



POLICY BRIEF #81

FROM PONDS TO PLATFORM: THE CASE FOR AIoT-ENABLED SHRIMP AQUACULTURE IN SIRSA, HARYANA

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Abstract

India has emerged as a major player in global shrimp trade following the expansion of *Litopenaeus vannamei* aquaculture since 2011, supported by access to imported broodstock and improvements in hatchery technology. As the world's second-largest shrimp exporter after Ecuador, India recorded seafood exports of USD 8.46 billion in 2025–26, of which frozen shrimp contributed USD 5.6 billion (66.2 per cent). Sustaining this export competitiveness requires a transition from production-led expansion towards efficiency-driven, sustainable and traceable aquaculture value chains. This entails addressing constraints across the entire production and marketing system, including broodstock sourcing, seed quality, feed-use efficiency, disease surveillance, energy management, harvesting decisions, processing infrastructure and market integration.

Against this backdrop, the brief examines the potential of Artificial Intelligence of Things (AIoT) technologies to transform inland saline shrimp aquaculture, using Sirsa district in Haryana as a demonstration cluster. Despite rapid expansion in shrimp cultivation, farmers in Sirsa face high feed and energy costs, production and disease risks, limited technical capacity, inadequate institutional credit, dependence on coastal input markets and the absence of local processing infrastructure. Evidence from Vietnam, Indonesia and India's emerging aquaculture technology ecosystem indicates that AIoT-enabled precision feeding, real-time monitoring, automation and predictive analytics can improve resource-use efficiency, strengthen disease-risk management and generate verifiable farm-level data for traceability and financial services. Farm-level evidence from the ICRIER–Kotak Karma AIoT pilot in Sirsa demonstrates these potential gains.

The AIoT-enabled treatment pond achieved approximately 30 per cent lower Feed Conversion Ratio (FCR) than the control pond, alongside improvements in productivity, labour efficiency and energy management. Estimated annual net returns increased from INR 5.63 lakh per acre under conventional shrimp farming to INR 10.40 lakh per acre with AIoT integration. Beyond farm-level profitability, continuous production monitoring and predictive disease-risk assessment can reduce uncertainty, improve crop survival and strengthen supply reliability, thereby creating conditions for investment in processing infrastructure and integration into higher-value export markets.

However, translating these gains into cluster-wide adoption requires institutional and financial innovations beyond technology deployment. The brief identifies subscription-based Hardware-as-a-Service models, data-backed credit and insurance, targeted PMMSY support, farmer aggregation and interoperable digital traceability systems as critical instruments for overcoming adoption barriers. It proposes a time-bound National AIoT Mission, positioning Sirsa as a demonstration cluster for scaling AIoT adoption through a competitive, platform-neutral framework. Such an approach can improve farmer incomes, strengthen supply-chain reliability and facilitate India's integration into high-value global seafood markets by leveraging opportunities under the India–UK and India–EU free trade agreements (FTAs), alongside evolving international traceability and sustainability standards.

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List of Abbreviations

AIOT	Artificial Intelligence of Things
APGB	Andhra Pradesh Grameena Bank
BBC	British Broadcasting Corporation
CACP	Commission for Agricultural Costs and Prices
CIBA	Central Institute of Brackish water Aquaculture
CIFE	Central Institute of Fisheries Education
CSR	Corporate Social Responsibility
DISCOM	Distribution Company
EHP	Enterocytozoon hepatopenaei
EU	European Union
FAO	Food and Agriculture Organization
FCR	Feed-Cost Ratio
FTA	Free Trade Agreements
GOH	Government of Haryana
GVC	Global Value Chain
HACCP	Hazard Analysis and Critical Control Points
HERC	Haryana Electricity Regulatory Commission
HPPA	Haryana Parivar Pehchaan Authority
HSN	harmonized System of Nomenclature
ICAR	Indian Council for Agricultural Research
ICRIER	Indian Council for Research on International Economic Relations
ICSF	International Collective in Support of Fish-workers
INR	Indian National Rupee
IRDAI	Insurance Regulatory and Development Authority of India
ITC	International Trade Centre
KCC	Kisan Credit Card
KVA	Kilovolt Ampere Hour
MPEDA	Marine Products Export Development Authority
NABARD	National Bank for Agriculture and Rural Development

NATP	National Aquaculture Traceability Platform
NFDB	National Fisheries Development Board
NOK	Norwegian Krone
NSSO	National Sample Survey Office
OICL	Oriental Insurance Company Limited
PIB	Press Information Bureau
PM-KISAN	Pradhan Mantri Kisan Samman Nidhi
PM-MKSSY	Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana
PMMSY	Pradhan Mantri Matsya Sampada Yojana
PPP	Public Private Partnership
RASFF	Rapid Alert System for Food and Feed
RBI	Reserve Bank of India
TAM	Technology Adoption Model
TIM	Technology Integration Model
US	United States of America
USD	United States Dollars
WIPO	World Intellectual Property Organization
WSSV	White spot syndrome virus

From Ponds to Platforms: The Case for AIoT-Enabled Shrimp Aquaculture in Sirsa, Haryana

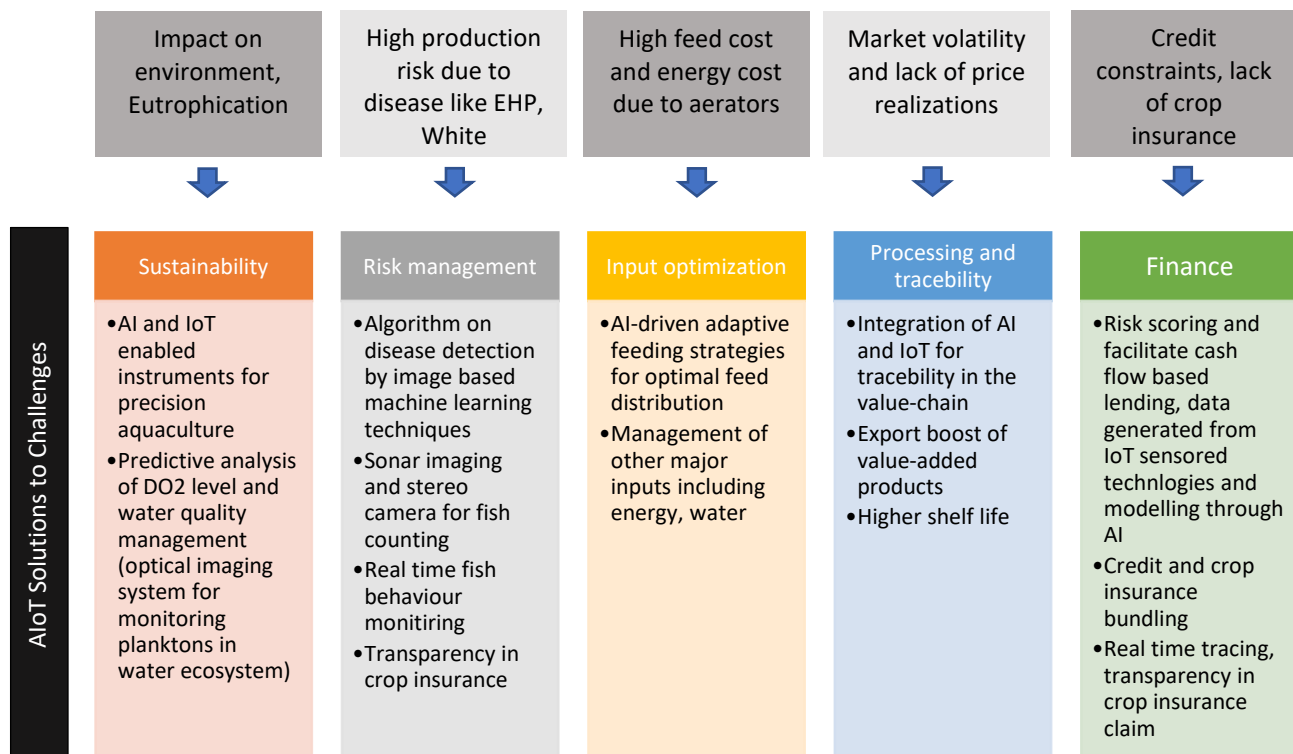
Raya Das, Tanay Suntwal and Ashok Gulati

1 Introduction

The increasing demand of global seafood indicates the need for traceable value-chain and the need of addressing the supply-chain from upstream to downstream including sourcing of brood stock, seed quality, feed use efficiency, timely disease identification, reducing energy cost, harvesting decision, linking to processing sector, and marketing. Shrimp production is concentrated in the global south countries with large section of small produce. Hence, technology adoption, aggregation, crop management, ensuring traceability to integrate with global value-chain (GVC) require strong integration of digital platform and upgradation of technology.

Artificial Intelligence (AI) and Internet of Things (IoT) sensor machineries can address these challenges by optimizing cost, real time decision making, disease monitoring, dynamic environmental challenges, and traceability in the production system (**Figure 1**). Together AIoT (Artificial Intelligence Internet of Things).

