

SMALL FISH: AN UNTAPPED OPPORTUNITY FOR IMPROVING NUTRITION



GAIN Working Paper n°61

February 2026

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Global Alliance for
Improved Nutrition

Recommended citation

Firdaus M, Budiman I, Sari EY, Lauwrhetta MN. Small Fish: An Untapped Opportunity for Improving Nutrition. Global Alliance for Improved Nutrition (GAIN). Working Paper #61. Geneva, Switzerland, 2026. DOI: <https://doi.org/10.36072/wp.61>

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Acknowledgements

This publication has been produced through the Nourishing Food Pathways programme which is jointly funded by the German Federal Ministry for Economic Cooperation and Development; the Ministry of Foreign Affairs of the Netherlands; the European Union; the government of Canada through Global Affairs Canada; Irish Aid through the Development Cooperation and Africa Division (DCAD); and the Swiss Agency for Development and Cooperation (SDC) of the Federal Department of Foreign Affairs (FDFA). The findings, ideas, and conclusions contained presented here are those of the authors and do not necessarily reflect positions or policies of any of GAIN's funding partners.

Our sincere thanks to all who made this research a success. Deepest gratitude to GAIN Indonesia to their funding and collaboration. To the fish farmers, aquaculture business practitioners, and traders in our target areas: thank you for your participation, insights and openness.

To the Ministry of Marine Affairs and Fisheries (KKP), the National Research and Innovation Agency (BRIN), and the Universitas Gadjah Mada (UGM) experts: we appreciate your knowledge, advice, and perspectives. This study's findings will be used to inform future discussions about promoting small fish as a healthy, safe, and sustainable food source in Indonesia. Finally, we extend our thanks to all stakeholders.

SUMMARY

Fish offer a potentially sustainable solution to food security and nutrition challenges in Indonesia, but while the country possesses abundant aquatic resources, its per capita fish consumption remains lower than that of neighbouring countries. Challenges such as overfishing, pollution, and unsustainable aquaculture practices hinder its growth, and climate change further threatens fish stocks.

This paper highlights the importance of small fish species, in particular, in addressing Indonesia's nutritional and environmental challenges. Small fish, often overlooked in favour of larger species, tend to be highly nutritious: they are rich in essential nutrients like protein, omega-3 fatty acids, vitamins, and minerals. As such, small fish can play a vital role in enhancing nutrition. When consumed whole, small fish can also foster zero-waste consumption. This paper assesses seven types of small fish and conducts a supply chain analysis of three of them. It also explores small-scale aquaculture practices, mapping the supply chain from sourcing to distribution. The findings offer actionable recommendations to enhance small fish consumption and support local economies.

Small fish development can offer a more sustainable alternative compared to large-scale farming, requiring fewer resources and producing less environmental impacts. However, the study identifies two primary challenges: a lack of consumer awareness and cultural preferences for larger fish species, and a consistent supply shortage due to limited access to fingerlings and modern farming resources. To overcome these, two key opportunities are emphasised: improving the effectiveness of restocking programmes and strengthening the supply chain by sourcing local fingerlings and sustainable feed. Among the three small fish species studied, *Wader* is the most profitable, offering higher returns and greater efficiency than *Nilem* or *Sepat Siam*. Combining traditional methods with modern aquaculture techniques is crucial for maximising productivity and long-term sustainability.

KEY MESSAGES

- Small fish are a nutritious and often environmentally sustainable food and can thus play a role in combating malnutrition and reducing environmental impacts of the food system.
- *Wader* small fish offers the highest cost-benefit resource allocation, maximum economic return, and livelihood enhancement for its supply chain actors.
- Improving effectiveness of fish restocking activities with rigorous initial assessment and community monitoring is important to increase small fish production.

BACKGROUND AND OBJECTIVE

Food from marine and freshwater ecosystems, including fish as well as shellfish, seaweed, and algae represent a promising avenue for addressing food security challenges in archipelago countries, such as Indonesia (1). The aquatic food market in South and Southeast Asia is a large and fast-growing with strategic opportunities to boost local consumption, implement sustainable aquaculture, and develop improved breeds (2). However, challenges such as overfishing, pollution, unsustainable aquaculture practices, and inadequate infrastructure are hindering its adoption. Climate change is also a severe threat to fish stocks and fishing livelihoods (3).

Despite the country's large bodies of water and long fishing traditions, fish consumption in Indonesia is lower than in neighbouring countries. Although FAO data show a significant increase from 19.4 kg per capita in 1999 to 45.1 kg in 2019, and national records reached 41.3 kg per capita in 2021, these figures are still below regional benchmarks (e.g., Malaysia 52.2 kg per capita) (4, 5). Despite relatively low consumption, fish is a major contributor to food loss and waste in Indonesia, responsible for about 6-8 million tons per year (21).

Small fish (usually between 1 - 4 inches or 2.5 - 10 centimetres when fully grown) can have a particularly important role to play. These fish are rich in important nutrients like protein, vitamins, minerals, and omega-3 fatty acids. These nutrients are crucial in combating malnutrition, particularly among vulnerable populations (3). Small fish also have relatively low environmental impacts (6). The consumption of small fish can thus contribute to both food security and environmental sustainability.

However, small fish are often overlooked and have not yet been prioritised by the Indonesian government, resulting in limited awareness of their potential to enhance nutrition and support sustainable fishing practices. Hence, it is essential to raise awareness of the critical role of small fish and the relevant sustainable management practices.

This study explores the role of small fish in nutrition and environmental sustainability. It examines sustainable harvesting and processing practices that improve human health and environmental resilience. We conducted a supply chain analysis of small fish to map the supply chains of small fish products (assessing key stakeholders, sourcing method, production techniques, distribution channels, and market access barriers) and identify the best practices, challenges, and growth opportunities for entrepreneurs and producer groups. Based on the results, it provides actionable recommendations to promote the sustainable production and consumption of small fish in Indonesia, supporting local economies and contributing to food security and sustainability. It emphasises the need for a holistic approach to support the growth of sustainable small fish production and consumption, potentially benefiting local communities, the environment, and food systems sustainability.

METHODOLOGY

DATA COLLECTION

This research employed a mixed-methods approach, combining qualitative and quantitative methods, with a focus on nutrition, environment, supply chains mapping, and the business case for small fish. Qualitative analysis examined consumer preferences,

supply chain dynamics, governance structures, and stakeholder perspectives, while quantitative analysis examined key commodities, costs margins, income distribution, and employment in the small fish sector.

