SCALE WELFARE

Vietnam Farmed Fish Industry & Welfare Review

January 2026

Contents

List of Tables

List of Figures

Introduction & Context

Scale Welfare's Mission

Our mission is to **improve the welfare of farmed fish in Southeast Asia**. We aim to achieve this by developing and implementing interventions that improve farmed fish health and quality.

Our first report - The Philippines

This is the second report we have published, with the first one related to the Philippines being published in October 2025. Following our initial scoping and research in the Philippines, we developed a longlist of intervention ideas to improve farmed fish welfare and have, at the time of writing (January 2026), narrowed that list down to three specific interventions we are researching and testing in more detail. Our work in the Philippines continues alongside the research we recently conducted in Vietnam.

Why Vietnam?

We decided to research welfare concerns in the aquaculture industry in Vietnam based on three primary factors:

- **Size of the aquaculture industry** – Vietnam is the fifth largest farmed fish-producing country in the world (by number of individuals; fourth by tonnage), and the second largest in Southeast Asia (after Indonesia).
- **Significance of pangasius exports** – We believe that the reliance of pangasius, Vietnam's most farmed fish species, on international exports, including to the EU, US and UK, provides opportunities for welfare reforms that improve market access for local producers.
- **Permanent co-founder residence** – One of our co-founders is permanently based in Ho Chi Minh City, Vietnam which facilitates relationship building and stakeholder communications more effectively.

Objectives of the scoping visit and research

The primary objective was to develop a practical understanding of current aquaculture practices in Vietnam, with a focus on pangasius farmed for export, given its economic significance. Through direct engagement with stakeholders throughout the supply chain, this ground research documented the challenges and opportunities in pangasius farming from a welfare perspective. Our goal is to use this valuable information to guide our next steps in developing an intervention on the ground.

Introduction & Context

This scoping report

The report serves as a foundational assessment, based on desk and on-the-ground research, to inform Scale Welfare's strategic decision-making regarding potential programs and partnerships in Vietnam to improve the welfare of farmed fish.

We hope it also serves as a useful information resource for other stakeholders interested in contributing to an aquaculture sector in Vietnam that more effectively addresses the welfare of fish. The report includes primary and secondary information covering the following key areas:

Vietnam Aquaculture Context – Introduction to the country's aquaculture sector, its economic importance, the socio-economic context, major species farmed and key stakeholders.

Life Cycle of Farmed Pangasius – Overview of farmed pangasius's life from hatchery through grow-out to harvesting and processing, including welfare implications at each stage.

Main Pangasius Welfare Concerns – Overview of the most significant welfare concerns for farmed pangasius in Vietnam that warrant further research.

Other ongoing projects on pangasius welfare

It should be noted that our research is not being conducted in a vacuum. One organisation in particular, Fresh Studio, is already exploring solutions to pangasius welfare issues in Vietnam. We communicated frequently with them during our own research process and learned a lot from them, but it was still important for our own organisational learning to conduct the ground-level research we did.

It could be argued that our added value to the space is limited given there is already an organisation working on pangasius welfare, however given the size of the industry and general challenges in making aquatic animal welfare improvements, we strongly believe additional actors are necessary. We are very open to collaboration and strive to ensure our work does not overlap with or replace that of other organisations, and instead contributes to it.

Executive Summary

The importance of aquaculture in Vietnam

Vietnam is currently the world's **fourth-largest aquaculture producer**, contributing **5% of global production** by tonnage. The industry is a vital economic pillar, accounting for **4% of the national GDP** and providing livelihoods for **2.6 million workers**. Aquaculture has now overtaken wild-capture fisheries, representing **60% of total fisheries production**.

Our focus on pangasius farming in southern Vietnam

The Mekong River Delta is the heart of this sector, generating over 70% of national output and serving as the hub for the country’s two primary exports: pangasius and shrimp. This report focuses specifically on **pangasius**, the most farmed species in Vietnam by volume. As Vietnam accounts for over **90% of global pangasius exports**, the industry is fundamentally export-oriented, leading to the widespread adoption of international sustainability and quality certifications.

Our scoping visit & research into the pangasius industry

The findings in this report are based on intensive research conducted from **October 2025 to January 2026**. Our methodology included a detailed literature review and expert interviews, anchored by primary field observations in the Mekong River Delta. Field research included visits to:

- **One nursery**
- **Seven grow-out farms**
- **Three processing facilities**

Key pangasius welfare concerns identified

Our research identified critical welfare challenges across every stage of the production cycle:

1. **Hatchery stage:** High mortality rates and instances of cannibalism.
2. **Larvae transportation:** Significant handling stress, exposure to high temperatures, and physical injury.
3. **Nursery stage:** Sub-optimal environmental conditions and high handling stress.
4. **Grow-out stage:** Disease outbreaks, poor water quality, and high stocking densities.
5. **Harvest:** Prolonged fasting periods prior to collection.
6. **Well-boat transportation from farm to factory:** Extreme stocking densities leading to stress, physical injury, and asphyxiation.
7. **Processing:** The prevalence of slaughter without prior stunning.

Executive Summary

Other species researched

While pangasius was the primary focus, we also conducted preliminary research into other commonly farmed species to provide a comprehensive overview of the broader Vietnamese aquaculture landscape:

- Tilapia
- Carps
- Snakehead
- Barramundi
- Various Catfish species

Next Steps

The information gathered to compile this report will form the basis of our future work in Vietnam. Further ground visits, expert interviews and desk research will be conducted in order to help us prioritise interventions, align welfare improvements with industry interests, and build strategic partnerships.

Vietnam Aquaculture Context

We begin the report with a detailed overview of the aquaculture industry in Vietnam, focusing on farmed fish but also including crustaceans (e.g. shrimp), based on secondary literature and field observations:

Industry Overview and Economic Importance

Vietnam ranks as the **world's fourth-largest aquaculture producer**[1] with a total output of approximately 5.8 million metric tons (MT) in 2024, 3.8 million MT of which was fish[2].

The nation accounts for **5% of the world's total aquaculture production**[1] (measured by tonnage), and the industry creates jobs for **2.6 million workers**[3].

Since the country's reunification in 1975, the government has methodically transformed the aquaculture sector into a cornerstone of the national economy, positioning it as a primary engine for economic growth, national food security, and poverty reduction in rural areas[4].

Total Fisheries Production

Total fisheries production, including aquaculture and capture (wild-caught) fisheries, reached 9.6 million MT in 2024, with **aquaculture farming now accounting for 60% of this total**[2]. This milestone confirms a long-term, deliberate pivot away from capture fisheries to preserve marine resources, as demonstrated in the chart below[2].

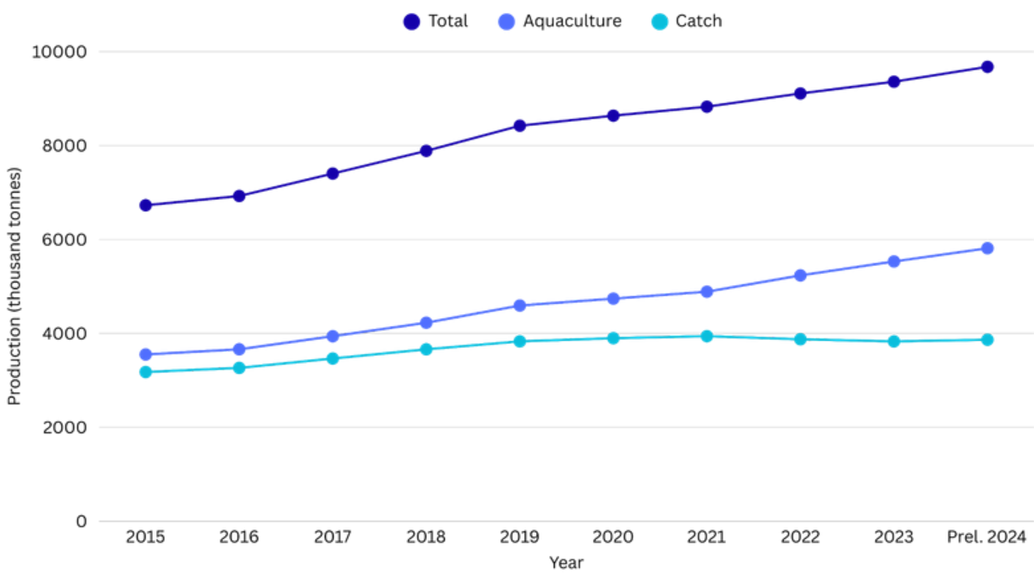

Figure 1. Aquaculture's increasing importance in Vietnam's fisheries industry since 2015

[1]FAO. *The State of World Fisheries and Aquaculture 2024 – Blue Transformation in Action*. FAO EBooks. Rome: FAO, 2024. https://doi.org/10.4060/cd0683en.
[2]National Statistics Office. *Statistical Yearbook of Viet Nam 2024*. Ha Noi: Statistical Publishing House, 2025.
[3]FAO. "Viet Nam, 2019. In: Fisheries and Aquaculture." https://www.fao.org/fishery/en/facp/vnm, 2026.
[4]Tri, N N, N P C Tu, D T Nhan, and N V Tu. "An Overview of Aquaculture Development in Vietnam." *Proceedings of International Conference on Fisheries and Aquaculture* 7, no. 1 (2022). https://doi.org/10.17501/23861282.2021.7105.

Economic importance

The sector's economic contribution is substantial. It generates **over 25% of the country's total agricultural output and contributes 4% of the national Gross Domestic Product (GDP)**[5]. This economic weight is reflected in its resilient trade performance, with total seafood exports reaching $10 billion in 2024, marking a 12% increase from 2023[6]. Policy support for the industry is formalised in ambitious government objectives, which include increasing aquaculture output to 7 million MT and boosting export values to $12 billion by 2030[7].

Table 1. Aquaculture production by region, species and quantity

Ecological Zone	Aquaculture Area in 2024 (ha)[2]	All Aquaculture Production in 2024 (Tonnes)[2]	Farmed Fish Production in 2024 (Tonnes)[4]	Primary Farmed Species
Mekong River Delta (MRD)	814.4	4,147,767	2,718,347	Fresh and brackish water species in ponds: Pangasius, Whiteleg Shrimp, Giant Tiger Prawn, Tilapia, Climbing Perch, Snakehead
Red River Delta (RRD)	139.9	946,232	628,039	Freshwater fish in ponds and cages: Carps and Tilapia
North & South Central Coast	86.9	327,966	167,171	Mariculture in floating net cages: Spiny Lobster, Groupers, Cobia, Snubnose Pompano, Barramundi Whiteleg Shrimp, Giant Tiger Prawn

[5] VASEP. "Fishery Profile." VASEP. Accessed January 7, 2026. https://seafood.vasep.com.vn/why-buy-seafood/fishery-profile.
[6] VASEP. *Report on Vietnam Seafood Exports in 2024*. Ha Noi: VASEP, 2025.
[7] Prime Minister. "Decision No. 339/QD-TTg: Approving the Strategy for Development of Vietnam's Fisheries by 2030 with Vision towards 2045," March 11, 2021.

Map of Vietnam's Key Aquaculture Production Hubs

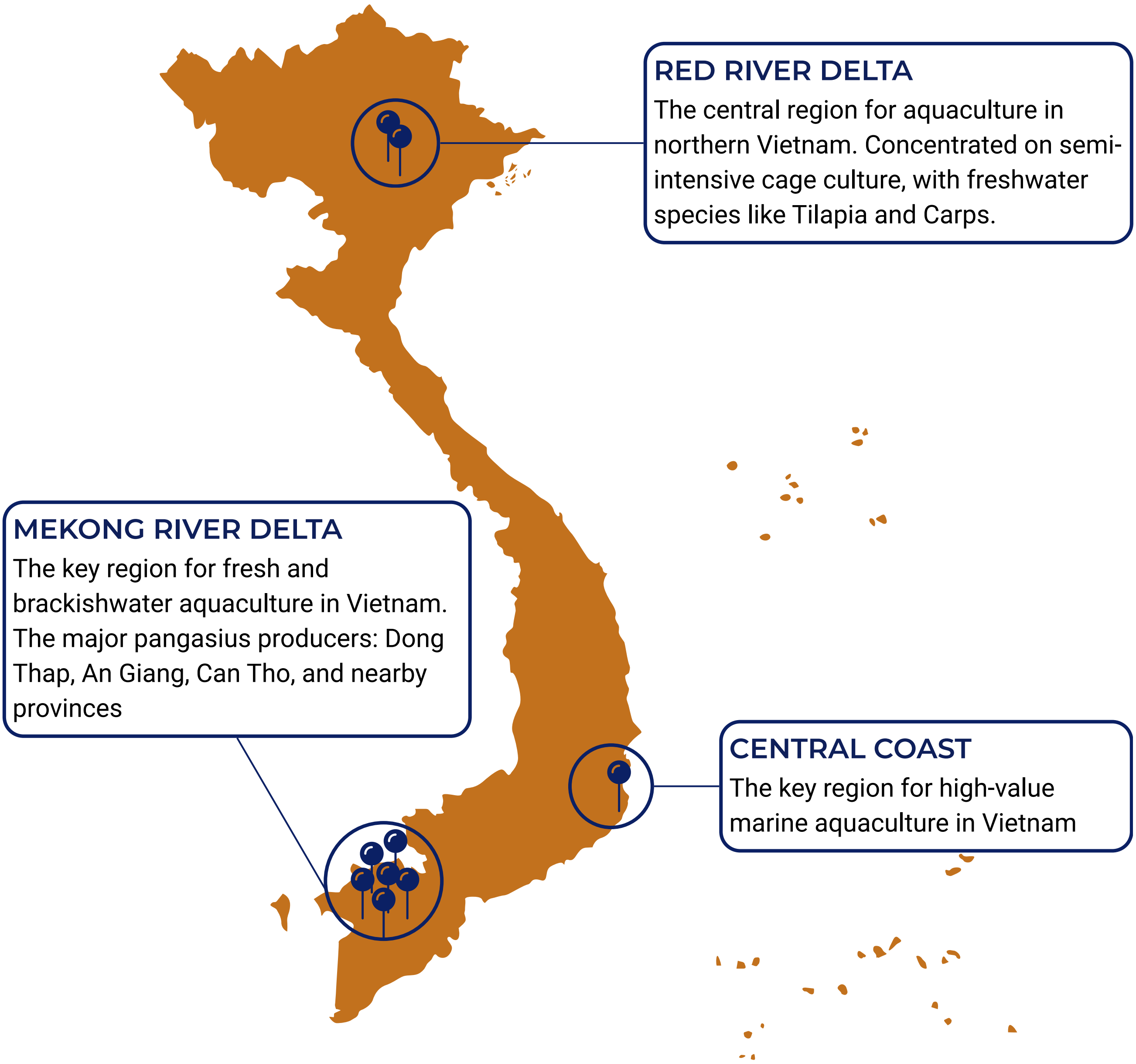

Figure 2. Map of Vietnam's key aquaculture production hubs

The Mekong River Delta (MRD) - Vietnam's "Aquaculture Heartland"

This region, one of the world's most fertile deltas, generates over 70% of the nation's total aquaculture output[2]. The MRD is the primary production hub for the nation's two primary aquaculture exports: pangasius and shrimp[4].

92% of the total production is inland, with less than 10% being marine-based. Aquaculture is heavily concentrated in provinces situated along the Tien and Hau Rivers, the two main tributaries of the Mekong. The primary production hubs are the provinces of An Giang, Dong Thap, Can Tho, and Vinh Long[4].

