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India needs science-based, life-cycle-oriented Hilsa fisheries management framework

26 November 2026 | Features

With rising regional demand and export opportunities, ICAR-CIFRI scientists outline how India can strengthen hilsa value chains through sustainable fisheries management, habitat restoration, cold-chain infrastructure and traceability



Indiaâ??s hilsa sector presents opportunities to strengthen regional trade, improve value realisation and develop more efficient fisheries value chains. However, converting rising demand into sustained commercial growth will depend on reliable supply, quality assurance, cold-chain infrastructure, traceability and responsible harvesting. **In this exclusive AgroSpectrum interview, Dr Pradip Dey, Director, ICAR-CIFRI, and Dr Ranjan Kumar Manna, Principal Scientist and Head of Department, ICAR-CIFRI,** discuss the commercial potential of Indian hilsa, export opportunities, fisheries management and the infrastructure and market linkages needed to build a sustainable, higher-value hilsa industry. Edited excerpts :

Indiaâ??s recent hilsa exports to Bangladesh suggest that market demand can rapidly emerge when supply conditions change. Does this episode represent a temporary trade opportunity created by lower Bangladeshi catches, or does it indicate that India has the potential to build a sustained regional market for hilsa? What would determine the difference?

The recent movement of Indian hilsa to Bangladesh is a highly encouraging development for regional fisheries trade and demonstrates the potential for India to respond effectively to emerging market opportunities. The reported export of around 500 tonnes over the past two months, with further consignments anticipated, indicates that Indian hilsa can find strong demand in neighbouring markets.

At the same time, this development should be viewed as an important emerging opportunity rather than immediate evidence of a permanently established export market. The present demand is partly linked to lower hilsa availability in Bangladesh and the availability of Indian supplies, particularly from Gujarat. However, it also demonstrates that India has the potential to develop a wider regional market if supply and quality can be maintained consistently.

The strong preference for hilsa with higher roe content in markets such as Chattogram and Sylhet, along with opportunities for roe processing, re-export and value-added products such as dried and salted fish, further expands the scope for value addition and diversification of the hilsa trade.

The key to converting this emerging opportunity into a sustained regional market will be consistent supply, quality assurance, traceability, efficient cold-chain and logistics infrastructure, market linkages and sustainable resource management. Since hilsa is primarily a wild, migratory resource, export growth should be accompanied by responsible harvesting, habitat conservation and restoration, scientific fisheries management and appropriate value-addition strategies.

Thus, the recent exports should be seen positively as a promising signal of Indiaâ??s growing potential in regional hilsa trade. The long-term opportunity will depend on India's ability to combine market development with ecological sustainability, ensuring that increased trade strengthens rather than compromises the future of the hilsa resource.

Hilsa is fundamentally a migratory fish, making its productivity dependent on river connectivity, freshwater discharge, salinity and access to spawning grounds. How significant are changes in the Gangaâ??Hooghlyâ??Sundarban hydrological system to the long-term productivity of hilsa, and which ecological interventions should receive the highest scientific priority?

The hydrological system of the Gangaâ??Hooghlyâ??Sundarban is not simply a supporting environment for hilsaâ??it is a **core determinant of its migration, spawning and recruitment**. Changes in freshwater discharge, flow regime, salinity gradients, channel connectivity and sedimentation can alter the ecological conditions that govern access to spawning and nursery grounds. ICAR-CIFRI has specifically documented the strong relationship between freshwater discharge and upstream hilsa migration in the Hooghly estuary.

The experience of the Ganga provides particularly compelling evidence. The commissioning of the Farakka Barrage in 1975 significantly disrupted the upstream migratory pathway of hilsa, with ICAR-CIFRI documenting a major decline in hilsa fisheries in the middle and upper Ganga like Varanasi, Allahabad, etc. At the same time, recent ICAR-CIFRI interventions under the National Mission for Clean Gangaâ??including tagging, ranching, stock enhancement and systematic monitoring in Farakka barrage upstreamâ??have demonstrated that **restoration of hilsa migration is scientifically possible**. Tagged hilsa have been recorded moving substantial distances in the Ganga, while recent monitoring has documented upstream movement beyond Farakka.