Figure 1: AIoT applications in Shrimp Aquaculture



Source: Literature review (Yang et al., 2025; Kolli et al., 2022; Yang et al., 2023; Cheng & Deng, 2022; Cao et al., 2023; Bowman et al., 2024; Aung et al., 2024)

Shrimp is the single most valuable seafood commodity crossing international borders valued at USD 21.8 billion in 2025. Global farmed shrimp output touched around 9.2 million tonnes in 2024 (Fishstatj,2025). Ecuador, China, India, Vietnam and Indonesia together supply roughly three-quarters of the world's farmed shrimp. On the trade side, the global shrimp import value at close to USD 29.8 billion in 2025 (ITC Trademap,2025), more than salmon, tuna or any single whitefish category. The year 2022 was the first-year aquaculture output actually overtook capture fisheries worldwide, and Asia supplied over 90 percent of that farmed volume (FAO,2024). Consumption concentrates in developed nations, such as the US (USD 4.92 billion in TE25), EU (USD 4.47 billion in TE25), China (USD 4.90 billion in TE25) and Japan (USD 1.23 billion in TE25), account for most (75 percent of total market) of the import bill between them.

India became a major shrimp exporter after 2011, following the import of brood stock from Taiwan, and is now the world's second-largest exporter after Ecuador. According to MPEDA's 2025-26 figures, India's total seafood exports stood at USD 8.46 billion, of which frozen shrimp contributed USD 5.6 billion, or 66.2 percent (PIB, 2026). The US, being the largest buyer, is seeing this dependence loosen on both sides as US importers are diversifying their sourcing, and Indian exporters are turning to China, the European Union, and Southeast Asia (MPEDA, 2024). US tariff measures have accelerated this shift, raising effective duties on Indian shrimp from approximately 8 percent to over 58 percent once anti-dumping and countervailing duties were applied cumulatively. This reinforces a pivot toward the EU (particularly Germany and France) and Japan, markets that demand verifiable traceability, residue testing, chain of custody documentation, and evidence of sustainable production. Continued US access will likely depend on similar transparency requirements, as market access becomes tied to verifiable, sustainable sourcing rather than price competitiveness alone. A sustainable value chain, from hatchery and farm-level resource management to processing and export logistics, is therefore inseparable from market access, and AIoT integration, including sensor-based farm monitoring, automated water quality and feed logging, disease and effluent management, and ledger-based pond-to-port traceability, is shifting from a productivity tool to a baseline requirement for premium market access and long-term sustainability.

The trade numbers shows that India's frozen shrimp exports grew from USD 2.58 billion in 2013 to just under USD 4.97 billion in 2025. But India's share of world frozen shrimp exports barely moved over the same stretch. It was about 19.5 percent in 2013, peaked near 25.8 percent in 2019, and currently at 22.7 percent in the most recent years (**Figure 2**). This indicates that India has largely kept pace with overall market expansion rather than increased its relative position within it, a distinction of consequence, since maintaining market share and gaining market share represent fundamentally different outcomes. In this context, the brief examines how closing that gap, and securing durable access to premium export markets, depends substantially on building a sustainable, AIoT enabled shrimp value chain rather than on price or volume competitiveness alone.

Figure 2: World Frozen Shrimp Exports (2013–2025)

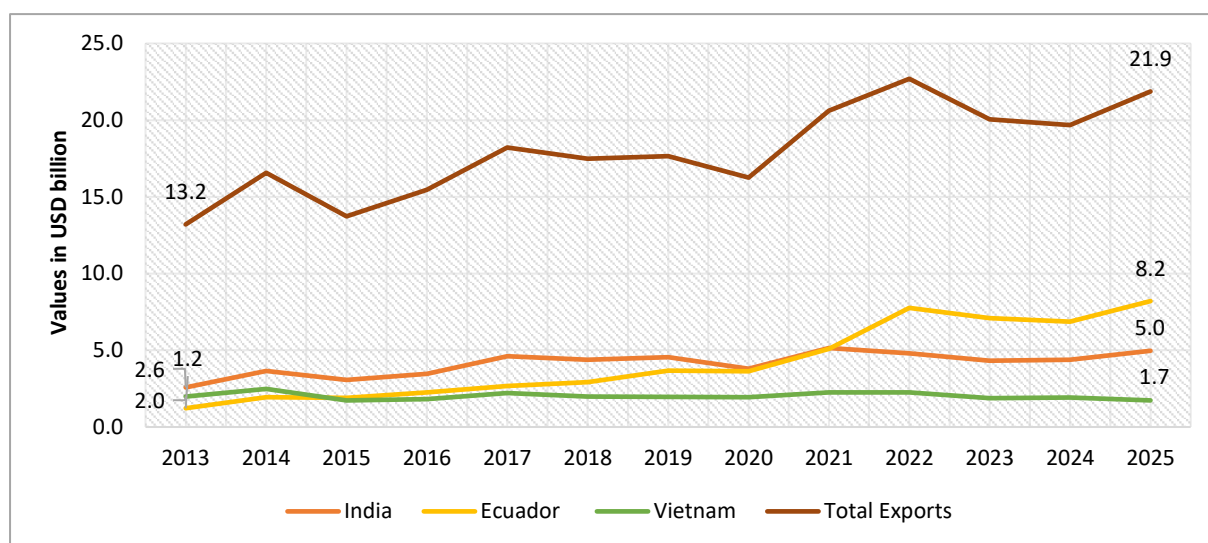
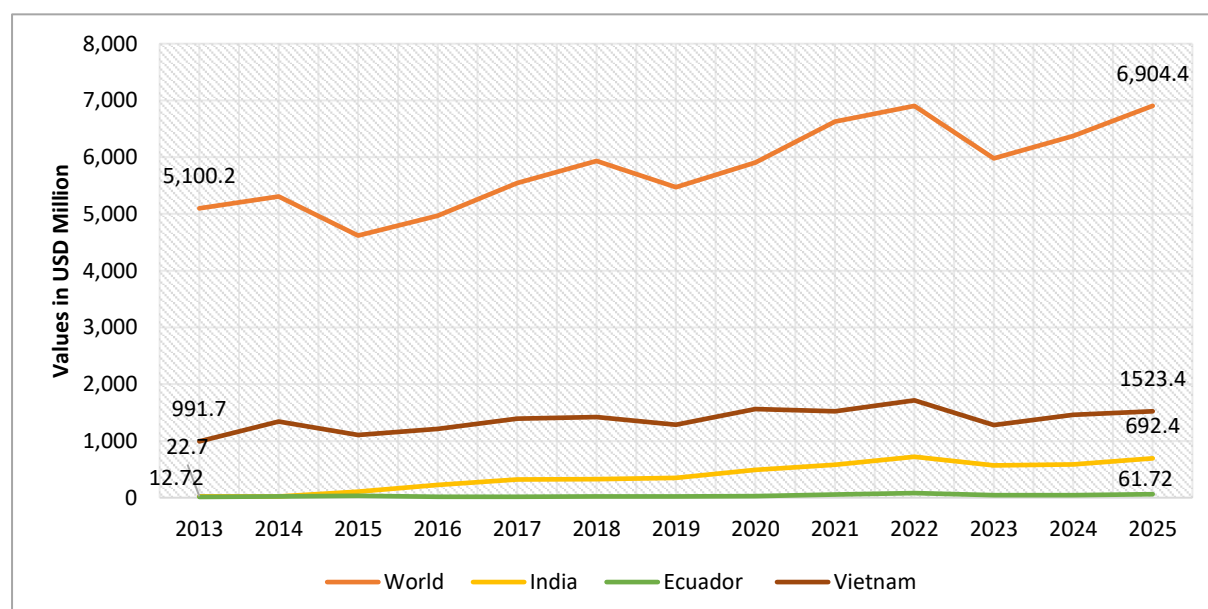


Figure 3: World Exports of Value-Added Products



Note: Frozen shrimp, HS 030617; value-added shrimp is HS 160521 & 160529;

Source: ITC trademap, 2025

A more significant shift is occurring in value-added and processed shrimp, a smaller but much faster-growing segment (**Figure 3**). India's value-added exports rose from USD 22.7 million in 2013 (about 0.5 percent of world value-added trade) to USD 692 million in 2025, roughly 10 percent of the global market. Frozen, minimally processed shrimp still dominates the export basket, but value-added products carry the highest margins. *L. vannamei* accounted for USD 4.2 billion of frozen shrimp exports in 2025, while Black Tiger, a smaller (USD 0.5 billion) and higher-priced segment, grew faster in volume the previous year (ITC Trademap, 2025).

Put it all together and the last decade and a half of growth in Indian shrimp exports has mostly come from farming more area and shipping more raw products. It hasn't come from getting meaningfully better at the business of farming itself. India needs a bigger share of a market it currently just keeps pace with, and that need has gotten sharper now that the US tariff shock has turned single-market dependence into a real liability rather than a convenience. The next phase of growth has to come from higher survival rates, steadier crop quality, and more value addition at the farm and processing stage.