Table 2. Production volume in tonnes of farmed aquaculture species (2025)[1]

Species name	Environment	Production (tonnes)	% of National Production
Pangasius	Freshwater	1,752,528	32.6
Whiteleg shrimp	Brackishwater	821,978	15.6
Cyprinids NEI (not elsewhere included)	Freshwater	532,541	9.9
Giant tiger prawn	Brackishwater	277,360	5.2
Tilapias NEI	Freshwater	206,678	3.9
Common carp	Freshwater	167,119	3.1
Indo-Pacific swamp carp	Brackishwater	80,770	1.5
Torpedo-shaped catfishes	Freshwater	46,053	0.9
Pirapatinga	Freshwater	25,729	0.5
Frogs	Freshwater	13,317	0.3
Seaweeds NEI	Mixed	10,733	0.2
Cobia	Marine	6,401	0.1
Sturgeons NEI	Freshwater	3,436	0.1

Table 3. Number of individual fish farmed per species (2022)[2]

	Numbers in millions (2022) – *the below are estimates*		
Species name	**Lower**	**Upper**	**Midpoint**
Pangasius	1,100	1,700	1,400
Tilapias NEI (not elsewhere included)	450	650	550
Cyprinids NEI	330	720	530
Common carp	200	530	360
Torpedo-shaped catfishes NEI	43	290	170
Pirapatinga	23	47	35
Cobia	1	1	1
Sturgeons NEI	< 1	1	1

Note: Number of individuals farmed is more important than volume in the context of welfare.

[8]FishStatJ. *Global Production by Production Source 1950-2023*. Rome: FAO, 2025.
[9]Mood, A, and P Brooke. "Estimated Farmed Finfish Numbers." Fish Count Organization, 2024. https://fishcount.org.uk/estimates/farmedfishes/data01/fishcount_global_farmed_fish_estimate.php.

Seafood Exports

Vietnam's aquaculture industry is fundamentally export-oriented, positioning the country as a dominant force in the global seafood market. The total seafood export value reached $10 billion in 2024, representing a 12% increase from 2023[6].

The export market is geographically diverse, with Vietnamese seafood shipped to over 170 countries. The primary markets in 2024 were China & Hong Kong and the United States, which together received over 37% of exports[6].

For the critical pangasius sector, the vast majority of exports are in the form of frozen fillets, which accounted for 79% of pangasius export value in 2024[6].

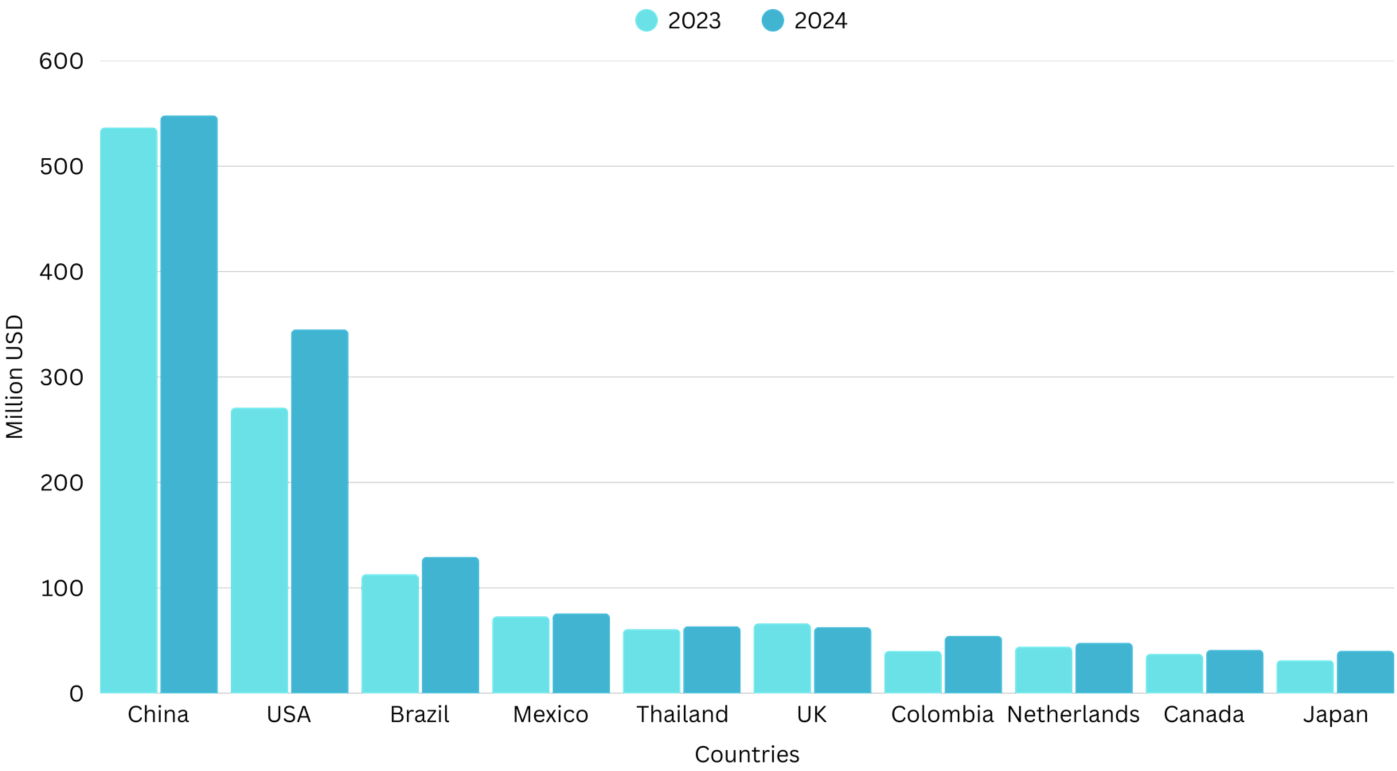

Figure 3. Top 10 import markets for Vietnam's pangasius in 2023-2024 (US$ mil.)[6]

Note: The Netherlands is the EU's biggest pangasius importer because it is a major port that re-distributes pangasius throughout the EU.

Pangasius export prices in 2024

In 2024, pangasius export prices were at a three-year low across several markets. The US market recovered in 2024, rising from $2.64/kg in January to a peak of $3.17/kg in September. In contrast, the EU market price remained low, fluctuating below $3.00/kg and hitting a low of $2.24/kg in November. Prices in China, Mexico, the UK, and Brazil also hit three-year lows in 2024[6].

Divergence between production volume and value

By volume, finfish (primarily pangasius) are the clear dominant category, accounting for 70% of total production in 2024. However, by value, the hierarchy is reversed. Shrimp (specifically whiteleg shrimp) is the single most valuable export commodity, generating USD 3.88 billion in 2024. Pangasius (USD 2.03 billion), represents the second most valuable category[6].

Table 4. Value of Seafood Exports in 2024[6]

Most Valuable Seafood Exports (aquaculture and capture fisheries)	Export value (in 2024)
Shrimp	$3.88 Billion (38.7%)
Pangasius	$2.03 Billion (20.2%)
Tuna (from capture fisheries)	$988.6 Million (9.9%)
Cephalopods	$657 Million (6.6%)

Note: The majority of this report focuses on the high-volume finfish sector, specifically pangasius, given that it is the most farmed finfish species in Vietnam.

Socio-Economic Context

The aquaculture sector is also a critical source of livelihoods, providing employment for an estimated 2.6 million workers[9]. It serves as a vital tool for rural development and social stability, particularly in the Mekong River Delta.

While consolidation defines the export sector, 75% of Vietnam's aquaculture producers remain small-scale operators on farms of less than 2 hectares[9]. For the majority, aquaculture is a vital component of household livelihood[10]. "Climate variability" and "poor infrastructure" are primary challenges[11].

This highlights a deep structural inequality. The large, vertically integrated exporters possess the capital to invest in climate adaptation (e.g., R&D on saline-tolerant broodstock and water-saving technologies) and to absorb the high costs of international certification[12]. The smallholder majority, in contrast, lacks the finance, infrastructure, and direct market integration to adapt, making them the most probable casualties of the sector's environmental and market shifts[10,11].

[9]Johnson, Alexandra, and Pham Quoc Hung. "Impacts of Climate Change on Aquaculture in Vietnam: A Review of Local Knowledge." *Aquaculture Asia Magazine* 14, no. 1 (2020): 8–14.
[10]Trieu, Tran Thi Ngoc, and Nguyen Thanh Phong. "The Impact of Climate Change on Salinity Intrusion and Pangasius (*Pangasianodon Hypophthalmus*) Farming in the Mekong Delta, Vietnam." *Aquaculture International* 23, no. 2 (2015): 523–34. https://doi.org/10.1007/s10499-014-9833-z.
[11]Tho, Nguyen V. "Salinity Intrusion in the Vietnamese Mekong Delta, a Threat: Possible Causes, Effects on People's Life and Production, and Temporary Solutions and Adaptable Strategies." In *Sustainable Development of Water and Environment*, edited by H Y Jeon, 1–10. Cham: Springer, 2022. https://doi.org/10.1007/978-3-031-07500-1_1.
[12]Netherlands Enterprise Agency. "Aquaculture Landscape: Mekong River Delta," 2025.

Regulatory & Organisational Framework

The modern Vietnamese aquaculture sector is governed by a comprehensive legal and institutional framework designed to manage its rapid expansion and transition toward sustainability. This architecture, established by the 2017 Law on Fisheries, represents a significant policy evolution from a focus on economic expansion to a model that legally mandates sustainable practices.

Government Structure & Stakeholders[*]

The Vietnamese government, through the Ministry of Agriculture and Environment, MAE (previously known as the Ministry of Agriculture and Rural Development, MARD) and its Department of Fisheries and Fisheries Surveillance (previously known as Directorate of Fisheries – D-Fish), maintains a strong, directive role in the sector, setting ambitious national targets for production and exports, as well as managing the environmental impacts of this growth.

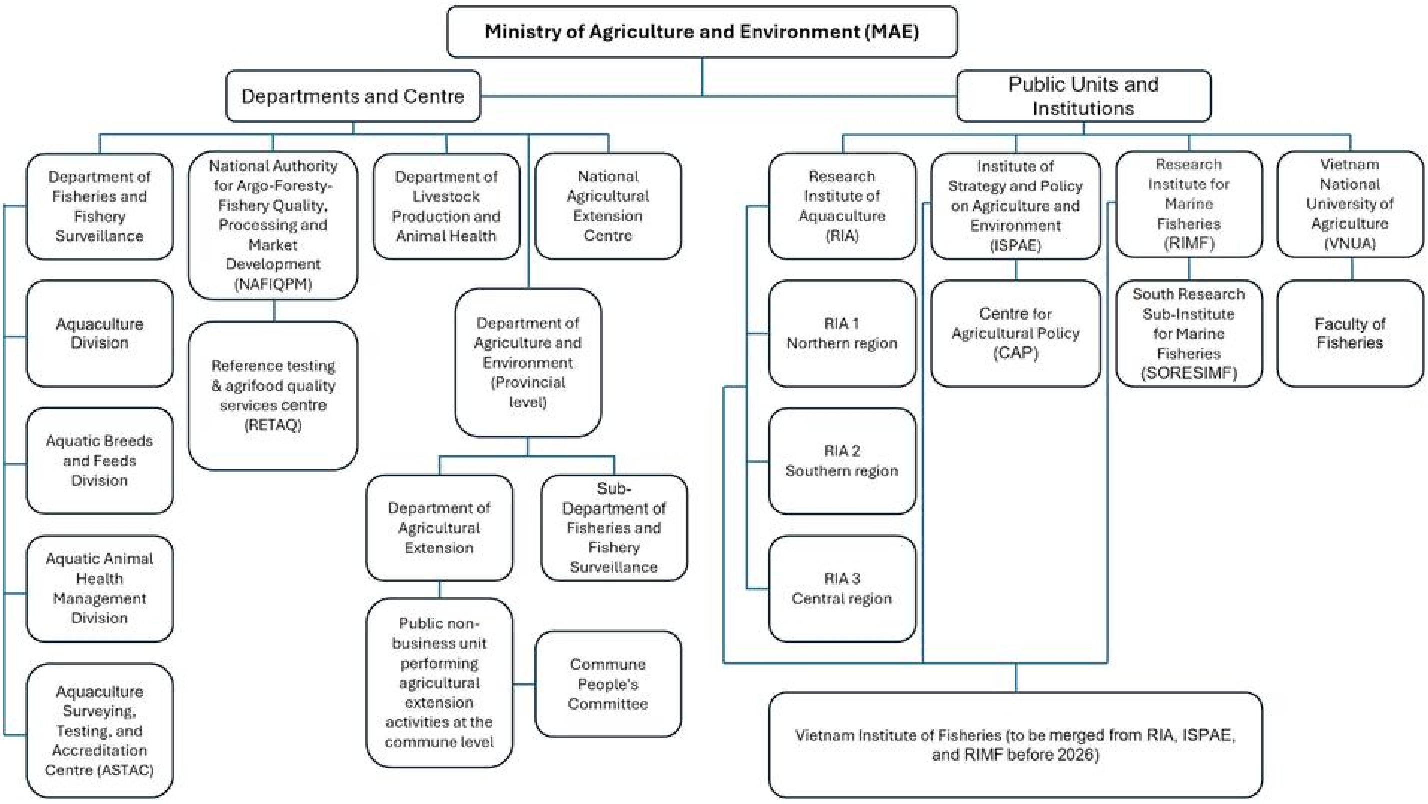

Figure 4. Organisational structure of the Ministry of Agriculture and Environment and affiliated organisations[1]

Ministry of Agriculture and Environment (MAE): Sets overarching national policy, strategy, and production targets.
National Agricultural Extension Centre: Disseminates technical knowledge and trains farmers.
Research Institute for Aquaculture (RIA 1, 2, 3): These government institutes in the north, south and centre provide specialised research, technology transfer, training, international cooperation, and consultation.

Note: More detailed information about these and several other key government stakeholders can be found in Appendix A.

[*]Circular No. 60/2025/TT-BNNMT; Decision No. 04/2005/QD-BTS; Decision No. 08/2005/QD-BTS; Decision No. 09/2005/QD-BTS; Decision No. 1080/QD-BNNMT; Decision No. 132/QD-BNNMT; Decision No. 1588/QD-BNN-TCCB; Decision No. 1811/QD-TTg; Decision No. 22/2025/QD-UBND; Decision No. 27/2004/QD-BTS; Decision No. 305/QD-BNNMT; Decision No. 32/QD-BNNMT; Decision No.1403/QD-BNN-TCCB; Decree No. 35/2025/ND-CP

Primary non-government value chain stakeholders

In addition to the key government stakeholders outlined above, the success and sustainability of Vietnam's aquaculture sector depend on the collaborative efforts of various other stakeholders:

Academia:

- **National academic and research hubs**, such as Can Tho University, Viet Nam National University of Agriculture, and the University of Agriculture and Forestry, train students and professionals in aquaculture at the bachelor's, master's, and doctoral levels[13].
- **University of Stirling (Scotland)** - leads the "Asian Fish Welfare Network" project (2025 to 2028) that raises awareness and knowledge about aquatic animal welfare and supports capacity building activities for research in Vietnam, Thailand and Indonesia[14].

Industry Associations:

- **Vietnam Association of Seafood Exporters and Producers (VASEP)** – a large association representing exporters that lobbies for policy, promotes trade, and provides critical market intelligence[15].
- **Vietnam Pangasius Association (VINAPA)** – advocates specifically for the interests of pangasius farmers and processors in the Mekong River Delta[16].
- **Various informal local cooperatives and associations** – two farms we visited reported being part of these.

Production services:

Detailed information about the stakeholders involved in production is provided **later in the report**.

National NGOs:

- **Vietnam Fisheries Society (VINAFIS)** – gathers and unites individuals and organisations in the fisheries sector to contribute to the overall development of Vietnam's fisheries sector[17].
- **International Collaboration Centre for Aquaculture and Fisheries Sustainability (ICAFIS)** – operating under VINAFIS, promotes aquaculture and fisheries sustainability in Vietnam and shares Vietnam's experiences internationally, primarily with developing countries[18].
- **MCD (Centre for Marinelife Conservation and Community Development)** – started a project in 2025 to work with farmers on seabass welfare in the Mekong Delta Region[19].