Therefore, the highest scientific priority should be **restoring the ecological functionality of the riverâ??estuary continuum**, rather than treating hilsa only as a fisheries-production issue. Priority interventions should include:

Maintaining ecologically appropriate freshwater flows and freshwaterâ??salinity gradients during critical migration and spawning periods;

Improving longitudinal river connectivity and identifying/ protecting critical migration corridors;

Protecting spawning and nursery habitats, particularly areas that support recruitment;

Monitoring sedimentation, channel morphology and depth and undertaking dredging only where scientific assessment demonstrates ecological justification;

Strengthening seasonal fisheries management, particularly during critical migration and spawning periods; and

Long-term tagging, telemetry and hydrological monitoring to establish a quantitative relationship between river discharge, salinity, migration and recruitment.

The Sundarban requires particular attention because ICAR has identified the **Saptamukhi, Matla, Thakuran and Herobhanga** systems as having relatively low hilsa abundance, associated in part with reduced freshwater discharge and altered salinity regimes. ICAR has suggested scientifically planned restoration of hydrological connectivity ensuring freshwater inflow from river upstream, including strategic dredging where environmentally appropriate for providing required depth for smooth migration, alongside protection of deep-water migration corridors and strategic fishing-free areas.

The central message is clear: the long-term productivity of hilsa cannot be secured by stocking or regulating fishing alone. The river itself must remain capable of supporting the fish's natural migration and reproduction. The most important scientific investment, therefore, is to restore and maintain the **flowâ??salinityâ??connectivityâ??habitat continuum** of the Gangaâ??Hooghlyâ??Sundarban system, while using ranching and stock-enhancement technologies as complementaryâ??not substituteâ??measures. This approach aligns with the ongoing ICAR-CIFRI/NMCG experience that combining ecological restoration, fisheries science and community participation can help re-establish hilsa in historically important river stretches.

There is an inherent tension between rising commercial demand and conservation of wild stocks. If hilsa prices and export demand continue to strengthen, what management framework would allow India to capture the economic opportunity without creating additional pressure on juvenile fish, brooders and spawning populations?

The answer is not more fishing; it is better-managed fishing.

The core principle should be **â??protect the fish before harvest, not after it.â?•** Rising domestic and export demand can create economic opportunities, but those opportunities will be sustainable only if fishing mortality is kept within the productive capacity of the wild hilsa stock.

India therefore needs a **science-based, life-cycle-oriented hilsa fisheries management framework** built around three priorities: **protect juveniles, protect mature and spawning fish, and safeguard critical migration and spawning habitats** .

In the Hooghlyâ??Bhagirathi system, management should give particular attention to reducing juvenile mortality during return to the sea and avoiding excessive harvest of mature fish during their upstream migration and spawning periods. ICAR-CIFRI has undertaken long-term research on hilsa migration, recruitment, stock structure and fisheries management, providing an important scientific basis for such measures. Management should therefore be adaptiveâ??using regular assessment of size composition, recruitment, catch trends, migration and environmental conditions to adjust fishing regulations when required.

Gear regulation is equally important. Fishing practices (e.g. bag net, boat-operated lift net, etc) that disproportionately remove juvenile hilsa should be controlled. At the same time, appropriate mesh-size regulations and effective enforcement should be maintained for protecting brooders and spawning fish through scientifically determined seasonal and spatial restrictions rather than relying solely on blanket restrictions.

However, **regulation without fisher participation is unlikely to deliver durable conservation**. During scientifically determined closed seasons or restricted fishing periods, fishers should have access to appropriate livelihood support, alternative income opportunities and institutional mechanisms for participation in surveillance and compliance. Conservation measures should be designed so that the short-term costs of protecting the resource are not borne disproportionately by fishing communities.

Finally, stronger monitoring is essential. **Catch-and-effort data, fish-size composition, juvenile recruitment, spawning indicators, migration patterns and hydrological conditions should be integrated into a single management framework.** This would allow regulations to respond to the actual condition of the stock rather than relying on fixed measures indefinitely.