2 The AIoT Landscape and Aquaculture

India's shrimp export growth can no longer rely mainly on expanding production volumes and cultivated area; future competitiveness will depend on farm-level productivity, resource-use efficiency, production quality, and value-chain performance. AIoT in aquaculture combines IoT sensors and automated equipment that continuously monitor and respond to pond conditions with an AI layer that analyses these data streams to predict changes in water quality, feeding requirements, biomass, and disease risk, enabling anticipatory rather than reactive management. These applications span feeding optimisation, water-quality management, disease detection, and biomass estimation (Huang, 2025), and are already deployable through commercially available sensor networks, automated feeders, and connected monitoring systems.

Box 1: AKVA Group and Aquabyte: the incumbent and the disease specialist

AKVA Group (Norway) is less a single product than the operating system much of the salmon industry already runs on. Its Fishtalk platform holds roughly 60 percent of the market for aquaculture production-management software (AKVA Group, 2026). It does not treat disease but is built to remember it, letting farmers and vets log the cause of every fish death, outbreak, algae bloom, and handling-stress event per cage and retrieve that history when similar patterns recur (Aunsmo et al., 2023; AKVA Group, 2026). This lets a farm learn from cycle to cycle rather than treat each outbreak as a fresh emergency, a different kind of value than prevention, but not a smaller one.

Aquabyte (United States, founded 2017) targets sea lice, a problem that costs the Norwegian salmon industry alone an estimated NOK 6 billion (a little over half a billion US dollars) every year in treatment and lost growth (Johnston, 2025). Instead of technicians manually netting and counting lice on a small sample of fish, underwater cameras count lice across far more fish daily and flag when levels approach a treatment threshold, early enough to avoid a larger chemical or mechanical delousing operation (Aquabyte, n.d.). Although no clean accuracy figure is published, the system has cleared a real regulatory bar: Iceland's Food and Veterinary Authority approved one of its computer-vision health assessments as a substitute for the invasive physical sampling regulators normally require (Johnston, 2025).

Continuous sensing changes what one person can responsibly monitor. A farmer checking oxygen once or twice a day can miss a crash in the morning but a sensor will not. The gap matters more in shrimp farming than in most crops, because a pond can go from healthy to collapsed within days once something goes wrong. Field evidence from Sirsa quantifies the risk as roughly one cycle in five in Haryana ends in failure from a biological or market shock, and a single bad cycle can wipe out INR 10 to 15 lakh in working capital, before the cost of restarting (Das, Gupta & Gulati, 2025). This is the real entry point for IoT: it is less about growing shrimp faster than about protecting the crop already in the pond.

The same sensor data also helps the person deciding whether to lend or not. Shrimp farming has always been hard to finance formally, because a bank has no real way to tell a well-run pond from a badly-run one until the harvest already failed. Digitised farm data starts to close that gap. Tepbac, the Vietnamese platform, already converts consistent app usage and good farm records into "credit points" that farmers can borrow against through its financial partners (WIPO, 2022). eFishery built something similar in Indonesia, bundling its smart feeders with financing so that farmers who previously had no credit history at all could still access working capital (Barton, 2024). It's about recording a farm's daily operations so that a lender can read them.

3 AIoT: Lessons across South-East Asia

The first wave was simple monitoring and automation, with nothing predictive about it. Tepbac's Envisor, a self-cleaning water sensor paired with its Farmext app, gave Mekong Delta farmers real-time readings on oxygen, pH, temperature, and salinity; the company reports this cut costs by around 20 percent and added up to 30 percent more value per harvest, and the system now runs on more than 5,000 ponds across Vietnam. eFishery's smart feeder used acoustic sensors to detect actual hunger and release feed accordingly, cutting feed waste by about 21 percent in early deployment (BBC, 2016). Both measured accurately and reacted automatically, but neither predicted anything. The second wave added judgment on top of the sensors. DELOS in Indonesia built AquaHero around a biological model trained on data from hundreds of ponds, designed to flag a likely disease outbreak roughly a week in advance (White, 2023). AquaEasy, a Bosch company, paired its i-feeder with AI that adjusts feeding to shrimp behaviour rather than a fixed schedule, and has been credited with productivity gains of around 30 percent across farms in Vietnam, Indonesia, and Singapore (The Fish Site, 2022). Tepbac's AI layer now learns from its best-performing farmers and pushes those recommendations to all users, so performance improves each season (WIPO, 2022).

3.1 Vertical integration in a shrimp-farm data context

Vertical integration here doesn't mean owning the hatchery, the feed mill and the export licence, the way it's traditionally used in agribusiness. It means one connected data thread running from the pond sensor through the farm-management software to whoever is

deciding on credit, insurance or a buyback contract. DELOS calls this an institutional bridge; Tepbac builds it through its e-shop, which ties input-purchase data into the same platform as the sensor readings. The point in both cases is the same i.e., capture the data once, and let it serve three or four different downstream decisions instead of re-collecting it each time.

Benefits specifically relevant to small farms:

- Lower entry cost, since a subscription doesn't require the upfront capital a hardware purchase does.
- Access to credit and insurance that a farmer with no formal track record couldn't get otherwise, once digitised farm data stands in for collateral history.
- A built-in substitute for extension staff, since the platform's advisory layer partly replaces the technical support, a smallholder can't otherwise afford to hire.
- Group bargaining power on inputs and outputs, where cooperative or platform-pooled data gives smallholders leverage they wouldn't have alone.

3.2 Technology Adoption Model (TAM)

The Technology Adoption Model (TAM) provides a framework for understanding how and under what conditions farmers transition from initial exposure to sustained adoption of new technologies. In aquaculture, this transition is shaped not only by the perceived usefulness and ease of use of a technology, but also by farm scale, investment capacity, risk exposure, access to finance, technical support, and the institutional environment. Technology adoption is therefore unlikely to follow a uniform pathway across farmers. The four financing and ownership models presented in **Table 1** broadly represent different stages and conditions of adoption. Matching these models to farmers' technological readiness and financial capacity may facilitate more sustained adoption than promoting an immediate transition to capital-intensive, advanced technologies.

Table 1: Major Entry Points and Technology Adoption Model

Adoption stage	What the farmer has	Matching model
Manual	No sensors, decisions by eye and experience	Basic test kits, extension advisory
Sensored	Point sensors, no automation yet	Digital cooperative — shared hub, pooled hardware cost
Automated (IoT)	Sensors plus automated aerators/feeders	HaaS subscription, or B2B2C input-linked finance
Predictive (AIoT)	Full platform with AI advisory, pooled-data models	B2B2C aggregator with buyback, or PPP-backed early-warning grid

The four models namely Hardware-as-a-Service, digital cooperatives, B2B2C corporate aggregation, and pay-per-use/public-private partnerships, draw on patterns observed across the case studies in the models are referred here.

Box 2: Major Case Studies that shaped the Shrimp Market

Tepbac (Vietnam): the subscription model for the smallholder majority

Tepbac's core offer is a self-cleaning water sensor, Envisor, paired with a farm-management app, Farmext, priced well below the foreign monitoring systems that were once the only option for Mekong Delta farmers. The company reports a roughly 20 percent cut in operating costs and up to 30 percent more value per harvest, and the system now runs on more than 5,000 ponds across Vietnam, up from a few hundred at launch (Tay, 2024). Continuous oxygen monitoring catches the night-time crashes that often precede disease before they escalate. A financial layer sits on top: farmers who consistently follow recommended practices earn a certificate of good practice, which the company says helps them sell at a premium, and "credit points" redeemable for loans through its financial partners (WIPO, 2022). For Sirsa, the relevant detail is the price point: Tepbac was built for farmers who could never afford a foreign system, close to the constraint facing Haryana's recent converts from wheat and cotton.

RYNAN Aquaculture / TOMGOXY (Vietnam): water-and-power efficiency model

TOMGOXY redesigns the pond itself rather than just the sensors around it. Where a conventional intensive farm splits land roughly equally between grow-out ponds and water-treatment area, TOMGOXY's layout and oxygenation system flips that balance. RYNAN's own demonstration farm reports yield more than 20 times those of a conventional layout on the same land, with daily water exchange cut from around 50 percent to 3 to 5 percent (Wong, 2024). This efficiency travels well to Haryana, where Sirsa farmers pay roughly three times what Andhra Pradesh farmers pay for electricity, driven mainly by aeration and groundwater extraction (Das, Gupta & Gulati, 2025), making it a closer fit than a monitoring-only tool. Less water movement and steadier oxygen also reduce pond-to-pond pathogen spread.

4 Challenges in Haryana

Disease is the single biggest source of risk in shrimp farming. A 2021 study put the probability of a white spot syndrome virus outbreak in a given cycle at 25 percent, and of *Enterocytozoon hepatopenaei*, a slower-acting parasite, at 17 percent (Patil et al., 2021). Sirsa's numbers track this closely as field research found roughly one cycle in five ending in failure, and a five-year Monte Carlo simulation showed 19 percent of farmers exiting the business after a single bad shock. Timing matters enormously, as a first-year failure carries a 68 percent chance of eventually forcing a farmer out, against just 2 percent if the same shock hits in year five (Das, Gupta & Gulati, 2025). Water-quality volatility, such as oxygen crashes, ammonia build-up, and sudden pH or salinity swings, is a key vulnerability factor, which is why continuous sensing matters more than periodic manual testing.