Data were collected in July-August 2024 in Greater Jakarta Area, West Java, and Banten provinces. Quantitative data were collected through an online survey targeting urban consumers in Greater Jakarta. The survey collected structured data on fish consumption behaviour, preferences, purchasing considerations, and awareness of small fish species. There were 48 valid responses that were used for analysis. This is a relatively small sample, so the results should be considered merely indicative. Respondents were primarily fairly young (15-25 years old), reflecting the target demographic for urban consumption analysis.

Qualitative data were gathered through two Focus Group Discussions (FGDs) and 16 semi-structured interviews with key stakeholders across the small fish supply chain. The first FGD, held in Jakarta, focused on identifying opportunities and challenges in the small fish supply chain to support sustainable food consumption, with experts from the National Research and Innovation Agency (BRIN), the Ministry of Marine Affairs and Fisheries (MMAF), and Gadjah Mada University. The findings of this session informed the second FGD, which aimed to prioritise the most promising small fish species. This second discussion involved a broader range of practitioners, including freshwater fish suppliers from Sukabumi and Bogor, traders and retailers from five regional markets, members of the Indonesian Marine and Fisheries Social Economic Research Network (IMFISERN), and specialised policy and aquaculture analysts. Additionally, field-based semi-structured interviews were conducted with farmers, processors, and market actors in West Java, Banten, and Jakarta to capture nuanced perspectives across the upstream, midstream, and downstream segments of the supply chain.

DATA ANALYSIS

Data analysis combined content analysis for qualitative data and descriptive statistical analysis for survey results. A five-stage supply chain analysis was applied to map actors, activities, costs, and margins, supported by a profitability assessment using the Revenue-Cost (RC) Ratio. A Multi-Criteria Analysis (MCA) ranked small fish species based on nutritional value, market demand, supply potential, and environmental impact. Additionally, a life cycle analysis (LCA) evaluated the environmental impacts of small fish production and processing. These methods were jointly used to produce analysis that could inform policy and programme recommendations to support small fish as a sustainable food source in Indonesia. The details of the research questions, analytical methods, and data are presented in Table 1.

Table 1. Research design

Research Question	Objective	Methods	Data Type & Source
What are consumer preferences, price sensitivity, and consumption behaviour toward fish?	Analyse consumer preferences	Online surveys, field interviews	Preferences, average prices, consumptions patterns (from consumers)
How are small fish consumed, and what is their nutritional and market potential?	Analyse consumption patterns and small fish potential	Consumption & market analysis, nutritional assessment	Consumption data, nutrition content, market potential (from surveys, interviews, literatures)
Which small fish species are most suitable for promotion based on nutrition, environment, market, and aquaculture feasibility?	Select target small fish species	MCA, FGDs	Nutritional value, market demand, sustainability, ease of farming (from experts, stakeholders)
How do selected small fish species flow through the supply chain and what are the profitability and environmental aspects?	Understand supply chain structure and profitability	Supply chain, LCA, Profitability Assessment	Supply chain, cost-revenue data, environmental impact (from interviews, literatures)

NUTRITIONAL COMPARISON AND ECONOMIC VALUE OF SMALL FISH

In terms of nutrient composition, small fish are highly regarded for their richness in protein and essential nutrients. In addition to protein, small fish are a key source of omega-3 fatty acids, which are vital for brain health and reducing the risk of chronic diseases like heart disease (7, 8). Furthermore, small fish provide essential micronutrients such as calcium, iron, zinc, and vitamins A and B. This makes small fish a helpful addition to the diet in regions with limited access to other nutrient-dense food sources or where such foods are costly (9, 10).

Small fish in Indonesia include Wader (*Rasbora lateristriata*), Bilih (*Mystacoleucus padangensis*), Uceng (*Nemacheilus fasciatus*), Puyu (*Anabas testudineus*), Sepat Siam (*Trichogaster pectoralis*), Seluang (*Rasbora* spp.), and Nilem (*Osteochilus vittatus*), all of which are nutrient-rich, affordable, and relatively easy to prepare. In Indonesia, small fish like Wader and Seluang are key dietary staples (12). These fish are often eaten in traditional ways, like dried, salted, or fried. Wader is especially notable for its high protein content (19 grams per 100 grams). It also contains calcium and omega-3 fatty acids (11). Wader’s market price was lower than that of other small fish, reflecting its high consumer demand and supply. Nilem and Uceng provide a good mix of protein and calories; Nilem has 16 grams of protein and 110 calories per 100 grams and is priced at around IDR 35,000 to IDR 45,000 per kilogram (USD 2.11-2.71). Compared with some commonly consumed protein-rich foods like large fish or poultry products that may be available at similar or slightly lower prices, small fish like Nilem remain accessible options due to their local availability, minimal processing requirements, and the ability to provide multiple nutrients through whole consumption without waste (Table 2).

Table 2. Comparison of small fish species commonly consumed in Indonesia, based on different categories

Fish Species	Size (Length)	Protein Content (per 100 g)	Calorie Content (per 100 g)	Fat Content (per 100 g)	Calcium Content (per 100 g)	Distribution Area	Average Market Price per kg		Production Practices
							IDR	USD	
Sepat Siam	3-4 inches (7.5-10 cm)	15.2 grams	84 calories	0.6 grams	68 mg	Sumatra, Kalimantan	35,000 – 45,000	2.11 – 2.71	Captured, Cultured
Puyu	2-3 inches (5-7.5 cm)	14.3 grams	120 calories	4.9 grams	329 mg	Sumatra, Kalimantan, Papua	50,000 – 70,000	3.01 – 4.21	Captured, Cultured
Uceng	2-3 inches (5-7.5 cm)	18 grams	100 calories	3 grams	18 mg	Java, Sumatra	50,000 – 80,000	3.01 – 4.82	Captured, Cultured
Nilem	4 inches (10 cm)	16 grams	110 calories	2 grams	20 mg	Java, Bali, West Nusa Tenggara	35,000 – 45,000	2.11 – 2.71	Captured, Cultured
Wader	2-3 inches	19 grams	193 calories	13 grams	48 mg	Java, Bali, Lombok	20,000 – 35,000	0.71 – 1.41	Captured, Cultured
Seluang	(5-7.5 cm)	17 grams	110 calories	3 grams	20 mg	Sumatra, Kalimantan	40,000 – 50,000	2.41 – 3.01	Captured
Bilih	2-3 inches	15 grams	105 calories	2 grams	22 mg	West Sumatra (Lake Singkarak)	40,000 – 50,000	1.41 – 2.01	Captured

Source: authors' primary data. **Notes:** Cultured fish are farmed in controlled environments such as ponds, tanks, or aquaculture systems. This practice allows for more predictable production and quality control. Captured fish are harvested from natural habitats like rivers, lakes, and reservoirs. This method relies on natural population dynamics and environmental conditions. This study focuses on inland freshwater ecosystems, as the species analysed are indigenous to these habitats and not typically found in marine environments.