The objective, therefore, should not be to choose between **conservation and economic opportunity**. It should be to ensure that commercial exploitation occurs **after the fish has had an opportunity to reproduce**. Protecting juveniles and brooders, maintaining migration and spawning habitats, regulating destructive or excessively selective fishing practices, and involving fishing communities in compliance can allow India to derive greater economic value from hilsa **without undermining the wild stock on which that value ultimately depends**.

Juvenile fishing remains one of the most consequential challenges for hilsa recruitment. Are existing seasonal restrictions, mesh-size regulations and fishing-free zones delivering measurable improvements in recruitment and

stock structure, or does India need a fundamentally different approach to compliance and fisheries management?

Juvenile fishing is one of the most direct threats to the future productivity of hilsa because every undersized fish removed from the river represents a potential loss of future spawning biomass. India already has scientifically justified conservation measuresâ??minimum mesh-size requirements, restrictions on catching and possessing undersized hilsa, seasonal restrictions and protection of critical migration areas. For example, the Government of West Bengal through 2013 Gazette Notification prohibits the use of monofilament gill nets below 90 mm for hilsa and prohibits the capture, transport, marketing and possession of hilsa below 23 cm to avoid recruitment overfishing, alongwith the specific restrictions on juvenile (10 cm) fishing in estuarine areas during their sea-ward movement in Februaryâ??April using fishing gear like bag net (Binti jaal), small mesh (1 inch) gill net (Ghono Chaandi jaal), boat-operated lift net (Veti jaal), etc to reduce growth overfishing.

However, the key question is not simply whether regulations exist, but **whether they are delivering measurable biological outcomes**. Available government and ICAR sources clearly establish the scientific rationale for these measures and the continuing need to minimise juvenile mortality and protect mature and gravid fish. ICAR-CIFRI has specifically identified small-mesh fishing, overfishing of brooders and inadequate protection during critical life stages as concerns for hilsa conservation. At the same time, the available official material does not justify claiming that the present measures, by themselves, have already produced a demonstrated improvement in recruitment or stock structure across the entire hilsa fishery.

Therefore, India does not necessarily need to abandon the existing framework; it needs to **make it more adaptive, measurable and participatory**. Every major regulation should ultimately be linked to biological indicatorsâ??juvenile abundance, size composition of landings, recruitment, catch trends, migration patterns and spawning-stock indicatorsâ??and its effectiveness should be periodically evaluated against those indicators. Where the evidence shows continuing juvenile mortality, regulations on mesh size, closed periods or protected areas should be strengthened or spatially refined.

The next step should also be a stronger **compliance architecture**. ICAR has emphasised the importance of strategic fishing-free zones at estuarine entry points and protection of migration corridors, while Government of West Bengal regulations already provide a legal basis for controlling undersized hilsa and destructive fishing practices. Digital landing records, systematic catch sampling, geospatial monitoring where appropriate, fisher-led reporting and traceability can strengthen enforcementâ??but technology should support, not replace, field-level fisheries governance.

Most importantly, **fishers must be partners in conservation**. Restrictions become more durable when fishing communities participate in surveillance, reporting and local management and when the economic costs of seasonal conservation are recognised through appropriate livelihood-support mechanisms.

The management objective should therefore be very clear: **do not measure success merely by the number of nets seized or fishing days restricted; measure it by whether more hilsa survive to maturity, migrate successfully, reproduce and replenish the fishery.** That shiftâ??from regulation as an end in itself to measurable biological recovery as the management outcomeâ??is the fundamental improvement India should pursue.

The Sundarban riversâ??including the Saptamukhi, Matla, Thakuran and Herobhangaâ??face changing freshwater and salinity regimes. What does current scientific evidence tell us about the relationship between these changes and hilsa abundance, and can targeted restoration of hydrological connectivity realistically improve hilsa habitat at scale?

The relationship between **freshwater flow, salinity and hilsa habitat is fundamental to the fishery of Hooghly-Matlah estuary including Sundarban**. Hilsa is an anadromous species whose life cycle depends on movement between marine, estuarine and freshwater environments. Consequently, changes in freshwater discharge and the resulting salinity gradient can influence the accessibility and suitability of habitats used during migration and reproduction. The Government of India has also recognised the importance of maintaining suitable freshwaterâ??salinity gradients and unobstructed migration corridors for sustaining natural hilsa recruitment.

