Stunning Part 1 Final Report

Authors: *Abhishek Pandey, Subrata Deb, Manikanta Munganda*

Executive Summary

This report examines the feasibility of introducing and scaling pre-slaughter fish stunning in India. It is based on a detailed literature review, interviews with 24 key informants, field surveys with 70 fish farmers, and regional visits to three different aquaculture regions. Currently, fishes in India are mostly slaughtered using methods such as asphyxiation or ice slurry, which do not ensure that the fishes are unconscious right away, causing unnecessary stress and leading to poorer quality. Furthermore, awareness of stunning practices is extremely limited across the supply chain, and there are no legal mandates or incentives from regulatory bodies like the Food Safety and Standards Authority of India (FSSAI). Economic constraints, logistical challenges, lack of market demand, and cultural factors further inhibit adoption.

This report recommends prioritizing exporters as the key stakeholder group for initiating stunning practices, since they cater to and have access to international markets where welfare standards are more valued. By creating demand for humane practices, exporters can influence the adoption of stunning techniques throughout the supply chain, including among processors and farmers.

Among the fish species studied, seabass is considered a good candidate for stunning, due to its higher market price and export potential. However, the scale of farmed seabass production in India is currently limited, and export levels remain minimal, raising questions about its viability as a high-impact starting point. Much of the seabass sold at premium prices is wild-caught, and there are relatively few organized farming operations or exporters currently handling this species. While trout is also considered suitable for stunning, its adoption depends on the availability of exporters in Jammu & Kashmir. Tilapia, on the other hand, is excluded from the priority species due to its low market value and the growing consumer preference for live fishes in local markets.

Chemical stunning is recommended as the most practical method due to its low cost and ease of use. However, further studies are needed to confirm that international markets will accept chemically stunned fishes. Incentives such as premium pricing and government subsidies could significantly improve adoption rates. Barriers include high equipment costs, lack of awareness, religious considerations, and uncertainty around the regulatory future of stunning.

To scale the use of pre-slaughter stunning, the report emphasizes the importance of working with exporters to create a demand for stunned fishes. However, a key challenge is the limited number of exporters, which makes large-scale implementation difficult at this stage. Running pilot projects in feasible regions like Andhra Pradesh (for seabass) can demonstrate the benefits of pre-slaughter stunning and build trust within the industry. Certification schemes, along with targeted awareness and training programs, can help drive widespread adoption and understanding across the aquaculture sector.

Table of Contents

Introduction

Fish welfare in India, particularly in relation to humane slaughter methods, remains an underexplored issue. Traditional slaughter practices, such as asphyxiation and ice slurry, do not ensure immediate unconsciousness, leading to prolonged suffering and poor fish quality. As global awareness of animal welfare issues grows, there is increasing interest in improving the humane treatment of fishes, especially in the aquaculture industry.

This report investigates the feasibility of introducing and scaling pre-slaughter stunning techniques for fishes in India, focusing on species with high market value, such as seabass and trout. Fish stunning, a method aimed at rendering fishes unconscious before slaughter, is a more humane alternative to traditional slaughter methods. However, the adoption of stunning practices in India is hindered by several barriers, includinga lack of awareness, economic constraints, and logistical challenges.

This report aims to assess the viability of stunning technologies for improving fish welfare in India's aquaculture sector. The study draws on a comprehensive literature review, key informant interviews with stakeholders working in the fisheries domain, field surveys of farmers, and regional visits to key aquaculture hubs in Andhra Pradesh, Jammu & Kashmir, and Maharashtra. This report not only highlights the challenges to the widespread adoption of stunning in India but also provides practical recommendations for overcoming these barriers, with a focus on engaging stakeholders such as exporters, processors, and farmers.

The report is structured around three main objectives:

1. Identifying key stakeholders most likely to adopt pre-slaughter stunning technology,
2. Understanding the incentives and barriers that could affect its adoption, and
3. Exploring strategies required to scale this technology across the aquaculture industry in India.

By examining these factors, the report aims to provide a comprehensive assessment of the potential for introducing humane fish stunning practices in India.

Objectives

The following are the objectives of this report, as listed in the original request for proposals:

1. **Target Population:** Which stakeholder groups within India's aquaculture sector are most likely to adopt pre-slaughter stunning technology?
2. **Incentives and Barriers:** What economic, logistical, cultural, or market-driven factors could incentivize or hinder the adoption of stunning technology?
3. **Pathway to Scalability:** What strategies or adjustments will be required to scale stunning technology across the aquaculture industry?

These objectives are explored in-depth through a combination of literature review, key informant interviews with stakeholders, field surveys of farmers, and regional visits to key aquaculture hubs in India. The findings from these methods will provide insights into the current landscape of fish welfare and the adoption potential for stunning technologies.

Methodology

This study used a mixed-methods approach to assess the feasibility of introducing pre-slaughter stunning technology in India's aquaculture sector. The research combined a structured literature review, key informant interviews (KIIs), field surveys, and regional visits to gather comprehensive data on current practices, stakeholder perspectives, and potential barriers to adoption.

1. Literature Review

A structured review of 35 peer-reviewed papers, industry reports, and publications was conducted to provide an overview of existing knowledge on fish stunning techniques and their application in the aquaculture industry. The selection of papers was based on a systematic search of research paper libraries using keywords such as "*fish stunning*," "*pre-slaughter stunning*," "*fish stunning in India*," "*humane slaughter techniques*," "*aquaculture welfare*," "*electrical stunning*," "*global fish stunning*," "*fish stunning in Western countries*," and "*fish welfare standards*." These keywords were chosen based on the need to capture both global practices and specific insights into Indian aquaculture. Additionally, several key papers were referred to us through stakeholder interviews, which contributed valuable insights to the literature review.

The literature review focused on advancements in stunning technology, its effectiveness across different species, industry adoption rates, and welfare considerations. It also

explored the regulatory and policy landscapes worldwide, with particular emphasis on practices in countries with established fish welfare regulations.

2. Key Informant Interviews (KIIs)

In-depth interviews were conducted with 24 stakeholders working with fishes across India and globally. Stakeholders were identified using the existing network of the Fish Welfare Initiative (FWI) team, followed by a snowball sampling method where one stakeholder referred us to others in the industry. This approach ensured that the group of stakeholders included a diverse range of perspectives from fish farmers, processors, exporters, animal welfare organizations, civil society organizations, and government agencies. The selection process was designed to capture a comprehensive view of the aquaculture market, fish handling and slaughter practices, and the perceived benefits and challenges of stunning.

The decision to conduct interviews with 24 stakeholders was based on the principle of data saturation and time constraints, ensuring that key themes and insights emerged across various sectors. These interviews provided valuable qualitative insights into stakeholders' readiness to adopt new technologies, as well as identifying barriers such as lack of awareness, economic constraints, and cultural considerations that could hinder the widespread adoption of stunning technologies in India.

3. Selection of Species

The selection of trout, seabass, and tilapia as the focus species for this study was based on their significance within India's aquaculture sector, along with their varying market potential and the feasibility of adopting pre-slaughter stunning technologies. The key farming regions for these species were identified in consultation with industry experts and government agencies, including Central Institute of Freshwater Aquaculture (CIFA) and Rajiv Gandhi Centre for Aquaculture (RGCA).[1,2] Jammu & Kashmir was selected for trout, Maharashtra for tilapia, and Andhra Pradesh for seabass. The regional visits and field surveys were conducted in alignment with the chosen species. A detailed rationale for the species selection criteria is provided in the Key Findings section.

4. Regional Visits

Regional visits were conducted in three states—Andhra Pradesh, Jammu & Kashmir, and Maharashtra—to gain firsthand insights into the local fish farming practices for the species under study (seabass, trout, and tilapia). Each regional visit lasted 3 to 4 days and involved visits to at least 1 to 2 stakeholders along the supply chains of these species, including farms, processing plants, exporters, and fish farmers. Whenever possible, local fish

[1] CIFA. (n.d.). *Central Institute of Freshwater Aquaculture*. Retrieved April 23, 2025, from https://cifa.nic.in/
[2] RGCA. (n.d.). Rajiv Gandhi Centre for Aquaculture. Retrieved April 23, 2025, from https://www.rgca.co.in/

markets were also visited to gain a deeper understanding of market dynamics and consumer preferences related to each species.

To facilitate these visits, local stakeholders were identified in each region to help organize and guide the research team's activities. For seabass in Andhra Pradesh, FWI's network was leveraged for coordination. In Jammu & Kashmir, the visit was carried out in collaboration with SKUAST-Kashmir University to focus on the trout farming industry.[3] For tilapia in Maharashtra, the team connected with an industry player operating in the region to ensure access to relevant stakeholders.

The main objective of the regional visits was to understand the complete supply chain for each species, including insights into pre-slaughter stunning practices, handling, and transportation methods. The visits also provided an opportunity to observe the challenges faced by stakeholders and to assess the feasibility of implementing stunning technologies across different farming systems, such as recirculating aquaculture systems (RAS) and traditional pond-based farming. These visits were concentrated in regions where the respective species are farmed, ensuring that the research team visited areas with the most relevant stakeholders available.

5. Field Surveys

A field survey was conducted with 70 fish farmers across two major aquaculture regions: Andhra Pradesh and Jammu & Kashmir. The survey aimed to assess farmers' awareness and practices regarding fish stunning, and their familiarity with different stunning methods (chemical, electrical, percussive, etc.). It also explored factors influencing adoption, such as cost, perceived benefits, and market demand.

The field survey was a quantitative study that focused primarily on farmers' practices. The survey was face-to-face and structured with predefined questions. Local individuals were identified and hired to conduct the surveys, with the FWI team overseeing the data collection process to ensure consistency, accuracy, and proper cleaning of the data. The surveys were administered using Google Forms on mobile devices for efficient data capture.

We successfully conducted 20 surveys with seabass farmers and 50 surveys with trout farmers. However, due to time constraints and challenges in identifying suitable local surveyors in Maharashtra, we were unable to initiate the survey for tilapia species. Initially, we aimed to conduct 50 surveys per species, but due to time constraints and logistical challenges, we could only survey 20 seabass farmers.

Not being able to survey tilapia farmers does limit our findings, particularly in understanding how pre-slaughter stunning could be adopted for this species. Since we

[3] SKUAST-Kashmir. (n.d.). Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. Retrieved April 23, 2025, from https://skuastkashmir.ac.in/

couldn't complete these surveys, our insights into tilapia farming practices rely more heavily on qualitative inputs gathered during regional visits and key informant interviews.

