LIFE CYCLE ASSESSMENT OF SHRIMP POST-LARVAE PRODUCTION: EVIDENCE FROM COMMERCIAL HATCHERY IN INDIA

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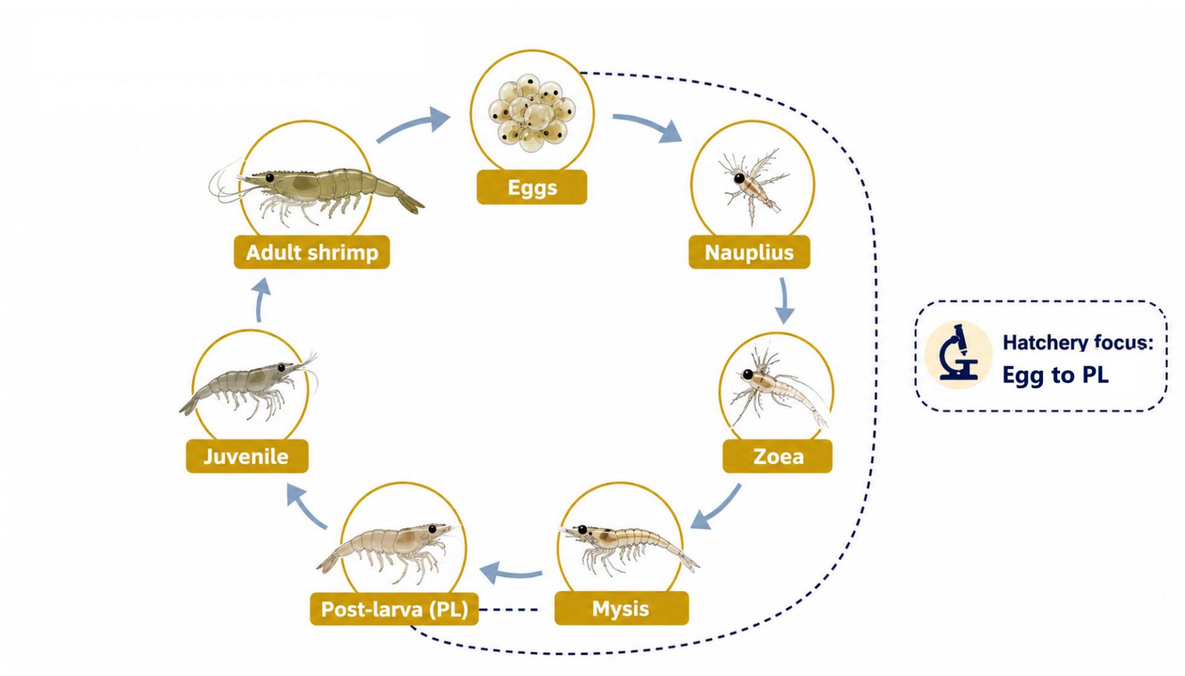


Background & Aims

Aquaculture is one of the **fastest-growing food production sectors globally**, with shrimp farming representing one of its most economically important industries (FAO 2024).

Increasing production has raised **environmental sustainability concerns**, highlighting the need to assess impacts across the entire production value chain (Bohnes et al. 2019; Pazmiño et al. 2025).

Current shrimp aquaculture LCAs **focus mainly on grow-out systems** (Mayekar et al. 2025; Pazmiño et al. 2025); the hatchery stage, where post-larvae (PL12) are produced, is **often considered negligible and a full attributional hatchery LCA has never been done**. This creates a knowledge gap on the environmental contribution of hatchery production and on opportunities for improvement.



