Integrated Mangrove Aquaculture: Business Models for Climate-Resilient Shrimp Farming

October 2026

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Suggested citation

Sathiskumar, Abinaya, and Avinandan Taron. 2026. *Integrated Mangrove Aquaculture: Business Models for Climate-Resilient Shrimp Farming.* International Water Management Institute (IWMI).

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Front cover photo: Sourabh Kumar Dubey

Acknowledgments

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We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund (https://www.cgiar.org/funders/).

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Contents

1. Introduction 5

2. Conventional Shrimp Farming and Its Impact on Mangrove Ecosystems in India and Bangladesh 6

3. IMA Business Models for Climate-Resilient Coastal Production 7

3.1. Case Identification and Selection 7

3.2. Classification and Overview of IMA Business models 8

4. Mangrove Restoration and Regeneration through IMA Models 13

5. Recommendations for aligning shrimp aquaculture, mangrove conservation and carbon finance 14

6. References 15

Executive summary



Mangroves provide coastal protection, support fisheries and store carbon, yet continue to be lost to shrimp aquaculture across Asia. In Bangladesh and India, conventional shrimp farming has contributed to mangrove loss in the Sundarbans and major east-coast deltas, while exposing farms to cyclones, salinity intrusion and disease. Integrated Mangrove Aquaculture (IMA), including silvofisheries, offers an alternative by combining aquaculture with mangrove conservation. Globally, restoring 10–50% of the 1.5 million hectares of mangroves lost to shrimp farming could sequester 0.17–1.04 million tonnes of carbon annually.

Based on secondary case evidence, this report examines three business models for implementing and scaling IMA:

- **Market aggregator model:** Organizes smallholders into producer groups and connects them to premium markets through aggregation, internal control systems and traceability.
- **Vertically integrated producer model:** A single company manages hatcheries, farming, processing and exports, with centralized certification and compliance.
- **Farmer-led co-management model:** Farmer groups manage production with state or forest authorities, with land access conditional on mangrove conservation.

The first two models offer greater potential for blue carbon and sustainability finance through coordinated monitoring. The farmer-led model is more inclusive but faces challenges in integrating production and environmental data. Cases from five countries highlight the role of land-use regulations, market incentives and farm investment in mangrove conservation.

For India and Bangladesh, the report recommends protecting existing mangroves, preventing aquaculture expansion into intact forests, improving existing ponds and restoring abandoned or low-productivity ponds. Stronger monitoring, clear land-use arrangements and certification can attract private and carbon finance while supporting livelihoods and conservation outcomes.

1. Introduction

Mangroves are intertidal ecosystems in tropical and subtropical coastlines (Peng et al. 2009; Saenger 2002). Despite their ecological importance, they continue to decline, particularly through conversion to shrimp ponds, with Asia experiencing the largest net loss (Venkatachalam et al. 2018; Peng et al. 2009). Integrated Mangrove Aquaculture (IMA), also known as silvoaquaculture or silvofisheries, combines aquaculture with mangrove conservation (Ahmed et al. 2018).

IMA integrates mangroves with brackishwater aquaculture to improve nutrient recycling and pond health (Fitzgerald 2002; Peng et al. 2009). Systems may be integrated, associated or separated, depending on the spatial arrangement of ponds and mangroves (Bosma et al. 2016). Mangrove conversion to shrimp ponds can generate emissions of 437 kg of carbon per kilogram of shrimp produced (Ahmed et al. 2018; Kauffman et al. 2017). Conversely, IMA can support blue carbon sequestration and climate resilience (Ahmed et al. 2018; Bouillon et al. 2008; Donato et al. 2011; McLeod et al. 2011; Pendleton et al. 2012). Despite their limited coastal area, mangroves contribute nearly 30% of annual blue carbon sequestration (Ahmed et al. 2018; Siikamäki et al. 2012). Table 1 presents IMA's potential contribution to global carbon sequestration..