Table 2 compares the nutritional content of different types of small fish. It focuses on protein, calories, fat, and calcium per 100 grams. Uceng has the most protein, with over 18 g, which meets 30-40% of average daily needs. Wader is relatively calorie-dense, with almost 200 calories and over 12 g of fat per 100 g. Sepat Siam and Uceng have minimal fat, making them suitable for those who are trying to limit their fat intake. Puyu is notable for its high calcium content, with over 300 mg per 100 g, which meets 30% of the daily needs, making it good for bone health. Each fish offers unique benefits: Uceng is high in protein, Wader in calories and fat, and Puyu is rich in calcium.

SMALL FISH FOR ENVIRONMENT AND SUSTAINABILITY

Small fish are also important for the environment. As food for larger animals, they help keep the food chain balanced (3). Small fish often have traits like rapid reproduction that lower extinction risks. Freshwater small fish face challenges such as habitat destruction, pollution, overfishing, and competition with non-native species. These pressures can lead to population declines (13-15). In Indonesia, many of these fish are farmed in controlled aquaculture systems, helping to ensure a steady supply and reducing pressures on wild fish populations. As a result, overfishing and habitat destruction are mitigated (16).

Three key opportunities were identified for small fish to support environmental sustainability in Indonesia: reducing food waste, improving water efficiency, and improving biodiversity.

Food Loss and Waste Reduction

Unlike larger fish species that require gutting and processing, small fish species are eaten whole. This practice reduces food waste and makes sure that important nutrients found in the bones and organs of the fish are retained. These nutrients are usually thrown away when larger fish are processed. Small fish are also more resistant to damage during handling, reducing post-harvest losses (Table 3).

Efficiency in Water Use and Wastewater Reuse

Small fish are known for their efficiency in aquaculture, particularly in water usage. They thrive in compact environments that require less water, making them well-suited for sustainable farming practices. Systems like aquaponics further enhance water efficiency by recycling wastewater, which is purified and reused in plant cultivation. Additionally, these fish have lower feed and fertiliser requirements, contributing to reduced environmental impact. Integrated systems, such as aquaponics and IMTA (Integrated Multi-Trophic Aquaculture), promote nutrient cycling and reduce waste while increasing productivity (17).

Table 3. Potential loss, processing, and resistance to damage of small fish vs larger fish

Fish Species	Potential Food Loss (%) ¹	Primary Reasons for Loss	Processing Requirements	Whole Consumption	Resistance to Damage ²
Small Fish Species					
Wader (Rasbora spp.)	0-5	Consumed whole, no gutting needed	Minimal (cleaning only)	Yes	High
Nilem (Osteochilues vittatus)	0-5	Consumed whole, no gutting needed	Minimal (cleaning only)	Yes	High
Sepat Siam (Trichogaster pectoralis)	5-10	Consumed whole, no gutting needed	Minimal (cleaning only)	Yes	Moderate
Larger Fish Species					
Common Carp (Cyprinus carpio)	20-25	Requires gutting; prone to damage during handling	Gutting, filleting, bone removal	No	Low
Nile Tilapia (Oreochromis niloticus)	15-20	Requires gutting; moderately prone to damage	Gutting, filleting	No	Moderate
Catfish (<i>Clarias spp.</i>)	15-20	Requires gutting; moderately prone to skin/muscle damage	Gutting, trimming	No	Moderate
Milkfish (Chanos chanos)	25-30	Many small bones; requires gutting and complex deboning	Gutting, deboning	No	Low

¹ Potential Food Loss (%):

Refers to the estimated proportion of the edible mass lost during post-harvest handling, processing, and preparation

- Low loss: 0-10% (e.g., small fish consumed whole)
- Moderate loss: 15-20% (e.g., fish requiring basic processing)
- High loss: 25-30% (e.g., fish with many bones, or complex processing needs)

² Resistance to Damage:

Refers to the physical resilience of the fish during handling, transportation, and processing, which affects post-harvest loss

- High: Tough skin, low spoilage risk, and minimal handling damage
- Moderate: Some sensitivity to handling, moderate spoilage risk
- Low: Easily bruised, damaged, or spoiled during post-harvest processes

Promoting Biodiversity Conservation

Due to overfishing, small fish species face population declines in their natural habitats. Aquaculture and restocking of these species have thus been promoted to meet food security needs and conserve the species. By cultivating these species in controlled environments, overfishing pressure is reduced, and efforts are made to replenish wild populations through restocking (18). Unlike large-scale industrial aquaculture, which often faces criticism for using wild-capture fishmeal, farming of small indigenous species relies on more sustainable, low-trophic feed compositions. Because species such as Nilem, Wader, and Sepat are primarily herbivorous or omnivorous, they can be reared using locally available, plant-based inputs such as rice bran, algae, cassava leaves, and kitchen waste. This reduces the likelihood of the aquaculture process putting pressure on other wild stocks, maintaining a net-positive impact on marine and freshwater biodiversity. The restocking programme of Indonesia's Ministry of Marine Affairs and Fisheries (MMAF) is regulated in the Ministerial Regulation of Marine Affairs and Fisheries Number 19/2021 regarding Restocking and Aquaculture-Based Fishing. In various regions, restocking programmes have released thousands of fish back into their natural habitats, attempting to restore biodiversity and ensuring the sustainability of local fisheries.

SMALL FISH CONSUMPTION

Small fish species like *wader* and *bilih* hold immense cultural, nutritional, and economic significance in Indonesia, particularly in rural communities. *Wader*, native to freshwater habitats across Central and East Java. *Bilih*, endemic to Lake Singkarak in West Sumatra, is renowned for its unique flavour and high nutritional profile, particularly its contribution to local protein and mineral intake. In urban areas like Greater Jakarta, small fish together with other fish varieties such as Salmon, Milkfish (*Bandeng*), Snapper (*Kakap*), and Indian Mackarel Tuna (*Ikan Tongkol*) featured in preferences of 33% of consumers.

Other small fish species are integral to the Indonesian diet. *Teri* (anchovies) are one of the most common fish consumed across the archipelago, often used in dishes such as *nasi goreng* (fried rice) or *pepes teri* (steamed fish in banana leaves). Average annual consumption of this small fish was 0.34 kg per capita (19). Anchovies are particularly valued for their high calcium content and are frequently dried or salted to extend their shelf life. This makes them an important and accessible source of nutrition in both coastal and rural regions. Similarly, *seluang*, a popular small fish in Sumatra, is typically fried or preserved by salting, while *sepat siam* and *nilem* are commonly consumed in Java. These fish are featured in traditional dishes such as *pepes* and *sambal*, adding to the diversity of local cuisine.