The survey results will be presented with clear visual representations, including graphs and tables to highlight key trends and differences in practices across species and regions. These visual aids will enhance clarity and ensure the data is accessible to readers.

6. Distinction Between Regional Visits and Field Surveys

The field surveys differed from the regional visits in that they were primarily focused on obtaining quantitative insights from farmers only regarding their practices and awareness. In contrast, the regional visits were broader in scope, involving a diverse set of stakeholders across the entire fish supply chain, including farmers, processors, exporters, wet markets, and others. The regional visits aimed to provide qualitative insights into the broader challenges and feasibility of implementing stunning technologies across different farming systems.

7. Data Analysis

Insights from qualitative data (KIIs, regional visits) were used to complement and interpret the quantitative data (field surveys), providing a more comprehensive understanding of the challenges and opportunities for stunning technology adoption. Qualitative data from interviews were analyzed thematically, while quantitative survey data were analyzed to identify trends and patterns in the adoption of stunning practices across species and regions.

Key Findings

Criteria for Selection of Fish Species

The selection of seabass, trout, and tilapia for this study was based on a combination of insights from stakeholder interviews, data obtained from the Marine Products Export Development Authority (MPEDA) through a Right to Information request (RTI), and external market data such as the EU import portal. Our species selection was guided by the following key considerations:

1. **Export Market Potential and High-Value Species:** While there is no comprehensive or publicly available data on fish exports (especially for species like seabass and trout), information from the MPEDA RTI response and EU data portals suggests that seabass, trout, and tilapia species have export potential to premium international markets like the US and EU. Seabass and trout are considered high-value species, which are exported in limited quantities to these premium markets from India, as shown in the EU data (Figure 1). In contrast, tilapia is widely farmed in India and is the species with the highest export volume from India, as shown in the MPEDA data (Figure 2).

2. **Stakeholder Interviews:** During stakeholder interviews, it became evident that seabass, trout, and tilapia have the potential for export to premium markets such as the US, EU, and other western countries. These markets have higher purchasing power, making them more likely to absorb the additional costs associated with pre-slaughter stunning. As a result, these species were identified as the primary focus for potential stunning technology adoption.

3. **Global Stakeholder Validation:** The rationale for focusing on seabass and trout was further validated by global stakeholders who have worked on pre-slaughter stunning in premium markets like the US and EU. These stakeholders confirmed that high-value fish species are more likely to absorb the costs associated with adopting stunning practices, making them suitable species for the introduction of humane slaughter methods.

Year › Month

Reporting country	Country	2021		2022		2023		2024	
		Value (EUR)	Volume (Kg)	Value (EUR)	Volume (Kg)	Value (EUR)	Volume (Kg)	Value (EUR)	Volume (Kg)
India	France							184.00	30.00
	Hong Kong							1 437.00	103.00
	Korea, ...							3 824.00	341.00
	Kuwait	123.00	20.00						
	Maldives	2 948.00	500.00	10 071.00	848.00			264.00	200.00
	Singapore							6 016.00	313.00
	Spain			11.00	4.00				
	Switzerland	4 186.00	780.00	420.00	85.00				
Total		10 054.00	1 813.00	10 973.00	1 006.00	734.00	178.00	17 995.00	2 090.00

Year › Month

Reporting country	Country	2021		2022		2023		2024	
		Value (EUR)	Volume (Kg)	Value (EUR)	Volume (Kg)	Value (EUR)	Volume (Kg)	Value (EUR)	Volume (Kg)
India	Jordan			86 467.00	7 043.00	53 964.00	4 088.00		
	Maldives					467.00	3.00		
	Mauritius	207.00	20.00	736.00	114.00				
	Nepal	2 538.00	2 000.00						
	Sierra ...							251.00	87.00
	United ...	10 307.00	2 650.00	292.00	29.00				
	United ...					116.00	9.00		
Total		13 052.00	4 670.00	87 495.00	7 186.00	54 547.00	4 100.00	251.00	87.00

Figure 1. Export data of seabass (top) and trout (bottom) from India to various countries from 2021 to 2024, based on EU Import Portal data

COUNTRY WISE EXPORT OF CULTURED FIN FISH

		2021-22	2022-23	2023-24
SL No	Country Name	Quantity Tons	Quantity Tons	Quantity Tons
1	CAMEROON	1149	4777	4241
2	BHUTAN	159	897	1096
3	TANZANIA	50	51	1313
4	U A E	1508	1575	993
5	SENAGAL/DAKAR (W. AFRICA)	155	52	769
6	MOZAMBIQUE	526	554	967
7	CONGO	0	105	548
8	KUWAIT	177	256	314
9	COTE D IVOIRE	0	0	237
10	QATAR/DOHA	274	244	188

TOP 10 ITEM WISE EXPORT OF CULTURED FIN FISH

		2021-22	2022-23	2023-24
SL No	Item Name	Quantity Tons	Quantity Tons	Quantity Tons
1	FR. (F.W.) FISH (ROHU)	887	4113	3965
2	FR (F.W) TILAPIA WHOLE	1716	1959	3374
3	FR. (F W) TILAPIA GUTTED H/ON	1349	2147	2673
4	CHILLED ROHU (F W)	467	752	603
5	CHILLED PANGESIUS FISH	69	408	457
6	FR (F.W)TILAPIA GUTTED H/L	472	310	250
7	FR TILAPIA FILLETS	0	65	46
8	CHILLED PANGASIUS FISH	6	109	64
9	CHILLED PEARL SPOT	57	57	23
10	IQF TILAPIA WHOLE ROUND	74	35	48

Figure 2. MPEDA data on India's cultured fin fish exports from 2021 to 2024, showing top destination countries (left) and most exported fish species (right), with tilapia having the highest export quantity

Literature Review

1. Technological Advancements in Fish Stunning

Technological advancements in fish stunning have significantly evolved, with the primary goal of minimizing stress and ensuring humane practices in the aquaculture industry. Several methods, including electrical stunning, CO_2 narcosis, and newer approaches like in-water stunning, have been studied and implemented to improve fish welfare.

- **Electrical stunning**, particularly at the optimal voltage and frequency, has emerged as one of the most effective techniques for inducing unconsciousness in fishes. This method, when applied correctly, ensures that the fishes do not experience pain during slaughter.[4,5] Lines et al. (2003) highlighted that electrical stunning is a humane slaughter method for trout, ensuring rapid unconsciousness without causing damage to the fishes' flesh. This study supports electrical stunning as a feasible and ethical alternative to traditional methods, particularly for species like trout, where precise stunning parameters ensure welfare while maintaining end-product quality.[6] Notably, electrical stunning can be customized to specific species, providing a tailored approach to welfare. However, challenges persist in achieving consistent results across different species due to variations in size, anatomical features, and sensitivity.[7,8] Despite these challenges, research by Alves et al. (2015) emphasizes the effectiveness of electrical stunning for various species, ensuring humane slaughter when applied with proper parameters.[9] Furthermore, Future for Fish (2023) reported that electrical stunning systems are increasingly adopted in countries like Turkey, showcasing their practicality and effectiveness in the industry.[10]

[4] Southgate, Peter, Tony Wall (2001). Welfare of Farmed Fish at Slaughter. In Practice.
[5] Van de Vis, I., et al. (2003). Is Humane Slaughter of Fish Possible for Industry?. Aquatic Living Resources.
[6] Lines, J.A., et al. (2003). Electric Stunning: A Humane Slaughter Method for trout. Aquacultural Engineering.
[7] Barkerud, Rickard (2021). Welfare Evaluation of Stunning Practices for Farmed Fish in the European Union. Master Thesis, Linnaeus University.
[8] Robb, D.H.F., S.C. Kestin (2002). Methods Used to Kill Fish: Field Observations and Literature Reviewed. Animal Welfare.
[9] Alves, Rachel Cristina Prehl, et al. (2015). Stunning Methods for Fish. Global Aquaculture Advocate.
[10] Future for Fish (2023). Electrical Stunning System: Türkiye Review. Report on Electrical Stunning System.

- **CO_2 narcosis** has yielded mixed results, with some studies noting that it induces prolonged stress and does not always result in immediate unconsciousness.[11,12] This method often leads to aversive behaviors, such as struggling and escape attempts, which can undermine animal welfare during the stunning process.[13] In contrast, in-water electrical stunning and other innovative methods have been explored to mitigate these issues and offer better outcomes for both fish welfare and operational efficiency.[14,15] For example, Acerete et al. (2009) found that electrical stunning in seabass significantly improved both fish welfare and the preservation of quality compared to CO_2 narcosis.[16] Pozhoth & Jeffs (2022) explored the use of isobutanol, a food-safe anesthetic, to reduce stress and mortality in tropical spiny lobsters during live transport.[17] Their findings suggest that isobutanol is effective in lowering stress markers like ammonia, providing a humane solution for lobster transport, which could be adapted for aquaculture operations dealing with stress-related challenges during handling and transport. This study brings attention to the broader field of humane transport practices and highlights the potential of anesthetics in ensuring welfare during transport, expanding the scope of humane practices beyond slaughter alone.

- **Clove oil**, as a humane alternative to cyanide and CO_2, has shown promise, particularly in the live reef fish industry.[18] The study by López-Cánovas et al. (2020) demonstrated that nanoencapsulated clove oil can be highly effective in reducing stress and enhancing the freshness and shelf life of fishes at slaughter, making it a valuable option for aquaculture.[19]

[11] Gräns, A., et al. (2015). Stunning Fish with CO2 or Electricity: Contradictory Results on Behavioural and Physiological Stress Responses. Animal.
[12] Zampacavallo, Giulia, et al. (2014). Evaluation of Different Methods of Stunning/Killing Sea Bass (Dicentrarchus labrax) by Tissue Stress/Quality Indicators. Journal of Food Science and Technology.
[13] Oliveira Filho, P.R.C., et al. (2014). How Stunning Methods Affect the Quality of Nile tilapia Meat. CyTA - Journal of Food.
[14] Aquatic Life Institute (2023). Marine Capture Fisheries: Best Practices for Aquatic Animal Welfare V2. Aquatic Life Institute Report.
[15] Aquatic Life Institute (2023). Stunning and Slaughter: Best Practices for Animal Welfare in Aquaculture. Aquatic Life Institute Report.
[16] Acerete, L., et al. (2009). Comparison of Two Stunning/Slaughtering Methods on Stress Response and Quality Indicators of European Sea Bass. Aquaculture.
[17] Pozhoth, Jayagopal, Andrew Jeffs (2022). Effectiveness of the Food-Safe Anaesthetic Isobutanol in the Live Transport of Tropical Spiny Lobster Species. Fishes.
[18] Erdmann, Mark V. (1999). Clove Oil: An Eco-Friendly Alternative to Cyanide Use in the Live Reef Fish Industry?. SPC Live Reef Fish Information Bulletin.
[19] López-Cánovas, Amanda Esperanza, et al. (2020). Nanoencapsulated Clove Oil Applied as an Anesthetic at Slaughtering Decreases Stress, Extends the Freshness, and Lengthens Shelf Life of Cultured Fish. Foods.