Table 1. Potential for blue carbon sequestration through integrated mangrove-shrimp cultivation

Global mangrove area lost to shrimp culture (million ha)	Restoration of mangrove area (%) through IMA	Restoration of mangrove area (million ha) through IMA	Carbon sequestration rate (t ha^{-1} $year^{-1}$)	Total carbon Sequestration (million t $year^{-1}$)
1.5	10	0.15	1.15-1.39	0.17-0.21
	20	0.30		0.35-0.42
	30	0.45		0.52-0.63
	40	0.60		0.69-0.83
	50	0.75		0.86-1.04

Source: Ahmed et al., 2018; Bouillon et al., 2008; Nellemann et al., 2009; Siikamaki et al., 2012

2. Conventional Shrimp Farming and Its Impact on Mangrove Ecosystems in India and Bangladesh

Conventional shrimp farming has expanded rapidly across Bangladesh and India, generating economic benefits but contributing to mangrove loss and coastal degradation. Understanding existing production systems is essential for assessing alternatives such as IMA.

In Bangladesh, shrimp farming expanded from the 1970s as higher profitability encouraged farmers to shift from rice cultivation. Farms are predominantly extensive, using tidal water for shrimp-rice rotation, shrimp-salt rotation or year-round shrimp production, depending on salinity (Ahmed et al. 2018). In the Indian Sundarbans, traditional farming takes place in large tidal ponds (bheris), where sluice gates admit brackish water for cultivating mainly tiger shrimp (*Penaeus monodon*) (Das et al. 2016). The introduction of *Litopenaeus vannamei* has diversified production into extensive, semi-intensive and intensive systems, including biofloc. However, inadequate biosecurity increases disease risks and production failures (Maity et al. 2021).

Mangroves support coastal protection, fisheries, biodiversity, nutrient cycling and carbon sequestration (Ahmed et al. 2018; Hoq 2007; Islam & Haque 2004). Their conversion to aquaculture has caused substantial habitat loss, including nearly 10,000 ha in Bangladesh (Ahmed et al. 2018; Hossain 2001) and losses in India's Sundarbans, Krishna, Godavari and Mahanadi deltas (Table 2).

Table 2. Major mangrove forest losses attributed to shrimp farming in coastal Bangladesh and India

Country	Mangrove forest area	Assessment period	Area lost (ha)
Bangladesh	Chakaria Sundarbans		8,500
	Mangroves along the Naf River	1976 - 2010	667–1,800
	Maiskhali Island		290
	Jaliardwip Island		133
	Matabar Island		104
India	Sundarbans	1999 - 2009	1005
	Krishna Delta	1977 - 2013	1312
	Godavari Delta	1977 - 2013	596
	Mahanadi delta	1973 - 2006	2381

Source: Ahmed et al., 2017, 2018; Giri et al., 2022; Hossain, 2001; Pattanaik & Narendra Prasad, 2011; Sumiko et al., 2017

Shrimp farming in Bangladesh and India faces cyclones, flooding, salinity intrusion, sea-level rise and temperature fluctuations, threatening production and livelihoods (Ahmed et al. 2018; Ahmed & Diana 2015). IMA offers a more sustainable alternative by combining shrimp production with mangrove conservation and improved resource efficiency (Ahmed et al. 2018; Ahmed & Troell 2010; Chopin et al. 2012).

3. IMA Business Models for Climate-Resilient Coastal Production

3.1. Case Identification and Selection

This section develops three Integrated Mangrove Aquaculture (IMA) business models for India and Bangladesh, illustrating alternative approaches to integrating ecological functions, livelihoods and market structures within mangrove-based aquaculture landscapes.

The ten cases were identified through a two-stage review of secondary literature, including peer-reviewed studies, project reports, program documents and information published by companies, funders and certification bodies. Google Scholar was used to identify academic studies, while Google searches were used to locate grey literature and relevant organizational websites. These sources provided additional information on business arrangements, operational scale and financing, which was often not covered in academic publications.

