 10 days before stocking. In addition to this, after stocking, 500 kg/ha of cow dung and 10 kg/ha of single superphosphate are added two times a month. In cases where poultry droppings are applied, the dose may be reduced from one-third to half of the amount of cow dung. The usual stocking density followed varies from 2.0 to 3.0 lakh fry/ha. Feed requirements of the growing fingerlings are met through the available natural fish food and the provision of supplementary feed, commonly in the form of a mixture of groundnut/mustard oil cake and rice bran/wheat bran at a 1:1 ratio by weight. Other ingredients, such as fish meal, soybean flour, a vitamin-mineral mixture, etc., are also suggested to be incorporated for improving the feed quality. Feed is provided at the rate of 8-10% of the biomass of fry stocked per day during the first month, which is reduced to 6-8% and 4-6% of the standing biomass during the subsequent two months. Crumbled pellets, preferably 1-2 mm in diameter, may also be used to reduce feed waste. Periodical samplings of the fry at a fortnightly interval are done to assess the growth and biomass. Once the seed or fingerlings reach >100 mm in size, they are ready for ranching. Small-size fish are not preferred for ranching because they have lower survival rates and are prone to predation in open waters.

5.1 Harvesting

Harvesting of fingerlings is done when they reach about 80-100 mm in length, which generally takes around 2-3 months. Rearing of fingerlings can be extended when advanced-size fingerlings are required. If the fingerlings are needed to be transported, the feeding should be stopped one or two days before harvest to improve conditioning. A minimum of 60-70% survival is attained if best practices are adopted.

5.2 Transportation of fingerlings to the ranching sites

Transportation of live fish is a crucial thing in the river ranching programme. Hence, proper pre-transportation care should be taken. Pre-netting should be done two days before transportation; feeding should be stopped for gut evacuation, application of mahua oil cake at a low dose in the pond, and the fish should be kept in hapa for at least 2-3 hours before transportation. Transportation of live fry and fingerlings is always challenging, as heavy mortality occurs in faulty transportation practices. The seed is commonly transported in polythene bags filled with 1/3 water and 2/3 of high-pressure pure oxygen for short-distance travel. The

Fig. 17. Transportation of seed in Oxygen packets

polythene bags with fish are packed in a cardboard box or tin container. In the case of long-distance, it may prefer to transport the fingerlings in an open tank transportation system (with water exchange, medical grade oxygen supply, oxygen enhancing tablets, and application of sedatives) to reduce stress. The extent of care and precautions during transportation depends on the duration and distance of ranching sites.

Sedatives or anaesthetics may also be used during transportation to ensure better survival. The purpose of this is to ensure that the fish seed survives for a more extended period and to minimize the concentration of toxic gases like ammonia and carbon dioxide in the medium by lowering the metabolic rate of the fish seed.

6 River Ranching

6.1 Fish species to be stocked

The selection of fish species can be prioritised depending on the availability of a standard breeding protocol and the presence of the selected fishes' brooders in the river. Indian major carps (IMCs) are available in all river basins, and since their breeding techniques have long been standardized, these can be considered for the ranching program. The species selection within IMCs may depend greatly on regional importance and the species' availability. ICAR-CIFRI time to time studied riverine fish stocks of several river systems and the depleted species of the respective rivers. A recent study found that rivers like Narmada *Labeo fimbriatus*, *Tor tor*, and *Rita rita* are in declining stages. Orangefin labeo, *Labeo calbasu* is a suitable candidate species of river Cauvery in the Tamil Nadu and Karnataka stretches, as plenty of brooders are available and the species have good local market demands. Mahseer, *Labeo gonius*, etc., have already considerably declined from

Fig. 18. Tor barb, *Tor tor*, a rapidly declining species from the Indian river systems

the river Tapti; henceforth those depleted species might be chosen for ranching of those river systems. Several river systems and states have been identified for the river ranching program. Also, those standard breeding techniques and the native fish species in the chosen rivers might be used for hatchery and nursery rearing. The seed of the indigenous fishes whose breeding techniques have not been standardized can collect from the rivers during their breeding season. They are stocked in the nursery rearing facilities to grow them to fingerling size and used as stocking material for river ranching programs.

