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Sustainable Aquaculture Practices

Module 2: Fisheries and Aquaculture Sustainability

Duration: 1 Hour

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Content

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Introduction

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Over the past few decades, scientific advancements and technological innovations have played a critical role in transforming global food production systems. In particular, aquaculture has emerged as the fastest-growing food sector, driven by improvements in breeding, disease control, feed formulation, and farming techniques.

To respond to increasing global demand for seafood as wild fish stocks plateau due to overfishing and ecological limits.

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What is Aquaculture?

- Aquaculture is the *fastest-growing food sector* and continues to expand alongside terrestrial crop and livestock production.
- Aquaculture is the **breeding**, **rearing**, and **harvesting** of fish, shellfish, algae, and other organisms in *all types of water environments.*
- Aquaculture has the potential to support sustainability and resilience, *but only if managed to reduce environmental costs and resource dependency, meaning that it needs sustainability to avoid negative environmental impact*

Source: Troell et al., 2014.

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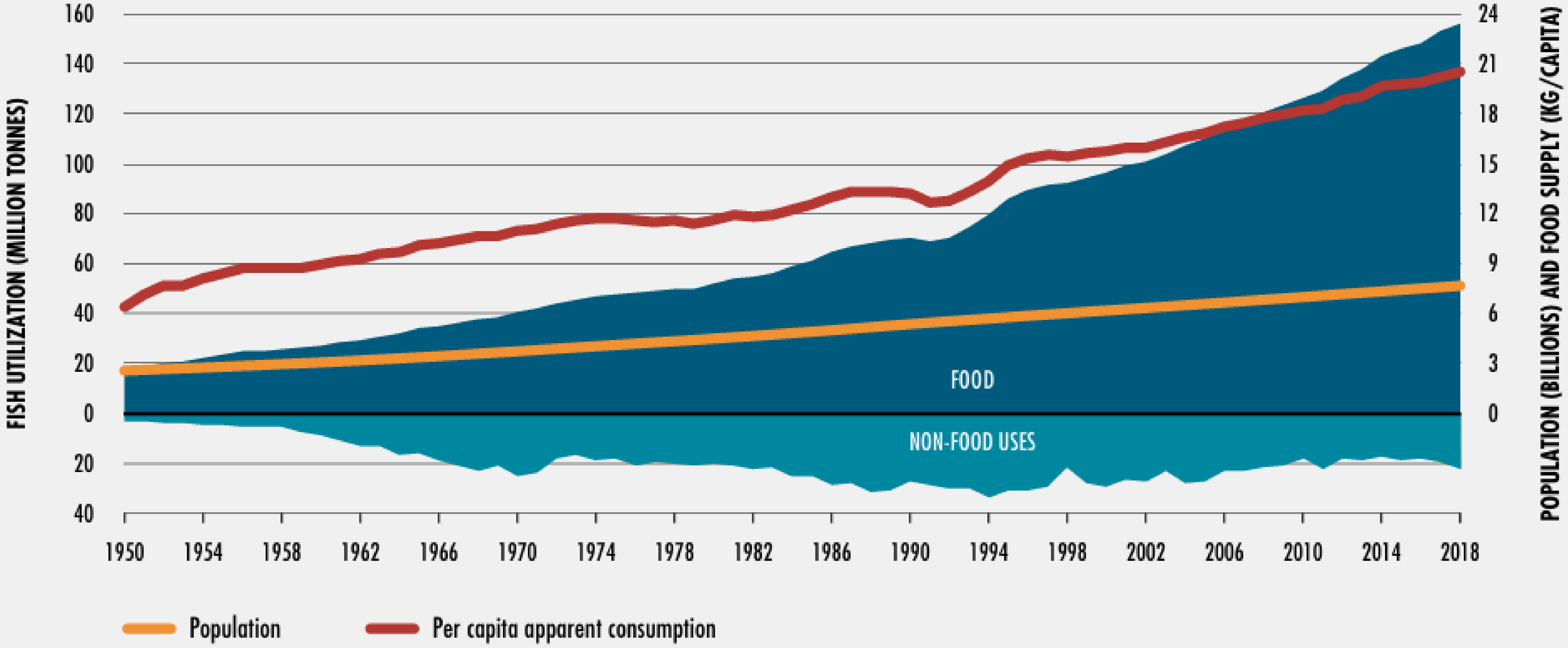
FIGURE 1 WORLD FISH UTILIZATION AND APPARENT CONSUMPTION



NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants.
SOURCE: FAO.