In the first stage, broad searches combined terms describing the production system (e.g., "mangrove aquaculture", "mangrove shrimp" and "silvofisheries") with terms relating to business arrangements (e.g., "business model", "value chain", "smallholder" and "certification"). Searches were conducted without geographical restrictions to identify the different types of arrangements documented in the literature. Titles and abstracts or summaries were screened to identify recurring organizational structures. In the second stage, the search was refined based on the arrangements identified during the initial screening. Additional terms describing these arrangements (e.g., "aggregator", "contract farming", "vertically integrated", "co-management" and "conservation lease") were incorporated, and searches were repeated using regional terms (e.g., "South Asia", "Southeast Asia" and "Latin America"), reflecting where documented mangrove-linked cases were available, to identify cases across different geographical and institutional settings. Reference lists of key documents were also examined to identify additional cases.

Cases were selected using four criteria: (i) integration of aquaculture with mangrove or coastal wetland ecosystems; (ii) information on organizational roles in production coordination and market access; (iii) sufficient evidence on operational scale, financing, certification or income for comparison; and (iv) coverage of different countries and institutional arrangements. Selection also considered the availability of publicly accessible information. Consequently, less-documented mangrove-linked aquaculture arrangements may not be represented.

3.2. Classification and Overview of IMA Business models

The ten cases were classified according to the primary actor coordinating production, financing and market access into three models: (i) **market aggregator model** (five cases); (ii) **vertically integrated producer model** (two cases); and (iii) **farmer-led co-management model** (three cases). Figure 1 illustrates their characteristics, while Table 3 summarizes the selected cases, locations and operational arrangements.