Figure 1. Dried Fish Products from Small Fish (Seluang)

Consumer preferences for small fish in Indonesia are influenced by various factors, including price, taste, accessibility, and perceived health benefits. Freshwater fish tend to be more affordable than marine species, making them a vital source of protein for lower-income households. For instance, *teri* (anchovies) generally sell for around Rp. 40,000 to Rp. 60,000 per kilogram depending on whether they are fresh, dried, or salted. *Wader* and *bilih* are more expensive, typically ranging from Rp. 50,000 to Rp. 70,000 per kilogram, with *bilih* often being priced higher due to its limited availability and regional exclusivity. In contrast, *nilem* and *sepat siam* are relatively more affordable, often priced between Rp. 25,000 and Rp. 40,000 per kilogram in local markets. These fish are crucial for economically disadvantaged communities, where they support food security by providing a cheap and accessible source of protein.

The price of small fish is a key factor in their popularity, especially in economically disadvantaged areas. Consumers in these regions tend to prioritise price over variety, often opting for more affordable species like *nilem* or *sepat siam*, which are widely available in local markets at lower prices. Species like *wader* and *bilih* are often more expensive due to factors such as overfishing, environmental stress, and regional limitations in supply. Seasonal fluctuations also play a role in price variations; for instance, during peak fishing seasons, the price of small fish may drop, but during times of scarcity, prices can rise sharply. Despite these fluctuations, small fish remain a staple in many regions due to their overall affordability and widespread availability.

Beyond their affordability, small fish are also perceived as a healthier choice by many Indonesian consumers. Freshwater fish are often seen as fresher and more natural compared to imported or frozen options, which may contain preservatives. This perception of healthiness, combined with the cultural tradition of consuming locally sourced fish, strengthens the demand for small fish in both urban and rural areas. Their inclusion in traditional dishes that have been passed down through generations also contributes to their continued relevance in Indonesian cuisine, reinforcing their role not only as a nutritional resource but as a key element of the nation's cultural heritage.

Consumer preferences in Indonesia tend to lean toward more affordable fish options like *nilem* and *sepat siam*, but higher-priced species such as *wader* and *bilih* remain popular due to their cultural significance and superior nutritional benefits. The price sensitivity of most Indonesian consumers, especially those from lower-income households, often dictates their choices, with cheaper fish being more widely consumed (20). However, as awareness of sustainability grows, there is an increasing need to balance affordability with conservation to ensure that small fish species remain an integral part of Indonesia's food security and cultural heritage.

IDENTIFICATION OF PRIORITY SMALL FISH SPECIES

Although several small fish species are nutritionally valuable and commonly consumed in Indonesia, this study focuses on a subset of species with the strongest potential to be promoted as safe, healthy, and sustainable food sources in Greater Jakarta. The FGD clarified the definition of small fish as species that remain small at maturity, rather than juvenile forms of larger fish, and identified a preliminary list of freshwater small fish commonly supplied to urban markets (Table 2). Participants then assessed each species using multi-criteria analysis based on five equally weighted criteria: price, consumer preference, potential supply, market viability, and ecological impact. Each criterion was scored using a standardised scale, and the results were aggregated using multi-criteria analysis to rank species according to their overall suitability for promotion.

Based on the assessment, Nilem, Wader, and Sepat Siam emerged as the top three priority species. Nilem was selected due to its strong performance across price, supply potential, and ecological impact, combined with broad geographic distribution. Wader was chosen due to strong consumer preference and favourable ecological performance, despite more limited market development. Sepat Siam has stable supply potential, moderate consumer acceptance, and suitability for freshwater aquaculture systems.

While other species listed in Table 2 remain nutritionally important, their lower combined performance across economic, supply, and sustainability criteria makes them less suitable for targeted promotion in Greater Jakarta. For example, Bilih is produced in West Sumatra and North Sumatra. The next section's analysis of environmental sustainability and supply chain interventions thus focuses on Nilem, Wader, and Sepat Siam.

BUSINESS CASE FOR FARMING SMALL FISH

Small-scale fish farming, especially in low- and middle-income countries, can provide a viable and sustainable livelihood option when appropriately managed. Unlike large-scale industrial aquaculture, small-scale farmers often combine traditional knowledge with basic modern techniques. They typically rely on locally available inputs such as fingerlings and feed sources including rice bran, algae, cassava leaves, kitchen waste, and insects or earthworms. These practices can help reduce production costs and lower environmental footprints. Fish are raised in controlled environments, with attention to water quality and basic disease management to support growth and survival.

However, small-scale small fish farming also faces several constraints. Farmers are vulnerable to fluctuations in feed availability and prices, disease outbreaks, water quality degradation, and limited access to technical support and finance. Production is often labour-intensive, and profit margins can be sensitive to changes in market prices or

harvest yields. In addition, limited scale means that income from a single pond may not be sufficient to meet household needs without expansion or diversification. These challenges highlight the importance of appropriate species selection, efficient pond management, and access to markets to ensure economic viability.

Tarpaulin ponds, which are commonly used in West Java regions like Sukabumi and Bogor, offer cost-effective and space-efficient solutions for small-scale aquaculture. These ponds are easy to set up and maintain, making them ideal for farmers with limited land or resources. These round tarpaulin ponds can hold up to 1,000 fish and have a volume of about 8.48 cubic meters and can be highly productive. The fish are harvested twice a year for Nilem and three times a year for Wader and Sepat Siam. Even though Nilem is harvested less often, it generates more revenue because it produces a higher yield per harvest.

Table 4 provides a profitability analysis of small-scale aquaculture in Indonesia.