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TABLE 1 WORLD FISHERIES AND AQUACULTURE PRODUCTION, UTILIZATION AND TRADE

	1986–1995	1996–2005	2006–2015	2016	2017	2018
	Average per year					
	(million tonnes, live weight)					
Production						
Capture						
Inland	6.4	8.3	10.6	11.4	11.9	12.0
Marine	80.5	83.0	79.3	78.3	81.2	84.4
Total capture	**86.9**	**91.4**	**89.8**	**89.6**	**93.1**	**96.4**
Aquaculture						
Inland	8.6	19.8	36.8	48.0	49.6	51.3
Marine	6.3	14.4	22.8	28.5	30.0	30.8
Total aquaculture	**14.9**	**34.2**	**59.7**	**76.5**	**79.5**	**82.1**
Total world fisheries and aquaculture	**101.8**	**125.6**	**149.5**	**166.1**	**172.7**	**178.5**
Utilization[2]						
Human consumption	71.8	98.5	129.2	148.2	152.9	156.4
Non-food uses	29.9	27.1	20.3	17.9	19.7	22.2
Population (*billions*)[3]	5.4	6.2	7.0	7.5	7.5	7.6
Per capita apparent consumption (*kg*)	13.4	15.9	18.4	19.9	20.3	20.5
Trade						
Fish exports – in quantity	34.9	46.7	56.7	59.5	64.9	67.1
Share of exports in total production	*34.3%*	*37.2%*	*37.9%*	*35.8%*	*37.6%*	*37.6%*
Fish exports – in value (*USD billions*)	37.0	59.6	117.1	142.6	156.0	164.1

[1] Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants. Totals may not match due to rounding.
[2] Utilization data for 2014–2018 are provisional estimates.
[3] Source of population figures: UN DESA, 2019.

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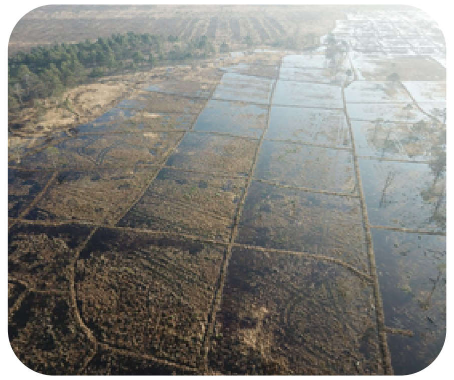
Source: FAO, 2020.

Environment Concern

Water pollution from effluent and feed waste

Disease transmission to wild stocks



Habitat destruction

Unsustainable feed

To meet the rising global demand for seafood, fish and shrimp farming have become increasingly reliant on intensive aquaculture techniques. These practices often involve crowding large numbers of animals in confined spaces, using formulated feeds, and applying various chemical treatments to boost growth and prevent disease. While such methods have significantly increased production efficiency, they also raise serious environmental and sustainability concerns.