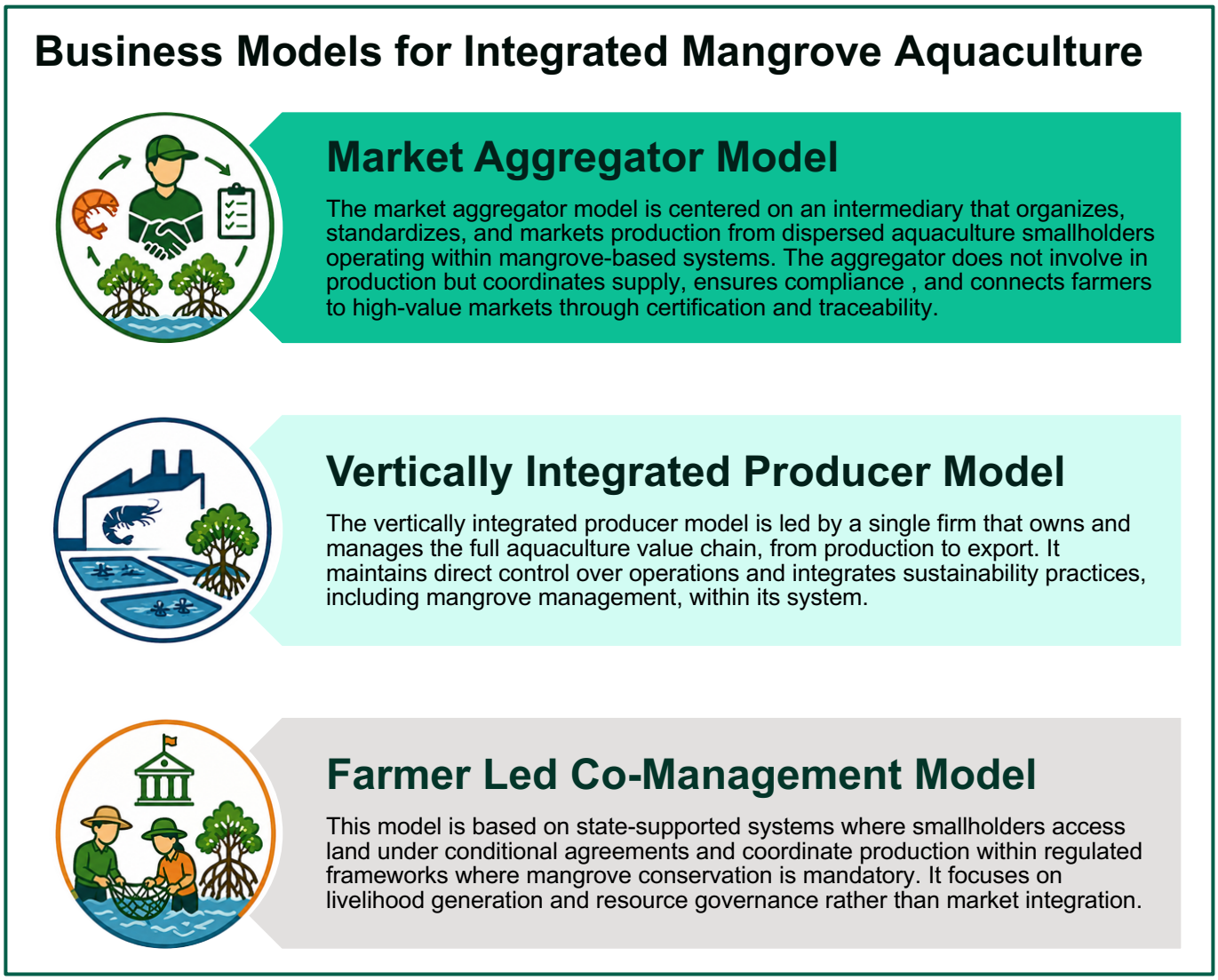

Figure 1: Description of Business Models for Integrated Mangrove Aquaculture
Source: Authors' creation

Table 3. Business models and case studies of IMA systems

Business model	Case study	Location	Coordinating organization	Scale	Key features	Source
1. Market aggregator	JALA and Conservation International	Indonesia	JALA, in partnership with CI Ventures	70,000+ ponds; 30,000+ farmers and employees	IoT-based pond monitoring; an integrated platform connecting farmers with production inputs and markets; blended finance through the Climate Smart Shrimp Fund to support mangrove restoration.	Conservation International 2026; JALA 2026.
	Selva Shrimp	Mekong Delta, Vietnam	Blueyou Consulting	3,350 farmers; 17,700 ha	Stepwise ASC and organic certification; minimum 50% mangrove cover within farms; traceability across the shrimp supply chain from production to market.	BlueYou, 2026; IDH, 2026
	Camimex Group	Ca Mau, Vietnam	Camimex (processor)	1,200+ farmers; 6,300 ha	Direct sourcing from farmers; FMO and DFCD financing; technical training in organic shrimp production and mangrove management.	FMO. 2026
	Mangroves and Markets (MAM)	Nhung Mien Forest, Vietnam	Forest authorities, processors and farmers	800 household plots; 3,371 ha	Naturland certification linked to mangrove conservation; price premiums for compliant production; project funding through the International Climate Initiative.	FAO 2012
	Minh Phu	Ca Mau, Vietnam	Minh Phu (processor and exporter)	2,370+ households; approximately 11,500 ha	Group certification under ASC, BAP and organic standards; 10–20% export price premiums; payments for maintaining mangrove forests through forest environmental services.	Global Seafood Alliance, 2024
2. Vertically integrated producer	Omarsa	Gulf of Guayaquil, Ecuador	Omarsa (company)	6,000+ workers; exports to approximately 40 markets	Company-managed production estates; mangrove buffer protection and restoration; and ASC-certified shrimp exports.	Aquaculture Stewardship Council 2020
	Seajoy Group	Gulf of Fonseca, Honduras and Nicaragua	Seajoy (company)	3,800 ha in the Gulf; 41,500 ha across both countries	Extensive shrimp farming (8–10 shrimp/m²); distributed mangrove nurseries supporting propagule production and planting.	Holmyard 2022
3. Farmer-led co-management	Perum Perhutani	Java, Indonesia	Perum Perhutani (state forestry enterprise), with farmers	6,600 ha (Cikiong); 5,300 ha (Blanakan); 3,568 farmers	Conservation-linked leases requiring farmers to maintain mangrove cover; an 8:2 mangrove-to-water ratio; silvofisheries contribute approximately 50% of household income.	Hilmi et al. 2021
	Cha La	Nam Can, Ca Mau, Vietnam	State-Owned Forest Company 184, with farmers	235 households; approximately 70% organically certified (estimated)	Integrated layout, with ponds and mangroves on shared land; renewable 20-year leases; organic shrimp production.	Vietnam Fisheries Magazine 2026