Fig. 19. Fringed-lipped peninsula carp, *Labeo fimbriatus*, a declining species from river Narmada

Fig. 20. Orangefin labeo, *Labeo calbasu* a suitable candidate species to be stocked at River Cauvery

6.2 Points to be considered during ranching

- ✓ Ranching must be done with advanced fingerlings (preferably with >100 mm), as the river is a multi-species ecosystem with the habitat of several large carnivores.
- ✓ Prior acclimatization before ranching is vital to an effective programme because the riverine environment differs entirely from the lentic growing environment.
- ✓ Targeted fish species should be released to the respective river systems from a boat or any fishing craft in the middle of the river because local fishers often result in immediate large-scale capture of the released fish and sometimes occasionally.
- ✓ To prevent the intentional immediate capture of the released fish, a public-awareness effort and participation from the wider populace are necessary for the ranching program's success.
- ✓ Local stakeholders, including the fishers' community and administrators, should be involved in the program's successful implementation.
- ✓ To determine the effects of such ranching programme, post-release monitoring is required to limit the use of selective fishing gear.
- ✓ Popular print and media publications, in addition to the distribution of leaflets and pamphlets in the local languages, may produce greater results.

The lives of fishers, who are struggling for their livelihoods due to shifting fishing practices and the decline of fish populations, will be improved by such ranching programmes. In addition to their biomass, fish will serve as biological agents for cleaning up river pollution.


NAMAMI GANGE

Fig. 21. River ranching cum awareness program at river Ganga

6.3 River ranching: an initiative by ICAR-CIFRI, Barrackpore

ICAR-CIFRI continuously strives to manage inland open waters in a way that promotes sustainable fishing, aquatic biodiversity preservation, the integrity of ecological services, and the exploitation of these waters for societal purposes. The food chain and the economy depending on fish are gravely concerned about the loss in fish yield in the Ganga River. Given this, ICAR-CIFRI has taken the initiative to restore sustainable fisheries for a healthy Ganga River system under the flagship program of the National Mission for Clean Ganga (NMCG) under the 'Namami Gange' program. Through this programme, Indian Major Carps (IMCs) wild brooders are collected from the Ganga and reared in ponds. The IMC seed was grown to fingerling size in nurseries using an induced breeding method. At the Ganga River depleted stretches, the fingerlings are deployed for ranching. In India, ICAR-CIFRI pioneered the concept

Fig. 22. Different ranching sites throughout river Ganga

of river ranching and released more than 86.97 lakhs of IMC fingerlings (upto 2022) along the various stretches of the Ganga. Along with this, an awareness was also created among the fishers to conserve the fish stock of the river for sustainable management.

In addition, ICAR-CIFRI is aiming to preserve the endangered Hilsa shad, *Tenualosa ilisha*, an anadromous clupeid with significant cultural and economic value among the people of Bangladesh and India and a very high market demand. It's a good idea to have a backup plan if something goes wrong. Thus, ICAR-CIFRI conducted a study to increase the natural stock of hilsa in river Ganga (upstream of Farraka barrage) through ranching of wild-collected hilsa seed/juveniles to expand the hilsa population in the area upstream of the Farakka barrage. In the hopes of reviving the fish in the Ganga River, 90,669 hilsa brood fish were released upstream of the Farakka barrage. 1313 of these fish were marked with tags to determine their

Fig. 23. Fish ranching by Shri Parshottam Rupala, Honorable Union Minister of Fisheries at Assi Ghat, Varanasi, Uttar Pradesh

migration path. Based on contacts with fishermen and numerous awareness campaigns, it is interesting to note that 1921 numbers of juvenile Hilsa were retrieved from several locations, including Murshidabad and Maldah (West Bengal), Jharkhand, and Bihar.

Fig. 24. River ranching at Patna, in the presence of Shri Tarkishore Prasad, Hon'ble Dy. Chief Minister of Bihar

Fig. 25. Director General NMCG & PD, NRCD, Shri G. Asok Kumar, IAS, released the fish seed in Gandhi ghat, Barrackpore, West Bengal

7 Conclusion

Programs for river ranching can measure ecosystem services, restore the health of inland water ecosystems, minimise habitat degradation, preserve aquatic biodiversity, and optimise socioeconomic benefits. River ranching of indigenous fish is one of the best methods to propagate and enhance the depleted fish species in their natural habitat. The protocol followed, starting from brood stock selection to ranching, would support different stakeholders, including state fisheries departments and various private industries linked to river valley projects, to propagate the native germplasm for the depleted fish species enhancement in rivers.

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