Table 4. Profitability analysis of small fish aquaculture (small scale) per year

Item	Nilem		Wader		Sepat Siam	
	IDR	USD	IDR	USD	IDR	USD
Initial Asset Investment						
Round pool made of tarpaulin	2,325,000	139.99	2,325,000	139.99	2,325,000	139.99
Water pump and aeration	500,000	30.11	500,000	30.11	500,000	30.11
Feed storage and equipment	200,000	12.04	200,000	12.04	200,000	12.04
Other equipment	100,000	6.02	100,000	6.02	100,000	6.02
Total Initial Investment	3,125,000	188.16	3,125,000	188.16	3,125,000	188.16
Fixed Costs (per year)						
Depreciation (pond & equip)	450,000	27.10	450,000	27.10	450,000	27.10
Total Fixed Costs	450,000	27.10	450,000	27.10	450,000	27.10
Variable Costs (per year)						
Fingerlings (IDR 20 each)	40,000	2.41	60,000	3.61	60,000	3.61
Feed	200,000	12.04	225,000	13.55	250,000	15.05
Vitamins and supplements	30,000	1.81	35,000	2.11	40,000	2.41
Labour (1 person)	1,200,000	72.25	1,200,000	72.25	1,200,000	72.25
Electricity	150,000	9.03	150,000	9.03	150,000	9.03
Miscellaneous	10,000	6.02	100,000	6.02	100,000	6.02
Total Variable Costs	1,720,000	103.56	1,770,000	106.58	1,740,000	104.77
Total Costs (per year)	2,170,000	130.66	2,220,000	133.67	2,190,000	131.86
Revenue (per year)	2,500,000	150.53	3,600,000	216.76	3,360,000	202.31
Profit (per year)	330,000	19.87	1,380,000	83.09	1,170,000	70.45
RC Ratio	1.15		1.62		1.53	

Notes: RC Ratio > 1 indicates that the business is generating more revenue than it costs to operate (i.e., is profitable); RC Ratio = 1 indicates that the business exactly matches its costs (breaks even); RC Ratio < 1 indicates that the business is not generating enough revenue to cover its operational costs (i.e., operating at a loss).

Fish farming is financially feasible, with an initial investment of around IDR 3,125,000 (USD 188.16) for setting up a pond, including equipment such as pumps and aeration systems. It

is lower than the typical initial cost of small-scale backyard poultry farming, which commonly ranges from IDR 5-10 million (USD 300-500) for housing, chicks, feed, and basic biosecurity. However, while entry costs for small fish farming are relatively low, income from a single pond remains modest. Annual operating costs are relatively stable, though some variable expenses fluctuate. Among the three species analysed, Nilem is the least costly to maintain. Annual income varies by species: Nilem earns approximately IDR 2,500,000 (USD 150.53) a year, and Wader and Sepat Siam earn each IDR 3,600,000 (USD 216.76) and IDR 3,360,000 (USD 202.31) annually, respectively.

Based on this analysis, the total annual costs for Nilem, Wader, and Sepat Siam are IDR 2,170,000; IDR 2,220,000; and IDR 2,190,000; respectively. Revenue varies due to differences in harvest cycles and market prices. Nilem earns IDR 2,500,000 a year (two cycles, 50 kg at IDR 25,000/kg), Wader returns IDR 3,600,000/year (three cycles, 40 kg at IDR 30,000/kg), and Sepat Siam makes IDR 3,360,000 a year (three cycles, 40 kg at IDR 28,000/kg). The analysis shows that Wader is the most profitable, with a profit of IDR 1,380,000 and an RC Ratio of 1.62. Sepat Siam in the third-highest profit with IDR 1,170,000 and an RC Ratio of 1.53. Nilem has lower costs; however, it only earned IDR 330,000 in profit and an RC Ratio of 1.15. Wader offers the highest returns, while Nilem offers the lowest, but it remains profitable. This suggests that farmers should focus on Wader, using more ponds to maximise income, as these species offer better financial returns. Nilem requires significantly more ponds to match the Regional Minimum Wage (RMW), making it less competitive unless larger-scale operations are adopted. Table 5 shows the number of ponds needed to earn the same amount as the 2024 minimum wage in West Java (IDR 24,864,000).

Table 5. Comparison of profit per pond and required number of ponds

Species	Annual Profit per Pond		Ponds Needed to Match Annual RMW (12 months)	Total Profit with Required Ponds	
	IDR	USD		IDR	USD
Wader	1,380,000	83.09	18	24,840,000	1495.66
Sepat Siam	1,170,000	70.45	21	24,570,000	1479.41
Nilem	330,000	19.87	75	24,750,000	1490.24

This analysis (Table 5) shows that Wader and Sepat Siam need fewer ponds (18 and 21, respectively) to reach the RMW target. Nilem needs 75 ponds to produce the same income. Wader and Sepat Siam are better choices for farmers who want to reach the RMW threshold, because they need fewer ponds, labour, and resources. Wader is the most efficient species for small-scale aquaculture because it has higher profitability and lower pond requirements (18 ponds for IDR 24,840,000 profit). It is recommended for farmers seeking optimal financial outcomes with fewer resources.

In comparison to other fish species like Tilapia and Catfish, Wader and Sepat Siam offer better economic returns. Tilapia and catfish are known for their fast growth and market demand. Their economic performance is usually better than Nilem. This shows that farmers in West Java should choose species based on profitability and market demand. Wader holds significant economic potential. However, currently, most Wader is produced

through inland fishing and wild catch rather than aquaculture. These inland fishing and wild catch rely heavily on restocking programmes from government and corporate social responsibility programmes. Figure 2 depicts restocking programmes for Nilem and Wader conducted by the Department of Agriculture and Food in Yogyakarta and Sukabumi (West Java) in 2021. These local government interventions aim to replenish wild populations in their natural ecosystems to restore the population.



Figure 2. Restocking Nilem and Wader in Sukabumi and Yogyakarta (Source: Department of Agriculture and Food Yogyakarta, 2021)

From 2011 to 2018, the amount of Wader produced in Indonesia has steadily increased (Figure 3). National production is highly concentrated within three primary regions: North Sumatra (63.11%), South Kalimantan (22.30%), and Jambi (9.15%). In contrast, nine other regions contributed less than 2% each to the national total. West Java, though a smaller producer, has significant potential for expanding Wader farming due to a large consumer market, such as across Java Island and in several regions of Sumatera.

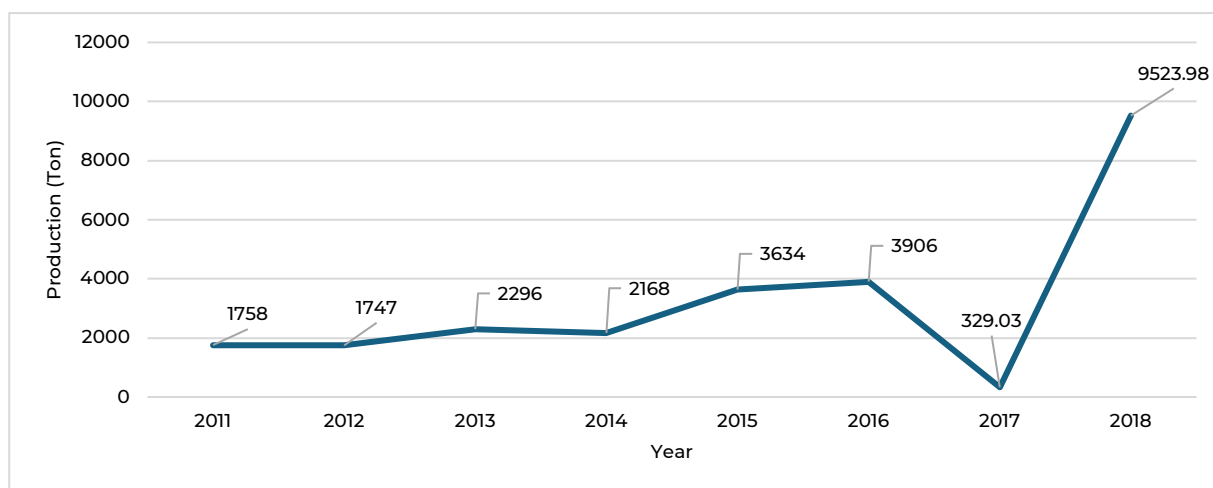


Figure 3. Wader production in Indonesia (2011-2018) (Source: Ministry of Marine Affairs and Fisheries, 2024)