	Kinh 17	Nam Can, Ca Mau, Vietnam	Tam Giang 3 state forestry company, with farmers	242 households; plots originally allocated as 10 ha strips in the 1980s and later subdivided	Separated layout, with mangroves and shrimp ponds in distinct areas of each farm; renewable 20-year leases; state-mandated mangrove allocation of 50–70%, depending on farm size.	Vietnam Fisheries Magazine 2026

Source: Author's creation.

The market aggregator model (Figure 2) operates in mangrove-dominated coastal areas where smallholders practice low-input shrimp farming, often facing fragmented production, weak coordination and limited market access. Farmers are organized into groups supported by Internal Control Systems (ICS) for monitoring, record-keeping and compliance. Aggregators coordinate harvesting and collection, while processors handle grading, freezing and packaging. Certification and traceability enable access to higher-value markets. Farmers retain ownership of their ponds, while aggregators provide technical support, market access and links to finance. Digital platforms further support transparency, production planning and compliance. The market aggregator model (Figure 2) operates in mangrove-dominated coastal areas where smallholders practice low-input shrimp farming, often facing fragmented production, weak coordination and limited market access. Farmers are organized into groups supported by Internal Control Systems (ICS) for monitoring, record-keeping and compliance. Aggregators coordinate harvesting and collection, while processors handle grading, freezing and packaging. Certification and traceability enable access to higher-value markets. Farmers retain ownership of their ponds, while aggregators provide technical support, market access and links to finance. Digital platforms further support transparency, production planning and compliance..