Three structural constraints compound this risk. First, credit access: most Sirsa ponds are on leased land, which cannot be pledged as collateral, locking farmers out of much formal bank lending regardless of farm performance. Second, technical know-how: unlike Andhra Pradesh, where shrimp farming is often a two-generation family trade, most Haryana farmers are first-

generation entrants who converted from wheat, cotton, or paddy within the last five years, with no peer network to turn to when problems arise. Third, distance: Sirsa farmers rely on feed, seed, and processing facilities roughly 4,500 kilometres away by road, adding an estimated INR 20-30 per kilogram to production costs (Das, Gupta & Gulati, 2025). A sensor does not fix any of these directly, but each becomes easier to address once a farm's operating data exists in a form that a lender, trainer, or buyer can act on. (Table 2).

Table 2: Brackish-water farming in Andhra Pradesh versus inland saline farming in Haryana

Andhra Pradesh Brackish water experienced farmers	Attribute	Haryana Inland saline water first-generation farmers
Estuarine and marine brackish water drawn from coastal creeks and canals.	Water source and system	Groundwater of variable salinity, alkalinity and mineral content on salt-affected land; sensors need recalibrating for the inland ionic profile.
Experienced, multi-generation farming families; knowledge built up over decades of repeated cycles.	Farmer background	Mostly first-generation shrimp farmers, former paddy and wheat croppers with no prior aquaculture experience.
Long-established coastal industry; AquaExchange itself began in Vijayawada and added 3,427 new adopters in 2025 (AquaExchange, 2026).	How the sector grew	Slow start: 3 farmers on 12 acres in 2014, 25 farmers on 75 acres in 2015; output reached about 15,468 tonnes in 2024-25 (Das, Gupta & Gulati, 2025).
Two to three cycles, so one bad crop can be absorbed by the next.	Crop cycles per year	One cycle, so a single failure takes a much larger share of annual income.
About 1.6 to 1.8; falls to 1.38 with AIoT feeding (AquaExchange, 2026).	Baseline feed conversion (FCR)	About 1.8 to 2.0, leaving more room for AIoT gains.
Roughly INR 1.25 per unit in notified aqua zones.	Electricity tariff	INR 4.65 to 5.00 per unit, with no agricultural tariff (ICSF, 2024).
Crop success of 83 percent on AIoT farms against a 67 percent baseline (AquaExchange, 2026); 74 percent of antibiotic-residue rejections traced to the state (Jha, 2026).	Disease and crop risk	92.86 percent of surveyed farmers name disease as the main challenge (Singh et al., 2025); per-cycle WSSV risk of 25 percent and EHP 17 percent (Patil et al., 2021); a first-year failure carries a 68 percent chance of exit, against 2 percent in year five (Das, Gupta & Gulati, 2025).
Tenant farmers on leased ponds are excluded from KCC, which requires a land mortgage (RBI, 2019).	Land and credit	Much farming is on saline Panchayati land under informal lease, which does not count as collateral (Singh et al., 2025); informal credit costs 20 to 25 percent.
Tightens practice farmers already know: feed and power waste, with power factor lifted from 0.81 to 0.96 (AquaExchange, 2026).	What AIoT does	Stands in for missing tacit knowledge as an advisory and decision-support tool; intensive operators earn INR 8 to 10 lakh per hectare (PIB2, 2025).

Source: Authors' compilation from stakeholder consultations and focused group discussions in Bhimavaram and Sirsa clusters (April 2025).

4.1 Why IoT and AIoT Adoption Remains Limited Across India

Around 90 percent of India's aquaculture farmers work three-to-five-acre holdings, yet most IoT packages were priced and designed for a very different scale. One industry estimate puts a basic deployment at roughly INR 1,00,000 per pond, beyond what a smallholder converting from wheat or cotton can spend in year one. Many vendors also sell the device and stop there, without teaching farmers what to do with the readings, a gap that shows up later as low renewal rates rather than outright refusal. And unlike crop farmers, aquaculture farmers in India receive no insurance premium subsidy, which raises the real cost of adopting any risk-reducing technology (Somasundaram, 2022). The problem is not uniquely Indian. A global review of IoT in aquaculture found that small operators often see the technology as not useful for them, largely because they have never seen it work on a farm like theirs. Its practical recommendation is that policymakers fund visible pilot farms first and let the demonstration effect do the persuading (Rastegari et al., 2023). India already has several start-ups actively contributing to the development of this ecosystem. It needs a strategy to scale up the technology.

4.2 Aqua Exchange: India's Full-Stack AIoT Platform

Aqua Exchange, founded in Vijayawada manufactures its own IoT devices near Vijayawada to keep prices within reach of smallholder and tenant farmers, and does not sell hardware as a standalone product. Its platform links three layers: a technology stack that generates farm data, a finance stack that turns that data into a credit and insurance case, and a market-linkage stack that turns certified, traceable output into better prices, so better data feeds better finance, inputs, and data in turn. As of its March 2026 Series B round (USD 8 million, co-led by Endiya Partners and Factor Analytics), Aqua Exchange monitors more than 80,000 acres, making it one of the pioneer aquaculture-tech company to automate more than a quarter of the country's shrimp farming acreage. It operates across five Indian states plus Ecuador, Saudi Arabia, and Madagascar, with over 20,000 devices across 15 categories, and has been onboarded as a technology partner by three of the world's largest shrimp producers (Sanjay Singh, 2026). Its first product was not a sensor but PowerMon, a power-monitoring device built around the fear that a few hours of aeration failure can cost an entire crop (Goled, 2026).

A unit-level analysis of 225 Aqua Exchange-monitored farms in Andhra Pradesh (just under 2,000 hectares, drawn from a roughly 3,500-farm database) shows what automation changes at farm level to make the production system more efficient.

Figure 4: Farm-size distribution of selected farmers in Bhimavaram Cluster, Andhra Pradesh

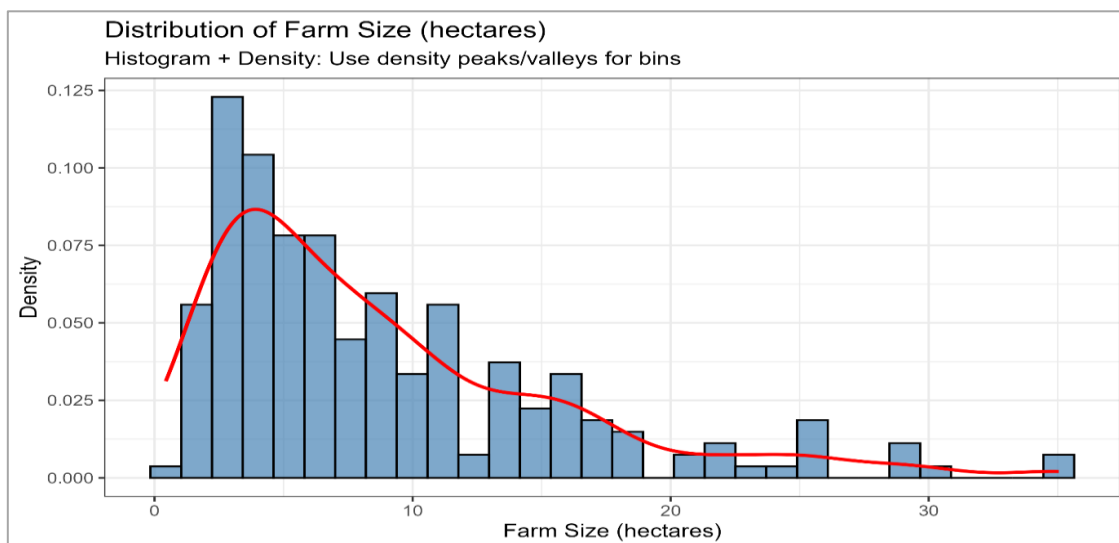


Table 3: Paired t-Tests: Before vs. After Technology Adoption

Metric	N	Before	After	t-statistic	p-value
Power factor (APFC adoption)	225	0.807 (SD 0.067)	0.965 (SD 0.022)	23.54	< 0.001***
FCR (smart auto feeder)	225	1.846 (SD 0.258)	1.380 (SD 0.233)	13.05	< 0.001***

Source: Aqua Exchange farm-level dataset, authors' calculations.

Table 4: Efficiency gains from AIoT adoption

Metric	Before AIoT	After AIoT	Change
Feed Conversion Ratio	1.85	1.38	25.4% less feed per kg of shrimp
Feed cost / ha / cycle	INR 15.0 lakh	INR 13.1 lakh	INR 1.87 lakh saved
Power Factor	0.81	0.96	18.5% more efficient power use
Crop success rate (sample)	~67%	~83%	+16 percentage points

Source: Aqua Exchange unit-level data, 225 farms / 1,984 ha, Andhra Pradesh; 2026

A paired t-test on the same farms before and after adoption shows both gains are statistically significant (**Figure 4**). The feed number is the more important one, since feed alone runs 50 to 60 percent of variable cost in shrimp farming. The mechanism is fairly simple, a centrifugal thrower spreads feed evenly instead of dumping it in one spot the way manual broadcasting does, a scheduling unit feeds every four hours instead of two or three big meals, and a check-tray system flags leftover feed the same day instead of the next morning. It's the consistency that turns out to be worth roughly INR 1.87 lakh per hectare per cycle in this sample.