Shrimp life cycle: *the hatchery covers Egg to PL12* (12-day-old post-larvae)*, the stage that produces seeds for grow-out*

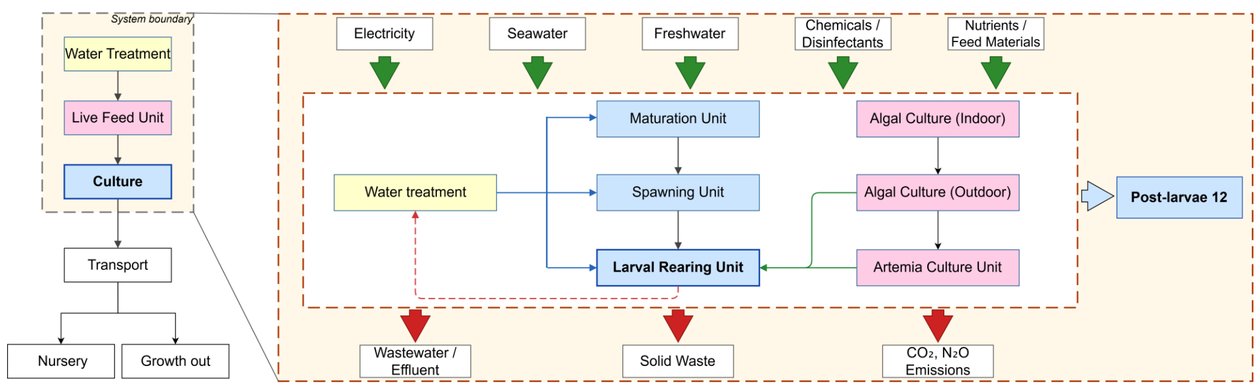
Aims

1. **To characterise the impacts** of commercial shrimp hatchery production and establish a baseline environmental profile.
2. **To identify which hatchery subsystems** contribute most strongly to environmental impacts and assess variations across impact categories.
3. **To identify environmental hotspots** and opportunities to improve the environmental sustainability of hatchery production.

Methods

This study used a **Life Cycle Assessment (LCA)** approach following the ISO 14040/14044 framework, based on primary data collected from a commercial shrimp hatchery operating in Tamil Nadu, India.

- **Functional unit:** 1 million PL12 post-larvae
- **LCIA method:** SimaPro 10.3 with ReCiPe 2016 Midpoint (H)
- **Impact categories:** 18 ReCiPe midpoints
- **Data:** primary on-site, covering 7 subsystems
- **Scope:** gate-to-gate system boundary



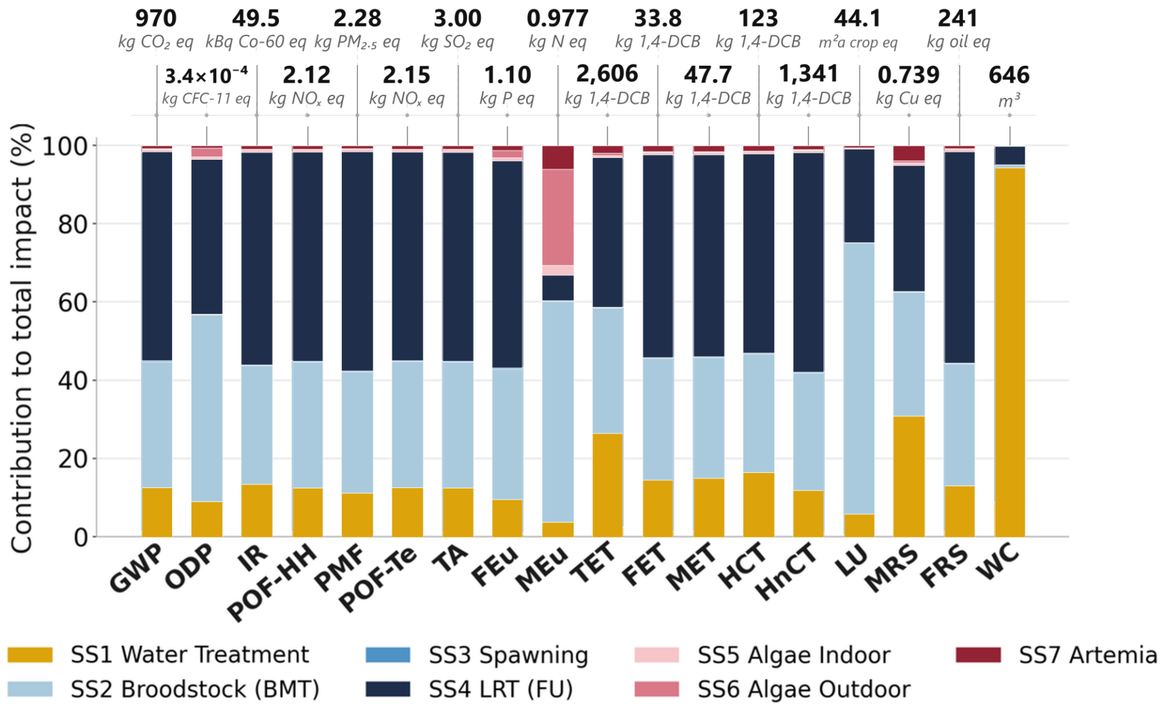
System boundary: gate-to-gate; PL12 is the output flow.