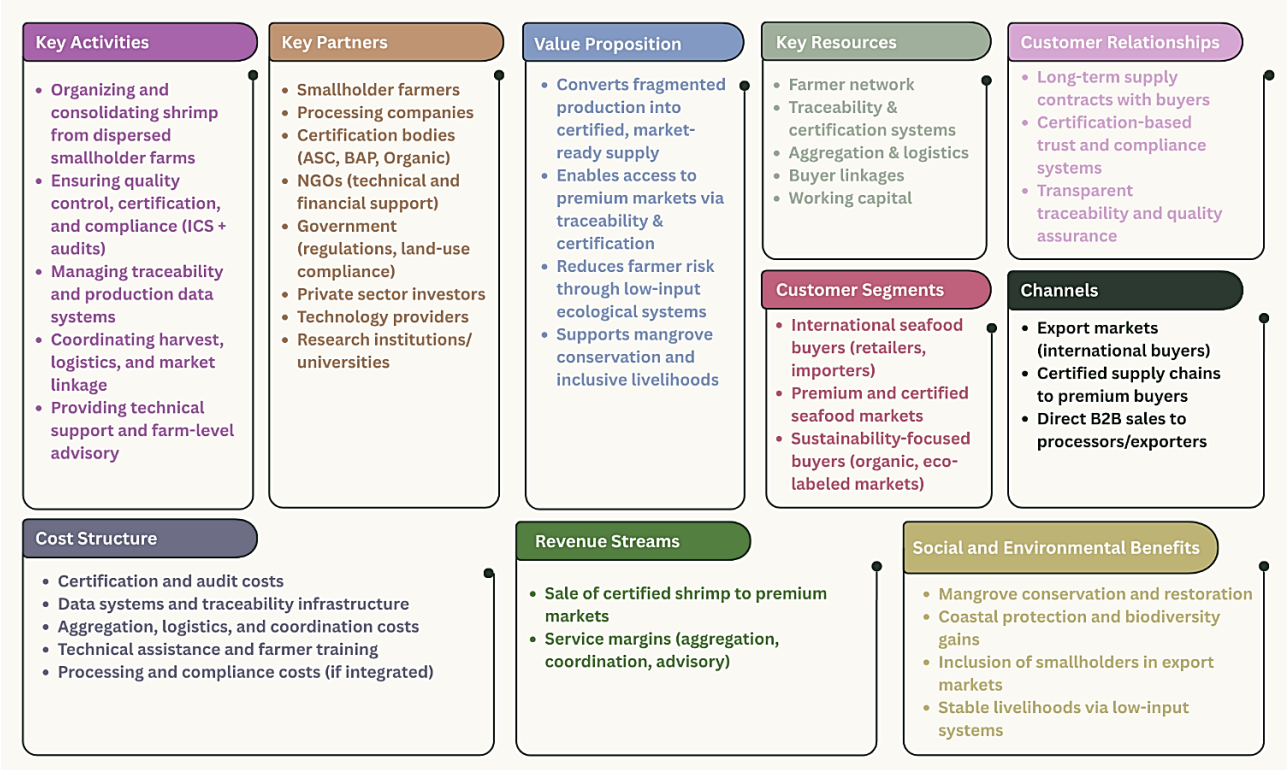

Figure 2: Business canvas for BM 1 – Market aggregator model
Source: Authors' creation

The second model, the vertically integrated producer system (Figure 3) consolidates the shrimp value chain under a single company, covering hatcheries, farming estates, processing and exports. Mangroves are incorporated into estate planning and farm design, while production is generally extensive or semi-extensive and relies on natural productivity. Company-managed mangroves support water quality, nutrient cycling and disease control. Integrated processing and export operations enable direct market access, consistent quality and traceability. Certification standards, including Aquaculture Stewardship Council (ASC) and Best Aquaculture Practices (BAP), are centrally managed to strengthen compliance and export competitiveness. .