[13]Tu, N V, N P C Tu, and N H H Kha. "Roles of Research and Education in Freshwater Aquaculture Development: A Case of Striped Catfish Farming in Vietnam." In *Bologna Process and Fisheries Education for Sustainable Development*, edited by A Figus and T Potempa. Rome: Eurilink University Press, 2019.
[14]Sustainable Aquaculture at Stirling. "Asian Fish Welfare Network Project." Sustainable Aquaculture @ Stirling. Accessed January 7, 2026. https://www.susaquastirling.net/asiafishwelfare.
[15]VASEP. "VASEP Introduction." VASEP. Accessed January 7, 2026. https://seafood.vasep.com.vn/vasep-introduction.
[16]VINAPA. "Hiệp Hội Cá Tra Việt Nam." VINAPA. Accessed January 7, 2026. https://pangasiusmap.com/vi.
[17]VINFIS. VINAFIS Introduction. Accessed January 7, 2026. https://vinafis.org.vn/
[18]ICAFIS. About ICAFIS. Accessed January 7, 2026. https://icafis.vn/en/about-icafis
[19]MCD. Who we are. Accessed January 7, 2026. https://mcdvietnam.org/who-we-are/

Welfare-centric organisations:

- **Fresh Studio** – a consultancy that leads the *DeltaCare Initiative* in Vietnam, a project dedicated to establishing ethical benchmarks for farmed pangasius and shrimp. Their work focuses on developing practical welfare assessment tools and conducting in-depth evaluations across the entire value chain to improve fish health and production outcomes. We are in close contact with them, given our overlapping objectives[1].
- **FAI Farms** – provides data-driven welfare solutions through its FAI Academy and specialised mobile applications that help farmers monitor real-time welfare indicators for tilapia and shrimp[2].
- **Shrimp Welfare Project** – the first global organisation dedicated exclusively to the well-being of farmed shrimp, actively working in Vietnam to implement their Humane Slaughter Initiative via electrical stunning technology[3].
- **Agriterra (international NGO)** – works with shrimp farming cooperatives in the Mekong Delta to organise capacity-building workshops[4].

Overview of Pangasius Value Chain

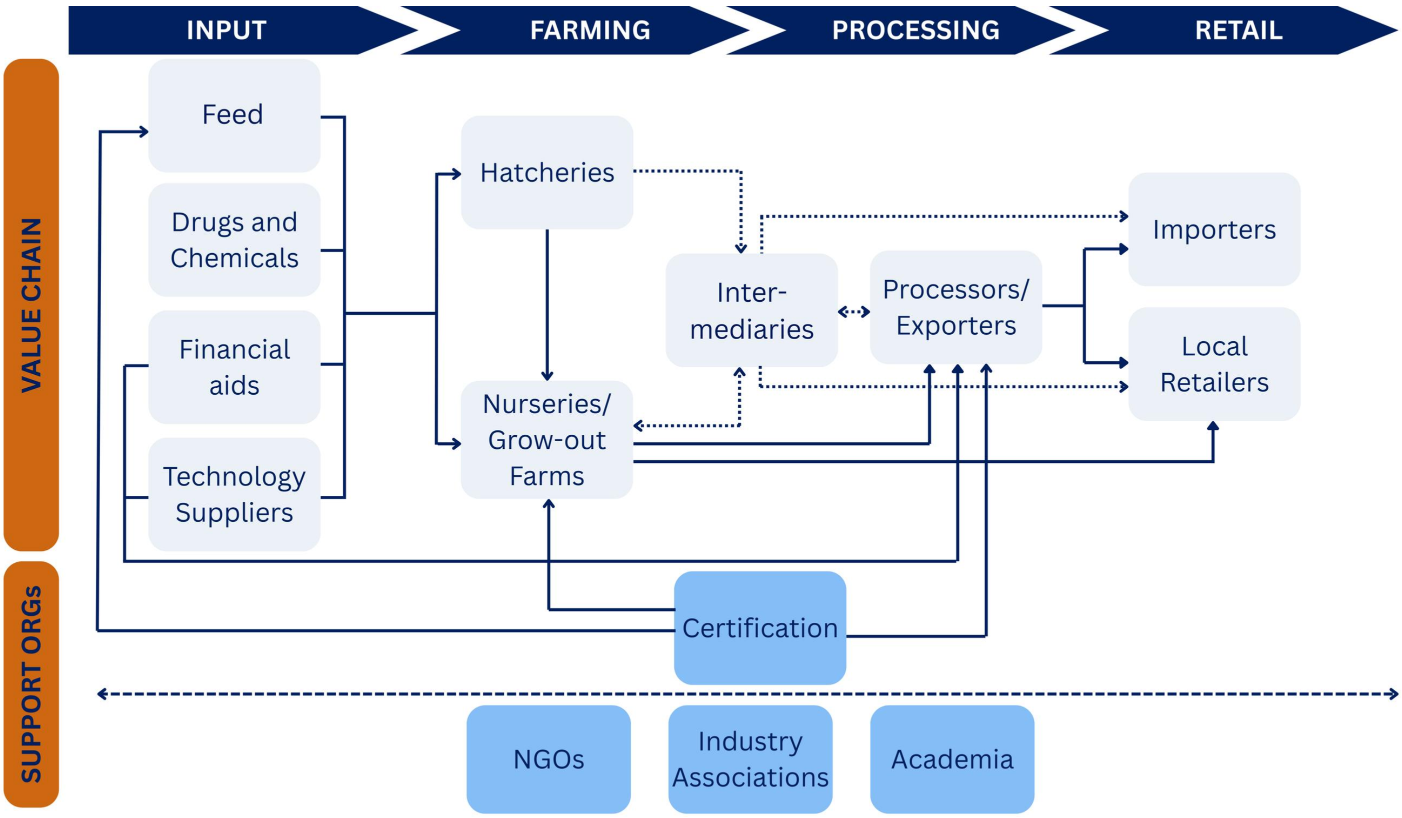

Figure 5. Pangasius value chain in Vietnam

[20]Fresh Studio. Aquaculture. Accessed January 7, 2026. https://freshstudio.vn/aquaculture/
[21]FAI. Tilapia Welfare App. Accessed January 7, 2026. https://www.faifarms.com/products/tilapia-welfare/
[22]Shirmp Welfare Project. (Shr)Impact. Accessed January 7, 2026. https://www.shrimpwelfareproject.org/shrimpact
[23]Agriterra. What we do. Accessed January 7, 2026. https://www.agriterra.org/what-we-do

Aquaculture certification (national and international)

To ensure the global competitiveness and sustainability of its seafood sector, Vietnam has integrated a variety of national and international aquaculture standards.

At the foundational level, state-mandated regulations (ATTP and VietGAP) primarily focus on hygiene, disease control, and chemical safety, serving as a prerequisite for operating and exporting. In contrast, international standards (ASC, BAP, GlobalG.A.P.) operate as a license to trade in high-value Western markets, imposing rigorous, outcome-based criteria that extend beyond national legal baselines, including the concept of "animal welfare".

Our main focus when considering standards is **ASC and BAP** (and GlobalG.A.P. to a lesser extent), given their significance in the export market. Of the farms we visited, two were ASC-certified, one mentioned GlobalG.A.P., and one other mentioned VietGAP.

An Toàn Thực Phẩm (ATTP) - "Certificate of Food Safety Eligibility"

This represents the absolute minimum legal threshold for operation in the Vietnamese food sector. It is not a marketing label but a regulatory license. The ATTP scheme does not contain any explicit animal welfare requirements. Its remit is the protection of human health, not animal sentience[24].

Vietnamese Good Agricultural Practices (VietGAP)

This is the government's primary standard for on-farm operations and promoting sustainable practices[25]. Academic analysis of VietGAP reveals that it often raises production costs for the small-scale farmers who dominate the industry[26]. Furthermore, adoption rates are significantly influenced by farmer education levels and the total farming area, indicating barriers to entry for the smallest producers[26].

Critically, scientific studies note that VietGAP "does not generate a high price premium in itself because it is not a recognised certificate in the global markets"[27]. Its function is as a state-led tool for domestic capacity building. It serves to gradually elevate the technical proficiency of Vietnam's millions of small-scale farmers, making them eligible for future, more rigorous international certification[25,27].

[24]Ministry of Science and Technology. "TCVN 5603:2023 on General Principles of Food Hygiene," 2023.
[25]Auwkit, Daniel, Sarah Yates, Patrick White, Vo Nam Son, and Dao Minh Hai. "Study on the Environmental And/or Socio-Economic Impacts of ASC Certification: Public Summary," 2023.
[26]Quyen, Nguyen Thi Kim, Tran Thi Bach Yen, and Anna Karia Leroy Riple. "Adoption of Vietnamese Good Agricultural Practices (VietGAP) in Aquaculture: Evidence from Small-Scale Shrimp Farming." *Asian Fisheries Science* 34, no. 4 (2022). https://doi.org/10.33997/j.afs.2021.34.4.012.
[27]Quyen, Nguyen Thi Kim, Huynh Van Hien, Le Nguyen Doan Khoi, Nobuyuki Yagi, and Anna Karia Lerøy Riple. "Quality Management Practices of Intensive Whiteleg Shrimp (*Litopenaeus Vannamei*) Farming: A Study of the Mekong Delta, Vietnam." *Sustainability* 12, no. 11 (2020): 4520. https://doi.org/10.3390/su12114520.

Aquaculture Stewardship Council (ASC)

The ASC is widely regarded as the most rigorous standard regarding environmental sustainability and social responsibility. It is the preferred label for many European retailers.

ASC standards were previously species-specific (e.g., ASC Pangasius Standard, ASC Shrimp Standard), however, they transitioned to a unified ASC Farm Standard in 2025. This standard harmonises requirements across all species and includes a dedicated "Fish Welfare" module (one of four)[28]. Potentially most relevant to our work is the introduction of humane slaughter standards and monitoring of operational welfare indicators (OWIs)[28].

Certification, based on an audit, is valid for 3 years, including annual surveillance audits[28]. ASC has also pioneered a specific Group Certification methodology for Vietnam, allowing clusters of smallholders to implement a shared management system, making the standard accessible to the fragmented pangasius and shrimp sectors[29].

One farmer we met reported that their main ASC farm audit is conducted every 3 years.

Best Aquaculture Practices (BAP)

Operated by the Global Seafood Alliance (GSA), BAP is the dominant certification for the North American market. As with ASC, its processing standard also requires humane slaughter[30].

We did not meet any farmers who said their farms were BAP-certified.

The audits for BAP certification are conducted once per annum, with re-visits, short notice, or unannounced visits also being conducted. Audits are conducted by third-party certification bodies.

GLOBALG.A.P.

GlobalG.A.P. is a business-to-business (B2B) standard deeply rooted in Good Agricultural Practices (G.A.P.)[31]. Many European retailers view it as a comprehensive risk management tool and also hold ASC certification. Rather than prescribing a single way to farm, it requires the producer to assess risks (e.g., bird predation and oxygen depletion) and implement a management plan[32].

[28]ASC. *ASC Farm Standard – Version 1.0.1*. Utrecht: Aquaculture Stewardship Council, 2025.
[29]ASC. *ASC Requirements for the Certification of Producer Groups – ASC Farm Standard*. Utrecht: Aquaculture Stewardship Council, 2019.
[30]GSA. *Seafood Processing Standard – Animal Welfare Module*. Missouri: Global Seafood Alliance, 2024.
[31]Mazé, Armelle. “Standard-Setting Activities and New Institutional Economics.” Journal of Institutional Economics 13, no. 03 (2017): 599–621. https://doi.org/10.1017/s174413741600045x.
[32]GLOBALG.A.P. *Intergrated Farm Assurance GFS: Priciples and Criteria for Aquaculture – Finfish, Crustaceans, Mollucs, Seaweed*. Ver6.0. Colonge: GLOBALG.A.P, 2024.

GLOBALG.A.P. [cont.]

GlobalG.A.P. is explicit and progressive regarding slaughter. The standard states that "If technology is available...use of ice slurry or asphyxia shall be phased out."[32] Other welfare-related criteria are also included, but they are less prescriptive than ASC and BAP and serve as a baseline for market access.

The Growth of Aquaculture Certification in Vietnam

The story began in 2008, when allegations emerged of unsanitary farming conditions, antibiotic overuse, and environmental degradation in the pangasius industry. During this period, the WWF placed Vietnamese pangasius on its "red list" in 2010, advising consumers against buying it[33].

Subsequent scientific assessments largely debunked these claims, finding negligible food safety risks and noting that pangasius farming often had a lower environmental impact than other intensive systems[34]. However, the damaging claims, combined with several critical documentaries, stained pangasius's international reputation, particularly in the EU.

Responding to this backlash, the recently formed ASC, initiated by the WWF, set standards for sustainable pangasius farming and processing. These efforts began to bear fruit, and by the end of 2010, the WWF removed pangasius from its "red list"[35]. The shift towards ASC certification helped restore market access and improve the industry's reputation in the EU.

[33] CNA. "The Truth behind Dory Fish | Undercover Asia | Full Episode." YouTube, September 19, 2019. https://www.youtube.com/watch?v=-7ff7fbZO5Q.
[34] Little, David C., Simon R. Bush, Ben Belton, Nguyen Thanh Phuong, James A. Young, and Francis J. Murray. "Whitefish Wars: Pangasius, Politics and Consumer Confusion in Europe." *Marine Policy* 36, no. 3 (2012): 738–45. https://doi.org/10.1016/j.marpol.2011.10.006.
[35] WWF. "WWF Putting 'Tra' Fish on Consumer Red List Angers Vietnam." World Wide Fund, 2010. wwf.panda.org/.

Scoping Visit Methodology

This chapter outlines the methodology employed during our scoping visit to assess fish farming practices in Vietnam. It outlines the rationale for selecting specific regions and farms, the limitations encountered during fieldwork, and the data-collection methods used.

Period of scoping visit

The scoping visit took place from **October 2025 to January 2026**, and all observations described in this report are from that period. The majority of visits occurred over a 2-week period in October 2025, during which both co-founders were in Vietnam.

Species focus

This report focuses predominantly on **pangasius**, the most farmed aquaculture species by mass and number of individuals in Vietnam, and because of its high export numbers to regions such as the EU, UK, and US, where welfare is a growing concern.

Pangasius (*Pangasianodon hypophthalmus*)

Pangasius, locally known as *Cá Tra*, is the defining species of Vietnam's freshwater aquaculture industry and the primary subject of this report. Native to the Mekong River, it has evolved a facultative air-breathing capability (utilising a modified swim bladder) that allows it to tolerate, albeit not thrive in, low dissolved oxygen levels[1]. This unique biological trait is the foundation of the industry's intensive model, enabling farmers to stock ponds at exceptionally high densities (60–80 fish/m²) that would be lethal to most other finfish[2].

Vietnam dominates the global supply of this species, producing over 1.7 million tonnes annually and accounting for over 90% of global exports. The industry is concentrated almost entirely in the Mekong River Delta provinces of An Giang and Dong Thap, where fish are raised in deep earthen ponds for a 7–12 month grow-out cycle[3]. Its white, neutral-tasting fillet has made pangasius a staple whitefish in major markets like the EU, UK, US, China, and the Middle East.

[1]Ha, Nguyen Thi Kim, Doan Minh Hieu, Le Thi Truc Mo, Nguyen Van Toan, Do Thi Thanh Huong, and Nguyen Thanh Phuong. "Effects of Dissolved Oxygen Levels on the Growth and Digestibility of Catfish (*Pangasianodon Hypophthalmus*)." *Can Tho University Journal of Science* 22a (2021): 154–64.
[2]Phuong, N T, and D T H Oanh. "Striped Catfish Aquaculture in Vietnam: A Decade of Unprecedented Development." In *Success Stories in Asian Aquaculture*, edited by S S De Silva and F B Davy. Dordrecht: Springer, 2010.
[3]Tran, Vi L.T., Andrew C. Barnes, Francisca Samsing, Ut N. Vu, and Kerrie Wiley. "Striped Catfish (*Pangasianodon Hypophthalmus*) Farmers' Perspectives on Challenges and Health Management Practices in the Mekong Delta, Vietnam: A Qualitative Study." *Preventive Veterinary Medicine* 239 (2025): 106527. https://doi.org/10.1016/j.prevetmed.2025.106527.