Aqua Exchange's PowerMon device applies automatic power factor correction, and one consumption fell from 17,919 to 16,458 kilowatt-hours in a billing cycle, reactive-power charges (KVAh) fell by 19.2 percent, and the farm saved close to INR 9,900 in that single cycle. Multiplied across the platform, Aqua Exchange puts cumulative electricity savings at roughly INR 16.4 crore by 2025. For a state like Haryana, where electricity is already the single biggest cost disadvantage against Andhra Pradesh, a device that pays for itself through the power bill alone is an easier sell than one that only promises better yields down the line.

83 percent of monitored crops succeeded in this sample, against roughly 67 percent for non-technology farms, a gap the company's own platform-wide figures put slightly higher still, at 85 percent versus a 55-60 percent industry benchmark (Singh, 2026). The failure breakdown in the Aqua Exchange Dissolved-oxygen events, the single most preventable cause of pond collapse, account for just 0.2 percent of failures on the platform, against a typical industry rate of 5 to 10 percent, which is about as clean a demonstration of what continuous water-quality monitoring.

Turning data into credit and insurance

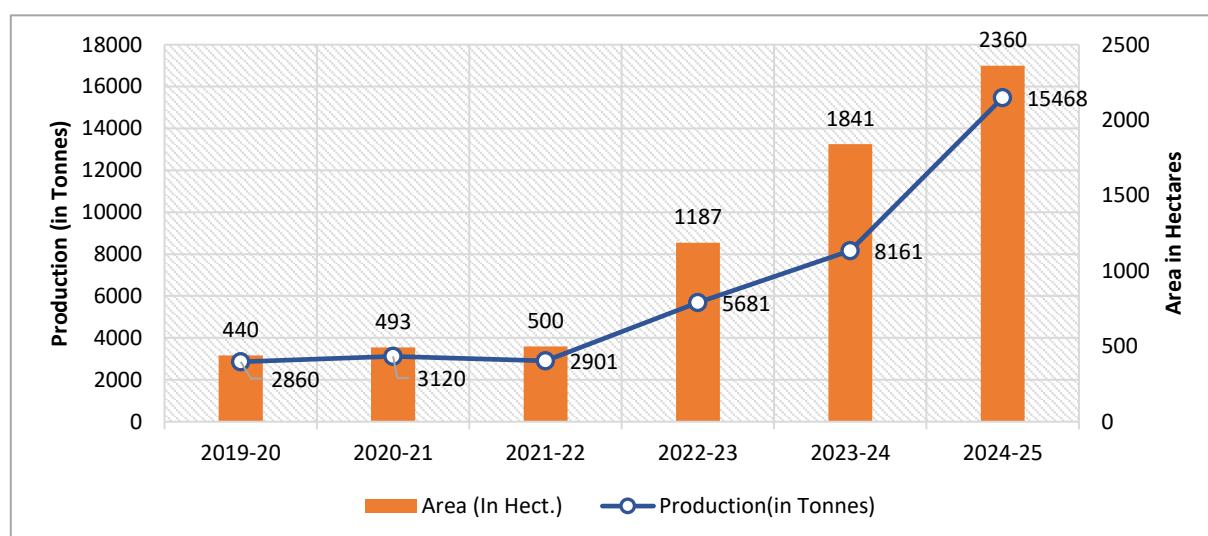
The AIoT technology also integrates farmers into institutional credit and insurance. India's Kisan Credit Card scheme, the main formal working-capital channel for farmers, requires mortgageable land as collateral, which categorically excludes tenant farmers on leased ponds, exactly the profile of most new entrants in Haryana. In Aqua Exchange's sample, roughly 42 percent of farmers were linked to formal credit and 34 percent held insurance, largely because continuous farm data gives a lender something to underwrite against that isn't land.

The insurance side is the more striking result. Aquaculture crop insurance in India has historically struggled because assessing an underwater loss is genuinely hard to verify; a 2021 NFDB-OICL pilot product got, in the government's own words, a lukewarm response specifically because it didn't cover disease losses, the very thing farmers most needed covered. Aqua Exchange's version ties claim to IoT-verified data instead of field assessment, and the results so far are close to unprecedented for aquaculture insurance anywhere, 87 farmers covered, 224 policies, 2,660 acres insured, INR 1.47 crore in claims paid, and zero claim rejections. A zero-rejection insurance product is, in a sector where farmers have historically distrusted insurers, arguably a bigger deal than any single yield number. On the lending side, the same data foundation has unlocked roughly USD 13 million in collateral-free crop loans channelled through NABARD, APGB and a handful of agri-lenders including Caspian Debt, Samunnati and Kinara Capital, which is the clearest existing proof that Indian financial institutions will lend into smallholder aquaculture once the information problem is solved, not before.

4.3 Inland Saline Aquaculture in Haryana

Haryana's shrimp story. ICAR-CIFE (Central Institute of Fisheries Education) has run a dedicated inland saline aquaculture research centre in Rohtak since 1996, and the technology didn't reach farmers' fields overnight, a tiger shrimp demonstration in 2013 was followed by just three farmers trying Pacific white shrimp on 12 acres in 2014, growing to 25 farmers on 75 acres by 2015 ([ICAR,2014](#); [ICAR \(CIFE\),2015](#)). That slow start matters for creating expansion recently, what looks like a sudden boom is really a decade of groundwork that only became visible once PMMSY subsidies arrived in 2020.

Figure 5: Area under Saline Aquaculture in Haryana



Source: Haryana Statistical Abstract, 2024-25

Haryana's biggest shift has come in the last two years. Between 2019-20 and 2024-25, area under aquaculture grew more than five times and production more than 5.5 times, so yields are rising, not just acreage. A viable shrimp processing plant (50-60 tonnes per day) needs roughly 8,800 tonnes of raw material a year. Haryana's 2023-24 output of 8,161 tonnes fell just short, but 2024-25 output of 15,468 tonnes clears the bar (**Figure 5**), so the state may for the first time produce enough to justify local processing infrastructure (Das, Gupta & Gulati, 2025).

Sirsa anchors this growth, contributing an estimated 4,000-4,500 tonnes from over 678 hectares in 2023-24, more than half the state's output. Costs remain a constraint as Haryana farmers pay INR 4.75 per unit of electricity against roughly INR 1.25 in Andhra Pradesh's notified aqua zones, since they receive none of the subsidised power extended to crop irrigation. With one cycle a year against Andhra Pradesh's two or three, a single bad cycle does proportionately more damage and pushes farmers towards informal, high-interest credit, the trap Aqua Exchange's data-backed lending model is designed to avoid. Farmers in Haryana also practices partial harvesting making 2 cycles in a year. However, there is scope

for improvement in terms of nursery-based biofloc systems similar to Andhra Pradesh to increase number of cycles and better crop management.

Case Study: Sumitra Devi, Karamsana

When COVID-19 brought Sumitra Devi back to Karamsana village in Sirsa, Haryana, rising soil salinity had made paddy farming increasingly difficult. Looking for an alternative, she and her husband turned to shrimp aquaculture with support from government schemes and local networks. Her experience offers a practical test of this transition, she stocked nine ponds covering about 0.4 hectares with 150,000 post-larvae (PL) at a salinity of 14 parts per thousand (ppt) and an intensive stocking density (**Figure 8**). Since starting shrimp farming, Sumitra has expanded her operations, adopted IoT-based auto-feeders, created 10–12 jobs, and built strong market and institutional linkages. Her journey shows how aquaculture, technology and institutional support can help farmers adapt to environmental constraints and build viable livelihoods.

Figure 6: Digital Record of the Plot at Real Time



Source: The real time image of AIoT plot vs. other control ponds

4.4 Empirical evidence of pilot

Aqua Exchange devices ran on the farm through the cycle, an automated feeder and a PowerMon unit monitoring the aeration motors. Over twelve weeks, the feeder held 97.8 percent uptime and dispensed 4,786 kg of feed on a fixed schedule, with total motor-fault downtime across the whole period logged at well under one hour. The PowerMon unit is the more interesting record, because it shows the fault-catching function working in real time rather than in theory, 383 alerts fired over the cycle (See **Annex 1**), the overwhelming majority flagging a current-drop fault on a single aeration line, each one timestamped to the minute. No single averted disaster to point to and it's exactly the kind of continuous catch that argument matters more than any one big save, 383 small warnings, each a point where a twice-daily manual check could have missed a fault.