Subsystem index

SS1	SS2	SS3	SS4	SS5	SS6	SS7
Water Treatment	Maturation Unit	Spawning Unit	**Larval Rearing Unit**	Algal Culture (Indoor)	Algal Culture (Outdoor)	Artemia Culture Unit

Results & Discussion

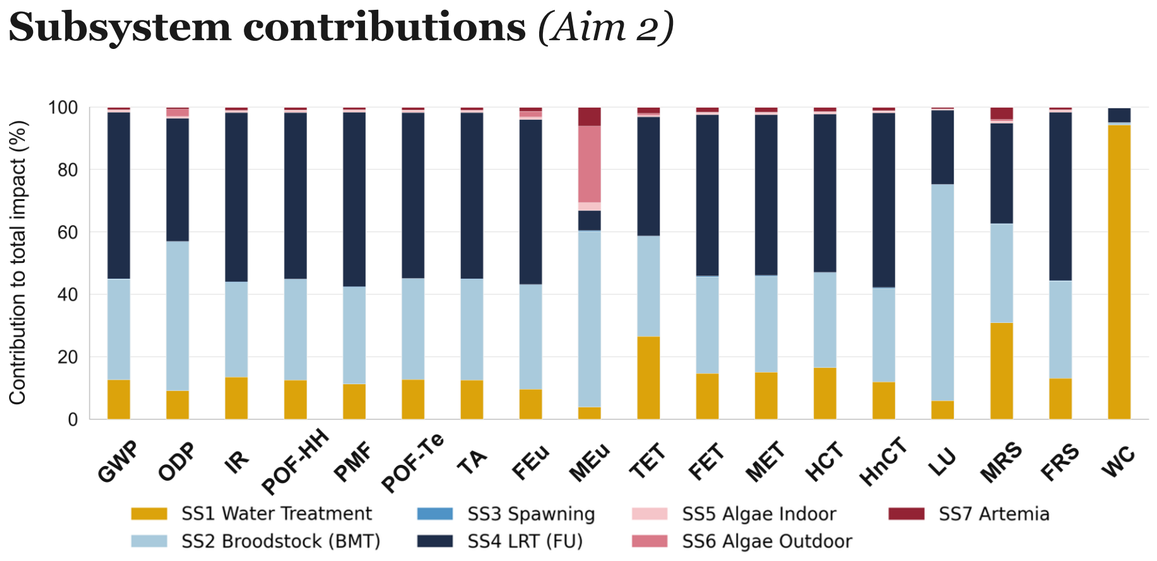
Characterisation of hatchery impact (*Aim 1)*