2. Effectiveness of Stunning Methods

Evaluating the effectiveness of stunning methods requires considering several factors: their ability to induce rapid unconsciousness, minimize recovery times, and maintain high product quality. Research consistently demonstrates that electrical stunning, when properly executed, is the most reliable method for achieving humane slaughter with minimal physiological stress. Notably, percussive stunning, which involves a blow to the head, has also shown promising results, as it ensures immediate insensibility without harming the quality.[20,21] The use of a combination of percussive and electrical stunning has been particularly beneficial in reducing injuries and ensuring rapid unconsciousness.[22]

- Percussive stunning has been particularly noted for its effectiveness in common carp slaughter, where it minimizes injuries and enhances welfare outcomes.[23] Studies have found that manual stunning and electrical stunning in combination provide the best results for ensuring welfare, especially in species with variations in size and anatomical features.[24] Mercogliano et al. (2024) also identified percussive stunning as the most humane method in their review of slaughter practices in Italy, underlining its widespread acceptance.[25]

- By contrast, CO_2 narcosis, while effective for some species, has been identified as less optimal, with reports indicating higher stress levels and negative effects on quality.[26] This is due to the slower onset of unconsciousness and the aversive reactions exhibited by fishes exposed to high CO_2 concentrations. Similarly, methods like hypothermia, which are commonly used in certain regions, have been shown to induce prolonged suffering and reduce the overall quality.[27] The effectiveness of these stunning methods can be quantified. According to Pozhoth & Jeffs (2022), the application of isobutanol resulted in a 35-55% reduction in stress markers such as ammonia levels in lobsters during live transport. This data

[20] Retter, Karina, et al. (2018). Stunning of Common Carp: Results From a Field and a Laboratory Study. BMC Veterinary Research.
[21] Retter, Karina, et al. (2018). Stunning of Common Carp: Results From a Field and a Laboratory Study. BMC Veterinary Research.
[22] Saraiva, João L., Filippo Faccenda, et al. (2024). Welfare of Rainbow trout at Slaughter: Integrating Behavioural, Physiological, Proteomic, and Quality Indicators and Testing a Novel Fast-Chill Stunning Method. Aquaculture.
[23] Daskalova, Aleksandra, et al. (2016). Humane Slaughter of Carp – A Comparison Between Three Stunning Procedures. Turkish Journal of Fisheries and Aquatic Sciences.
[24] Scherer, Rodrigo, et al. (2005). Effect of Slaughter Method on Postmortem Changes of Grass Carp (Ctenopharyngodon idella) Stored in Ice. Journal of Food Science.
[25] Mercogliano, Raffaelina, et al. (2024). Development of Welfare Protocols at Slaughter in Farmed Fish. Animals.
[26] Bermejo-Poza, Rubén, Montserrat Fernández-Muela, et al. (2021). Effect of Ice Stunning versus Electronarcosis on Stress Response and Flesh Quality of Rainbow trout. Aquaculture.
[27] Marx, Hans, et al. (1997). Methods of Stunning Freshwater Fish: Impact on Meat Quality and Animal Welfare. Z Lebensm Unters Forsch A.

emphasizes the potential of isobutanol as a humane solution for transporting lobsters under stress. Additionally, Acerete et al. (2009) reported a 20% improvement in quality and a 15% reduction in fish stress following the adoption of electrical stunning systems in seabass farming. These quantitative findings support the efficacy of electrical stunning in improving welfare and product quality compared to CO_2 narcosis.

- Clove oil continues to show promise, especially for species where other methods may be insufficient. Research by Rahmanifarah et al. (2011) indicated that clove oil was effective in reducing behavioral stress and improving the sensory quality of common carp, particularly in terms of firmness and color, compared to more traditional stunning techniques.[28]

In addition to the methods discussed, a comparative study by Concollato et al. (2018) on rainbow trout showed that electrical stunning consistently achieved the best results in terms of both quality and reduction in stress, compared to CO_2 narcosis and air asphyxiation.[29] Retter et al. (2018) also found that percussive stunning yielded superior welfare outcomes, particularly for common carp, minimizing injuries and improving sensory quality. These studies highlight the need for species-specific stunning methods to ensure optimal welfare and product quality.

3. Industry Adoption and Challenges

While advancements in stunning technologies have shown promising results, their widespread adoption remains inconsistent across the global aquaculture industry. In the Turkish aquaculture sector, while 90% of producers have adopted electrical stunning systems, their use remains limited to certain species or market demands. Similarly, the uptake of CO_2 narcosis has been impeded by its inconsistent effectiveness and higher operational costs compared to traditional methods like chilling. Moreover, small-scale operations face additional barriers, such as the high cost of equipment and a lack of regulatory frameworks that mandate humane practices.[30]

Operational complexities also hinder the implementation of these methods, particularly in ensuring the correct parameters for each species. As the aquaculture industry continues to evolve, developing regulatory standards and cost-effective solutions will be crucial to facilitate the broader adoption of humane stunning practices. The Animal Welfare Observatory (2024) also highlights the feasibility of implementing humane stunning

[28] Rahmanifarah, Kaveh, Bahareh Shabanpour, Amir Sattari (2011). Effects of Clove Oil on Behavior and Flesh Quality of Common Carp (Cyprinus carpio L.). Turkish Journal of Fisheries and Aquatic Sciences.
[29] Concollato, Anna, et al. (2018). Effects of Three Different Stunning/Slaughtering Methods on Physical, Chemical, and Sensory Changes in Rainbow trout. Journal of the Science of Food and Agriculture.
[30] Gregory, N.G. (2005). Recent Concerns About Stunning and Slaughter. Meat Science.

technologies for seabream and seabass, underscoring the importance of pilot testing and region-specific adaptations.[31]

4. Animal Welfare and Ethical Considerations

The growing awareness of fish sentience has led to increased emphasis on ethical slaughter practices that ensure the welfare of farmed fishes. Studies consistently emphasize the importance of using stunning methods that induce rapid unconsciousness and minimize suffering. Poli et al. (2005) emphasized that poor pre-slaughter handling, including inadequate stunning methods, can negatively affect fish welfare and quality.[32] The paper also highlighted that effective pre-slaughter and slaughter management is crucial for reducing stress and improving product quality in aquaculture, which aligns with the push for standardized welfare practices across the industry. Poorly applied stunning methods, such as asphyxiation or improper electrical stunning, can result in prolonged suffering, raising significant ethical concerns.[33]

Furthermore, welfare-related indicators, such as cortisol and glucose levels, rigor mortis onset, and tissue quality, are frequently used to assess the efficacy of stunning methods in reducing stress and improving fish quality. The integration of behavioral, physiological, and proteomic markers in recent studies highlights the complexity of assessing welfare outcomes and the need for comprehensive evaluation frameworks that incorporate multiple indicators of stress. In addition to stunning methods, humane fish bleeding practices are also an important aspect of fish welfare. MyWaterEarth&Sky Report (2024) provides a detailed guide on humane fish bleeding techniques, which are designed to reduce fish suffering and improve quality. These techniques, such as severing the main artery to facilitate blood drainage, are essential for ensuring that the fish undergoes a quick and less painful process.[34] By implementing more humane bleeding methods, aquaculture operations can improve both the ethical treatment of animals and the quality of the final product. Silva et al. (2023) conducted a similar assessment on tilapia, underscoring the importance of stunning efficiency and the impact of slaughter methods on both welfare and quality.[35]

- Research from López-Cánovas et al. (2020) on nanoencapsulated clove oil has shown that not only does this method enhance the welfare of farmed fishes by reducing stress, but it also contributes to extending product freshness, which is an

[31] Animal Welfare Observatory (2024). Report on the Feasibility of Implementing Stunning Prior to Slaughter in Farmed Seabream and seabass. Animal Welfare Education Centre.
[32] Poli, B.M., et al. (2005). Fish Welfare and Quality as Affected by Pre-slaughter and Slaughter Management. Aquaculture International.
[33] Coelho, M.E.G., et al. (2022). Fish Slaughter Practices in Brazilian Aquaculture and Their Consequences for Animal Welfare. Animal Welfare.
[34] MyWaterEarth&Sky (2024). How to Bleed a Fish Humanely: Complete Guide on Fish Bleeding. NA.
[35] Silva, A.C., et al. (2023). Assessing the Welfare of Farmed tilapia at Slaughter: An Evaluation of Stunning Efficiency. Aquaculture Reports.

important consideration for the aquaculture industry aiming to improve both welfare and product quality.

- Alessio Clemente et al. (2023) added valuable insights into welfare protocols at slaughter, emphasizing the importance of unconsciousness assessment and highlighting welfare challenges faced during the slaughter of farmed fishes in Italy.[36]

5. Regulatory and Policy Implications

Regulation plays a critical role in ensuring the humane slaughter of fishes and addressing industry-wide welfare concerns. In Europe, regulations such as EC 1099/2009 and the Farm-to-Fork strategy have set the foundation for improving animal welfare at slaughter. However, gaps remain, particularly with the absence of species-specific protocols, which leaves room for inconsistent application of welfare standards. A major gap in current policy frameworks is the absence of globally standardized stunning protocols. While organizations such as the World Organisation for Animal Health (WOAH) provide general guidelines on fish welfare, there is no universal agreement on humane slaughter requirements.