The most directly relevant current evidence comes from **ICAR-CIFRI**. Its recent assessment identifies the **Saptamukhi, Matla, Thakuran and Herobhanga** systems as supporting relatively low hilsa abundance and associates this condition, at least partly, with reduced freshwater discharge and altered salinity regimes. ICAR-CIFRI has therefore identified scientifically planned restoration of hydrological connectivityâ??including strategic dredging where feasible and environmentally appropriateâ??as a potential means of improving habitat conditions.

However, this should **not be interpreted as evidence that dredging alone will restore hilsa populations**. The Sundarban is a highly dynamic tidal ecosystem in which freshwater inflow, tidal exchange, sediment transport, channel depth and salinity interact. Government of West Bengal water-resource documentation similarly recognises degradation and disconnection of

parts of the deltaic river network and identifies restoration of riverine connections as an important water-management objective.

Therefore, the realistic opportunity is **targeted ecological restoration rather than indiscriminate channel intervention**. Before any major intervention, the priority should be to identify the specific channels and reaches that are important for hilsa migration and habitat and establish their seasonal hydrological and biological characteristics. Continuous measurements of discharge, salinity and channel conditions, combined with fish-catch monitoring and tagging-based movement studies, can provide the evidence needed to determine where connectivity restoration is most likely to deliver ecological benefits.

Where such evidence demonstrates a clear habitat or migration constraint, interventions could include **restoring selected river connections, maintaining appropriate channel depth and flow pathways, protecting critical deep-water migration corridors, and undertaking environmentally appropriate dredging where scientifically justified**. Importantly, interventions should be monitored before and after implementation so that changes in salinity, fish movement, abundance and recruitment can be objectively evaluated.

Thus, **yesâ??targeted restoration of hydrological connectivity can realistically contribute to improving hilsa habitat, but it should be treated as an ecosystem-restoration programme, not as a dredging programme**. The objective should be to restore the ecological functionality of the freshwaterâ??estuarine continuum while avoiding unintended impacts on mangroves, sediment dynamics and other components of the Sundarban ecosystem.

The broader management message is therefore powerful: **if India wants a stronger hilsa fishery in the Sundarban, it must also maintain the river system that allows hilsa to complete its life cycle.** Hydrological restoration, sustainable fishing, protection of migration corridors and rigorous ecological monitoring should move together rather than being treated as separate interventions.

Not only the rivers of Bengal, almost all the rivers of India which joins Bay of Bengal or Arabian Sea were having Hilsa earlier. However, now Hilsa has vanished from most of the rivers (e.g. Godavari, Krishna, Cauvery, Mahanadi, etc) as required water depth for Hilsa migration in estuarine zone is not available. Again, due do obstruction caused by barrages and dams in all the rivers, gravid Hilsa cannot reach to their upstream breeding ground even during major migration period in monsoon. Fish passes constructed for migration purpose in the barrages (like gate 25A and 25B in Farakka barrage) are mostly remain non-functional hindering the migratory hilsa. To improve hilsa fishery in Indian rivers, scientific knowledge based intervention to improve longitudinal connectivity is need of the hour.

It was heard that CIFRI and collaborating ICAR institutes are successful in pond culture of Hilsa where advancing technologies such as ultrasonography-based maturity assessment and cryopreserved milt for hilsa seed production were successfully tested. How close is India to translating these research advances into commercially viable stock enhancement or controlled hilsa production, and what scientific risks must be resolved before scaling up?

India has crossed an important scientific threshold in hilsa research, but **we are not yet at the stage where controlled hilsa production can be regarded as a fully commercialised aquaculture technology**. The distinction between scientific proof-of-concept and dependable, large-scale seed production is particularly important for a species as biologically demanding as hilsa.

ICAR-CIFRI, in collaboration with ICAR-NBFGR and other ICAR fisheries institutes, has successfully demonstrated the use of **cryopreserved milt collected from wild hilsa to produce offspring**. This is a significant breakthrough because synchronously obtaining mature males and females from the wild is difficult, while cryopreservation creates the possibility of maintaining valuable genetic material and using it when suitable females become available. ICAR has described this as the first such technology developed for hilsa breeding.