Figure 7: PowerMon, Automatic Feeder and Aerator Starter



Source: Aqua-exchange

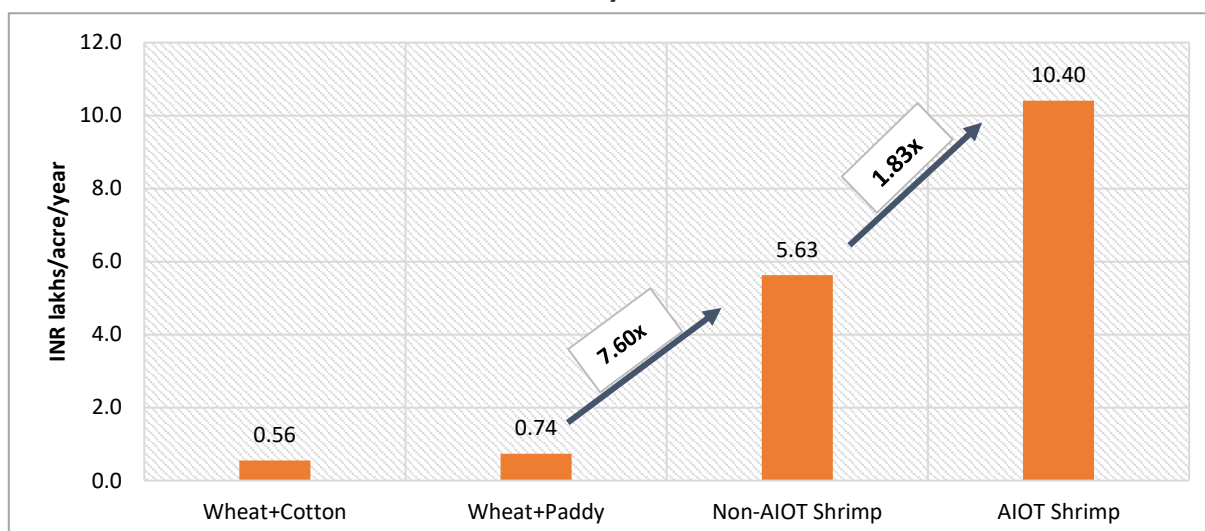
Aqua Exchange's hardware comprises three purpose-built devices rather than one general sensor kit (**Figure 7**). PowerMon, fitted to the farm's power control board, corrects power factor to cut electricity use, can manage aeration for a whole farm from one unit, and alerts the farmer to power fluctuations; it rents for INR 5,085 per cycle. The Automatic Feeder serves one pond, spreading feed evenly and logging daily reports via a mobile app. The use of AIoT devices reduces labour cost by up to 25 percent and improving FCR by a similar margin, at INR 12,712 per cycle. The Aerator Starter runs aerators automatically or remotely, protects motors from power fluctuations, and sends phone alerts, with one unit managing four to six operators; unlike the other two, it is sold outright at INR 16,949.

Figure 8: Pilot visit to Karamsana, Haryana



Source: Field visit to the pilot, Sirsa, Haryana.

Figure 9: Profitability Comparisons between crop cultivation and shrimp farming in Haryana



Source: farm-level device and harvest records, Aqua Exchange, Karamsana, Haryana. Sample not representative of population. Numbers verified from diverse stakeholders during the field visits. Net returns for crops calculated through data from CACP 2026-27 Kharif and Rabi reports at A2 level (CACP, 2026-27). Data for paddy and cotton for TE 2024-25, for wheat TE 2023-24 and rate per 30 count shrimp has been taken as INR 430/kg.

4.5 Cost, Yield and Profitability

Pond 8, designated as the control pond, produced 3,839 kg of shrimp using 5,500 kg of feed, whereas Pond 7, the AIoT-enabled treatment pond, achieved a higher yield of 4,810 kg with a lower feed consumption of 4,700 kg. The corresponding Feed Conversion Ratios (FCRs) were 1.43 and 0.98, respectively, compared with an assumed industry benchmark of approximately 1.85. At this benchmark, producing 4,810 kg of shrimp would require nearly 8,900 kg of feed. The AIoT-enabled pond therefore consumed approximately 4,200 kg (47.2 percent) less feed than the benchmark requirement. Given that feed accounts for a substantial share of shrimp production costs, these efficiency gains translate into considerable cost savings and improved farm-level profitability within a single production cycle. The data indicate a reduction in variable production costs and an increase in net returns from approximately INR 5.63 lakh to INR 10.40 lakh per acre (see [Annex 2](#)), reflecting efficiency gains from data-driven precision feeding and improved feed management (see [Annex 2](#)).

Even without AIoT integration, inland saline shrimp aquaculture in Haryana generates substantially higher net returns than conventional cropping systems. Non-AIoT shrimp farming yields approximately INR 5.63 lakh per acre annually ([Figure 9](#)), compared with INR 74,007 under wheat–paddy and INR 55,562 under wheat–cotton cultivation (CACP, 2025), representing returns approximately 7.6 and 10.1 times higher, respectively ([Annex 3](#)). With AIoT adoption, estimated net returns increase further to INR 10.40 lakh per acre, equivalent to nearly 14 times the returns from wheat–paddy and 19 times those from wheat–cotton systems (

Annex 3). These findings highlight the substantial economic potential of transitioning salinity-affected agricultural land towards inland shrimp aquaculture, particularly in regions where soil salinisation has constrained the productivity and profitability of conventional crops. AIoT integration further strengthens this comparative advantage through improvements in input-use efficiency, production management and farm-level profitability.

5 Scaling up the sector

Despite demonstrated improvements in farm-level productivity and resource-use efficiency, the wider adoption of AIoT technologies remains constrained by high upfront investment costs, uncertain returns at the individual farm level, and limited access to institutional finance. Bridging this financing gap is critical to translating successful pilot interventions into scalable, cluster-level adoption. Emerging experiences from India and Southeast Asia highlight three financing and technology deployment models that offer potential pathways for reducing adoption barriers. Rather than relying on a single approach, Haryana could adopt a combination of these models, tailored to farmers' financial capacities, risk profiles and stages of technology adoption.

5.1 Hardware-as-a-Service

The subscription logic behind Tepbac and eFishery isn't actually new; it's a shrimp-farming version of something agricultural economists have been documenting in machinery markets across South and South-East Asia for over a decade. Fee-for-service arrangements, where a smallholder pays to use equipment on a per-cycle or per-use basis instead of buying it outright, are already the dominant way farmers in Bangladesh access irrigation pumps, threshers and tillers, and research tracing this back through census-level data found it consistently lowers the capital barrier that would otherwise keep small operators out entirely (Mottaleb et al., 2017). A separate study of mechanization service-provider models across Bangladesh, Zimbabwe and Mexico found the same pattern held even for the most capital-intensive equipment, so long as a rural entrepreneur or provider was willing to hold the asset and rent out its use rather than expecting each smallholder to own one (Van Loon et al., 2020).

5.2 Rent Model and Loans

Evidence from South-East Asia makes the case for credit persuasive. A Mekong Delta study using instrumental-variable estimation found that farmers with credit access ran more productive and profitable shrimp operations than those without, all else equal (Duy Le et al., 2025). World Fish guidance, drawn from smallholder shrimp farmers in Aceh and catfish farmers in Vietnam, points to two mechanisms that reach smallholders like value-chain finance, where an input supplier or buyer extends credit against a future harvest, and mobile-phone-based finance, which lowers the cost of small, frequent loans. Vietnam's 2020 decree raised the ceiling on collateral-free loans for agricultural households and offered more generous terms for high-tech agriculture (de Brauw et al., 2021), a lever Haryana needs so that tenant farmers on leased ponds can access working capital without land collateral.

Three points matter most for Haryana. First, data can substitute for collateral only if the scoring model is built properly. Credit scoring works best when it combines transaction history, agronomic data, and behavioural indicators (Kumar, Sharma & Mahdavi, 2021), and a 2026 study of smallholders in Vizianagaram and Srikakulam found that weighting character and repayment capacity alongside collateral changed who qualified for credit without changing who deserved it (Jonnalagadda, 2026). This is the model Aqua Exchange's risk score already uses, and it is worth formalising for Haryana. Second, government instruments exist as NABARD refinances fish-farming loans at rates as low as 4.5 percent (Reddy, 2023), and the Fisheries and Aquaculture Infrastructure Development Fund holds INR 7,522 crore for processing and cold-chain infrastructure (NABARD, 2021). Neither was designed for AIoT, but neither excludes it. Third, none of this works in isolation; a HaaS subscription without credit merely turns a lump-sum affordability problem into a recurring one, and a loan without farm data to price risk pushes rates back toward informal levels. The model that scales designs technology, credit, and insurance together.

5.3 Financial solution for Haryana's Shrimp sector

Electricity tariffs represent a significant operating cost for shrimp farmers in Sirsa, who face substantially higher rates than those applicable to conventional agricultural activities. While wheat and cotton cultivators benefit from subsidised electricity tariffs of approximately INR 0.10 per unit for metered agricultural tube wells, aquaculture farmers with a connected load of 20 kW or above are charged INR 4.75 per unit. This tariff differential increases the cost of aeration and pond management, with farmers expressing a preference for a reduced tariff of approximately INR 2 per unit to improve the economic viability of shrimp aquaculture (ICSF, 2024). With an aerator running nearly around the clock through a 120-day cycle, every wasted kilowatt-hour comes out of the farmer's own pocket. The state's only relief is on the capital side; solar conversion is supported at INR 20,000 per horsepower, capped at INR 2 lakh, which does nothing for farmers still on the grid. That is the gap PowerMon-style monitoring closes, by cutting units drawn so the saving reaches the farmer directly rather than depending on a scheme. The opportunity is large. Haryana brought 58,293 acres under fish and shrimp farming in 2024-25 against a 59,397.50-acre target for the following year, shrimp acreage has grown more than threefold since 2020, and the state produced upward of 15,000 tonnes of white-leg shrimp last year, mostly from Sirsa and Fatehabad (Sharma, 2025). Barely 2,600 of the 58,000 hectares of identified saline land across Haryana, Punjab, Rajasthan, and Uttar Pradesh is in use (Rani, Sharma, 2025). The power bill problem is small today but will grow, so efficiency should be built in now rather than retrofitted.