Scoping Visit Methodology

Cá Tra vs Cá Basa

While the industry historically mainly exported *Pangasius bocourti* (Cá Basa/ Basa), it is now dominated by the hardier, faster-growing *P. hypophthalmus* (Cá Tra/ Tra Catfish), which is the focus of high-intensity farming for export[1]. Confusingly, at present, *P. hypophthalmus* is still sometimes referred to in international markets as 'Basa' for familiarity, even though this name technically refers to *P. bocourti*.

We also conducted **shallow research into other commonly-farmed fish species** (we decided early on not to explore shrimp welfare because the aforementioned Shrimp Welfare Project is already working on this):

Tilapia (*Oreochromis sp.*)

Often referred to as the "aquatic chicken" for its versatility, tilapia is a hardy Cichlid currently undergoing a strategic shift in Vietnam. While traditionally farmed in the north (the Red River Delta – Nile tilapia) and the south (the Mekong River Delta – red hybrid tilapia) for domestic consumption, production of Nile tilapia is rapidly expanding in the south to meet export demand, particularly to the US market.

Snakehead (*Channa striata*)

Known locally as *Cá Loc*, this carnivorous freshwater species is a favourite in the domestic market. It is an obligate air-breather, meaning it possesses a specialised suprabranchial organ that compels it to the surface regularly to gulp atmospheric oxygen. While this adaptation enables the fish to thrive in hypoxic waters that would be fatal to other species, it also means they must have unobstructed access to the surface, or they will drown.

Barramundi (*Lates calcarifer*)

Also known as Asian Sea Bass, this catadromous species (i.e. living in freshwater and migrating to the sea to spawn) is farmed in diverse environments, ranging from brackish ponds to industrial offshore marine cages. It represents the high-value future of Vietnam's marine aquaculture, with a focus on sustainable, high-tech farming models (e.g. Australis Aquaculture).

[4]Tri, N N, N P C Tu, D T Nhan, and N V Tu. "An Overview of Aquaculture Development in Vietnam." *Proceedings of International Conference on Fisheries and Aquaculture* 7, no. 1 (2022). https://doi.org/10.17501/23861282.2021.7105.

Geographical Focus and Stakeholders Visited

Mekong River Delta (southern Vietnam)

This region is the industry's high-volume, export-focused engine. Its ecology, with vast alluvial freshwater zones and coastal brackish-water areas, makes it the ideal centre for the intensive monoculture of Vietnam's two primary exports: pangasius and shrimp.

Figure 6. Aerial view of farms in the Mekong River Delta. © Tom Fisk via Pexels

Mekong River Delta (southern Vietnam)

Given our species focus on pangasius, the vast majority of our scoping took place here - specifically in the provinces of An Giang, Dong Thap, Can Tho and Vinh Long.

In this region, including Ho Chi Minh City, we visited and conducted interviews at:

- 2 pangasius hatcheries
- 1 pangasius nursery
- 7 pangasius grow-out farms
- 1 other grow-out farm (African catfish and spotted eel)
- 3 pangasius processing facilities
- 3 academic institutions (Can Tho University, Tra Vinh University, Ton Duc Thang University)
- 3 research institutions (RIA2, Fresh Studio, and a research farm)
- 2 wholesale markets
- 4 retail markets
- 3 international trading companies
- 2 others (Agriculture Extension, Pharmaq – a vaccination company)

Of the seven pangasius grow-out farms we visited, four were independent small-scale farmers, two were contracted by large processors, and one was a company's own farm.

How do contracted farmers operate?

One such farmer shared with us the following:

- All their fish are bought by one processor.
- Contracts are re-signed annually, but renewal is common (this farmer had been with the same processor for 18 years).
- Contracts include a fixed price and harvest period.
- The processor visits the farm regularly to monitor feed and mortalities. They also do sampling after four months, or whenever they observe an issue.

How do international trading companies operate?

We gathered the following information from three meetings:

- Many importers do not buy directly from processors - they work with an intermediary trading company that handles quality checks at processing plants, customs clearance in Vietnam and international freight.
- Trading companies will often export and import a range of seafood products on behalf of partners, both into and out of Vietnam.

Red River Delta (northern Vietnam)

This region represents the second major production zone; however, given its domestic-focused economy and challenges in organising farm visits for research purposes alone, we only visited one farm here. More time was spent visiting other stakeholders in Hanoi, the capital city.

In this region, we visited and conducted interviews at:

- 1 grow-out farm (multiple species, incl. sturgeon)
- 2 academic institutions (Vietnam National University of Agriculture, Hung Vuong University)
- 1 research institution (RIA1)
- 2 international organisations (Dutch Embassy, Norwegian Embassy)

Central Coast

We visited two inland nurseries here but did not prioritise the region during this scoping stage.

In this region, we visited and conducted interviews at:

- 2 nurseries (multiple marine species, incl. grouper)

Process of Identifying Farms and Stakeholders to Visit

Connections with the majority of stakeholders visited were made through academics at academic institutions and Innovation Norway cum Commercial section of the Norwegian Embassy in Hanoi, Vietnam.

Stakeholders seemed open to sharing information and communicating the challenges they face, while also expressing interest in future collaboration to research and adapt new methods to improve aquaculture in Vietnam. However, we would need to have further discussions to get a clearer impression.

Size of Farms Visited

While the pangasius sector is industrially consolidated, with an estimated 80% of all production either directly owned by processing companies or operating under contract farming agreements with those companies, the scoping visit included a mix of large-scale vertically integrated corporate farms, independent contract farmers, and smaller farms to understand the contrasts in production characteristics and welfare challenges.

All of the pangasius farms we visited had between 3–10 ponds, apart from one, which had 23 – this was the corporate farm. Individual ponds ranged in size from 0.5 to 1 hectare.

Data Collection Methods

Data gathering combined several strategies to ensure a comprehensive assessment of fish farm operations, welfare practices, and stakeholder perspectives:

Structured Interviews with Supply Chain Stakeholders – Standardised questionnaires guided discussions with farm operators, researchers and other stakeholders. The full farm questionnaire is available in Appendix B.

Direct Observational Visits – On-site inspections of facilities documented daily practices, infrastructure, and environmental conditions, enabling verification of reported practices and identification of welfare concerns not reported through interviews.

Wider Stakeholder Engagement – Discussions with national and international fisheries experts, researchers, and government officials provided broader industry perspectives on regional challenges and emerging trends.

Secondary Data Review – Supplementary information was gathered from the literature, published institutional reports, and farm documentation to strengthen and validate primary observations and interview responses.

Additional Methods

- Photo-documentation to systematically record environmental conditions, fish health, and management practices.
- Online interviews with industry experts accommodated scheduling constraints while enriching sector-wide understanding.
- Informal market visits for observation purposes assessed fish welfare in downstream supply chain segments, providing a complete production-to-market perspective on welfare issues.

Limitations and Areas Not Covered

Early Stage of Pangasius Life Cycle: While nursery and grow-out farms were assessed, the team only visited two informal pangasius hatcheries and did not observe larvae transportation. This leaves a critical gap in understanding welfare practices during the early life stages, particularly regarding handling and transport.

Exclusion of Key Freshwater Species: A significant gap exists regarding the exclusion of tilapia and snakehead. Consequently, insights into the welfare and operational challenges of these species are drawn from secondary sources rather than direct field observation.

Geographical and Logistical Constraints: In the north, fieldwork was restricted to a single river cage facility in Bac Ninh. This sample is not representative of the diverse range of cage-farming models across Northern Vietnam. In the centre, storms prevented access to sea cage operations, limiting our assessment of the marine finfish sector in this region.

Post-harvest Domestic Supply Chains: We visited and observed activities in several retail markets and wholesale markets, including the country's largest in Ho Chi Minh City. However, this report does not explore these domestic supply chains as our focus was on exported pangasius, which does not pass through local wholesale markets.

Research Team

The scoping visit and all stakeholder engagement were conducted by Scale Welfare's two co-founders, Koen van Pelt and Ameer Virani, and our Vietnam Field Coordinator, Phan Do Trong Nghia.

Figure 7. The research team at a Pangasius roundabout, Dong Thap. From left to right: Koen, Ameer, and Nghia.

Pangasius Industry Overview & Welfare Concerns

This chapter provides an **overview of the main stages of pangasius production in Vietnam**. It summarises how these species move through the cycle from hatchery to processing and highlights key practices, timelines, and systems at each stage.

Note: The emphasis here is on exported pangasius, as pangasius cultured for domestic consumption have different production characteristics.

Figure 8. Pangasinodon hypophthalmus, Cá Tra in Vietnamese. © Kamrul Haq via Getty Images

The advent of modern-day pangasius farming in Vietnam

The modern Pangasius industry was born from a 1994 supply shock when Cambodia banned the harvesting of wild juveniles, cutting off Vietnam's primary seedstock supply[1]. This forced a rapid pivot to research, leading to the mastery of artificial propagation by 1996[2].

Many farmers today have been farming pangasius for several years. Two of the farmers we met have been farming for 20+ years.

Production Stages

Table 5 outlines the typical production stages for pangasius. Farming durations vary with management intensity, feeding practices, and target market size, but they reflect the ranges most frequently reported during field visits and in the literature.

[1] Nicolaas, Van Zalinge, Lieng Sopha, Ngor Peng Bun, Heng Kong, and John Valbo Jørgensen. "Status of the Mekong *Pangasianodon hypophthalmus* Resources, with Special Reference to the Stock Shared between Cambodia and Viet Nam." Phnom Penh: Mekong River Commission, 2002.
[2] Tri, N N, N P C Tu, D T Nhan, and N V Tu. "An Overview of Aquaculture Development in Vietnam." *Proceedings of International Conference on Fisheries and Aquaculture* 7, no. 1 (2022). https://doi.org/10.17501/23861282.2021.7105.

Table 5. Production stages of pangasius in Vietnam[3]

Stage	Description	Typical Duration
Hatchery	Eggs hatch into larvae	After hatching, larvae are typically transferred to nurseries within 24 hours
Nursery	The fish are nursed in two stages: 1. Larvae are reared in tanks or small earthen ponds until they reach the fry stage (0.3-1g). 2. Fry are grown in prepared earthen ponds to fingerling size (~30g), suitable for stocking in grow-out ponds.	~80-120 days from larvae to fingerling size. The first stage (larvae to fry) takes 21-30 days. The second stage (fry to fingerling) takes 60-80 days. *Note: Vaccination can take place during the second stage when fish reach 20-30g (Intraperitoneal injection)*
Grow-Out	Fingerlings are stocked in intensive earthen ponds and raised to market size (0.8 -1.5kg per fish).	~8-15 months, depending on the required harvest size
Harvest & Transport	Fish are crowded, harvested, and transported to processing facilities by well-boats.	~2-5 days with fish being starved for 2 days pre-harvest and then harvesting lasting 1-3 days. Transportation takes several hours.

Stage 1: Breeding and Hatchery Operations

Today, hatchery operations are a national priority. Broodstock development is led by state bodies, such as the RIA2 and Can Tho University (CTU), as well as private vertically-integrated corporations, including Vinh Hoan, Viet Uc, and C.P. Group, which are developing genetically selected lines with superior growth, disease resistance, and environmental adaptation potential[4]. However, small-scale hatcheries continue to provide the majority of seed. Until now, there has been limited investment in hatcheries due to the life stage sensitivity, with most large-scale investment going into the processing stage.

The process involves injecting mature broodfish with synthetic hormones to stimulate breeding. Eggs and semen are carefully extracted and mixed for fertilization. Fertilised eggs are then incubated in specialised round-bottomed conical jars for 22-26 hours[5]. The eggs hatch into larvae within a few days.

[3]FAO. "Pangasianodon Hypophthalmus. Cultured Aquatic Species Information Programme," February 16, 2010. https://www.fao.org/fishery/en/culturedspecies/pangasius_hypophthalmus/en.
[4]Nguyen, Thuy T. T. "Patterns of Use and Exchange of Genetic Resources of the Striped Catfish *Pangasianodon Hypophthalmus* (Sauvage 1878)." *Reviews in Aquaculture* 1, no. 3-4 (2009): 224–31. https://doi.org/10.1111/j.1753-5131.2009.01016.x.
[5]Nguyen, Thanh Phuong. "Artificial Seed Production of Pangasiid Catfish in the Mekong Delta, Vietnam." *CABI Compendium*, 2020. https://doi.org/10.1079/cabicompendium.92519.

Husbandry at this stage is focused on maintaining broodstock health to ensure viable seed production. Broodstock are stocked in earthen ponds (at 5–10 tonnes per hectare) and fed a diet of 35% protein floating pellets or trash fish/meat[5]. Hatcheries are usually located upstream due to better water quality.

The high-intensity pangasius industry is sustained by a massive seed (fry) production sector. In 2024, the total output of pangasius seed reached 30 billion, representing a 7% increase from 2023. In the next stage of production, the output of fingerlings (larger fish fry) reached 4.02 billion, a 3.2% increase from the previous year. This seed production supports the 5,700 hectares of pangasius farming, enabling the high average stocking densities of 68 fish/m² [6].

Our meeting with a large-scale private hatchery

We met with one of these corporations at their Ho Chi Minh City office. They informed us that the hatchery stage lasts 21 days, with the first 10 days being most critical. They did not mention a specific mortality rate within their processes but did suggest it was high due to poor nutrition and biosecurity. Regarding vaccination, which currently only happens via injection during the nursery stage, they said they would be keen to research and experiment with different types of vaccine (e.g. immersion vaccine) at an earlier stage in the pangasius life cycle.

Welfare concerns at the hatchery stage

Low survival rates – Caused by poor biosecurity and larval nutrition, one farm reported 10% survival rates from larvae to the fingerling stage, which is common in the industry. The large-scale private hatchery we met with mentioned especially high mortality rates during the off-season (October–March).

Cannibalism – High mortality rates during the first week of larval development due to larger larvae preying on smaller siblings using specialised oral spines.

Stage 2: Transportation from Hatchery to Nursery

The timing of transfer from the hatchery to the nursery pond is a critical operational control point. This transfer ideally occurs within 24 hours of hatching, just before the larvae fully absorb the yolk sac, to prevent cannibalism[7]. Fry are transported from hatcheries to nursery farms by road, using trucks or motorbikes equipped with oxygenated bags or tanks.

[6] Phuong, N T, and D T H Oanh. “Striped Catfish Aquaculture in Vietnam: A Decade of Unprecedented Development.” In *Success Stories in Asian Aquaculture*, edited by S S De Silva and F B Davy. Dordrecht: Springer, 2010.

[7] Subagja, J, J Slembrouck, L T Hung, and M Legendre. “Larval Rearing of an Asian Catfish (Siluroidei, Pangasiidae): Analysis of Precocious Mortality and Proposition of Appropriate Treatments.” *Aquatic Living Resources* 12, no. 1 (1999): 37–44. https://doi.org/10.1016/s0990-7440(99)80013-8.

Figure 9. Pangasius larvae transportation in oxygenated bags on a motorbike.
Ⓒ Dr Chau Thi Da via Sustainable Aquaculture @ Stirling[8]

One academic we met recently conducted research on larval transportation and suggested that the ideal window is within 24 hours of the egg hatching, not just to prevent cannibalism, but also to optimise survival rate and health later in the life cycle. The paper is yet to be published at the time of writing this report.

Welfare concerns during larval transportation

Stress from poor handling – Stress from the entire process can result in 70 to 80% mortality during the first week of stocking at the nursery.

High temperatures – Larvae usually travel in a clear, oxygenated bag, which can act as a greenhouse, leading to overheating.

Extended transportation duration –If the travel duration is long, the above factors are exacerbated.
Physical injury – The high density of larvae and stress can make the fish aggressive, leading to physical injury and mortality.

Stage 3: Nursery and Grow-Out Stages

Both nursery and grow-out operations are typically conducted in earthen ponds, with similar management practices.

Nursery

Nursery operations are a high-risk and high-mortality stage, comprising two distinct phases[3]:

- From larvae to fry
- From fry to fingerlings

[8]Da, Chau Thi. “Improving the Welfare of Pangasius Fry during Transport.” Sustainable Aquaculture @ Stirling, June 10, 2025. https://www.susaquastirling.net/welfare-news/2025/5/29/improving-the-welfare-of-pangasius-fry-during-transport.