Note: Data from 2019 onwards are no longer available in statistical records due to changes in data management policy at the Data and Information Center (Pusdatin) of the Ministry of Fisheries

Aquaculture plays a crucial role in addressing the growing demand for small fish in regions such as West Java, where consumption is high but local production, particularly for Wader, remains limited. Establishing aquaculture systems in environmentally suitable areas can reduce dependency on wild fish stocks, ensure a stable supply, and support conservation efforts. Controlled breeding, restocking programmes, and sustainable harvest practices are essential for maintaining wild populations, while aquaculture offers a scalable and environmentally sustainable solution to increase production. Small-scale aquaculture initiatives, such as tarpaulin pond systems in West Java, provide both economic and ecological benefits. These initiatives support local livelihoods and contribute to national food security and biodiversity preservation.

Considering demand for small fish, based on the analysed data from SUSENAS (2016), a survey by the Indonesian Bureau of Statistics (BPS) showed the average annual per capita consumption of freshwater and brackish fish including small fish like Wader, Bilih, and Nilem, which are commonly consumed in rural and inland communities, was 16.75 kg (20). Across regions there is a supply-demand imbalance; high consumption areas such as Yogyakarta and West Java are not major producers, resulting in reliance on supply from other regions or wild catch, which isn't sustainable in the long term, and drives up the price. However, it also creates the opportunity for aquaculture to scale up small-scale aquaculture (e.g., tarpaulin ponds), which could reduce the wild stocks, stabilise supply, and support local economies.

Analysis of inland capture fisheries production from 2019 to 2023 reveals distinct trends among key freshwater species (Figure 4). The catch of Bilih increased markedly, rising from 367.16 tons in 2019 to 1,722.92 tons in 2023, a pattern that may reflect both intensified exploitation and improvements in monitoring and reporting systems. In contrast, Nilem exhibited a declining trajectory after reaching a peak of 13,971.43 tons in 2020., with production decreasing to 10,303.27 tons by 2023. Although Nilem remains a major contributor to inland fisheries, the continuous increase in Bilih production underscores its growing importance in national fish supply chains and highlights the need for species-specific management strategies, including the exploration of aquaculture potential.

Production of Sepat remained relatively stable during the same period, with only moderate interannual fluctuations. Despite its lower capture volume compared to Nilem, Sepat is characterised by consistently high market demand, largely due to its utilisation in processed forms, particularly salted fish (*ikan asin sepat*). This product constitutes an important dietary component in West Java and other upland regions distant from marine fish sources, and it is also widely consumed in Sumatera. The cultural preference and established market niche for salted Sepat suggest that this species, currently underrepresented in capture statistics, holds significant potential for targeted aquaculture development to strengthen both local food security and rural livelihoods simultaneously.

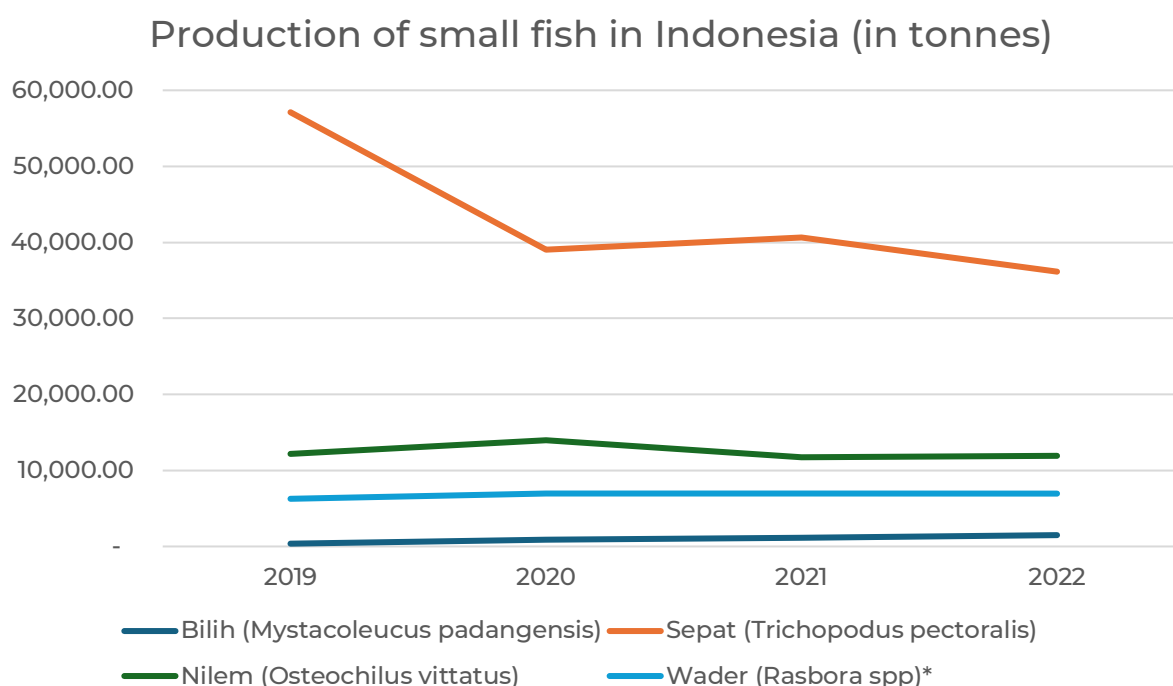


Figure 4. Production of small fish fishes in Indonesia. (Source: Ministry of Marine Affairs and Fisheries, 2025)

THE SMALL FISH SUPPLY CHAIN

In West Java, small fish farms are vital to the local economy. These farms cultivate small species like Wader, Nilem, and Sepat Siam. Figure 5 illustrates the supply chain for small fish aquaculture, detailing how fish are cultivated and reach consumers.