The development of **non-invasive ultrasonography for determining sex and reproductive maturity** is another important building block where ICAR-CIFE has extended full support to ICAR-CIFRI. ICAR records describe the technology as a rapid, non-lethal method for determining sex and maturity in hilsa. This could substantially improve broodstock selection and reproductive management while reducing the need to sacrifice valuable brood fish for maturity assessment.

There has also been measurable progress in captive broodstock development. ICAR's research programme has maintained hilsa broodstock under different freshwater, intermediate and brackish-water conditions and has reported substantial proportions of captive fish reaching different stages of maturity. At the same time, the continuing project objectivesâ??captive maturation and spawning and refinement of larval-rearing technologyâ??show that the complete production chain is still being scientifically refined.

The immediate scientific challenge, therefore, is **not simply to produce hilsa seed once, but to produce high-quality seed consistently, efficiently and at scale**. Before commercial-scale stock enhancement is undertaken, several questions require rigorous validation:

Reliable captive maturation and spawning across successive broodstock cycles;

Consistent egg, larval and juvenile survival under controlled conditions;

Broodstock nutrition and long-term husbandry capable of sustaining reproductive performance;

Genetic diversity and genetic fitness, particularly where cryopreserved material and hatchery propagation are used;

Disease prevention and biosecurity in captive broodstock and seed-production systems;

Post-release survival, migration and reproductive contribution of stocked / ranched fish; and

Cost-effectiveness and scalability of seed production and release.

These questions are particularly important because successful hatchery production does not automatically demonstrate successful **stock enhancement**. A released juvenile must survive, adapt to the river environment, migrate appropriately, enter the natural population and ultimately contribute to reproduction. ICAR-CIFRI's ongoing Ganga programme already combines ranching, stock enhancement, tagging and post-release monitoring, providing an important framework for evaluating these outcomes.

The pathway forward should therefore be **conservation aquaculture rather than conventional aquaculture alone**. Hilsa stock enhancement in rivers should run parallelly with pond aquaculture of Hilsa. The priority should be to integrate broodstock management, ultrasonographic maturity assessment, cryobanking, controlled breeding, larval and nursery rearing, genetic monitoring, tagging and rigorous post-release assessment into a single technology pipeline.

Most importantly, **stock enhancement must remain complementary to natural-stock conservation**. Releasing hatchery-produced hilsa cannot compensate for degraded spawning habitats, disrupted migration routes, excessive juvenile fishing or inadequate protection of brood fish. The strongest strategy is therefore to restore the natural reproductive system first and use hatchery technologies where they provide an evidence-based additional benefit.

In practical terms, India is now moving from **â??Can we breed and produce hilsa seed?â?• to â??Can we produce genetically and biologically suitable seed consistently, release it responsibly, and demonstrate that it contributes to sustainable wild-stock recovery?â?•** The answer to the first question is increasingly demonstrated; the second is the critical scientific challenge that must be resolved before large-scale commercial or conservation deployment. We have to ensure that ranched Hilsa in rivers reach sea, spend part of their life cycle in sea and again return to the rivers for breeding. So, both life cycle in pond and life cycle in rivers be completed in improved regime for sustainable Hilsa fishery of India.

If India wants hilsa to become a higher-value fisheries asset rather than simply a high-priced wild catch, what should the next decade of hilsa policy prioritiseâ??ecosystem restoration, stronger fisheries regulation, scientific stock enhancement, aquaculture research, post-harvest value addition, or a combination of theseâ??and what would success look like by 2035 ?

If India wants hilsa to become a **higher-value and more sustainable fisheries asset**, the next decade should not be framed as a choice between ecosystem restoration, fisheries regulation, stock enhancement, aquaculture research and value addition. These are complementary components of one strategyâ??but they should have a clear order of priority.