After free-swimming hatchlings have been collected and transferred to nursery ponds, they are reared for 20–30 days, growing from newly hatched larvae to fry measuring 15–20mm (0.3 to 1.0 g)[3]. This period is the most critical for fish, as it determines the animal's health later in its life cycle[9].

The fish are then nursed for ~70 days into fingerlings weighing approximately 20–30g[3]. After this period of ~100 days, fingerlings move on to a different pond or farm for the grow-out phase[3]. One farm we visited raised its fingerlings in three ponds before combining the survivors into a single grow-out pond.

Welfare concerns during larval transportation

High mortality rates are common during this stage. These can be caused by:

Sub-optimal environmental conditions – Juveniles are particularly vulnerable to environmental parameters that fall outside their optimal biological niche. Research confirms that growth is significantly lower at temperatures below 26^{0}C and over 32^{0}C[10], and performance is poor at salinities of over 8ppt[11].

Handling stress – Resulting from vaccinations, transportation, and grading[12].

Delayed transportation from hatcheries – Research suggests that transportation after the first 24 hours post-hatching can lead to short-term mortalities and longer-term increased susceptibility to disease and worsened health outcomes[13].

Grow-out

Grow-out operations are a highly intensive, industrialised monoculture[3]. Production is concentrated in large (from 0.1–1 hectare), deep (2.5–4 metres) earthen ponds[3]. Farms we visited were usually sized between 0.5–1 hectare, only one farm we visited had ponds outside of this range (< 0.5 hectare). The most common pond depth we observed was between 4–5 metres.

In the intensive monoculture systems of the Mekong River Delta, the grow-out phase typically lasts 8–15 months, allowing fish to reach the commercial harvest size of 0.8–1.5 kg, which optimises fillet size and colouration for key international markets[3]. Farms we visited were cultivating pangasius for 6–12 months on average, with harvest sizes averaging between 0.8–1.2kg. This is the norm for exports to the EU, which would be closer to 0.8kg, and for the US, which would be around 1.2kg per fish.

[9] Chakraborty, B. K. "Rearing and Nursing of Thai Pangas, *Pangasinodon hypophthalmus* (Sauvage, 1978) with Different Feeds." *International Journal of Biological Innovations* 02, no. 02 (2020): 277–86. https://doi.org/10.46505/ijbi.2020.2224.
[10] Islam, Md. Ariful, Md. Helal Uddin, Md. Jasim Uddin, and Md. Shahjahan. "Temperature Changes Influenced the Growth Performance and Physiological Functions of Thai Pangas *Pangasianodon hypophthalmus*." *Aquaculture Reports* 13 (2019): 100179. https://doi.org/10.1016/j.aqrep.2019.100179.
[11] Mandal, Shankar Chandra, Shahin Kadir, and Anwar Hossain. "Effects of Salinity on the Growth, Survival and Proximate Composition of Pangas, *Pangasius hypophthalmus*." *Bangladesh Journal of Zoology* 48, no. 1 (2020): 141–49. https://doi.org/10.3329/bjz.v48i1.47883.
[12] Ramsay, Jennifer M., Grant W. Feist, Zoltán M. Varga, Monte Westerfield, Michael L. Kent, and Carl B. Schreck. "Whole-Body Cortisol Response of Zebrafish to Acute Net Handling Stress." *Aquaculture* 297, no. 1-4 (2009): 157–62. https://doi.org/10.1016/j.aquaculture.2009.08.035.
[13] Da, Chau Thi. To be pulished.

Figure 10. Pangasius grow-out farms. Left: Dong Thap province, right: An Giang province

Pond preparation

The national technical regulation on pangasius ponds (QCVN 02-20:2014/BNNPTNT[14]) mandates that pond depth must be at least 3m, and the waste pond must be at least 10% of the total surface area. Waste ponds are used to store sludge from other ponds to prevent it from being discharged untreated into the natural environment. The sludge in the waste ponds is either treated before discharge, or used as agriculture fertilizer. Before stocking, the farm must level the pond bottom and remove the sludge. Pond preparation is essential to reduce the risk of cross-contamination and recontamination of the new crop from the previous one.

Pond preparation typically takes from 2 to 45 days. It involves the optional dry-out of the pond, followed by the application of some combination of lime, salt, and chlorine[15]. Pond preparation of some kind was common amongst the farms we visited. Five of seven farms mentioned they do pond preparation, with two of them drying out their ponds completely and three not doing so.

We observed several farms lining their ponds to prevent erosion and one farmer, when asked what he would do with a cash injection, even told us he would first invest in cementing all his ponds to serve this same purpose.

Water quality

The primary operational tool for managing the high-density environment of pangasius farming is high-volume water exchange. The literature suggests farms commonly replace 30–50% of the pond volume daily via pumping to flush wastes[16].

[14]Ministry of Agriculture and Rural Development. "QCVN 02-20:2014/BNNPTNT: National Technical Regulation on Conditions for Aquaculture." Ha Noi , 2014.
[15]Phuong, Nguyen Thanh, Nguyen Van Hao, Bui Minh Tam, Phan Thanh Lam, Vo Minh Son, Nguyen Nhut, Duong Nhut Long, et al. "Better Management Practices for Striped (Tra) Catfish Farming in the Mekong Delta, Vietnam." 3.0 ed. Bangkok: Network of Aquaculture Centres in Asia-Pacific, 2011.
[16]Phan, Lam T., Tam M. Bui, Thuy T.T. Nguyen, Geoff J. Gooley, Brett A. Ingram, Hao V. Nguyen, Phuong T. Nguyen, and Sena S. De Silva. "Current Status of Farming Practices of Striped Catfish, *Pangasianodon hypophthalmus* in the Mekong Delta, Vietnam." *Aquaculture* 296, no. 3-4 (2009): 227–36. https://doi.org/10.1016/j.aquaculture.2009.08.017.

Our interviews and observations presented the following:

- **Routine Water Exchanges:** The vast majority of farms maintain water quality through frequent, partial water exchanges, typically replacing 20-30% of the pond volume on a daily basis.
- **Variable Monitoring:** Water quality testing is a standard practice for most, focusing on dissolved oxygen, pH, and toxic gases (NH_3, NH_4^+, NO_2, NO_3^-). However, the frequency of these tests ranges widely from daily checks to reactive monitoring only when fish health declines.
- **Agricultural Runoff Risks:** There is a significant concern regarding seasonal environmental factors. Specifically, pesticide-laden runoff from neighbouring rice paddies during the rainy season is identified as a major cause of mass mortality events.
- **Pathogens:** One farmer complained about Swollen Swim Bladder, a fungal infection caused by *Fusarium sp.* and poor water quality that leads to severe internal inflammation, disorientation, and high mortality rates in fish.
- **Aeration:** Mechanical aeration is not currently a common industry standard. On the one occasion we saw it in place, it was a reactive measure implemented after significant stock losses.

Figure 11. Pangasius grow-out farm with cemented basin (left) and aeration (right), Dong Thap province

Feeding

Commercial floating pellets are used by 95-97% of producers and account for over 80% of total production costs. Average Feed Conversion Ratios (FCR) are 1.7–1.9[3]. This was confirmed by two farmers during interviews. Importantly, ASC standards require FCR to be less than 1.68[17].

Feeding is mostly conducted manually or via automatic feeders to ensure consistency and maximise growth[16]. We observed manual feeding at all the farms we visited.

[17]ASC. *ASC Pangasius Standard Version 1.2 – June 2019*. Utrecht: Aquaculture Stewardship Council, 2019

Figure 12. A feeding boat at a pangasius nursery, Dong Thap province

To ensure end-to-end accountability, all ASC-certified farms from Febuary 2026 must source feed exclusively from ASC-certified mills. This certification guarantees that sustainability efforts extend beyond the farm into the feed production process itself. The standard mandates that marine ingredients be traceable to sustainable sources and that agricultural inputs, such as soy and palm oil, be certified deforestation-free.

Stocking density

Extreme crowding is a defining, intentional feature of the pangasius production model. The species' unique biological adaptation—its ability to breathe atmospheric air—is exploited to achieve stocking densities far exceeding those possible for other finfish[18]. There is also a high reliance on imported raw ingredients for aquafeed, placing external financial pressure on farmers to maximise yield per unit of feed.

Stocking densities have been reported at 60–80 fish per m², with an average of 68 fish per m², producing exceptionally high outputs of 200–400 tonnes per hectare[18].

The information we received from six farms indicated the following estimated stocking densities (fish per m²): 42, 45, 50, 100, 120, 200. Three of these seem significantly high, although it should be noted that the farm where stocking of 200 fish per m² was calculated is a vertically integrated facility – growing fish from fry to market size – with a stocking size of around 1g per fish. The rate would drop during grow-out due to mortality.

The ASC standard for pangasius cultured in ponds mandates a maximum stocking density of 38 per m², which, if we assume the market size to be 0.8–1.5 kg per m², indicates a density of 25 to 47 fish per m², which some farms exceed by 2 to 4 times[17].

[18]De Silva, Sena S., and Nguyen T. Phuong. "Striped Catfish Farming in the Mekong Delta, Vietnam: A Tumultuous Path to a Global Success." *Reviews in Aquaculture* 3, no. 2 (2011): 45–73. https://doi.org/10.1111/j.1753-5131.2011.01046.x.

Antibiotic use

A 2015 qualitative study of pangasius farmers revealed systemic non-compliance with antibiotic regulations[19]. 82% of farmers reported using antibiotics for disease treatment, and 25% used them prophylactically (for prevention). Most alarmingly, 26% of farmers in this study admitted to still using the banned antibiotic Enrofloxacin. This practice, driven by high disease pressure and low vaccine adoption, creates a dual-pronged risk: it contributes to Antimicrobial Resistance (AMR) and poses a severe, immediate risk of export rejection from high-standard markets, threatening the industry's $2.03 billion in revenue.

During our interviews, three of the seven farms mentioned using antibiotics, but always only for treatment, not disease prevention.

Vaccination

While historical vaccine adoption has been extremely low, recent 2024 sales data indicate a significant upward trend, with an estimated 10-15% of fingerlings now being vaccinated[20]. Only one farm we visited had vaccinated pangasius, however, we specifically visited this site because we knew this fact and wanted to learn more about the process.

Pangasius vaccination by Pharmaq

Presently, pangasius fingerling vaccination is administered exclusively by the Norwegian company Pharmaq. During our meeting with Pharmaq, we learned that their vaccine is injected intraperitoneally (into the abdominal cavity) of the fish. The vaccine is most effective when the fish reaches 20 to 30g in size (i.e. during the second nursery stage). It protects against the two most common pangasius diseases – BNP and MAS (more details on these diseases below). There is currently no approved immersion or oral vaccine for pangasius, although international and national institutions are exploring this approach.

Figure 13. Pangasius being injected with Pharmaq vaccine. Ⓒ Pharmaq via IntraFish[21]

[19] Phu, Tran Minh, Nguyen Thanh Phuong, Marie-Louise Scippo, and Anders Dalsgaard. "Quality of Antimicrobial Products Used in Striped Catfish (*Pangasianodon hypophthalmus*) Aquaculture in Vietnam." *PLoS ONE* 10, no. 4 (2015). https://doi.org/10.1371/journal.pone.0124267.
[20] An, Bui Nguyen Thu, and Joe Pearce. "Pangasius Welfare Study," 2025.
[21] Mutter, Rachel. "Pangasius Vaccine Brings Hope in Stamping out Sector's Biggest Diseases." IntraFish, August 2018. www.intrafish.com/aquaculture/pangasius-vaccine-brings-hope-in-stamping-out-sectors-biggest-diseases/2-1-394602.

Effects of the vaccination

- 20% improvement in survival rate during the grow-out phase (verified by the one farm we interviewed that vaccinated its fish).
- Faster growth rate – vaccinated fish reach harvest size one month earlier, on average.
- Less than 1% of fingerlings die during vaccination as a result of handling.

Other key information

- Vaccination costs 400–500 VND (~1.5–1.9 US cents) per fish, which is close to the price per fingerling, so most farmers will just buy extra fingerlings to account for mortalities, rather than vaccinating.
- Fish need to be healthy in order to be vaccinated; weak fish can die from the stress of handling.
- Among existing clients, vaccination rates are low due to a lack of healthy fish stock. However, beyond existing clients, the barrier for farmers is that companies do not want to pay the 10% premium for vaccinated harvest-size fish, so there is no incentive for them to vaccinate.

Probiotics and other supplements

Farmers are increasingly focusing on preventive health management, including the application of probiotics to manage water quality and decompose pond bottom sludge[22]. There is also a growing emphasis on improving fish health via functional feed additives and immunostimulants, such as Vitamin C and herbal extracts. Studies on pangasius have shown that additives such as garlic (Allium sativum) can significantly enhance immune function and improve resistance to diseases, such as BNP[23]. Three of the seven farms we interviewed used probiotics of some kind.

Only one farm mentioned using additional supplements - micronutrients (Beta glucan, vitamins) and garlic (immunostimulant). They combine garlic that has fermented for seven days and B12, and add this to fish pellets as an immunostimulant. Garlic can increase growth rates and enhance disease resistance[23,24,25].

[22] Liaqat, Razia, Shafaq Fatima, Wajeeha Komal, Qandeel Minahal, Zakia Kanwal, Muhammad Suleman, and Chris G Carter. "Effects of Bacillus Subtilis as a Single Strain Probiotic on Growth, Disease Resistance and Immune Response of Striped Catfish (*Pangasius hypophthalmus*)." *PLoS ONE* 19, no. 1 (2024). https://doi.org/10.1371/journal.pone.0294949.

[23] Khang, L T P, Truong Vinh, L T L Tho, Nguyen Xuan Tong, and T T P Dung. "Use of Dietary Garlic (*Allium sativum* L.) and Vietnamese Balm (*Elsholtzia ciliata*) Extract for Prevention of Bacillary Necrosis in Pangasius (BNP) in Striped Catfish (*Pangasianodon hypophthalmus*)." *Academia Journal of Biology* 44, no. 4 (2022): 65–76. https://doi.org/10.15625/2615-9023/17534.

[24] Patel, P P, R V Borichangar, V R Patel, and S C Timbadia. "Garlic Powder Supplementation: Effects on Nutrient Utilization and Haematological Parameters of Sutchi Catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878)." *Indian Journal of Animal Nutrition* 39, no. 4 (2022).

[25] Siddique , Sumaia, Md Mubarack Hossain, and Md Nurul Haider. "Antimicrobial Efficacy of Garlic (*Allium sativum*) Extract against *Aeromonas hydrophila* Isolated from Diseased Pangasius Catfish." *Veterinary Medicine and Science* 12, no. 1 (2025). https://doi.org/10.1002/vms3.70724.

Welfare concerns during grow-out production

With the grow-out stage being the longest life stage of fish it is essential that practices do not interfere with fish welfare to an unreasonable extent. Based on the literature and interviews with farmers, multiple welfare concerns were identified during grow-out:

Disease-induced high mortality rates

The high-density pangasius farming environment creates significant disease pressure. The two dominant on-farm diseases are Bacillary Necrosis of Pangasius (BNP), caused by *Edwardsiella ictaluri*[26], and Motile *Aeromonas* Septicaemia caused by *Aeromonas hydrophila* (MAS)[27]. These bacterial outbreaks are a significant driver of economic loss and can result in mortality rates of up to 100% in affected populations.

Disease vulnerability is a symptom of a much larger, systemic threat. As salinity and temperatures rise as a result of climate change, fish are pushed out of their biological niche, leading to chronic stress[28]. This directly increases vulnerability to disease, which in turn drives the high (and illegal) use of antibiotics[29].

Disease rates in the Mekong River Delta spike significantly during the flood season (June to December), driven by warmer temperatures and an influx of pathogens. These conditions are exacerbated by the runoff of organic matter from neighbouring flood rice farms, which creates an environment highly conducive to the spread of illness within the ecosystem.

Five out of seven farms interviewed reported disease prevalence, with one farmer reporting losses of 100kg-1 tonne per day as a result. ASC standards require mortality rates during the grow-out period to be below 20%. The following average mortality rates were reported by five of the farms we visited: 1-2%, up to 10%, 10-15%, 15-40%, over 20%.