The supply chain starts with upstream activities directly related to fish farming. Local hatcheries provide fingerlings, the starting point for operations. Some farmers self-breed fingerlings, reducing costs and allowing for greater control over quality and adaptability to local conditions. Once in the ponds, farmers feed their fish a diet including locally sourced insects and plants as well as commercial feed pellets. This supports healthy population growth and preserves the flavours that consumers value. Fish farming is typically a family enterprise, with parents, children, and neighbours contributing. This communal labour shows the deep connection of these rural communities to aquaculture.

GAIN Working Paper n°61

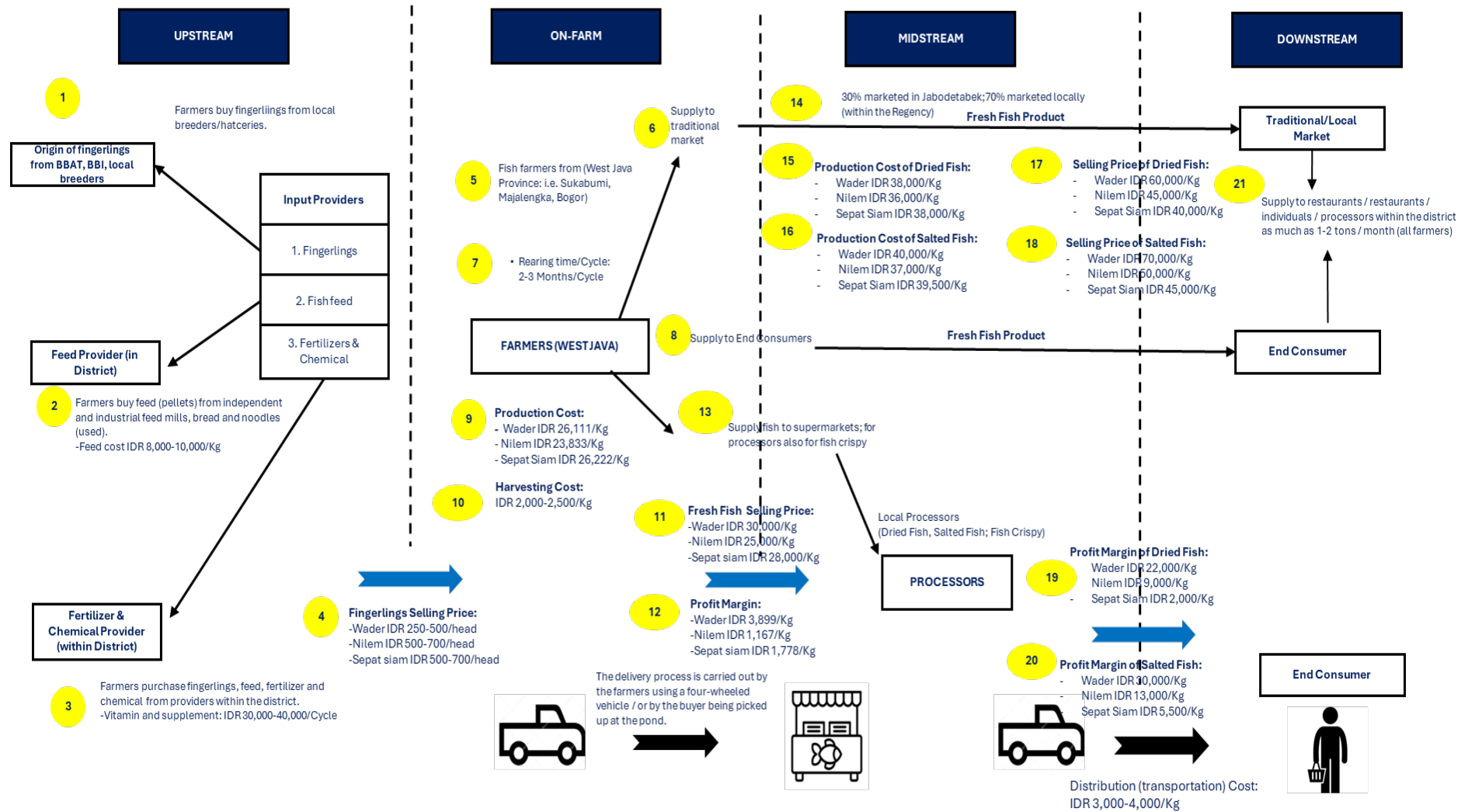


Figure 5. Supply chain of selected small fish

After the fish mature, the midstream segment of the supply chain enters into the picture, encompassing harvesting, processing, and preparing for market. These activities seek to maintain the quality and marketability of the fish. Buyers, including local traders and restaurant suppliers, visit the farms directly to purchase, ensuring the fish are fresh. The harvesting process is also usually a family farming effort, reflecting tradition and collective labour.

Some small fish, like Wader and Sepat Siam, are sold fresh directly at the farm, while others are processed into value-added products like dried fish, snacks, and fermented foods. These processes enhance their market reach and safeguard quality during transit. Marketing, sales, and consumption are the focus of the downstream activities. Retailers sell the fish products, often emphasising their local origin and preparation methods. Their unique flavours and high quality attract consumers, from individual buyers to restaurant chefs.

The analysis in Table 6 summarises the supply chain for small fish, from the sourcing of fingerlings to the marketing of processed fish to end consumers, noting the costs associated with each step. Some variation in costs arises at the processing stage depending on the end products (e.g., dried, crispy, or fermented fish). Costs associated with distribution and transport also have impacts on wholesale prices; retailers then apply a mark up to the wholesale prices, resulting in final consumer prices that reflect both the added value and the retail strategy.