In addition to enhancing regulatory frameworks, the industry requires more comprehensive guidelines that address the commercial feasibility of humane slaughter techniques, particularly in smaller aquaculture operations. The development of universal standards and the enforcement of humane practices are essential for achieving consistency in welfare outcomes across the global aquaculture sector.[37]

6. Research Gaps and Future Directions

Despite significant advances, several research gaps remain in the study of fish stunning techniques. While studies have provided valuable insights into the efficacy of stunning methods, there is a need for further research to optimize stunning parameters for different species, as current protocols may not be universally applicable. Moreover, the long-term impacts of stunning methods on fish health, quality, and consumer acceptance have not been fully explored, limiting the ability to assess their sustainability.

Future research should focus on addressing the economic feasibility of adopting humane stunning methods, particularly for small-scale aquaculture operations, and investigating the environmental impact of new technologies. Furthermore, studies on the consumer perception of ethically slaughtered fishes and the potential market benefits of humane practices will be crucial in driving industry-wide changes. Additionally, Padiyar et al. (2024) highlight the increasing fish consumption trends in India, which may drive demand for

[36] Alessio Clemente, Gianfilippo, et al. (2023). Farmed Fish Welfare During Slaughter in Italy: Survey on Stunning and Killing Methods and Indicators of Unconsciousness. Frontiers in Veterinary Science.
[37] Aquatic Life Institute (2024). Marine Capture Fisheries: Best Practices for Aquatic Animal Welfare V3. Aquatic Life Institute Report.

more humane and sustainable aquaculture practices, emphasizing the need for scalable solutions that meet both welfare and market demands.[38]

Key Informant Interviews (KIIs)

To understand stakeholder perspectives on the feasibility of introducing pre-slaughter stunning in India, a series of key informant interviews (KIIs) were conducted. These interviews captured insights from a diverse set of stakeholders involved in fish production, processing, policy, and welfare, both within India and internationally. The distribution of stakeholders interviewed is summarized in Table 1.

Table 1. Stakeholder distribution from 24 key informant interviews, categorized by type and region (Global and India)

Stakeholder Category	Global	India
Animal Organizations	4	1
Certification Organization	0	1
Exporters & Processors	0	2
Farmers	0	3
Government Agency	0	4
Non-Animal NGOs	0	1
Research Organization	2	4
Wholesalers & Retailers	0	2

1. Current Fish Handling and Slaughter Practices in India

In India, fishes are often slaughtered by asphyxiation in air or through the use of ice, a method known as chill killing, where fishes are placed on ice and left to die gradually. Chill killing is more commonly observed in cage farms, corporate operations, and facilities linked to e-commerce, typically driven by buyer requirements. In contrast, it is less prevalent in the broader sector, likely because most fishes are sold in domestic markets—unlike shrimps, which are primarily export-oriented—and there are no strong regulatory or third-party standards enforcing fish welfare practices.

[38] Padiyar, Arun P., Sourabh K. Dubey, et al. (2024). Fish Consumption in India: Patterns and Trends. World Fish.

Chill killing can offer a slight welfare improvement over in-air asphyxiation, but only if carried out correctly. In practice, poor logistics and unreliable ice supply often undermine its effectiveness. Moreover, it does not induce immediate unconsciousness, resulting in prolonged suffering for the fishes. In Recirculating Aquaculture Systems (RAS), pre-slaughter starvation is sometimes implemented to clean the gut and improve product quality—yet this does little to address the welfare concerns associated with the actual killing process.

Fish harvesting and transportation in India remain largely manual, with limited attention to welfare. The common practice of pile-loading fishes in heaps before transport subjects them to suffocation, physical injuries, and extreme stress. In contrast to countries like Japan and several in Europe—where stunning is a standard practice—Indian aquaculture continues to rely on asphyxiation and ice slurry methods, both of which cause prolonged distress.

Live transport of fishes is rare due to logistical challenges. However, in regions such as West Bengal and Assam, live fishes fetch higher prices, as consumers equate liveliness with freshness. Despite this, high transport costs and significant mortality rates restrict the broader adoption of live fish marketing.

2. Awareness and Adoption of Stunning Technology in India

Awareness of stunning technologies among farmers, processors, and retailers in India is limited. Unlike the poultry and livestock sectors, where stunning is a standard practice, many aquaculture stakeholders are unfamiliar with stunning methods such as electrical or percussive stunning. Even large-scale processors handling high volumes of fishes typically focus on reducing mortality and maintaining freshness, rather than on incorporating stunning techniques to improve fish welfare.

Exporters who cater to European and Japanese markets have some awareness of stunning, as certain international buyers require it for high-value species like tuna and salmon. However, stunning is virtually nonexistent in India's domestic market, as the country's dominant freshwater aquaculture species are not subject to such export regulations.

The Food Safety and Standards Authority of India (FSSAI) does not mandate stunning, and there is no existing policy framework in India that governs fish welfare at the time of slaughter. Many industry stakeholders confirmed that there is little to no demand for stunning in India, and without regulatory mandates or financial incentives, voluntary adoption remains unlikely. Additionally, Indian fish market prices are too low for producers to justify the extra cost of stunning equipment, and most fish farms lack mechanized harvesting systems where stunning could be easily integrated.

3. Challenges in Adopting Stunning Technology in India

The adoption of fish stunning technology in India faces economic, regulatory, logistical, and market-related challenges.

- **Economic Barriers:** Farmers operate on thin profit margins and see no financial incentive in adopting stunning. Unlike in poultry and livestock, where welfare measures enhance product value, the fish industry has no consumer-driven differentiation between stunned and non-stunned fishes. Since Indian consumers do not (currently) demand humane slaughter, processors and retailers see no justification for investing in stunning equipment.

- **Regulatory Gaps:** The FSSAI does not mandate stunning, and there are no enforceable welfare laws covering fish slaughter under India's Prevention of Cruelty to Animals Act (PCA) of 1960. Unlike the EU, which has introduced minimum welfare standards for farmed fishes, India lacks policy discussions on fish stunning. Interviewees noted that if global import markets mandate stunning, Indian exporters may be forced to comply, but there is no domestic regulatory push for voluntary adoption.

- **Technological and Logistical Challenges:** Most of India's fish production occurs in small-scale, pond-based farms, where mechanized processing is not the norm. Unlike in poultry, where conveyor-belt stunning is easily integrated into slaughter lines, fish harvesting is manual and highly unstructured, making stunning logistically difficult. Additionally, the underdeveloped cold chain infrastructure means that even if stunning were adopted, post-harvest fish quality issues would persist due to inadequate refrigeration.

4. Impact of Stunning on Fish Quality

Many experts acknowledged that stunning significantly improves fish quality by reducing pre-slaughter stress, which affects biochemical composition, rigor mortis, texture, and shelf life. High-stress slaughter conditions deplete muscle glycogen reserves, accelerating lactic acid buildup and pH drop, leading to:

- Paler, softer flesh with a shorter shelf life
- Faster rigor mortis onset, resulting in tougher fillets
- Greater fillet gaping, making the fishes less visually appealing
- Increased drip loss, reducing the weight and market value of fishes

Conversely, when stunning is applied before slaughter, fishes experience:

- Slower rigor mortis progression, preventing muscle contraction damage
- Firmer texture and better water retention, enhancing freshness

- Higher processing yields, benefiting commercial fillet production

Internationally, stunning is widely recognized as a quality control measure. In Japan, Norway, and Scotland, electrical stunning followed by immediate bleeding is standard practice for high-value species such as tuna, salmon, and seabass. Japanese exporters use *Ikijime* and *Shinkei Jime* techniques, which ensure superior texture, extended shelf life, and premium pricing.

In India, stunning remains unrecognized as a quality-enhancing practice due to lack of certification, consumer awareness, and limited processing for high-value fillets. Without a market-driven incentive, adoption will remain low.

5. Regulatory Considerations and Policy Landscape

India currently lacks a regulatory framework that mandates stunning for fish slaughter. The Prevention of Cruelty to Animals (PCA) Act of 1960, covers animals in a general sense but does not explicitly mention fishes, and its applicability to aquatic species remains unclear—resulting in limited enforceable legal protections for fish welfare at slaughter. Additionally, the Food Safety and Standards Authority of India (FSSAI) governs food safety but does not address animal welfare concerns in its fish processing guidelines.

Some interviewees suggested that India may eventually adopt welfare regulations, particularly if global seafood importers, especially the EU, impose mandatory stunning requirements. The EU is a key trading partner for India, and should the EU mandate stunning practices, Indian exporters would need to comply to maintain access to this market. However, enforcement mechanisms for such policies are weak within India, which could make widespread implementation challenging.

While the EU is an important trading partner, it is not the largest market for Indian seafood exports, with larger markets in the Middle East and Asia. This is reflect in Figure 1 and Figure 2, which show that India's exports to the EU are relatively low, especially for species like trout and seabass. Nonetheless, the potential impact of the EU's regulations on India's seafood exports could motivate discussions on adopting more comprehensive fish welfare policies in India. Additionally, stakeholders emphasized that scientific research on the quality and safety benefits of stunning could drive future policy changes. However, India currently lacks research on species-specific stunning protocols, which limits regulatory progress in this area.

6. Potential Future Adoption of Stunning

Despite the challenges, some interviewees suggested that the adoption of stunning may be feasible in more structured farming systems, such as RAS and cage farming, where

handling is more controlled. Additionally, export-driven processing plants may implement stunning if international trade requirements mandate it.

For widespread adoption in India, three key factors are crucial:

1. **Consumer Awareness:** Indian consumers often associate live fishes with freshness, making it challenging to market pre-stunned fishes. Awareness campaigns highlighting the benefits of stunning for improving quality and extending shelf life are essential.

2. **Regulatory Incentives:** The Food Safety and Standards Authority of India (FSSAI) or state fisheries departments could introduce guidelines to encourage humane slaughter. Offering subsidies or financial incentives could further support the adoption of stunning technologies.

3. **Economic Feasibility:** Studies are needed to identify cost-effective stunning methods that are suitable for India's small and medium-sized farms, making the technology economically viable for wider implementation.

While stunning is unlikely to be adopted on a large scale in the immediate future, targeted interventions in premium markets, export industries, and structured farming systems could help gradually drive acceptance.

Regional Visits

The following table (Table 2) summarizes the key stakeholders involved in the supply chains for seabass, trout, and tilapia across the respective regions, based on the regional visits conducted.