Characterisation of hatchery impact

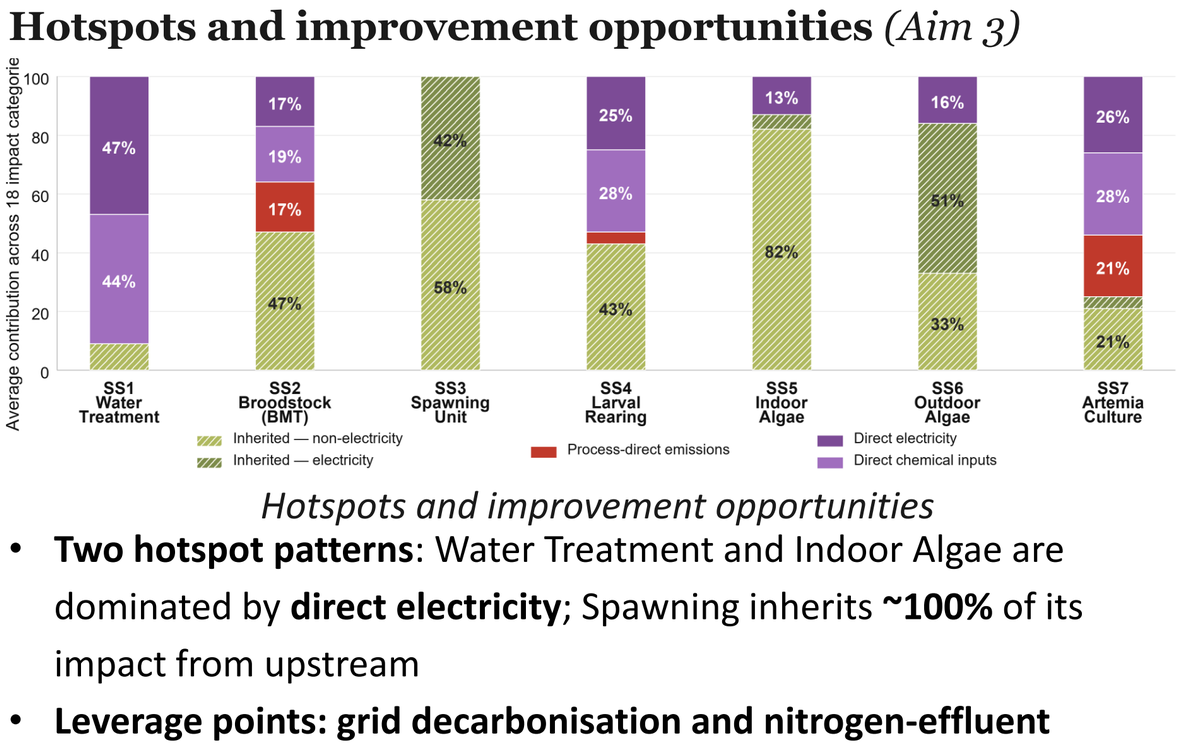
- **Impacts unevenly distributed across 18 categories;** no single category dominates the profile.
- **Marine eutrophication reaches ~51% of the supply-chain total** (Mayekar et al., 2025), showing the hatchery contribution is **not negligible** and contradicting the common assumption.

Subsystem contributions *(Aim 2)*



- **Broodstock and Larval Rearing dominate most categories**: early production stages drive the hatchery's overall environmental performance
- **Water Treatment drives water consumption (~94%)**
- **Indoor and Outdoor Algae drive marine eutrophication**.

Hotspots and improvement opportunities *(Aim 3)*



Hotspots and improvement opportunities

- **Two hotspot patterns**: Water Treatment and Indoor Algae are dominated by **direct electricity**; Spawning inherits **~100%** of its impact from upstream
- **Leverage points: grid decarbonisation and nitrogen-effluent treatment**. Targeted action on a few subsystems yields the largest reductions

Conclusions

1. **Fills a gap in shrimp hatchery LCA.** First subsystem-level LCA of a commercial shrimp hatchery built entirely on primary, on-site data.
2. **Subsystem hotspots.** Broodstock and Larval Rearing dominate most categories; Water Treatment drives water consumption; algae units drive marine eutrophication.
3. **Two cross-cutting drivers.** Most subsystem impacts trace back to inherited upstream burden and electricity use.

Hatcheries are not the small upstream step previously assumed. Decarbonising electricity and managing effluent are essential to lowering shrimp's footprint.

References

[1] Pazmiño, M. L., et al. (2025). Aquaculture and Fisheries, 10, 183–201.
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[3] FAO. (2024). The State of World Fisheries and Aquaculture 2024. FAO, Rome.
[4] Bohnes, F. A., et al. (2019). Reviews in Aquaculture, 11, 1061–1079.