Such mortality rates mean the death of hundreds of thousands of pangasius per farm per cycle, with numbers conceivably going over one million at larger farms with multiple ponds. Despite this, only one farm reported having a vet.

[26] Crumlish, M, T T Dung, J F Turnbull, N T N Ngoc, and H W Ferguson. "Identification of *Edwardsiella ictaluri* from Diseased Freshwater Catfish, *Pangasius hypophthalmus* (Sauvage), Cultured in the Mekong Delta, Vietnam." *Journal of Fish Diseases* 25 (2002): 733–36. https://doi.org/10.1046/j.1365-2761.2002.00412.x.

[27] Hassan, A, S Ali, T Xu, M R Lilies, and H H Mohammed. "Emergence of *Aeromonas dhakensis*-Linked Motile Aeromonas Septicemia in *Pangasius hypophthalmus* Biofloc Systems in Pakistan." *World Aquaculture Society* 56, no. 1 (2025). https://doi.org/10.1111/jwas.70001.

[28] Hieu, Dang Quang, Thi Bich, Thi Thanh, Najlae El Kertaoui, Frédéric Farnir, Nguyen Thanh Phuong, and Patrick Kestemont. "Salinity Affects Growth Performance, Physiology, Immune Responses and Temperature Resistance in Striped Catfish (*Pangasianodon hypophthalmus*) during Its Early Life Stages." *Fish Physiology and Biochemistry* 47, no. 6 (2021): 1995–2013. https://doi.org/10.1007/s10695-021-01021-9.

[29] Rico, Andreu, Tran Minh Phu, Kriengkrai Satapornvanit, Jiang Min, A.M. Shahabuddin, Patrik J.G. Henriksson, Francis J. Murray, David C. Little, Anders Dalsgaard, and Paul J. Van den Brink. "Use of Veterinary Medicines, Feed Additives and Probiotics in Four Major Internationally Traded Aquaculture Species Farmed in Asia." *Aquaculture* 412-413 (2013): 231–43. https://doi.org/10.1016/j.aquaculture.2013.07.028.

Figure 14. Dead, floating (top) and air-gasping (bottom) pangasius at a farm in An Giang province

Welfare concerns during grow-out production

Poor water quality caused by high stocking densities

With high mortality rates being the norm, farmers stock in high densities to account for losses. High stocking densities in average 4m deep ponds create a toxic, low-oxygen, and high-ammonia environment in the water[30]. This forces the entire population to "cluster near the surface" in the top metre of water to access oxygen[31]. The actual experienced density in this small, habitable surface layer is therefore 3–4 times greater than the previously-quoted average of 68 fish/m².

Pangasius is unique in its ability to switch to air-breathing (at dissolved oxygen levels of 2.5 mg/L) through its well-developed gills and modified swim bladder. Its breathing capacity can help it survive both hypoxia (low oxygen levels of 0.05-0.1 mg/L)[31] and hypercarbia (high carbon dioxide levels). While low dissolved oxygen does not affect pangasius survival, it reduces growth rates and increases blood glucose levels, a stress indicator[32]. In another study, lactace – a type of stress hormone – triggered the O_2 chemoreceptors of pangasius, similar to when the fish are in hypoxia, resulting in air-breathing[33]. Therefore, although the fish can survive in a low-oxygen environment thanks to its capacity to breathe air, it still possesses active O_2 chemoreceptors (O_2–sensing receptors) and shows stress indicators (elevated glucose, reduced growth). Consequently, pangasius does not suffer less in low-DO environments or during hypoxic events, and survival does not necessarily indicate no welfare impact.

[30] Anh, Nguyen Tuong, and Ngo Duc Quan. "Improvement of Tilapia Masculinization Method by 17α-Methyltestosterone Immersion." *Proceedings of the National Conference for Young Scientists 2011* 16, no. 12 (2011): 27–32.

[31] Lefevre, Sjannie, Do Thi Thanh Huong, Tobias Wang, Nguyen Thanh Phuong, and Mark Bayley. "Hypoxia Tolerance and Partitioning of Bimodal Respiration in the Striped Catfish (*Pangasianodon hypophthalmus*)." *Comparative Biochemistry and Physiology A-Molecular & Integrative Physiology* 158, no. 2 (2011): 207–14. https://doi.org/10.1016/j.cbpa.2010.10.029.

[32] Ha, Nguyen Thi Kim, Doan Minh Hieu, Le Thi Truc Mo, Nguyen Van Toan, Do Thi Thanh Huong, and Nguyen Thanh Phuong. "Effects of Dissolved Oxygen Levels on the Growth and Digestibility of Catfish (*Pangasianodon hypophthalmus*)." *Can Tho University Journal of Science* 22a (2021): 154–64.

[33] Thomsen, Mikkel T., Tobias Wang, William K. Milsom, and Mark Bayley. "Lactate Provides a Strong Ph-Independent Ventilatory Signal in the Facultative Air-Breathing Teleost *Pangasianodon hypophthalmus*." *Scientific Reports* 7, no. 1 (2017). https://doi.org/10.1038/s41598-017-06745-4.

Stage 4: Harvest, Transportation and Slaughter

Harvesting refers to the planned capture and removal of market-size fish from aquaculture systems for commercial sale. The process for pangasius generally follows a standardised sequence:

- **Pre-harvest fasting (48 hours or longer)**
- **Crowding and capture**
- **Transportation from farm to processing facility**

Pre-harvest fasting

Harvesting is preceded by a mandatory fasting period to empty the gut, which is a key requirement for processors. This fasting period typically lasts two days. However, on large farms where harvesting a single pond can take multiple days, fish harvested last may be starved for 5-6 days.

Crowding and capture

Harvesting is conducted using large seine nets (draft nets). The pond water level is partially lowered via tidal gravity drainage to concentrate the fish. Workers then use the nets to crowd the entire population. One farm reported crowding on a gradual basis – a maximum of 30 tonnes of fish at a time, the transportation well-boat's capacity.

To transfer the fish from the pond's crowding net to the well-boat involves manually collecting and moving them in baskets, without water, for durations reported to be between 1-5 minutes. Farmers we interviewed performed this process by motorbikes, conveyor belts, or a combination of the two. The one harvest we observed used motorbikes and involved the fish being out of the water for approximately one minute; however, this harvest was from the site’s closest pond to the river, where the well-boat was docked. Two other farmers reported that the fish are out of the water for approximately two and five minutes during harvest.

Figure 15. Left: Crowded fish on the pond ready for transportation; Right: Fish in blue bucket for weighing and transfer on motorbike to well-boat.

All farms outsource harvesting to a third party, and the processor organises transportation. Pumps would technically speed up the process of moving crowded fish into the well-boat. We did not see any installed but one farm mentioned they planned installation soon, albeit for inter-pond fish transfer rather than harvesting, and another farmer reported they would be interested in pump technology because they do not like dealing with the harvesting companies due to poor organisation and fluctuating prices. One farmer reported that they would not find pumps useful, and a general concern is that moving from baskets to pumps would make it difficult to weigh the fish during harvest.

Figure 16. Left: Chain reaction of transferring fish from motorbike to well-boat; Right: A well-boat

Transportation from farm to processing facility

The journey by well-boat to the processing plant typically takes 3–5 hours, although one plant we visited had fish coming after 6–7 hours of travel on the day we arrived. Well-boats are specialised boats with deep hulls perforated with holes to allow water into the central cargo hold. A well boat can carry 20–50 tonnes of live fish.

Figure 17. From left to right: Fish crowded in a well boat to be transferred to the processing plant; transferring truck; and Suction pump.
Suction pump Ⓒ Pham Cong[34].

[34]Pham, Cong. "Dai Thanh 2023 VIE." YouTube, October 18, 2023. https://www.youtube.com/watch?v=HJDUGxoluJg.

The common method for moving fish from the well-boat to the factory slaughter line involves placing them in baskets without water again. The process can take up to 20 minutes. Two of the three processing plants we visited did this by truck. Another had a suction pump transferring fish directly from the well-boat to a conveyor belt leading to the plant.

Slaughter

Most pangasius are killed via gill or throat cutting upon arrival inside the processing plant. They are then left to bleed out in a tank, taking up to 20 minutes to die. We observed fish frantically moving about in these ponds before finally dying.

Figure 18. Left: Fish receiving area without stunning. Right: Bleeding tank.

Very few exports destined for the EU and UK undergo prior stunning. Ultimately, because stunning is perceived to slow production lines, processing plants often avoid this step unless required, leaving the majority of fish to face slaughter without desensitisation[20]. One of the three plants we visited had an on-site dry electric stunner that had been in use for 5–6 years – produced, installed, and maintained by in-house technicians in accordance with EU requirements, which stunned the fish before they were bled. The stunner was used for all fish and did not seem to slow down the transfer process. This plant also suggested that pangasius bled 5–10 minutes quicker since they introduced stunning. Another plant informed us they plan to introduce electrical stunning in 2026, but didn't have more concrete details yet. They had several concerns about the quality and condition of the fish after stunning, compared to those without stunning.

The general lack of pre-slaughter stunning reveals a significant gap between certification and welfare standards. The pangasius industry is heavily reliant on international certifications (ASC, BAP, GlobalG.A.P., and Halal) to access premium EU and US markets. However, these dominant international standards have historically had no or only limited requirements for stunning before slaughter. This regulatory gap has disincentivised industry investment in stunning technology. At the time of writing this report, only ASC had introduced and specified electrical stunning prior to slaughter, and processing plants have to adapt by 2028. All three processing plants we visited sold some ASC-certified fish, ranging from 10% to 30% of total production.

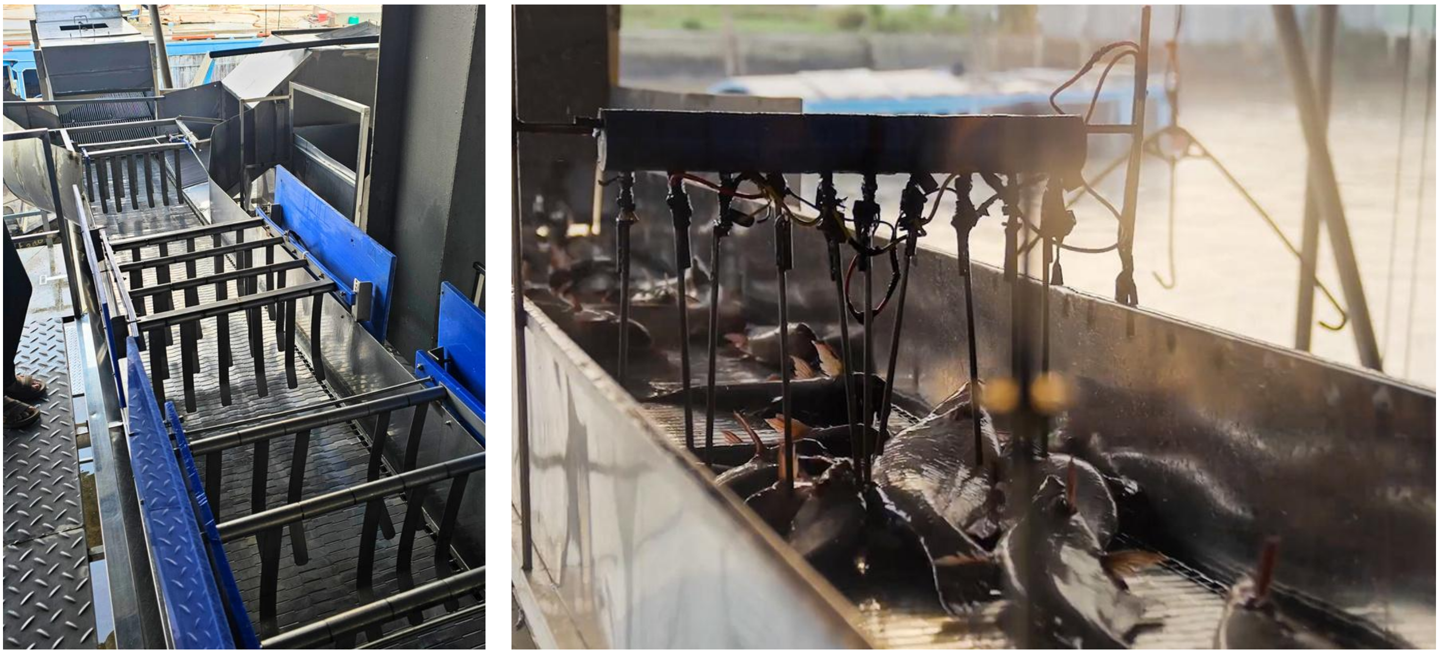

Figure 19. House-made dry stunner at one processing facility. Out of operation (left) and in operation (right). Right picture © Pham Cong[34].

Welfare concerns during harvest, transportation and slaughter

Lengthy pre-harvest fasting - Harvests in larger ponds can last 3-4 days, meaning the fish harvested last may be starved for 5-6 days, a duration that raises significant animal welfare concerns.

Stressful well-boat transport from farm to factory: High stocking densities in well-boats result in high mortality rates, estimated at 2–8% by weight, with some reports reaching 10%. One farmer we spoke to reported 2-3% mortality.

Stress, physical injury, and asphyxiation during transfer from well-boat to factory: On arrival at the processing facility, moving fish in baskets without water can cause acute stress, physical injury, and asphyxiation[20]. Fish at the bottom of the basket are significantly weighed down, resulting in wounds and scratches, exacerbated by pangasius' sharp pectoral spines[35].

Inhumane slaughter - The standard industry method for killing pangasius is gill-cutting or decapitation without prior stunning. Fish remain conscious and experience prolonged suffering during exsanguination (bleeding).

[35]Slembrouck, J, J Subagja, D Day, and M Legendre. "Broodstock Management." In *Technical Manual for Artificial Propagation of the Indonesian Catfish, Pangasius Djambal*, edited by J Slembrouck, O Komarudin, Maskur, and M Legendre. Jakarta: Departemen Kelautan dan Perikanan, 2003.

Overview of welfare concerns throughout the pangasius life cycle

This section provides a brief overview of the key welfare concerns we have identified through our research:

1. Hatchery & Larvae Transportation

The earliest stages of life are marked by extreme fragility and high mortality. Survival rates from larvae to the fingerling stage are frequently as low as **10%:**

- **Cannibalism:** During the first week of development, larger larvae use specialised oral spines to prey on smaller siblings, a primary driver of early-stage loss.
- **Thermal & Handling Stress:** Larvae are typically transported in oxygenated plastic bags. These can act as "greenhouses," leading to rapid overheating. Poor handling and high temperatures during transit can result in **70–80% mortality** within the first week of stocking at a nursery.
- **Physical Trauma:** High transport densities trigger aggression among larvae, leading to physical injuries that further compromise survival.

2. Nursery Stage

Juvenile pangasius are highly sensitive to environmental parameters:

- **Delayed Stocking:** Transportation occurring more than 24 hours post-hatch leads to long-term health issues and increased disease susceptibility.
- **Sub-Optimal Temperatures:** Growth is significantly lower at temperatures below 26^{0}C and over 32^{0}C
- **Salinity Limits:** Performance declines sharply at salinities over 8ppt, a growing concern as saltwater intrusion affects the Mekong Delta.

3. Grow-out Phase

The grow-out period represents the highest volume of animal suffering due to the sheer scale of the populations involved and the duration of exposure to poor conditions:

- **Systemic Disease Pressure:** High-density environments facilitate massive outbreaks of **Bacillary Necrosis (BNP)** and **Motile Aeromonas Septicaemia (MAS)**, which can cause mass mortality events in affected ponds. This pressure is exacerbated by climate change and organic runoff from nearby rice farms during the flood season (June–December).

- **Low Oxygen Levels and High Stocking Densities:** While pangasius can survive in low-oxygen (hypoxic) water by air-breathing via a modified swim bladder, this is a stress response, not a preference. High ammonia and low oxygen in deep water force fish to cluster in the top meter of the pond. This creates an "experienced density" 3–4 times higher than the calculated average, leading to elevated blood glucose and suppressed growth.