Sirsa's fish farming covers just 1,954 hectares, 0.46 percent of the district's area, yet produced 13,050 tonnes of fish, including 3,200 tonnes of shrimp from 236 hectares, around 56 percent of Haryana's output. Yet the sector's entire earmarked credit potential for 2025-26 is INR 35.47 crore against INR 9,196.06 crore for total farm credit, well under half a percent. Momentum exists as app-controlled automatic feeders are running with NABARD's backing,

a shrimp-farming FPO has been formed, and roughly 22,000 acres of high-salinity land across 18 to 20 villages in Nathusari Chopta block are ready for expansion. What is missing is supporting infrastructure, as Sirsa has almost no cold storage or hatchery capacity (NABARD,2025-26). The technology has arrived years ahead of the capital and infrastructure that should scale with it.

Feed tells much the same story, just from the other side. India's shrimp feed market was already worth close to USD 2 billion in 2024 and is projected to more than triple, to somewhere between USD 7.4 and 8.5 billion, by the early 2030s (IMARC,2025), and feed alone typically eats up 50 to 65 percent of a farm's running cost. Drawing on the experience of Andhra Pradesh, the relevance of AquaBOT-style automated feeding lies primarily in optimising feed application rather than technological novelty. Precision feeding minimises overfeeding, thereby reducing feed wastage, improving Feed Conversion Ratios (FCR), limiting organic waste accumulation and sludge formation at the pond bottom, and reducing the need for frequent pond-bottom sludge removal. These improvements can lower production costs, maintain water and sediment quality, and reduce disease risks associated with deteriorating pond conditions.

Table 5: Projected Impact of AIoT-Based Power Monitoring, Haryana¹

Metric	State level (Haryana)	Farm level
Electricity Consumption (kWh)	Est. 89.4 million kWh/year across current shrimp acreage	15,342 kWh/acre/year
Annual Power-Bill Savings (post-AIoT)	Est. INR 8.07 crore/year saved across the sector	INR 13,846.5/acre/year
Aerator Operating Hours	Est. 44.8 million aerator-hours/year state-wide	1,920 hrs/acre/year (1 crop cycle)
Electricity Bill (at INR 4.75/unit)	INR 42.48 crore/ha/year total, cut to INR 34.41 crore post-AIoT	Falls from INR 72,874.5 to INR 59,028.34/acre/year
Carbon Dioxide Reduction	Est. 12,064.3 tonnes CO ₂ /year saved	2.07 tonnes CO ₂ /acre/year saved
Energy Cost per kg Shrimp	Falls from INR 27.46/kg to INR 22.25/kg	Same, farm-level basis
Fiscal Savings per Hectare	INR 34,200/hectare/year in reduced power spend	Mirrors state figure at farm scale

Source: Singh, e.t, al, 2025; HERC; Aqua Exchange; CEA; (Das, Gupta & Gulati, 2025)

¹ Haryana-specific device telemetry from Aqua Exchange isn't published yet, so the figures above are modelled estimates, built on the state's actual INR 4.75/unit aquaculture tariff, the acreage and production figures cited above, and the roughly 19% consumption cut and power-factor improvement. PowerMon has measured in Andhra Pradesh. Treat them as the range worth validating through a pilot, not as audited numbers.

6 Policy Analysis and Recommendations

The evidence in these brief points one way: AIoT works on an Indian pond. The Karamsana pond used nearly half the feed an average pond would need for the same shrimp, and in the Aqua Exchange sample about 83 percent of crops succeeded against roughly 67 percent without the technology (Singh, 2026). What a single farm cannot do is fix the things around it. A first-generation farmer in Sirsa still faces a basic IoT set-up costing around INR 1 lakh per pond (Somasundaram, 2022), a lease no bank accepts as collateral, and buyers who want traceability records a logbook cannot supply. These are problems of price, trust and paperwork, and public policy is well placed to solve them.

6.1 A Mission AIoT Framework

We recommend a single, time-bound Mission with named institutions in charge, in the spirit of PM-KISAN or PM Gati Shakti, rather than another round of pilots. It rests on five commitments, each with a number attached:

- **Production efficiency:** a national average feed conversion ratio below 1.5 within five years, from about 1.85 today.
- **Traceability:** digital traceability for every shrimp export through a National Aquaculture Traceability Platform (NATP) run by MPEDA.
- **Disease risk:** AI-assisted surveillance across all ten major shrimp clusters, linked to ICAR-CIBA diagnostics.
- **Financial inclusion:** formal credit for 60 percent of shrimp farmers, tenants included.
- **Inland expansion:** 25,000 hectares of saline land in Haryana, Punjab, Rajasthan and Uttar Pradesh under shrimp by 2030.

The window is open now. The India–UK and India–EU trade talks, PMMSY's next phase and MPEDA's traceability framework are all arriving together, just as the US tariff shock has made single-market dependence costly. The Mission should scale a model, not one company as several technology providers competing on the same rules, standards and access to credit and insurance.

MPEDA should lead nationally, adding a technology mandate to its export role and running the NATP. NABARD should open an Aquaculture Technology Finance window, and ICAR-CIBA should set technical standards for AIoT in saline water (ICAR-CIBA, 2025). On the ground, each of the 34 PMMSY-notified clusters should have a Technology Integration Manager (TIM) who coordinates vendors, trains farmers and checks data quality. This is the answer to vendors who sell a device and leave, with nobody explaining what the readings mean (Somasundaram, 2022). Sirsa should be designated the National Demonstration Cluster, with the INR 110-crore Aquapark as its hub (PIB1, 2026), because smallholders adopt what they have seen work on a farm like their own (Rastegari et al., 2023). At the farm level, FPOs should be the channel, supported under PM-MKSSY's INR 6,000-crore outlay (PMO, 2024) and structured as data cooperatives, where members share farm data but keep their own ponds.

6.2 Immediate Priorities

- **Put a sensor on the pond:** PMMSY already covers 40 percent of project cost, and 60 percent for women and SC farmers (Harfish, 2024). We recommend extending it explicitly to AIoT sensors, feeders, aerator controls, and software subscriptions, with the highest rates for small, tenant, and inland saline farms, lower rates for medium and large ones, and a collective window for FPOs. Support should be released only after a TIM (Technology Integration Manager) confirms the device is installed and working, and should cover rental as well as purchase. Fee-for-service is how Bangladeshi smallholders already reach pumps and tillers (Mottaleb et al., 2017), and a power monitor at INR 5,085 per cycle is a far lighter ask than a lump-sum purchase.
- **Pay for efficient feeding:** Feed is the largest cost in the pond, and the sample shows feed conversion improving from 1.85 to 1.38, worth about INR 1.87 lakh per hectare per cycle. Equipment support should come bundled with TIM-led training and a vendor-neutral list of approved equipment. A farmer does not experience a conversion ratio; she experiences a lighter feed bill.
- **Build a shared early-warning net:** A single sensor can catch an oxygen crash, and dissolved-oxygen events cause just 0.2 percent of failures on the platform. Disease is harder, as white spot and Runt-Moribund Syndrome still account for about 17 percent each, and predicting them needs readings from many ponds together. We recommend cluster-level surveillance feeding ICAR-CIBA, paid for once and shared, since a first-year failure in Sirsa carries a 68 percent chance of pushing a farmer out for good (Das, Gupta & Gulati, 2025).
- **Let the farm's record count as collateral:** Leasehold land cannot be pledged, and fisheries get under half a percent of Sirsa's credit plan (NABARD, 2025-26). Aqua Exchange shows a way out, with about 42 percent of sampled farmers linked to formal credit and sensor-triggered insurance that has paid INR 1.47 crore in claims with no rejections, unlike the 2021 NFDB-OICL pilot that left out disease cover (PIB, 2024). NABARD should recognise an AIoT-derived Farm Risk Score as a collateral substitute under priority sector lending, at no new spending, and IRDAI should support parametric aquaculture insurance with disease cover. Credit, insurance, and technology must be designed together.
- **Give every vendor the same data language:** A common data schema and open API standards would enable farmers' production and credit histories to remain portable across technology platforms, rather than being confined to proprietary applications. Such interoperability would prevent farmers from having to rebuild their credit histories when switching service providers, while ensuring a platform-neutral and inclusive digital ecosystem.