Table 2. Distribution of stakeholders along the supply chains of seabass (Andhra Pradesh), trout (Jammu & Kashmir), and tilapia (Maharashtra), as identified during regional visits

Supply Chain Stakeholder Category	Seabass (Andhra Pradesh)	Trout (Jammu & Kashmir)	Tilapia (Maharashtra)
Fish Farmers	5	10*	4
Traders/Wholesalers	3	0	1
Fish Sellers/Retailers	3	1	2
Processors (Export/Domestic)	0	0	2
Consultants/Officials	1	1	2

*Nearly all trout farmers in Kashmir operate a small outlet or facility to sell fish directly from their farms.

The following table summarizes the key aspects of fish farming practices for seabass (Andhra Pradesh), trout (Jammu & Kashmir), and tilapia (Maharashtra) based on regional visits, highlighting farming models, challenges, and market dynamics observed in each region.

Table 3. Fish farming practices for seabass, trout, and tilapia across farming regions in India

Aspect	Seabass (Andhra Pradesh)	Trout (Jammu & Kashmir)	Tilapia (Maharashtra)
Region	Narasapuram, West Godavari and Krishna Districts	Anantnag & 10 districts	Konkan belt, Pune, Central Maharashtra
Fish Species	Seabass	Trout	Tilapia
Key Farming Areas	Clustering in specific regions; 80% former shrimp farmers using earthen ponds	Concentrated in Anantnag; 700+ trout farmers; measured in Kanal (1 acre = 8 Kanal)	Farmed in earthen ponds, cages, and dams; inland farms depend on rainwater
Supply Chain Model	Hatchery → Farmers → Traders → Wholesalers → Wet Markets → Consumers (80%)	Hatchery → Farmers → End Consumers (95%) → Buyers (5%) → Retail & Restaurants	Hatchery → Farmers → Vendors/Traders → Wet Markets → Consumers (80%)
Stocking & Growth	1,000–1,500 fish/acre; harvest weight: 2.5+ kg; 8–14 months culture period	Stocking 5-10g fingerlings; 750g harvest weight; 12–14 months culture period	Target size 700g+; major issue for farmers due to high feed costs
Water Quality & Aeration	Paddle wheel aerators (originally for shrimp) used to maintain dissolved oxygen	Running water system; dissolved oxygen above 6 ppm	Minimal water issues in cage farming due to continuous exchange
Survival Challenges	Larger fish eat smaller ones if underfed; hatcheries grade fish by size	None reported	Seed quality and diseases remain major concerns

Market Trends	Strong domestic market; dead fish sold through markets; fillets valued for HoReCa	Domestic market with seasonal variations; peak sales before summer	Live fish preferred in local markets; higher prices for live over dead fish
Key Buyers	West Bengal (65%), North India (12%), Tamil Nadu, Karnataka, Maharashtra (10%)	D2C model with some traders procuring 50-150 kg live trout for retail/restaurants	Local wet markets dominate; small export segment (Africa, Middle East)
Export Potential	Limited export; wild-caught fish fetch higher prices due to premium demand	Khyber Aquaculture leading export focus; first RAS unit in J&K	Processing plants focus on frozen fillets for export; farmers struggle with production size
Pre-Slaughter Stunning	Not practiced	Practiced but ineffective	Not practiced
Slaughter Practices	Asphyxiation; fish die before repacking at trader/wholesaler receiving centers	Fish struck on the head with PVC pipes/rods; gutting and scaling after stunning	Fish are scaled and gutted alive in local markets; arrive dead at processing plants
Detailed Notes	Click Here	Click Here	Click Here

1. Current Farming Practices

- **Seabass (Andhra Pradesh):** Many seabass farmers in Andhra Pradesh previously engaged in shrimp farming but shifted due to recurring disease outbreaks and an unstable shrimp market over the years. Most of these farms are equipped with paddle wheel aerators, either repurposed from their shrimp operations or purchased after learning from other seabass farmers—to maintain dissolved oxygen levels. The typical culture period ranges between 8 and 14 months, with fishws reaching an average weight of over 2.5 kg. Unlike Indian Major Carps (IMCs) and Rupchand farming, routine sampling is not a strict practice during the entire culture

period. Water quality testing is also done occasionally.

- **Trout (Jammu & Kashmir):** Trout farming in Jammu & Kashmir primarily relies on running water systems. The culture period spans 12 to 14 months, with fishes reaching an average weight of around 750g at harvest. The region operates largely on a direct-to-consumer model, where farmers sell fishes directly to buyers (possibly due to the much smaller market in comparison to other farmed fishes). The two major issues for trout farmers are seed quality and the high cost of feed inputs. Again, routine sampling is not something common and there is a lack of water quality testing facilities.

- **Tilapia (Maharashtra):** Tilapia is farmed in earthen ponds, cages, and dams across Maharashtra's Konkan belt, Pune, and central regions. There are challenges related to water scarcity, seed quality, and producing fishes suitable for the export market. The local wet markets primarily deal in smaller tilapia (less than 200 grams). When asked about their preference for selling to processing plants versus local vendors, most farmers favored local vendors due to the better prices offered compared to processing units. However, local markets have a much lower capacity than processing units. Partial harvesting has not been a major issue for farmers.

2. Market Dynamics

- **Seabass (High domestic value):** The states producing seabass are not its primary consumers, unlike in the case of trout. The demand for seabass is strong, especially in West Bengal, Assam, and other Northeastern states of India. The market prefers larger fishes, similar to Catla, and those weighing over 4 kg are valued even more due to their higher oil content. One of the other reasons for its high domestic demand is the fillet requirement by the Hotel, Restaurant, and Catering segment. Seabass caught from rivers and other natural water bodies is often auctioned at much higher prices than farmed ones due to strong consumer preference.
  Price reference: Farm gate price: INR 300-375 | Market price: INR 400-600 per unit biomass.

- **Trout (High export value):** Trout is currently limited to the domestic market, sold largely through a Direct-to-Consumer (D2C) channel. Since it is produced in hilly areas, most of it is marketed within the same state, with some farms supplying retail outlets in other regions. In supermarkets, it is often branded as "Himalayan trout" because it primarily comes from the Himalayan mountain states. Companies like Khyber Aquaculture with the support from the government are working on expanding trout production for export, given its strong international market value.
  Price reference: Farm gate and market price: INR 450-550 per unit biomass.

- **Tilapia (High export volume):** Tilapia has a much higher export volume than seabass or trout, but its price remains on the lower end. The major export markets are low-income regions in Africa and the Middle East, with limited access to premium markets due to size requirements and competitive pricing. There is also a preference for live tilapia in the domestic market, though its market price is lower compared to seabass and trout.
  Price reference: Farm gate price: INR 65-95 | Market price: INR 90-150 per unit biomass.

  Note:
  1. The term "unit biomass" is used instead of kilograms, as the number of fishes per unit varies across species and to respect the perspective of readers from animal welfare organizations.
  2. The prices mentioned are only for reference. Factors such as demand-supply conditions, farmed vs. wild-caught, and fish appearance also influence pricing.

3. Pre-Slaughter Practices

- **Seabass (Andhra Pradesh):** For seabass, asphyxiation is the commonly followed method, where fishes are kept in open air before being packed into ice crates. This practice, also seen with other farmed species in India, results in a gradual reduction in movement. Afterward, the fishes are sorted by size and transported, typically in insulated trucks.

- **Trout (Jammu & Kashmir):** For trout, a method involving striking the fishes on the head with PVC pipes, similar to the percussion, is often observed. On being asked the reason behind using this methodology, farmers shared that this method has been in use for a long time, meets consumer expectations, and helps with easy handling of the fishes during the slaughtering process. However, the method doesn't always work as intended—if the strike isn't accurate, the fishes may still keep moving.

- **Tilapia (Maharashtra):** Asphyxiation is the most commonly followed method for tilapia, similar to other farmed fishes. However, due to consumer demand for live fishes, some fish selling points provide artificial oxygen to keep them alive until sale. Fishes are then scaled and gutted while still alive in front of the consumers, as per traditional practices. Even in processing plants, the fishes typically arrive dead by the time they reach the facility, because of the distance of the processing unit from the harvest location and quantity.

Field Surveys

In this section, we present the results of field surveys conducted with farmers in the seabass farming regions of Andhra Pradesh and trout farming areas of Jammu & Kashmir. The surveys provided valuable insights into the farmers' preferences regarding stunning methods, their challenges, and the factors influencing their decisions about adopting new practices.

1. Key Differences

The table below summarizes the key findings from the surveys, including the most and least favored stunning methods for each species. It also highlights the reasons for these preferences and the potential impact of financial incentives, such as subsidies, on their willingness to adopt stunning technologies.

Table 4. Key differences in stunning methods favored by farmers for seabass (Andhra Pradesh) and trout (Jammu & Kashmir)

Aspect	Seabass Survey (Andhra Pradesh)	Trout Survey (Jammu & Kashmir)
Survey Links	Seabass Survey Link	Trout Survey Link
Total Respondents	20	50
Locations Covered	14	18
Summary of Farmer Responses	• Farmers prefer chemical based stunning but are concerned about cost, buyer demand, and subsidies. • Most would adopt stunning if linked to buyer demand and premium pricing. • Many suggest operational costs must be reduced for adoption. • Farmers require education on stunning benefits.	• Farmers are interested in stunning if financial support, training, or premium pricing is available. • Percussive stunning is ranked as the most feasible method. • Adoption barriers include high equipment costs, lack of buyer demand, and limited awareness. • Farmers struggle with water quality, marketing challenges, and high feed prices.

Most Favored Stunning Method	**Rank 1 (Most Favoured) Method:** Chemical-Based Stunning, favored by 18 farmers (90.0%). **Rank 2 Method:** Herbal-Based Stunning, supported by 18 farmers (90.0%). Although no seabass farmers are currently using stunning techniques, a significant number have expressed interest in adopting chemical-based stunning (Tricaine), especially if it is required by buyers or if its benefits can be effectively demonstrated.	**Rank 1 (Most Favoured) Method:** Percussive Stunning, rated as most feasible by 35 farmers (70%). **Rank 2 Method:** Herbal-Based Stunning, supported by 11 farmers (22%). A notable portion (62%) of trout farmers (30) already apply percussive stunning in their operations. Although not officially recognized as stunning, this technique is mainly used for convenience & cost-effectiveness, especially since farmers typically manage small quantities of fishes. Percussive stunning stands out as the most favored method, with the highest number of farmers ranking it as the most feasible.
Least Favored Stunning Method	Percussive Stunning	Electrical Stunning
Reason for Stunning Preference	Farmers favor chemical-based stunning primarily due to its perceived low cost, as they believe it to be the most affordable method. Additionally, chemical-based stunning is favored by farmers because it involves less labor and is easier to implement.	When discussing the various stunning methods during the survey, farmers often compared them to their existing practices, particularly percussive stunning. Farmers tend to favor percussive stunning for its ability to quickly render fishes unconscious. On the other hand, electrical stunning is the least favored method due to the lack of necessary equipment and doubts about its effectiveness.