4. Harvest, Transport, and Slaughter

The final stages of the production chain involve acute, high-intensity welfare breaches:

- **Pre-Harvest Fasting:** Because harvests can last several days, fish may be deprived of food for **5–6 days**, causing significant physiological distress.
- **Well-Boat Transit:** Fish are transported to factories in high-density well-boats, where mortality is estimated at **2–10% by weight**. Crowding leads to physical trauma and asphyxiation.
- **Asphyxiation & Mechanical Injury:** During transfer to the factory, fish are moved in waterless baskets, which can cause asphyxiation. Those at the bottom are crushed by the weight of those above, suffering wounds and scratches from the sharp pectoral spines of their conspecifics.
- **Slaughter without Stunning:** The industry standard remains **gill-cutting or decapitation without prior stunning**. Because pangasius are hardy, they remain conscious for extended periods during exsanguination (bleeding out), experiencing prolonged pain and distress.

Other species

Although our current focus for welfare improvement work is exported pangasius as we see the most tractable opportunities in that sector, we also learned about other commonly-farmed species to provide us with a more comprehensive overview of the farmed fish industry in Vietnam.

Below are brief overviews of these species, including information about their production and welfare concerns.

Tilapia

Tilapia (Oreochromis sp.) has traditionally been a domestic-market species in Vietnam, but it is now being rapidly repositioned as a strategic export pillar[1]. For this reason, it is a species of interest for us, however, our research so far has been predominantly desk-based, and we have not visited any tilapia supply chain stakeholders yet, apart from observational visits to wet markets.

The recent, sudden emergence of tilapia as an export focus is a direct response to shifts in global trade[2]. In the first eight months of 2025, Vietnam's tilapia exports surged by 359% to USD 52 million, with the US accounting for 62% of the total export value[2].

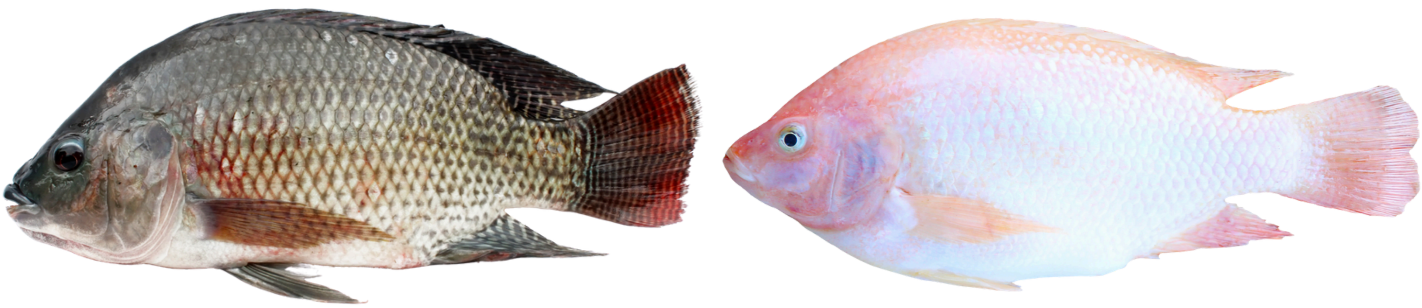

Figure 20. Left: Nile tilapia (Oreochromis niloticus) Ⓒ Dinhngochung via Getty Images, Right: Red hybrid tilapia Ⓒ Watcharapol_Kun via Getty Images

This boom is driven by US importers actively seeking alternatives to Chinese tilapia, which is subject to a 25% tariff in the US as of 2018 and a 125% tariff in 2025[3]. The Vietnamese government and VASEP are actively promoting tilapia as a major seafood commodity alongside shrimp and pangasius. Major pangasius-only producers, such as the Nam Viet Group (Navico), are now also farming and exporting tilapia to broaden their export base[4].

[1] Hai Dang. "Enhancing Production Output and Export Value for the Development of Tilapia Industry." Electronic Information Portal of the Department of Fisheries and Fisheries Surveillance, 2025. https://tongcucthuysan.gov.vn/.
[2] Toan Dao. "Vietnam Eyes Boosting Tilapia Exports amid Trade War." Seafood Source, 2026. https://www.seafoodsource.com/news/.
[3] Karsten, Jens. "Vietnam's Tilapia Exporters Identify Opportunities in US Market." Baird Maritime, 2025. https://www.bairdmaritime.com/fishing/aquaculture/.
[4] VASEP. "Vietnam's Seafood Industry Targets Tilapia as Strategic Export Product." VASEP, 2025. https://seafood.vasep.com.vn/.

Breeding and Hatchery Operations

This is identified as a key area for development, not a mature operation. The rapid growth in exports has exposed the need for a high-quality breeding system. Industry and government are calling for investment in regional breeding centres to ensure traceability and avoid the hybridisation that plagues unmanaged breeding systems[4]. The private hatchery operator we met with also highlighted that they were looking to research the production of tilapia seed going forward.

The TILACEN (Tilapia Research Centre) of RIA1 is tasked with developing the strain for Vietnam. Currently, they have the fourth generation (G4), which shows 10% faster growth and 26% higher fillet yield than the imported strains[4]. Private cooperations, such as GenoMar Genetics (an international company), are also developing tilapia strains through advanced gene selection[5].

Nursery & Grow-Out Stages

The nursery and grow-out cycle for tilapia in Vietnam typically lasts 5–6 months to reach a standard harvest size of 500–800g, though cycles may extend to 10–12 months for larger fish (over 1kg) intended for fillet processing[6].

In the north (Red River Delta), production is characterised by a mix of semi-intensive earthen ponds and cage culture in reservoirs. Farming in this region often involves the polyculture of black tilapia with Chinese carps (grass carp, common carp) to utilise different trophic levels within the pond ecosystem[6].

In contrast, in the south (Mekong River Delta), the industry is more heavily industrialised, with large-scale intensive monoculture ponds and high-density river cages dominating the landscape[4]. This is the epicentre of red tilapia cage culture[7]. Salinity intrusion, a consequence of climate change and upstream damming, is forcing a shift from freshwater species to more salinity-tolerant strains[8].

Harvest, Transportation and Sale

Harvest

Harvesting methods differ by production system but share significant welfare bottlenecks. In pond-based systems, which dominate the export supply chain, harvesting is primarily conducted using large seine nets similar to those used for pangasius. In cage culture systems, the net is lifted to crowd fish into a smaller volume for capture.

[5]VFM. "GenoMar Genetics Vietnam Honored as One of Asia's Top Trusted Brands 2025." Vietnam Fisheries Magazine, 2025. https://vietfishmagazine.com/news.
[6]Aquaculture Asia Pacific. "The Tilapia in North Vietnam," 2025. https://aquaasiapac.com/.
[7]Tri, N N, N P C Tu, D T Nhan, and N V Tu. "An Overview of Aquaculture Development in Vietnam." *Proceedings of International Conference on Fisheries and Aquaculture* 7, no. 1 (2022). https://doi.org/10.17501/23861282.2021.7105.
[8]Halls, Ashley S. "Addressing Fisheries in the Climate Change and Adaptation Initiative." *Catch and Culture* 15, no. 1 (2009).

Transportation

There are two main transportation systems for market-size tilapia, reflecting the industry's dual-market structure. In the north, tilapia farmed for domestic consumption are transported live via road (trucks)[9]. These trucks, equipped with tanks to keep the fish alive, service inland urban markets like Hanoi. The south supplies both the domestic and international markets, and all the farmed tilapia utilise the existing water-based logistical infrastructure. Fish are moved from ponds to processing plants via well-boats.

Tilapia is one of the more popular domestic consumer aquaculture species. Therefore, tilapia is also sold in wet markets[9,10]. Transportation to these wet markets is somewhat similar to the systems outlined above, in both the north and the south.

Sales at wet markets

Once tilapia reaches retail wet markets, stock is maintained in shallow containers oxygenated by electric aerators or chemical tablets, often utilising a "reserve tank" system to manage display density, however, inventory remaining unsold after approximately two days is typically slaughtered and discounted by up to 30% as fresh-dead product.

Figure 21. Left: red tilapia in a shallow metal pan for sale with supplied oxygen. Right: oxygen tablets in a bucket with red tilapia. Ⓒ Nghia.

The standard slaughter method at these outlets is manual percussion (being hit on the head with a stick), a practice primarily intended to immobilise the fish for safe handling during processing rather than to ensure humane death. Consequently, the effectiveness of this technique varies significantly based on operator skill and the force applied, often failing to induce immediate unconsciousness and resulting in the fish being definned and descaled for the customer while still conscious.

[9]Huong, Nguyen Van. “Economic Analysis of Small Scale Freshwater Aquaculture Production and Its Product Marketing Channels in Agro-Aquaculture System in Hai Duong Province, Vietnam.” *University of Liège*. Doctoral Dissertation, 2020. https://orbi.uliege.be/handle/2268/247570.
[10]Tung, Nguyen Thanh, Nguyen Van Thanh, and Michael Phillips. “Policy Research – Implications of Liberalisation of Fish Trade for Developing Countries: A Case Study of Vietnam.” *University of Greenwich*, 2004. http://www.onefish.org/id/225570.

Welfare concerns during the tilapia life cycle

It should be mentioned that this list is neither comprehensive nor detailed given our limited research and observations; its purpose is to provide an overview of the main welfare concerns:

Common concerns during grow-out - Most tilapia production is for the domestic market only, meaning that common welfare concerns are the same as for other freshwater species that are not certified to international standards (i.e., high stocking densities, overuse of antibiotics, limited water quality, and limited health management).

Stress and physical damage during harvest - Crowding fish into smaller volumes of water induces panic and escape behaviours, leading to scale loss and bruising.

Inhumane transport, holding and slaughter at wet markets - Tilapia are transported and then held in high concentrations in small, shallow basins before eventual filleting and descaling. Manual percussion only immobilises the fish, it doesn't fully stun it into unconsciousness.

Domestically-sold fish species

Vietnam farms several finfish species in addition to pangasius and tilapia, each with a distinct operational, husbandry, and compliance profile that partly reflects domestic rather than export production. Below are key details on the most commonly farmed domestic species and differences in their husbandry compared to pangasius farmed for export, with welfare implications highlighted.

As expected, without export-specific regulations and certifications, fish farmed for domestic consumption can experience greater welfare issues, however, the domestic focus currently leaves making welfare improvements more challenging.

Cyprinids

Location, Species & Production

Primary Farming Regions: North Vietnam

Main Species: Common carp (*Cyprinus carpio*), black carp (*Mylopharyngodon piceus*), grass carp (*Ctenopharyngodon idella*).

Production in 2022: 666,771 thousand tonnes, 890 million fish count (estimated)[11].

Consumption: Culturally significant in northern Vietnam – essential for the Lunar New Year and daily consumption.

Figure 22. From left to right. Common carp © intek1 via Getty Images, black carp © Tepbac, grass carp © wrangel via Getty Images

Farming Practices

Infrastructure: Predominantly earthen ponds. Ranges from subsistence VAC farming (fertilised by livestock manure) to semi-intensive commercial ponds[12].

Feed: Varies by species

Welfare concerns

Manure Loading (Carps): In traditional VAC systems, ponds are fertilised directly with livestock manure to stimulate algae growth. While resource-efficient, this creates fluctuating water quality parameters and exposes fish to uncomposted faecal pathogens.

[11] Mood, A, and P Brooke. "Estimated Farmed Finfish Numbers." Fish Count Organization, 2024. https://fishcount.org.uk/estimates/farmedfishes/.

[12] Luu, Le Thanh. "The VAC System in Northern Viet Nam." In *Integrated Agriculture-Aquaculture: A Primer, FAO Fisheries Technical Paper*. No. 407. Rome: FAO, 2001.

Snakehead

Location, Species & Production[13]

Primary Farming Regions: Dong Nai province, east of Ho Chi Minh City, and the Mekong Delta (Vietnam).

Main Species: *Channa maculata* and *C. striata.*

Consumption: majorly domestic, some exported to Cambodia.

Figure 23. Snakehead fish © Nghia.

Farming Practices

Infrastructure: Typically conducted in earthen ponds or hapa net[13].

Feed Transition: Shifting from "trash fish" (pollutant-heavy) to pelleted feed for sustainability[13].

Water Management: Minimal monitoring of water quality (specifically Dissolved Oxygen) because the fish are hardy and possess a breathing organ[14].

Welfare concerns

Antibiotic Misuse: Widespread use of prohibited substances to manage disease.

Banned Substances: Documentation shows use of Chloramphenicol (CAP) and restricted Amoxicillin (AMX)[15].

Root Causes: Lack of training and absence of effective legal alternatives.

[13] Sinh, Le Xuan, Hap Navy, and Robert S. Pomeroy. "Value Chain of Snakehead Fish in the Lower Mekong Basin of Cambodia and Vietnam." *Aquaculture Economics & Management* 18, no. 1 (January 2, 2014): 76–96. https://doi.org/10.1080/13657305.2014.855956.

[14] Hughes, G M, and D Munshi. "Scanning Electron Microscopy of the Accessory Respiratory Organs of the Snake-Headed Fish *Channa striata* (Bloch) (Channidae, Channiformes)." *Journal of Zoology* 209, no. 3 (July 1, 1986): 305–17. https://doi.org/10.1111/j.1469-7998.1986.tb03593.x.

[15] Ngo, Thao V, Phu Q Nguyen, Lam D Ngo, and Ngoc V Ngo. "Investigation on the Use of Chloramphenicol and Amoxicillin in Snakehead Fish (*Channa maculata*) Farming and Analysis of Those Antibiotic Residue in Muscle Samples." *The Journal of Agriculture and Development* 17, no. 4 (August 28, 2018): 118–25. https://doi.org/10.52997/jad.15.04.2018.

Barramundi (Asian Sea Bass)

Location, Species & Production

Primary Regions: Throughout Vietnam with specific concentrations in the Red River Delta (North), Mekong River Delta (South), and the Central region[16].

Main Species: Barramundi (*Lates calcarifer*), a euryhaline fish (can live in both fresh and saltwater).

Consumption: Domestic and Export (Australis is a dominant industrial player in the Central region, utilising high-tech farming techniques to produce high-quality products for the US market)[16,17].

Figure 24. Barramundi Ⓒ Dragos Nistor's Images via Canva.

Farming Practices

Infrastructure: Versatile systems, including earthen ponds and cages (river and sea-based)[16].

Industrial Model: Pioneer use of large Norwegian-style HDPE cages and "Clean Harvest" technology in offshore farms (e.g., Van Phong Bay)[17].

Seed Supply: 100% reliant on artificial hatchery production, ensuring a stable supply without wild capture[1].

Feed: Small-scale Northern farms often use trash fish[1], while industrial, high-tech farms like Australis predominantly use plant-based diets to achieve a low Fish-in-Fish-out ratio (<1:1)[17].

Welfare concerns

Biosecurity Issues: Traditional use of trash fish feed in the north increases the risk of cross-contamination and disease outbreaks.

[16]Dung, Tran Van, Pham Quoc Hung, and Nguyen Tien Thong. "Marine Finfish Farming in Viet Nam: Current Status and Directions." *Journal of Fisheries Science and Technology* 3, no. 1 (2016): 104–10.

[17]Dinh Hung, and Kim So. "Aiming for Sustainable Marine Farming: Applying Advanced Technology." Nong Nghiep & Moi Truong, December 12, 2024. https://van.nongnghiepmoitruong.vn/.

Pangasius (Domestically consumed)

Location, Species & Production

Primary Regions: Mekong Delta

Main Species: *Pangasius conchophilus* (Cá Hú)

Consumption: Domestic. Unlike the export-focused Cá Tra (P. hypophthalmus), Cá Hú is targeted at the domestic premium market (hotpots/sour soups) and fetches a higher price locally.

Figure 25. Pangasius conchophilus © AEyZRiO via Getty Images.

Farming Practices

Infrastructure: Primarily farmed in floating cages on rivers or earthen ponds (on a smaller scale than exported pangasius)

Feed: increasingly relies on commercial floating pellets, though some small-scale farmers may supplement with trash fish or farm-made feeds.