The foundation must be a healthy hilsa ecosystem and a productive wild stock. Riverâ??estuarine connectivity, suitable freshwater and salinity regimes, migration corridors, spawning and nursery habitats must be protected and restored, particularly across the Gangaâ??Hooghlyâ??Sundarban system. The recent ICAR-CIFRI experience in the Ganga demonstrates the value of combining habitat restoration, ranching, artificial breeding, release of fertilised eggs and hatchery-produced spawn, tagging, monitoring and community participation. ICAR reports that between 2019 and June 2026, more than 3.85 lakh juvenile and adult hilsa were ranched, along with more than 40 lakh fertilised eggs and about 9.4 lakh hatchery-produced spawn.

The second pillar must be stronger fisheries management. The objective should be to protect juvenile fish, mature and spawning individuals and critical migration periods and habitats. Regulations on mesh size, minimum legal size, seasonal closures and protected areas should be supported by systematic catch, effort, size-composition and recruitment monitoring.

Most importantly, compliance should be participatory, with fishing communities involved in local stewardship, monitoring and conservation.

Scientific stock enhancement should be developed as a complementary tool, not as a substitute for natural recruitment. The progress made by ICAR-CIFRI and collaborating institutions in breeding, ranching and stock enhancement is promising, but scaling up should be conditional on evidence of survival, migration, genetic fitness and actual contribution to the wild population. The objective should be to move from demonstrating that fish can be produced and released to demonstrating that such interventions produce measurable and sustainable improvements in wild-stock productivity. The Government's recent ICAR-CIFRI programme itself describes ranching together with habitat restoration and sustainable fisheries management, rather than ranching as a stand-alone solution.

Aquaculture research should continue, but with scientific caution. Hilsa is biologically different from conventional aquaculture species, and commercial controlled production should not be assumed simply because breeding or seed-production milestones have been achieved. Research should focus on broodstock management, maturation, seed quality, larval survival, genetics, disease management, economics and post-release performance in rivers / ponds. Any future stock-enhancement programme should have rigorous genetic and ecological safeguards.

The fifth pillar is where **ecological recovery can be converted into greater economic value**. India should invest in improved landing and handling facilities, cold chains, hygienic processing, packaging, traceability, certification and responsible branding. The Department of Fisheries' PMMSY framework explicitly supports modern post-harvest infrastructure, value addition, marketing and IT-enabled traceability from â??catch to consumer.â? Such measures can increase value captured by fishers and other stakeholders without requiring a proportional increase in fishing pressure.

What should success look like by 2035 in Hilsa fisheries?

Success should be defined by **measurable biological, ecological and economic indicators**, rather than simply by the volume or price of hilsa traded.

By 2035, India should aim to demonstrate:

A healthier riverâ??estuarine system, with improved connectivity and scientifically monitored freshwaterâ??salinity conditions in important hilsa habitats.

Stronger natural recruitment, demonstrated through improved juvenile survival, size structure, recruitment indicators and adequate spawning-stock biomass.

Effective and participatory fisheries governance, with demonstrable compliance of conservation regulations and reduced mortality of juveniles and spawning fish.

Evidence-based stock enhancement, where hatchery and ranching interventions are used only where they demonstrate measurable ecological benefits and acceptable genetic and ecological risk.

A stronger hilsa value chain, with better handling, cold-chain infrastructure, processing, traceability, quality assurance and responsible market development. The Government's fisheries programmes already recognise these components as essential for increasing value across the fisheries value chain.

Greater resilience of fishing communities, so that conservation measures translate into sustainable and more secure livelihoods rather than simply imposing additional restrictions.

Life cycle of Hilsa is completed within the captivity in ponds, where pond-reared matured Hilsa successfully breeds to have its next generations.

The ultimate measure of success should therefore not be **â??How much more hilsa can we catch from rivers?â?•** It should be **â??Can India maintain a larger and healthier wild hilsa population while generating greater value from every fish harvested?â?• and â??Can our pond reared Hilsa is able to contribute in overall Hilsa production?â?•**

That is the transition India should target by 2035: **from a high-priced wild catch to a high-value, scientifically managed and ecologically sustainable fisheries asset.** A stronger hilsa economy must begin with a stronger hilsa ecosystemâ??and the economic gains should come increasingly from **healthy stocks, better management and higher value per fish, rather than from greater fishing pressure.**

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