Table 6. Supply chain analysis for small fish

Stage	Key Activities	Stakeholders	Products	Cost Details
Upstream	Sourcing fingerlings	Hatcheries, fish farmers	Fingerlings (3-5 cm or 1 cm)	IDR 500-700/head (USD 0.030-0.042) (purchased); IDR 20/head (USD 0.0012) (self-bred)
	Feeding	Fish farmers, local feed traders	Growing fish	Feed cost: IDR 8,000 - 10,000/kg (USD 0.48 – 0.60)
	Pond maintenance and fish care	Fish farmers, family members	Juvenile fish	Labor cost: IDR 50,000 - 60,000/day (USD 3.01 – 3.61)
	Production	Fish farmers, family members	Fresh fish	Production cost: IDR 15,000 - 20,000/kg (USD 0.9 – 1.2)
	Sales to buyers	Fish farmers	Fresh Wader, fresh Nilem, fresh Sepat Siam	IDR 25,000 - 30,000/kg (USD 1.51 – 1.81)
Midstream	Harvesting	Fish farmers, family members	Fresh Wader, fresh Nilem, fresh Sepat Siam	Harvesting cost: IDR 2,000 - 2,500/kg (USD 0.12 – 0.15)
	Processing into dried fish	Fish farmers, local processor	Dried Wader, dried Nilem, dried Sepat Siam	Processing cost: IDR 5,000 - 7,000/kg (USD 0.30 – 0.42); Sold at: IDR 40,000 - 60,000/kg (USD 2.41 – 3.61)
	Processing into crispy snacks	Fish farmers, local processor	Crispy Wader	Processing cost: IDR 7,000/kg (USD 0.47); Sold at: IDR 70,000/kg (USD 4.21)
	Processing into fermented fish (ikan asin)	Fish farmers, local processors	Fermented Nilem, fermented Sepat Siam	Processing cost: IDR 8,000/kg (USD 0.48); Sold at: IDR 45,000 - 50,000/kg (USD 2.71 – 3.01)
	Distribution	Distributors, transporters	Dried or crispy Wader, dried or fermented Nilem, dried or fermented Sepat Siam	Distribution cost: IDR 3,000 - 4,000/kg (USD 0.18 – 0.24)
	Sales to retailers	Distributors, wholesalers	Dried or crispy Wader, dried or fermented Nilem, dried or fermented Sepat Siam	IDR 50,000 - 75,000/kg (USD 3.01 – 4.52)
Downstream	Retail marketing	Retailers	Dried or crispy Wader, dried or fermented Nilem, dried or fermented Sepat Siam	Retail markup: 15-30%
	Sale to end consumers	Retailers, market vendors	Dried or crispy Wader, dried or fermented Nilem, dried or fermented Sepat Siam	IDR 65,000 - 90,000/kg (USD) 3.91 – 5.42)

CONCLUSIONS

Their ease of preparation and high nutritional value make small fish an excellent food choice for Indonesian communities. Small fish farms can also be more environmentally sustainable than large-scale fish farms as they require fewer resources and use controlled aquaculture systems that can reduce overfishing and environmental impact. These practices can help improve resource efficiency, reduce food loss and waste, and conserve biodiversity.

There remain some challenges in promoting small fish consumption and production in Indonesia. First, consumer awareness regarding the nutritional and environmental benefits of small fish is limited. Consumers and farmers tend to favour larger species like tilapia and catfish. While small fish like Wader are highly nutritious, they remain less popular due to long-standing cultural preferences. Second, small-scale farmers face significant hurdles in accessing quality fingerlings, modern farming technologies, training, and resources. Furthermore, current small fish restocking activities have not yet fully successfully restored wild populations to sustainable levels.

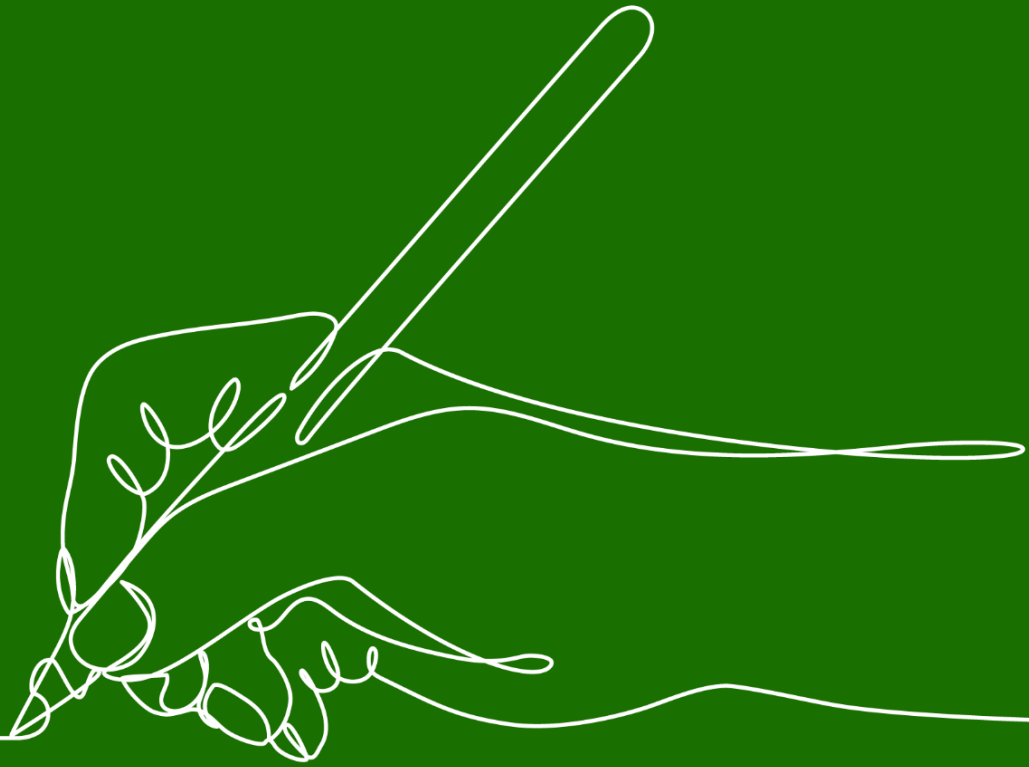
Two key opportunities to increase small fish production are improving the effectiveness of restocking programmes and expanding small fish aquaculture. For instance, tarpaulin pond systems offer a modern, effective technique for boosting production. For such systems, Wader was found to be the most profitable species, requiring fewer ponds to meet income targets. There are also numerous opportunities for improving efficiency, sustainability, and profitability at every stage of the supply chain, which can help stabilise the sector. Upstream, these include sourcing fingerlings from local hatcheries and utilising local feeds (e.g., rice bran, insects, earthworms). In the midstream segment, food waste can be reduced by promoting whole-fish consumption; there is also scope for creating value-added products like snacks and fermented delicacies. Finally, at the downstream stage, distributors and retailers can be leveraged to market these products based on their local origin and quality.

Current government priorities related to food security and specific attention to consumption of aquatic (or 'blue') foods provide critical momentum to advance small fish production and consumption. Integrating small fish into programmes such as the Blue Food initiative and school meal programmes could further strengthen their role in national nutrition strategies. Incorporating small fish into Indonesia's priority species under the National Blue Economy Roadmap would be a key step in aligning economic development, environmental protection, and food security objectives.

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The Global Alliance for Improved Nutrition (GAIN) is a Swiss-based foundation launched at the UN in 2002 to tackle the human suffering caused by malnutrition. Working with governments, businesses and civil society, we aim to transform food systems so that they deliver more nutritious food for all people, especially the most vulnerable.

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