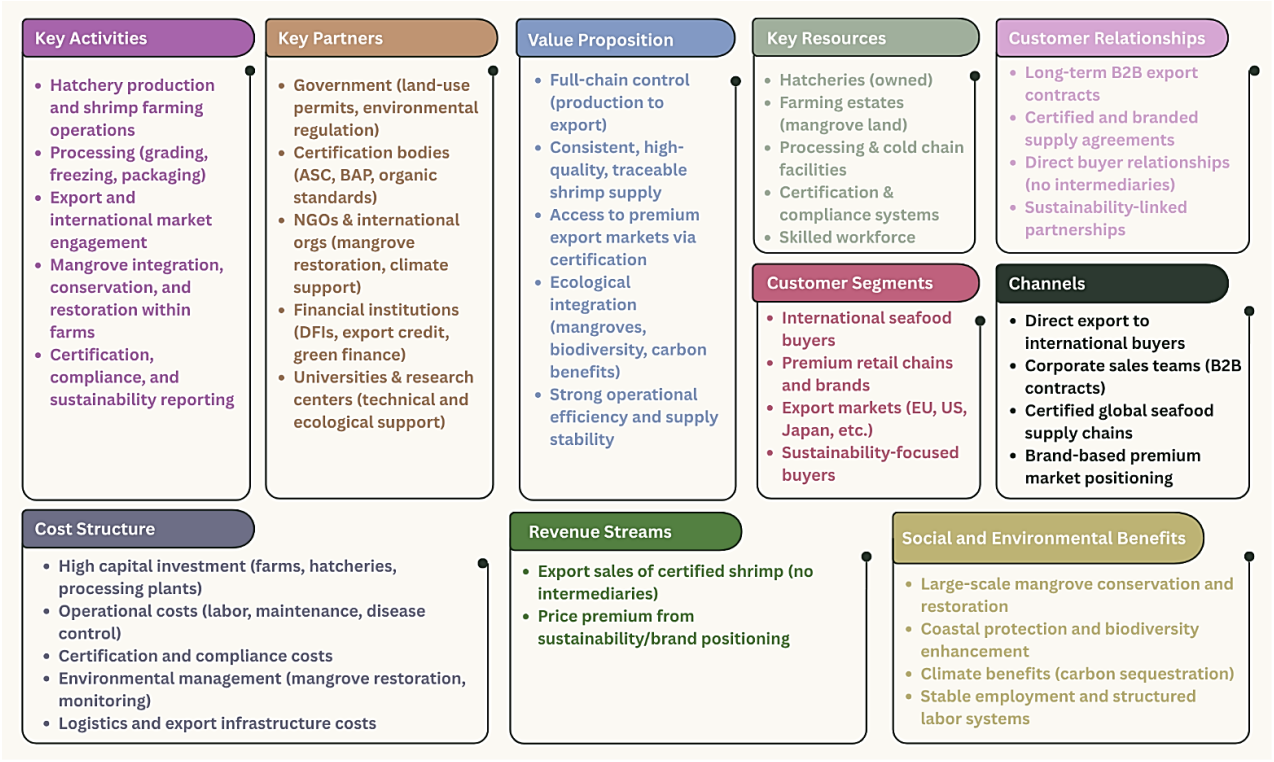

Figure 3: Business canvas for BM 2 – Vertically integrated producer model
Source: Authors' creation

The third model, the farmer-led co-management system (Figure 4), involves shared governance between farmer groups and state or forest authorities. Unlike corporate models, production is not centrally owned, while market coordination is generally limited. Land access is conditional on mangrove conservation and responsible aquaculture practices. Farmer groups coordinate water management, infrastructure use and compliance. Production ranges from low-input silvofisheries to semi-intensive and intensive aquaculture, with mangrove conservation remaining a requirement across systems.