Three supporting moves depend on the above. First, power: Haryana's farmers pay INR 4.65 to 5.00 a unit against about INR 1.25 in Andhra Pradesh (Das, Gupta & Gulati, 2026), so power-management support should sit inside the AIoT subsidy tiers, verified through DISCOM billing data, recovering margin from the transformer rather than through a new subsidy. Second, FPOs: PM-MKSSY grants should be tied to a data-cooperative structure, building on Sirsa's NABARD-backed shrimp FPO, which is also the natural home for registration and certification paperwork. Third, export compliance: with about half of India's EU-bound consignments inspected and 61 rejections between 2020 and July 2026 (RASFF, 2026), MPEDA should build an EU Compliance Digital Platform that turns NATP farm data into HACCP², residue-limit, and environmental records, and seek mutual recognition of that data in the India-EU negotiations.

Only about 2,600 of the 58,000 hectares of identified saline land is in use (Rani & Sharma, 2025), so the 2030 target implies roughly a tenfold expansion. It comes last because it works only once disease monitoring, credit, and data standards are in place. Sirsa is ready to lead but has almost no cold storage or hatchery capacity (NABARD, 2025-26), so the Aquapark and the INR 7,522-crore Fisheries and Aquaculture Infrastructure Development Fund (NABARD, 2021) matter as much as the sensors. New farms should have monitoring and power efficiency built in from the first cycle.

6.3 Sequencing and Way Forward

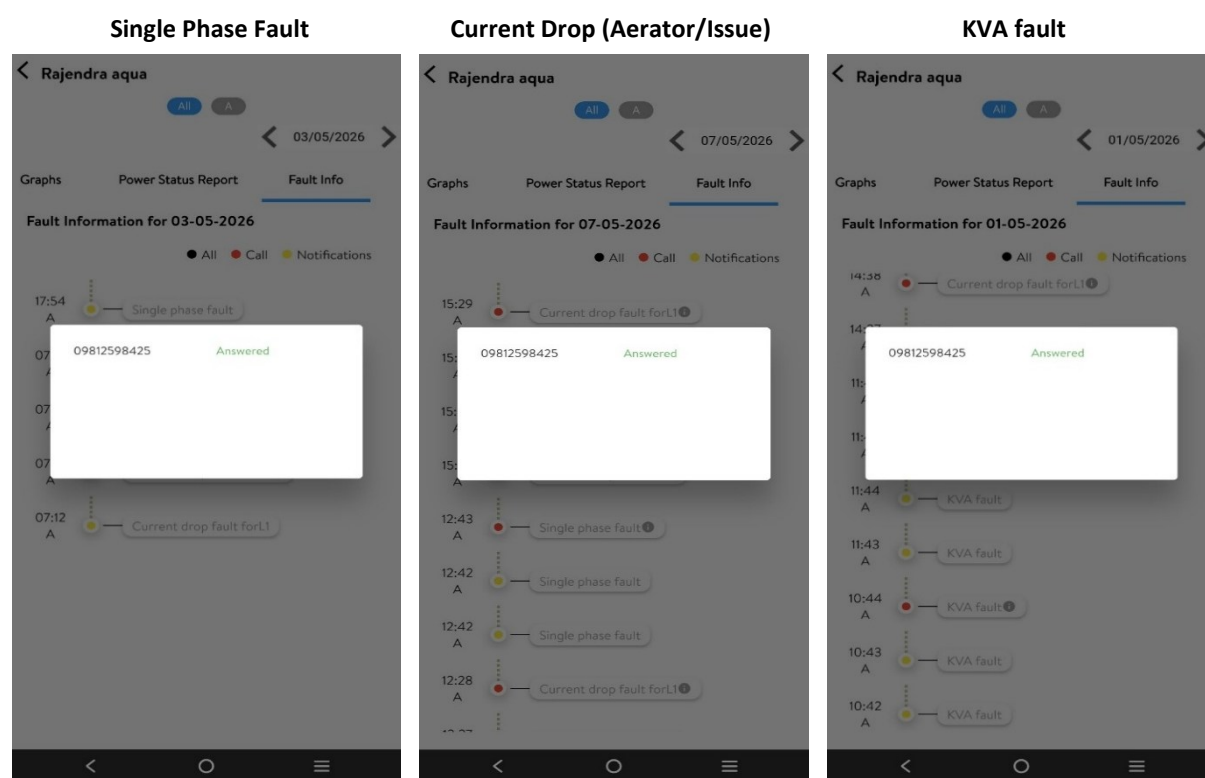
Most of this runs on instruments that already exist: PMMSY, PM-MKSSY, NABARD refinancing and MPEDA's own budget. We suggest three phases over 2026 to 2030. Years 1 and 2 cover the institutional groundwork includes the NABARD circular, the NATP design and data standard, and TIM appointments. Years 2 to 4 extend subsidies, FPO incentives and disease surveillance across all ten clusters. Years 4 and 5 consolidate around the credit and expansion targets. CSR and philanthropic capital can help early, by funding demonstration farms, first-year rentals, TIMs and group certification, which is the role the Karamsana pilot has already played.

The central policy task is to scale this proven model from its current reported footprint, an estimated 75,000 acres, or 25 percent of Indian shrimp farms to national coverage within five years, through a competitive, platform-neutral policy framework in which multiple technology providers compete on the same rules-based infrastructure of AIoT-linked credit, insurance and certification, rather than through the commercial expansion of any single company. The window of opportunity is defined by the convergence of the India–UK and India–EU FTA negotiations, the PMMSY Phase 2 expansion agenda, MPEDA's National Framework on Traceability, and the global seafood market's intensifying premium on certified, traceable, antibiotic-free product.

² HACCP (Hazard Analysis Critical Control Point) certification is a third-party verification that a food business operates a structured, science-based safety system to control biological, chemical, and physical hazards, and it functions as a proactive, risk-based regulatory and commercial standard rather than just a static government permit.

Annexures

Annex 1: Powermon and Aerator Alerts

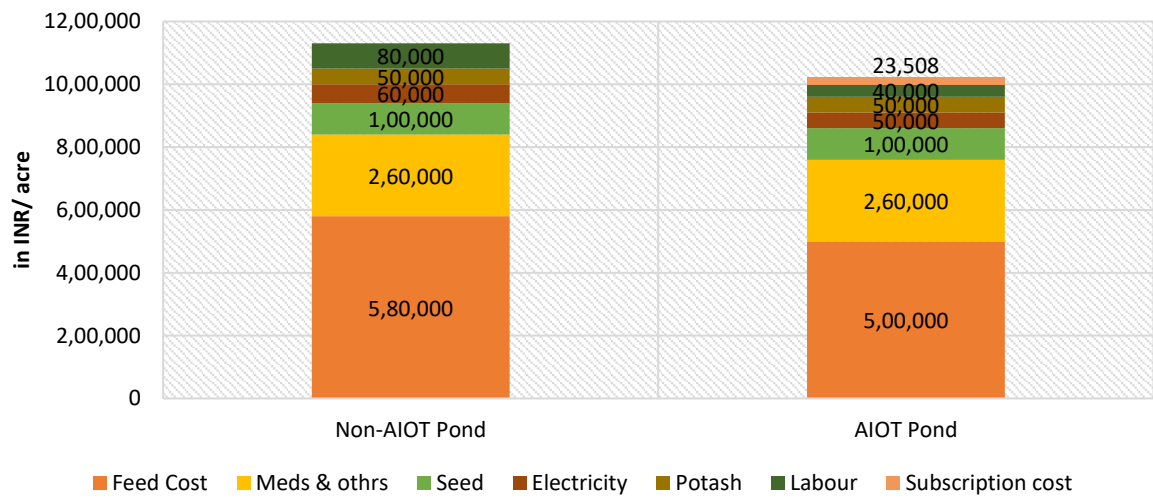


Annex 2: Weekly Feed Consumption & Feed Cost of Pond 8 (Baseline) vs Pond 7 (Observed)

Week	Pond 8 Feed (kg)	Pond 7 Feed (kg)	Pond 8 Cost (₹)	Pond 7 Cost (₹)	Pond 8 (₹/acre)	Pond 7 (₹/acre)	Difference
Wk 1	373	221.7	39302.9	23709	39763	23987	15776.2
Wk 2	457	303.2	48161.1	32425	48725	32805	15920.3
Wk 3	457	398.0	48161.1	42557	48725	43055	5670.1
Wk 4	387	461.9	40779.3	49387	41257	49966	-8708.9
Wk 5	597	410.7	62924.7	43920	63662	44435	19227.4
Wk 6	597	491.9	62924.7	52595	63662	53211	10450.6
Wk 7	597	437.6	62924.7	46794	63662	47342	16319.4
Wk 8	597	455.5	62924.7	48704	63662	49275	14387.3
Wk 9	527	511.4	55542.9	54681	56194	55322	871.7
Wk 10	457	476.1	48161.1	50910	48725	51506	-2781.1
Wk 11	457	507.6	48161.1	54280	48725	54916	-6191.0
Total	5,500	4,676	₹5,79,968	₹4,99,964	₹5,86,763	₹5,05,821	₹80,942

Source: Field Data from Sirsa, Haryana

Annex 3: Cost of Cultivation comparison of Non-AIoT and AIoT pond



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