Welfare concerns

Similar to exported pangasius: Without international export certifications, the concerns are expected to be more extreme.

Torpedo-shaped catfishes (*Clarias* spp.)

Location, Species & Production

Primary Regions: Nationwide, but concentrated in the Mekong Delta and peri-urban areas near Ho Chi Minh City and Hanoi

Main Species: African catfish (*C. gariepinus*), broadhead catfish (*C. macrocephalus*), hybrid catfish (*C. gariepinus x C. macrocephalus*).

Production in 2022: 36,462 thousand tons, 170 million fish count (estimated)[11].

Consumption: Domestic and Export (some fish cultured in the Mekong River Delta are exported to Cambodia).

Figure 26. Catfish © tepbac.com

Farming Practices[18]

Infrastructure: Mostly farmed in small earthen ponds or converted rice fields. Due to their air-breathing ability, they are often farmed in stagnant water systems with limited exchange.

Feed: Highly opportunistic feeders. While commercial pellets are used, farmers frequently use low-cost alternatives to maximise margins, including poultry slaughterhouse waste, restaurant scraps, and trash fish.

Scale & Model: Intensive monoculture at small-to-medium household scales. They are extremely hardy, allowing for very high stocking densities compared to other species.

Welfare concerns

Extreme Stocking Densities: African Catfish are often stocked at densities exceeding 100 fish/m², leading to intense aggression, skin lesions, and cannibalism. The lack of density limits exacerbates physical injury.

By-product feed: While resource-efficient and cheap, it can cause fluctuating water quality parameters and cross-contaminate the fish with pathogens from other species (one pangasius farmer reported that they sell the dead fish to these catfish farms).

Water Quality Neglect: African Catfish are tolerant of low dissolved oxygen and high ammonia. Consequently, farmers often maintain them in highly eutrophic, "soup-like" green water with minimal exchange or monitoring.

[18]Tram, Nguyen Duy Quynh. "Tram, Nguyen Duy Quynh. "Evaluation of Local Feed Resources for Hybrid Catfish (*Clarias macrocephalus X C. gariepinus*) in Smallholder Fish Farming Systems in Central Vietnam." *Swedish University of Agriculture*. Doctoral Thesis, 2010.

Spiny eel fish

Location, Species & Production

Primary Regions: Mekong Delta (specifically An Giang, Hau Giang, and Dong Thap provinces).

Main Species: *Mastacembelus armatus*

Consumption: Domestic. High-value speciality fish for domestic seafood restaurants and premium household consumption. Prized for firm, sweet flesh and lack of intermuscular bones.

Figure 27. Spiny eel © Mpi via Canva.

Farming Practices[19]

Infrastructure: Intensive "mud-free" farming in cement or canvas-lined tanks. These systems rely on artificial substrates (PVC pipes, plastic mesh, or brick piles) to provide hiding spots.

Feed: Weaned onto high-protein (>40%) sinking commercial pellets, often supplemented with trash fish to stimulate appetite.

Welfare concerns

Substrate Deprivation (Behavioural Restriction): Spiny eels are nocturnal burrowers that instinctively bury themselves in soft sediment to hide. In modern "mud-free" concrete tank systems, they are often unable to perform this natural behavior. If insufficient artificial shelter (PVC pipes) is provided, the fish suffer chronic stress and increased aggression.

Aggression & Cannibalism: They are territorial and exhibit significant size disparity during growth. Without frequent, stressful grading (sorting by size), larger eels will attack or cannibalise smaller ones.

[19] Banmali, Puja, Bui Minh Tam, and Pham Thanh Liem. "Effect of Different Stocking Densities on Growth Performance and Survival of Tire Track Eel (*Mastacembelus favus*) in Recirculating Aquaculture System (RAS)." *International Journal of Science and Research* 10, no. 9 (2021): 1135–41. https://doi.org/10.21275/sr21920100501.

Next steps

The information included in this report will form the basis of our future work in Vietnam. Over the course of 2026, further ground visits, expert interviews and desk research will be conducted to help us:

Prioritise Interventions – Analyse the welfare concerns identified to determine which issues affect the most animals, cause the most severe suffering, and offer the greatest potential for improving fish welfare and health.

Align Welfare Improvements with Industry Interests – Design targeted programs tailored to the local context to ensure welfare improvements are practically viable and supported by key industry stakeholders.

Build Strategic Partnerships – Continue communications with academic institutions, research agencies and other organisations to implement welfare improvements at scale.

Expand Research Coverage – Address the limitations identified in our initial scoping by engaging with additional stakeholders not covered in our research to date.

To keep updated on our work following up on the above, please feel free to sign up to our newsletter (https://www.scalewelfare.org/#newsletter) or contact us directly to learn more: info@scalewelfare.org

SCALE WELFARE

Acknowledgements

We extend our sincere gratitude to the following stakeholders for their valuable assistance and cooperation during our scoping visit and research:

- Research Institution of Aquaculture 1 (RIA1)
- Research Institution of Aquaculture 2 (RIA2)
- Innovation Norway cum Commercial section of the Norwegian Embassy in Hanoi, Vietnam
- Embassy of the Netherlands in Hanoi, Vietnam
- VASEP
- Can Tho University
- Ton Duc Thang University
- Tra Vinh University
- Dong Thap Community College
- Vietnam University of Agriculture
- Hung Vuong University
- Nha Trang University
- Pharmaq
- Fresh Studio

We also thank the supply chain stakeholders who generously shared their time and insights with us. Their knowledge and openness were essential to this research.

Any errors or omissions in this remain completely our responsibility.

Appendices

Appendix A

More detailed information about key government stakeholders:

Ministry of Agriculture and Environment (MAE): Sets overarching national policy, strategy, and production targets.

Department of Fisheries and Fishery Surveillance: Advises and assists the MAE in implementing state management of fisheries and fisheries surveillance, and organises law enforcement.

Department of Livestock Production and Animal Health: Advises and assists the MAE management and the organisation of law enforcement regarding livestock production and animal health (veterinary medicine).

National Authority for Argo-Foresty-Fishery Quality, Processing and Market Development (NAFIQPM): Advises and assists on law enforcement in the fields of quality, food safety, preservation, processing, and market development (including certifying plants for export).

National Agricultural Extension Centre: Disseminates technical knowledge and trains farmers. A retired staff member we met informed us that no welfare-specific training content is included, and they target small-scale farmers. They support these farmers to get certification (VietGAP and GLOBALG.A.P.), and the main training needs are in water quality management, fish health and feed management.

Institute of Strategy and Policy on Agriculture and Environment (ISPAE): Researches, advises on, and formulates strategies and policies for the sustainable development of the agriculture and environment sector.

Research Institute for Aquaculture (RIA 1, 2, 3): These government institutes provide specialised research, technology transfer, training, international cooperation, consultation, and services to support national and provincial development plans, focusing on the north (RIA1), south (RIA2), and central (RIA3) regions.

Appendix B

List of questions for farmers and farm managers:

1. Farm Basics & Infrastructure

- What type of facility do you run? (earthen pond, cage, tank, RAS, etc.)
- Pond/cage/tank setup:
  - Number of production units (ponds/cages/tanks): ______
  - Average surface area per unit
  - Average depth: ________________
  - Bottom type: liner or natural soil
  - Note: We will double-check rough dimensions later on Google Earth—please provide your best estimate now.
- Species reared:
  - Which species do you grow?
  - Are they a particular strain/breed? If yes, which one and why was it chosen?
- Experience:
  - How long have you been rearing this species/in aquaculture?
- Farm management:
  - Do you visit the ponds/cages/tanks every day? If not, how often?

2. Stocking & Seed

- Which hatchery/seed supplier do you buy from?
- What size of seed/fish do you stock? (fish/kg or average grams per piece)
- How many kilograms (or total pieces) did you stock this cycle?
- Current stock status:
  - Current average size (fish/kg or grams): _________
  - How many months since the last stocking? _________
- Target harvest:
  - Harvest size (fish/kg or grams): _________
  - Typical culture period from stocking to harvest: _________ months

3. Feeding & Husbandry

- What feed do you use? (brand, on-farm mix, by-products)
- Daily ration and frequency:
- How much per day (kg or % body weight)? _________
- How many times per day do you feed? _________
- Do you use any equipment to help with distributing feed? (brand)

4. Water Quality Monitoring

- Do you monitor water quality? If yes:
    - How do you take readings? (test kits, lab, handheld meters/probes, visual cues)
    - What equipment do you use (brand/model if known)?
    - How often do you take readings?
        - If irregular; what instigates your readings?
    - Do you keep a logbook or digital records of readings?
- Which parameters do you track most? (e.g., DO, pH, temperature, ammonia, salinity, etc.)
- Which parameters cause the most problems?
    - Do you take any corrective actions based on WQ readings?
- Does anyone else in the chain test your water or fish? (e.g., feed reps, vets, technicians)

5. Fish Health & Welfare

- Treatments:
    - Do you use antibiotics or other medications? If yes, when and why?
    - From whom do you get advice or medications when needed? Is it easy to reach them?
- Signs and issues:
    - What clinical signs do you observe that prompt you to call for assistance?
    - What diseases, parasites, or pests do you see most often?
    - How often do outbreaks happen? _________ per cycle/year
    - Has your farm had a disease outbreak? If yes, when and how was it resolved?
- Vaccination:
    - Do you use any vaccines? If yes, which diseases, delivery method(s), and when did you first apply them? Why did you choose vaccination?
    - Have you noticed differences after vaccination? (mortality rate, outbreaks, harvest yield)
    - Will you continue using vaccines in the future?
- Performance tracking:
    - What is the typical mortality rate per cycle? _________ %
    - How do you track fish health?
    - What does “fish welfare” mean to you?

6. Harvest & On-farm Handling

- What is your average harvest per crop? (total tonnes and/or tonnes per pond)
- Who conducts harvest? (farm staff or trader’s team)
- Walk me through a typical harvest day. How are fish collected and handled?
- Crowding and transfer:
    - What method is used to crowd the fish?
    - How are fish transferred to land?
    - Equipment used (e.g., fish pumps, graders, stunners): _________
    - If none, have you considered equipment? What would persuade you to try it?

6. Harvest & On-farm Handling (cont.)

- Timing and crew:
  - How long does harvest usually take (start to finish)?
  - How many people are involved per harvest?
- What are the pre-harvest preparations? grading, fasting, lowering water, etc.
- During/after removal from water:
  - Approximately how long after leaving the water do fish stop moving? (estimate)

7. Post-harvest, Transport & Sales

- Buyers and markets:
  - Who buys your fish? (trader, wholesaler, processor, direct retail)
  - If a trader: are you loyal to one trader or open to any? Do you have an offtake agreement?
  - Are fish sold in Vietnam or exported? If exported, to where?
- Pricing:
  - Is the price fixed or does it change throughout the year?
  - Who sets the price? If not you, do you know why the price changed?
- Product form and packaging:
  - In what form do you sell the fish? (live, whole on ice, gutted, filleted, etc.)
  - Any special packaging?
- Traceability and chain knowledge:
  - Do buyers or end-consumers know the origin of the fish?
  - Do you know what happens to the fish between your gate and the final customer? (briefly describe processing/handling steps)
- Transport logistics:
  - How are fish transported to and from your farm? (vehicles, tanks, ice, aeration, oxygen, etc.)
  - After leaving your facility, what proportion of fish remain alive until the processing facility/final customer? ________ %

8. Organisation, Support & Certification

- Cooperative/association:
  - Are you part of a cooperative? If yes, what are the pros and cons?
  - If not, are there cooperatives in this farming zone? If yes, why not join? If not, why do you think there aren't any?
  - Do you share information or collaborate with other local farmers? (formal groups, messaging apps, co-op)
- External support:
  - Have you interacted with organizations that aimed to help your operations? (NGOs, private, academic, government)
  - Do you receive any government support or subsidies? If yes, what form?

8. Organisation, Support & Certification (cont.)

- Certification:
  - Do you know about export certifications? Which certifications does your farm currently have, and since when?
  - Does certification help with market access or price?
  - Is it hard to maintain the required practices?
  - Does your cooperative help with certification for export?

9. Challenges & Goals

- What is the biggest challenge you face right now?
- What are you doing to address it?

Appendix C

List of questions for processors:

Part 1: Sourcing & Company Structure

Goal: To understand the chain of custody and how much control they have over the fish before they arrive at the factory.

1. How would you describe your company's sourcing model?

◻ 100% Vertical (Own farms only) ◻ 100% Outsource (Buy from external farmers)

◻ Mixed (Own farms + Outsource)

2. If you have a mixed model, can you estimate the percentage of self-produced fish?

3. For outsourced fish, do you use contract farming (signed agreements) or buy from the open market?

◻ Contract Farming ◻ Through middle man

◻ Both ◻ Others:

4. Where do you sell your panga products internationally?

◻ Europe ◻ USA

◻ China ◻ Others: ____________________

5. Do you notice any differences in raw fish quality when sourcing from different farms (e.g., due to water quality or farming practices)?

◻ Yes, significant differences

◻ No, quality is consistent

Part 2: Certifications

Goal: To gauge their current compliance level. Certifications like ASC/BAP often have specific welfare clauses.

6. Which certifications does your facility currently hold?

◻ ASC ◻ BAP

◻ GlobalGAP ◻ VietGAP, ATTP

◻ HALAL and Others

7. How long have you maintained these certifications?

Part 3: Slaughter & Stunning Methods

Goal: This is the core welfare section. We need to distinguish between "immobilisation" (ice) and actual "stunning" (loss of consciousness).

8. Do you currently use any method to STUN the fish (render unconscious) before slaughtering (cutting)?
□ Yes □ No

9. If YES, what represents your primary stunning method?
□ Electrical Stunning □ Percussion
□ Ice Slurry / Thermal Shock (Live chilling) □ Carbon Dioxide (CO2)

10. If you use electrical stunning, is it a dry system (conveyor belt) or in-water stunning?
□ Dry Stunning (Conveyor) □ In-water Stunning

11. If NO (you do not use electrical stunning), are you considering purchasing a machine in the near future?
□ Yes, actively looking □ Maybe, considering it □ No, not a priority right now

12. If you decide to buy an electrical stunner, would you prefer a local Vietnamese solution or an international brand? Why?
□ Local (Vietnam) □ International Reason: ______________________________

Part 4: Additional Welfare Indicators

Goal: Welfare is not just about the kill; it is about the stress before the kill. These questions show deep industry knowledge.

13. What is the average transport time from the farm to the processing plant? (Long transport = high stress)

14. Do you measure the mortality rate (DOA - Dead on Arrival) during transport?

15. Is water quality (Oxygen/Temperature) monitored during transport from farm to factory?
□ Yes, strictly monitored □ Sometimes □ No

16. Do you know if any of your fish are vaccinated? If yes, can you estimate the percentage?
□ Yes - Approx %: _______ □ No □ Do not know

17. What is your policy on antibiotic use? How do you monitor this?

18. What do you see as the biggest barrier to improving fish welfare technology (like stunning machines)?
□ High Investment Cost □ Operation Complexity
□ Affects Fillet Quality □ Lack of Buyer Demand

Part 4: Additional Welfare Indicators (cont.)

19. How are fish transferred from the transport truck/boat into the factory?

□ Manual Nets □ Vacuum Pump □ Gravity/Chutes

20. Have any of your international buyers explicitly asked about animal welfare or stunning methods recently?

□ Yes, mostly from Europe/USA □ Yes, mostly from Asia □ No

21. If European retailers (or other buyers) demand new standards (e.g., lower mortality rates), do they provide any support, advice, or connections to advisors to help you implement them?

□ Yes, they provide active support □ No, they only set the demands

Part 5: Information & Advocacy

Goal: This section addresses your request to understand where they get their information and who they trust, which is crucial for future advocacy.

22. When looking for new industry information or technical advancements, which sources do you trust the most?

□ Local Government □ Local Universities

□ International Universities/Experts/ NGOs □ Industry Peers

23. Where do you usually find this information?

□ Social Media □ Printed Newspapers/Magazines □ Radio/TV □ Industry Conferences/Workshops