If a 50% subsidy on stunning equipment was provided, how likely would you be willing to adopt it?	**35% (7 farmers)** are **very likely** to adopt stunning with the subsidy. **55% (11 farmers)** are **somewhat likely** to adopt stunning with the subsidy. **5% (1 farmer)** is **unlikely** to adopt stunning even with the subsidy.	**14% (7 farmers)** are **very likely** to adopt stunning with the subsidy. **44% (22 farmers)** are **somewhat likely** to adopt stunning with the subsidy. **32% (16 farmers)** are **unlikely** to adopt stunning even with the subsidy. **10% (5 farmers)** are **unsure** about adopting stunning even with the subsidy.
Certification for Welfare Labeling	**65% of farmers** believe stunning should be mandatory for welfare labeling. **35% of farmers** are unsure.	**50% of farmers** support welfare labeling certification. **34% of farmers** oppose it. **16% of farmers** remain unsure.

2. Shared Aspects

Table 5 highlights the common barriers and needs identified during the field surveys, such as the necessity for farmer education, financial support, and technological readiness for adopting stunning practices.

In the trout field survey, we found that 62% of trout farmers already use percussive stunning as part of their processing method. While it is not explicitly implemented as a formal stunning technique, farmers primarily use it for convenience rather than strict adherence to stunning protocols.

Since trout farming is typically small-scale, farmers handle low daily volumes (around 40–50 fishes per day). These fishes are caught directly from raceway systems and sold at the farm site. To ease processing, farmers render the fishes unconscious before slaughter using percussive stunning, which aligns with their traditional practices.

Table 5. Key barriers and needs identified by seabass and trout farmers for adopting stunning techniques

Aspect	Barriers or needs shared by farmers in the survey (seabass and trout)
Farmer Familiarity with Stunning Techniques	Farmers require education and awareness on stunning techniques.
Financial Support Mechanisms	Subsidies and loans for stunning equipment.
Technological Readiness and Infrastructure	Development of cost-effective stunning equipment is crucial for adoption.
Market Demand	Lack of buyer demand highlighted as a barrier.
Seasonal Challenges	Water quality and supply issues in seabass farming, and seasonal demand fluctuations and water quality issues in trout farming.

3. Additional Farmer Responses

- Many farmers emphasized that percussive stunning is cost-effective and does not require specialized equipment.
- Some stated that it is the only method commonly used in Kashmir due to its simplicity.
- A few mentioned that they would consider investing in advanced stunning methods if better training and welfare certifications were made available.

This confirms that, unlike seabass farmers who do not use stunning, a significant proportion (62%) of trout farmers already implement percussive stunning as a practical and economic choice in their operations.

4. Seabass Farmers Survey Data (Total Responses: 20)

A. Seabass Farmers Ranking of Each Stunning Method

As shown on Table 6, chemical-based stunning is the most favored method, with 18 farmers (90.0%) considering it the most favoured. In contrast, percussive stunning is the least favored method, with 19 farmers (95.0%) ranking it as the least favoured.

Table 6. Seabass farmers' ranking of stunning methods based on survey responses

Rankings	Stunning Method			
	Chemical-based Stunning	**Electrical Stunning**	**Herbal-based Stunning**	**Percussive Stunning**
Rank 1 (Most Favoured)	18 farmers	2 farmers		
Rank 2	2 farmers		18 farmers	
Rank 3		17 farmers	2 farmers	1 farmer
Rank 4 (Least Favoured)		1 farmer		19 farmers

B. Farmer Usage of Stunning Methods in Operations

None of the farmers surveyed are currently using stunning methods in their operations.

C. Factors That Could Encourage Farmers to Adopt Stunning Technology

Figure 3 shows the factors most likely to encourage farmers to adopt stunning technology. Market and buyer demand is the primary motivator, cited by 9 farmers (45%), followed by economic benefits such as price increases and farmer interest, mentioned by 7 farmers (35%). Financial support for equipment was identified by 4 farmers (20%) as a key factor in adoption.

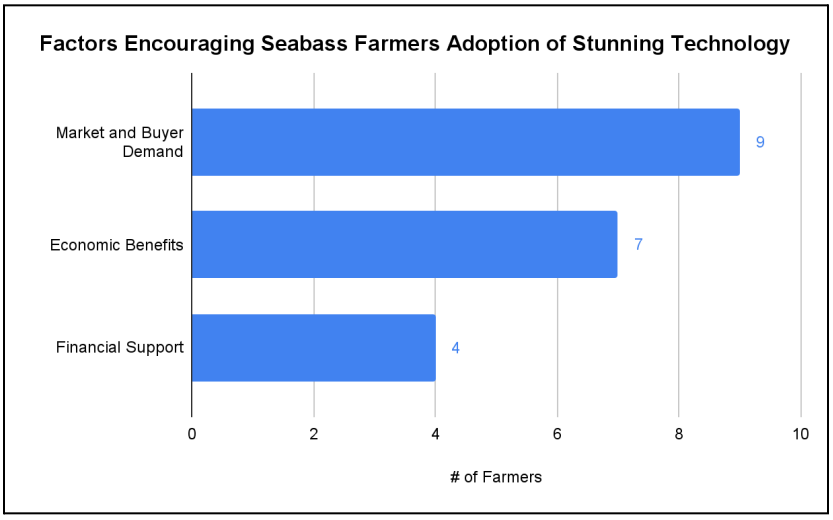


Figure 3. Summary of open-ended responses from seabass farmers, highlighting the key factors that would encourage them to adopt stunning technology

D. Investment Preferences for Stunning Technology

Figure 4 illustrates seabass farmers' investment preferences for stunning technology: 40% (8) of farmers are unwilling to invest at all, 40% (8) prefer low investment (≤ Rs. 50,000), 15% (3 farmers) are willing to invest medium amounts (Rs. 50,000 - 2,00,000), and 5% (1 farmer) is open to a high investment (> Rs. 2,00,000).

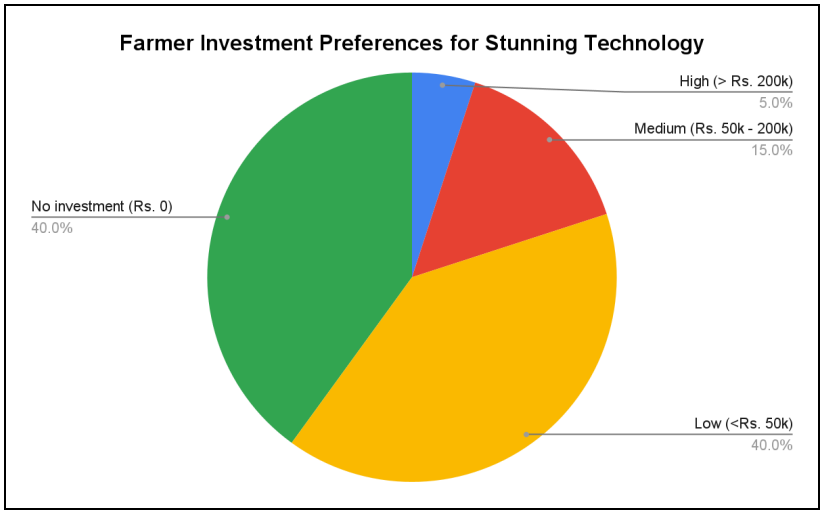


Figure 4. The distribution of farmer investment preferences for stunning technology

E. Response to Stunning Requirement for Export

Out of the surveyed farmers, 85% (17 farmers) would adopt stunning immediately if a major international buyer made it a requirement for exports, while 15% (3 farmers) would wait until it becomes mandatory.

F. Farmer Estimates of Stunning Adoption in Seabass Farming

Survey results show that 60% (12 farmers) estimate that 10-40% of farmers in their region would adopt stunning, 35% (7 farmers) estimate that 40-70% of farmers would adopt stunning, and 5% (1 farmer) estimate that fewer than 10% of farms would adopt stunning.

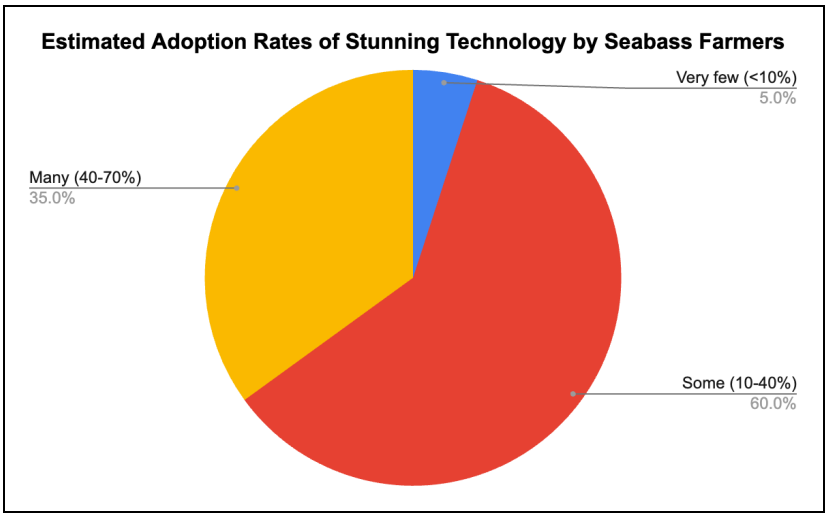


Figure 5. Estimated adoption rates of stunning technology by seabass farmers, based on survey responses

G. Government Subsidy Impact on Farmers' Adoption of Stunning Equipment

55% (11 farmers) would adopt stunning if required by buyers, 35% (7 farmers) would adopt immediately with a 50% subsidy, and 10% (2 farmers) would not adopt, citing that cost is not the only barrier.