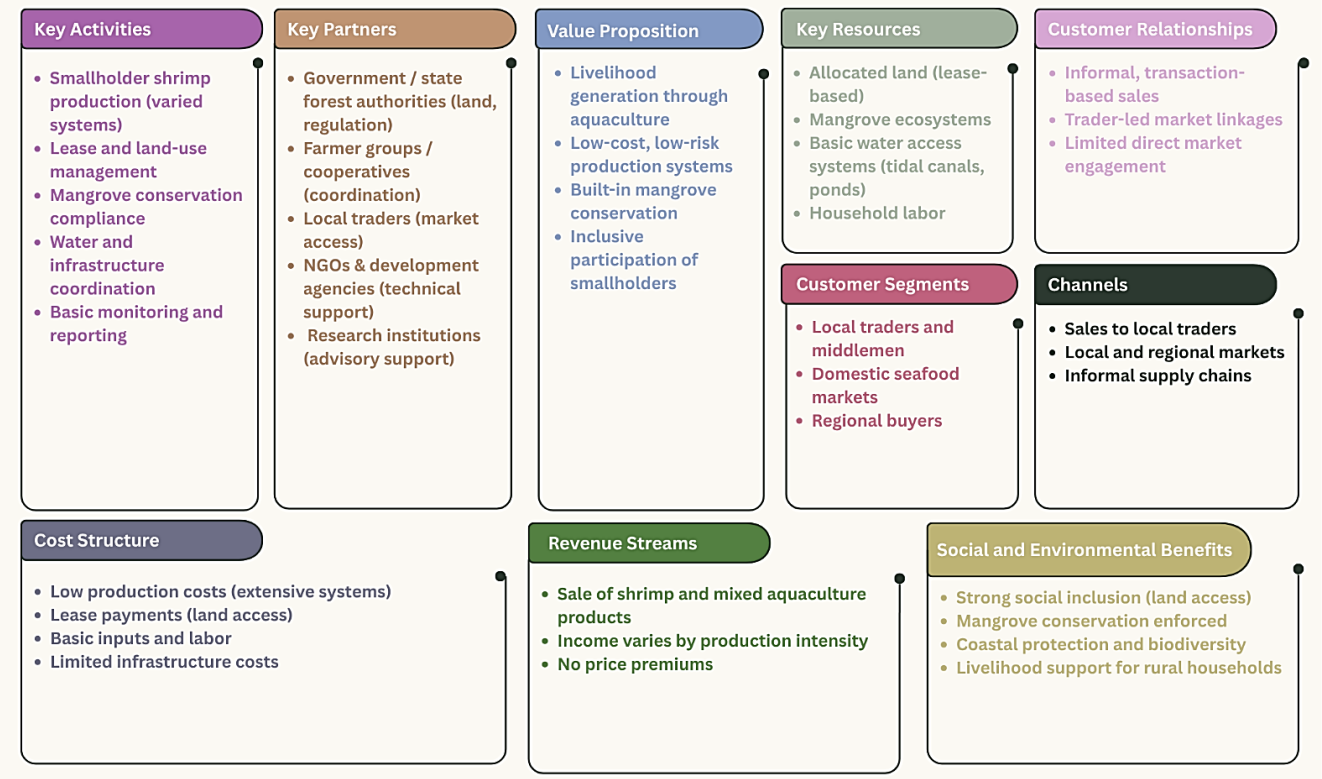

Figure 4: Business canvas for BM 3 – Farmer-led co-management model
Source: Authors' creation

Across the three models, mangroves are integrated into production rather than treated as separate conservation areas. Market aggregator and vertically integrated producer models offer stronger potential for climate finance because coordinated management, certification and traceability facilitate environmental monitoring and verification. These arrangements can support blue carbon credits, restoration finance and sustainability-linked investment. In contrast, farmer-led co-management faces greater challenges due to weaker data integration and less standardized monitoring, limiting its ability to generate verifiable carbon assets.

4. Mangrove Restoration and Regeneration through IMA Models

The business models discussed above demonstrate different approaches to integrating mangrove conservation with shrimp aquaculture. Restoration and regeneration are embedded within production landscapes through land-use arrangements, market incentives and investment in farm improvements.

In Indonesia, the JALA and Conservation International Climate Smart Shrimp initiative has restored approximately 115 ha of mangroves by converting degraded, low-productivity pond areas into mangrove stands while maintaining aquaculture production. Blended finance helps farmers manage the financial implications of this transition (Conservation International 2026; JALA 2026). Similarly, the Perum Perhutani silvofisheries model supports mangrove regeneration through lease arrangements requiring farmers to maintain prescribed mangrove-to-water ratios (Hilmi et al. 2021).

In Vietnam, the Selva Shrimp programme has supported the regeneration of approximately 13,500 ha of mangroves through production requirements, including maintaining around 50% mangrove cover within farms (BlueYou 2026; IDH 2026). The Markets and Mangroves project links restoration across more than 3,300 ha with certification, technical assistance and market incentives (Vietnam Fisheries Magazine 2026). Camimex and Minh Phu incorporate mangrove maintenance into certified export supply chains (FMO 2026; Global Seafood Alliance 2024). Outside Asia, Omarsa has restored over 100 ha in Ecuador, while Seajoy has supported regeneration through planting nearly 900,000 mangrove propagules across Honduras and Nicaragua (ASC 2020; Holmyard 2022).

Across these cases, three mechanisms support mangrove restoration: (i) land-use requirements that secure mangrove retention within production systems; (ii) certification and market incentives that reward ecological compliance; and (iii) investment in restoration as part of farm upgrading and supply-chain development.

5. Recommendations for aligning shrimp aquaculture, mangrove conservation and carbon finance

For India and Bangladesh, IMA development should balance conservation priorities with aquaculture production. Intact mangrove forests must be protected, and aquaculture expansion directed away from sensitive ecosystems. Existing shrimp ponds should be improved through better management and intensification rather than expanded into mangrove areas. Abandoned or low-productivity ponds can be targeted for mangrove restoration to recover water regulation, sediment stabilization and coastal protection. Climate finance and carbon markets can help make these transitions economically viable. Mangrove restoration in shrimp landscapes can generate blue carbon credits, providing additional income for farmers and cooperatives maintaining or expanding mangrove cover. However, access requires stronger monitoring, clear land-use arrangements and credible certification frameworks, which remain uneven in both countries. Strengthening these systems can align aquaculture profitability with long-term carbon sequestration.

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