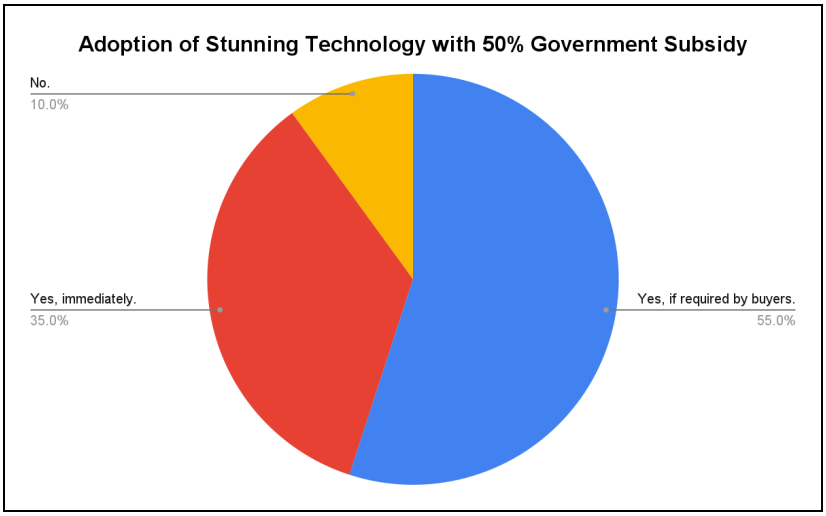


Figure 6. Response of seabass farmers to the potential adoption of stunning technology if a 50% government subsidy were provided

5. Trout Farmers Survey Data (Total Responses: 50)

A. Trout Farmers Ranking of Each Stunning Method

For trout farmers, percussive stunning is the most favored method, while electrical stunning is the least.

Table 7. Trout farmers' ranking of stunning methods based on survey responses

Rankings	Stunning Method			
	Chemical-based Stunning	**Electrical Stunning**	**Herbal-based Stunning**	**Percussive Stunning**
Rank 1 (Most Favoured)	3 farmers	1 farmer	11 farmers	35 farmers
Rank 2	19 farmers	8 farmers	15 farmers	8 farmers
Rank 3	15 farmers	24 farmers	7 farmers	4 farmers
Rank 4 (Least Favoured)	13 farmers	17 farmers	17 farmers	3 farmers

B. Farmer Usage of Stunning Methods in Operations

A majority (62%) of farmers are using percussive stunning in their operations, primarily for its convenience and cost-effectiveness. However, 32% of farmers are not utilizing any stunning methods at all.

Despite not being officially recognized as stunning, percussive stunning is favored by farmers due to its practicality and lower cost.

C. Factors That Could Encourage Farmers to Adopt Stunning Technology

The main factors encouraging trout farmers to adopt stunning technology are financial support (34%) and evidence of economic quality benefits (30%). Other factors, such as training (16%) and market demand (12%), are also important, but less prioritized. Regulatory support was the least mentioned factor (8%), suggesting that practical, financial incentives are the main drivers for adoption.

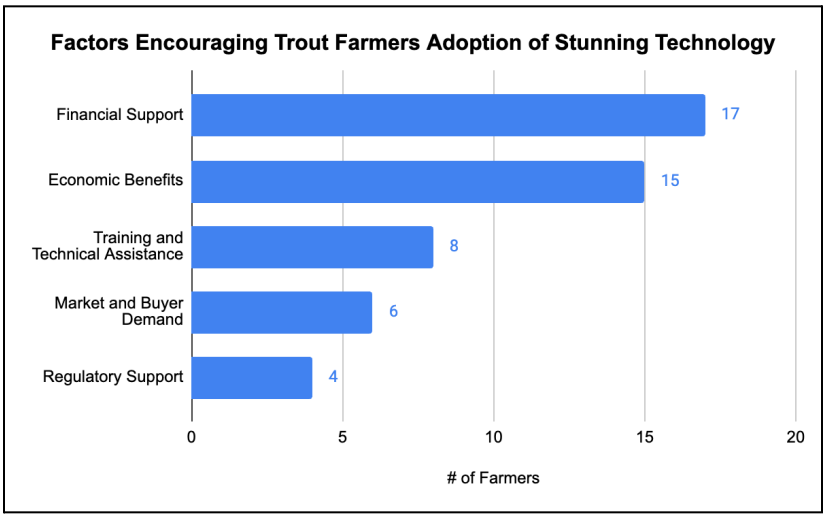


Figure 7. Summary of open-ended responses from trout farmers, highlighting the key factors that would encourage them to adopt stunning technology

D. Investment Preferences for Stunning Technology

Survey results show that the majority of farmers (88%) are willing to invest a low amount (< Rs. 50,000) in stunning technology, while 12% of farmers are not willing to invest at all.

E. Response to Stunning Requirement for Export

If stunning became a requirement for exports, 40% of farmers (28) would wait until it is mandatory, while 26% (13) would adopt it immediately. Another 26% (13) would seek alternative buyers, and 8% (4) remain unsure.

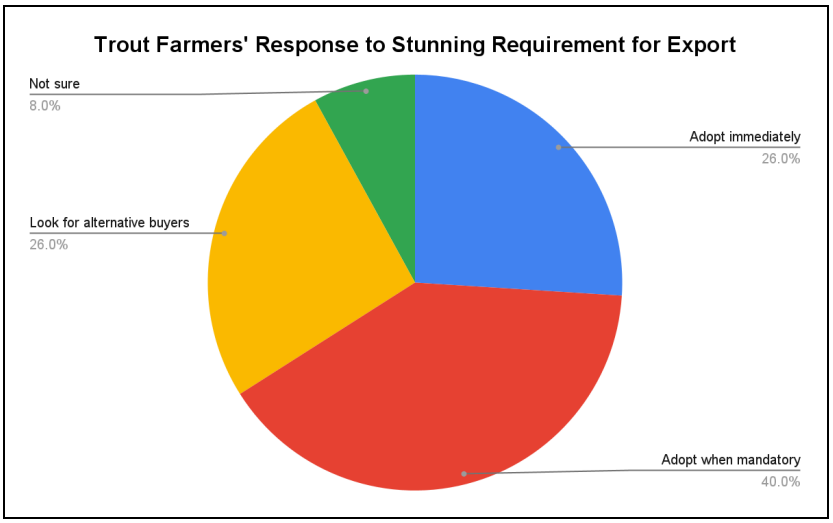


Figure 8. Trout farmers' response to stunning requirement for export

F. Farmer Estimates of Stunning Adoption in Trout Farming

The majority of trout farmers (75.5%, 37 farmers) estimate that very few farms (<10%) in their region would adopt stunning technology. A smaller proportion (20.4%, 10 farmers) expect some farms (10-40%) to adopt, while only 4.1% (2 farmers) anticipate that many farms (40-70%) would adopt the practice. These estimates suggest that while there is some interest in stunning technology, farmers generally expect its adoption to remain limited within the region.

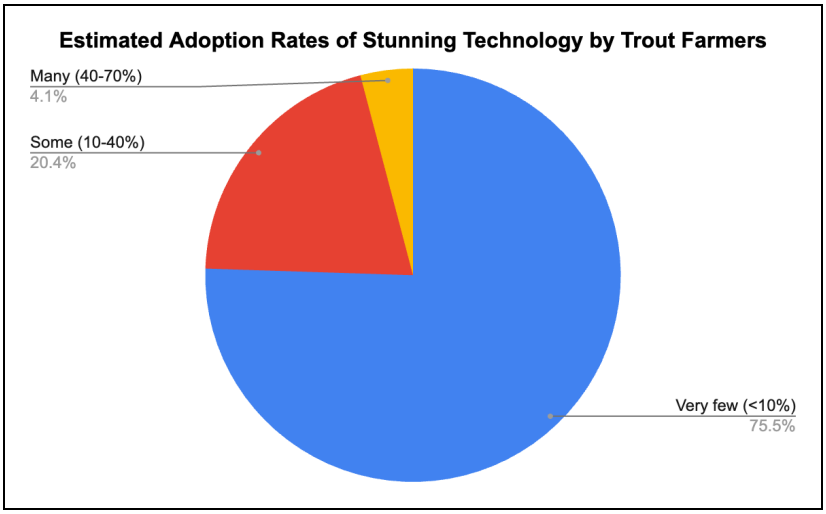


Figure 9. Estimated adoption rates of stunning technology by trout farmers, based on survey responses

G. Government Subsidy Impact on Farmers' Adoption of Stunning Equipment

If a 50% government subsidy covered equipment costs, 48% (24 farmers) would adopt it if required by buyers, while 24% (12 farmers) would adopt immediately. However, 20% (10 farmers) would not adopt due to reasons beyond cost, and 8% (4 farmers) were unsure.

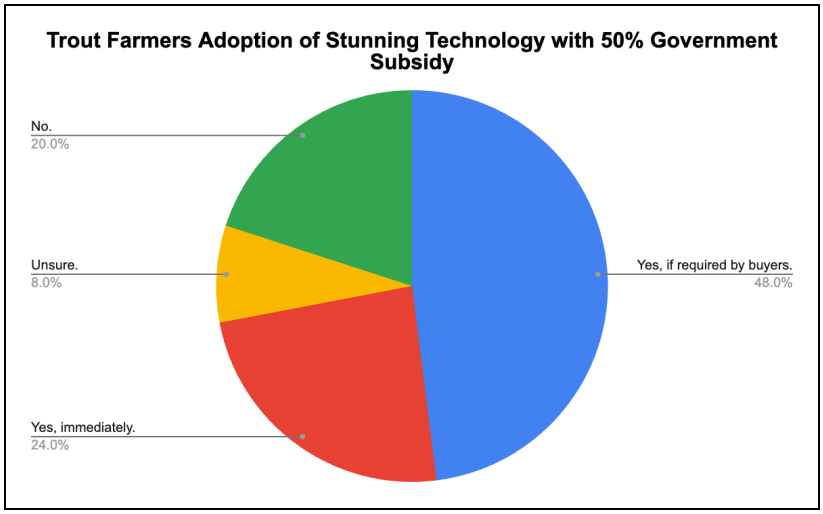


Figure 10. Response of trout farmers to the potential adoption of stunning technology if a 50% government subsidy were provided

Key Takeaways & Conclusion

In this section, we respond to each of the objectives as mentioned at the beginning of this report and conclude our findings.

a) Target Population: Which stakeholder groups within India's aquaculture sector are most likely to adopt pre-slaughter stunning technology?

Target Stakeholder Group: Based on our study's findings, fish processors engaged in export (exporters) should be the target stakeholder group for adopting pre-slaughter stunning technology in India's aquaculture sector. Within the supply chain—which includes farmers (individual or cooperatives), traders/wholesalers, retailers, processors, and buyers/consumers—exporters are best positioned to absorb the additional costs associated with stunning methods and handle higher fish volumes. Exporters are the key stakeholders who can drive the demand for stunning practices, given their access to premium markets such as the EU and the US. However, it is important to note that the number of active fish exporters, particularly for species like seabass, is currently very small. This constraint may restrict the immediate scalability of exporter-led adoption unless accompanied by broader market development efforts.

While exporters set the demand, processors and farmers are still the critical components of the supply chain. Stunning will be directly applied at the processor and farmer levels, but its adoption depends on exporter-driven requirements. Therefore, the most effective approach is to engage exporters first and then work backwards to ensure alignment across processors and farmers. Once an exporter is onboard, the supply chain must be traced to facilitate adoption at all relevant stages. This ensures alignment across stakeholders, enhancing the likelihood of successful adoption. However, despite exporters being the ideal stakeholder group for driving stunning adoption, the current lack of sufficient numbers makes it challenging to proceed.

Target Fish Species: Seabass is identified as a priority species due to its relevance in premium domestic markets and its potential in export markets. As a "high-value" fish, seabass is better positioned than many other species to absorb the additional costs associated with stunning, with minimal resistance from buyers and consumers. Domestically, seabass shows notable market potential—particularly in regions such as West Bengal, Assam, and the broader North East. However, while India does export seabass, the volumes remain modest, totaling approximately €150,000 in selling value over the five-year period from 2020 to 2024. In 2024, exports amounted to only €17,995.[39] These

[39] While our preference is to write about these animals in terms of individuals, unfortunately the most accurate data accessible only lists them in terms of economic value and total kilograms sold.

figures suggest that while there is some international demand, the scale is currently small, and seabass should be considered a niche species for early adoption rather than a vehicle for broad-scale impact.

Trout already involves percussion-like handling, though mainly for convenience, making it the second priority. This existing practice of pre-slaughter handling could help in transitioning to any stunning methods. However, trout farming is limited to colder regions such as Jammu & Kashmir, Himachal Pradesh, and Uttarakhand, making large-scale adoption difficult. Additionally, the availability of an exporter for trout remains uncertain, except for Khyber Aquaculture, which is planning a major processing and exporting unit. If this facility becomes operational, it could create opportunities for stunning adoption in the trout sector.

Tilapia is excluded as a priority species due to several challenges. It is often sold live in many fish markets, making stunning incompatible with its supply chain. Moreover, tilapia lacks a strong premium market in India, and its relatively low price point does not justify the additional costs of stunning. Its export is primarily directed to low-income countries with less emphasis on animal welfare standards, making it a less viable species for this initiative.

b) Incentives and Barriers: What economic, logistical, cultural, or market-driven factors could incentivize or hinder the adoption of stunning technology?

Chemical stunning is considered the most viable option for both seabass and trout due to its lower cost and ease of implementation compared to electrical or percussive stunning. Methods such as Tricaine (an FDA-approved anesthetic) require minimal labor and are more accessible for small and medium-sized farmers, who may be hesitant to invest in expensive and complex alternatives. Tricaine methanesulfonate (MS-222) is used for research purposes in India and is available through chemical suppliers, along with alternatives like clove oil.[40] It has also been used by FWI during past studies—including feed fortification and dissolved oxygen (DO) tolerance trials—at a typical dosage of ~40 mg/liter to sedate fishes for blood sample collection.

While percussive stunning may be suitable for larger species like seabass, it has limitations in terms of consistency and requires significant manual labor. Electrical stunning, though potentially more effective, poses challenges related to high equipment costs, electricity availability, and the technical expertise required for proper usage. Given these barriers, chemical stunning emerges as the most practical approach for smallholder systems and

[40] Institutional Animal Care and Use Committee. (2020). The use of Tricaine Methanesulfonate (MS-222) in fishes and other aquatic animals (Document #057, Version 01). University of North Texas Health Science Center.

early-stage adoption in India.

However, since the target population for this initiative is exporters, further validation of the chemical stunning method is required from their perspective. This aspect of the study, however, was beyond the scope of the current research. To fully assess the viability of chemical stunning, it is necessary to identify species-specific exporters and consult with them regarding the use of chemical stunning, particularly to determine if consumers in the export markets will accept and import chemically stunned fishes. This step is crucial to ensure that the stunning method aligns with the preferences of both exporters and the end consumers, along with producers.

Incentives for Adoption:

- **Premium pricing potential:** Stunned fishes are perceived as higher quality, which can lead to better prices in both domestic and international markets.

- **Potential government support:** If the government provides subsidies for stunning equipment, it could reduce the financial burden on farmers and encourage adoption.

- **Market-driven demand:** If exporters require stunned fishes for high-value species, it creates a market-driven push for farmers and processors to adopt stunning methods.

Barriers to Adoption:

- **High costs and technical limitations:** Pre-slaughter stunning equipment, such as electrical and automated percussive systems, is expensive, making it inaccessible for many small-scale farmers. Additionally, there are no scientifically validated chemical stunning methods, limiting alternative options.

- **Limited awareness and market demand:** Many farmers are unfamiliar with the benefits of stunning, and without clear buyer expectations, they are unlikely to invest in the technology. Adoption would require targeted education campaigns and stronger market signals from buyers.

- **Cultural and religious concerns:** Cultural and religious considerations further contribute to resistance. Some consumers prefer to purchase live fishes, and religious practices may be wary of stunning methods. For example, while fish is considered halal in Islamic dietary law, some Muslim consumers are concerned that stunning might interfere with proper blood drainage, a key requirement. Currently, the industry uses a pre-cutting method to ensure compliance with halal standards,

but there are concerns that stunning could interfere with this process, potentially rendering the fishes non-halal.

c) Pathway to Scalability: What strategies or adjustments will be required to scale stunning technology across the aquaculture industry?

The pathway to scalability hinges on collaboration with exporters, creating market demand, and providing financial incentives to both farmers and processors. To scale the adoption of stunning, it is crucial to work with exporters to establish clear market demand for stunned fishes and they have a financial incentive to adopt stunning practices. Pilot projects should be conducted in regions where the adoption of stunning is feasible, such as in Andhra Pradesh for seabass. These pilot projects will demonstrate the effectiveness of stunning and its impact on fish quality, helping to build trust within the industry. Government subsidies and shared-use models for stunning equipment will make the technology more accessible, especially since farmers will implement stunning, provided exporters create a market demand for it. Certification is also considered to be an effective pathway to engage buyers and producers in stunning fishes. Additionally, awareness campaigns and farmer education programs could be vital for ensuring that the stunning practices are widely understood and accepted across the aquaculture sector.

In conclusion, the report recommends starting with exporters and focusing on high-value species like seabass and trout, with chemical stunning being the favored method due to its cost-effectiveness and ease of implementation. The path to scalability requires both demand creation through exporter collaboration and the provision of financial and logistical support to farmers and processors.

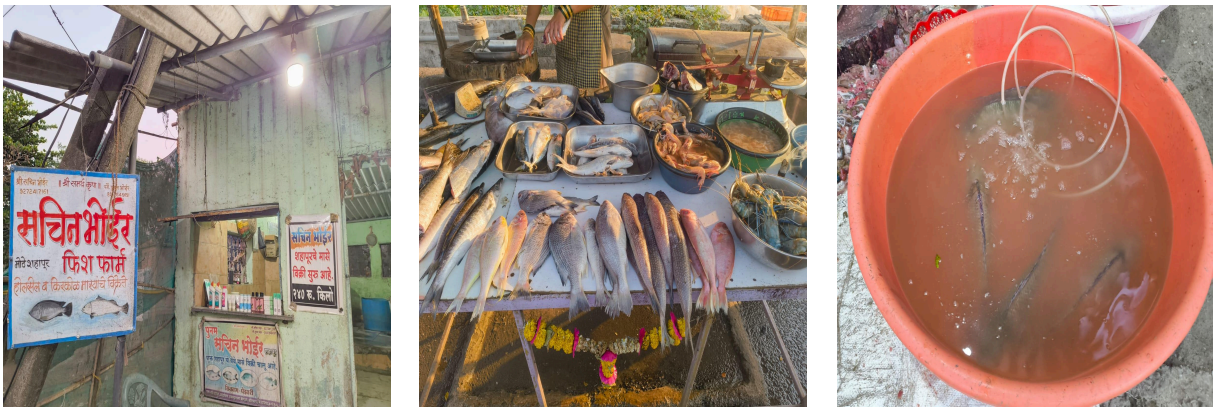
Pictures from Visits


Left: A seabass harvest scene, Right: Fish wholesaler in Narsapuram




Meeting with seabass fish farmers in Undi, Bhimavaram, & Narsapuram regions (AP)

Visit to a big fish wholesale market, meeting suppliers and wet market retailers



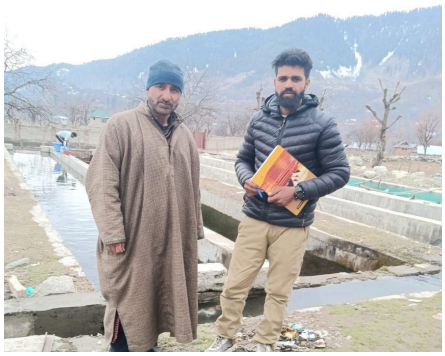
A few snapshots from the local wet fish market in Sahapur and Pen Bus Stand areas



Royal Rainbow trout Fish Unit, a trout fish farm unit and selling point


Meeting with trout fish farmers and sellers of Pahalgam area in Anantnag district

Interacted with young entrepreneurs about the stunning project and fish welfare



Our intern meeting with trout fish farmers in Now Bugh, Zalam Gam regions (J&K)

Left: Meeting with one of the directors of a processing plant, Right: QC inspection of fillets

Photo: 1-3) Meeting with tilapia reservoir-cage farmers in Raigad area (Maharashtra)
4) Meeting with the director of one of the oldest seafood buying agents- August SF in Mumbai