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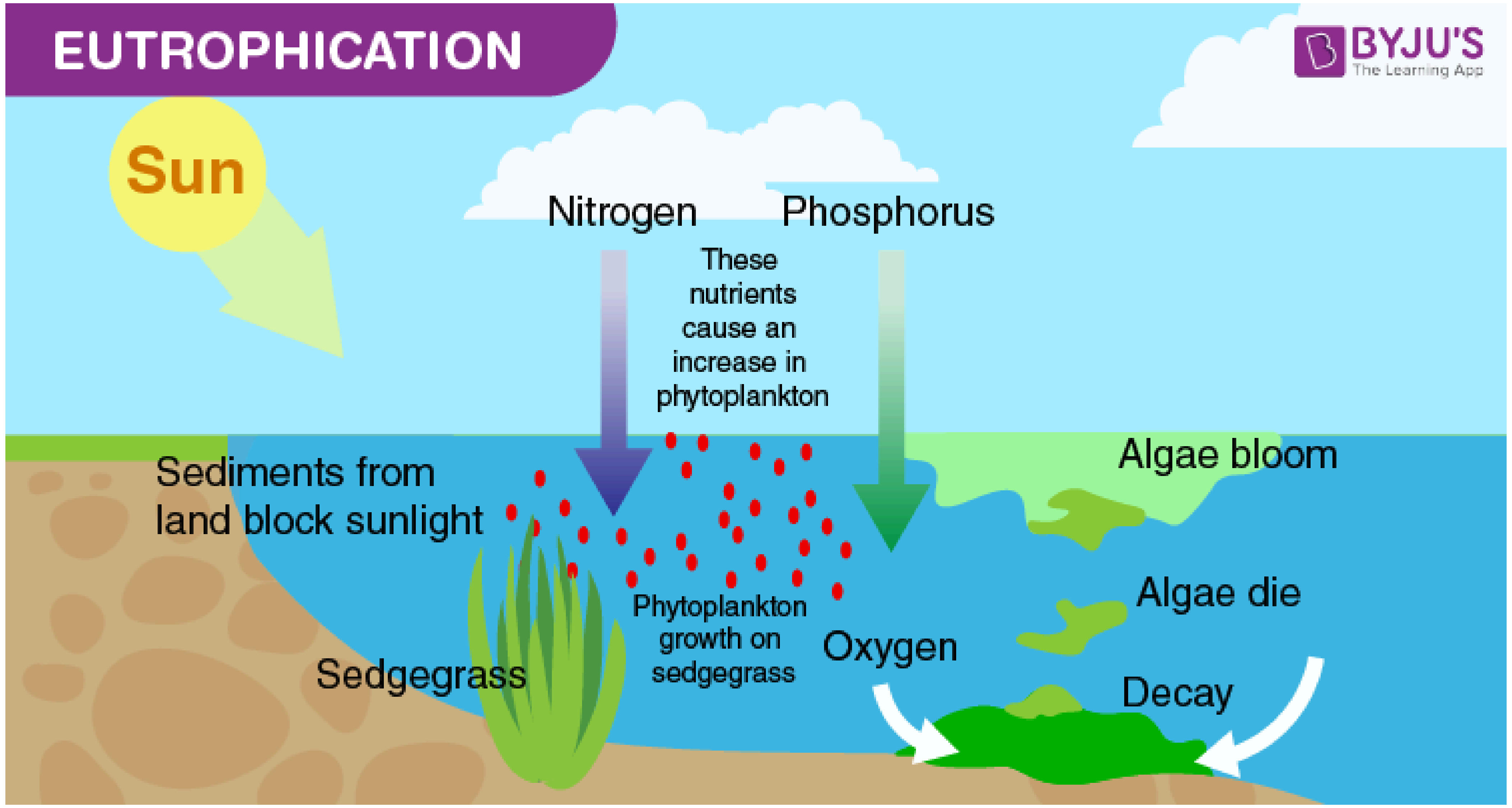
Water pollution from effluent and feed waste



Source: BYJU'S, n.d.

Overfeeding, uneaten feed, and excretions in intensive systems.

Excess nutrients (nitrogen, phosphorus) from waste enter surrounding water bodies.

Leads to eutrophication, oxygen depletion, and harmful algal blooms.

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Disease transmission to wild stocks

High-density farming and poor biosecurity

↓

Pathogens and parasites can spread from farmed species to nearby wild populations through water exchange.

↓

Increases disease risk and mortality in wild fish, reducing biodiversity and ecosystem stability.

Source: FAO, 2020 and Troell et al. (2014).

prevent

Picture from: Jayaprakashvel & Subramani, 2019.

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Habitat Destruction

Construction of shrimp ponds or fish cages in coastal zones.

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Mangroves and wetlands are cleared to make room for farming infrastructure.

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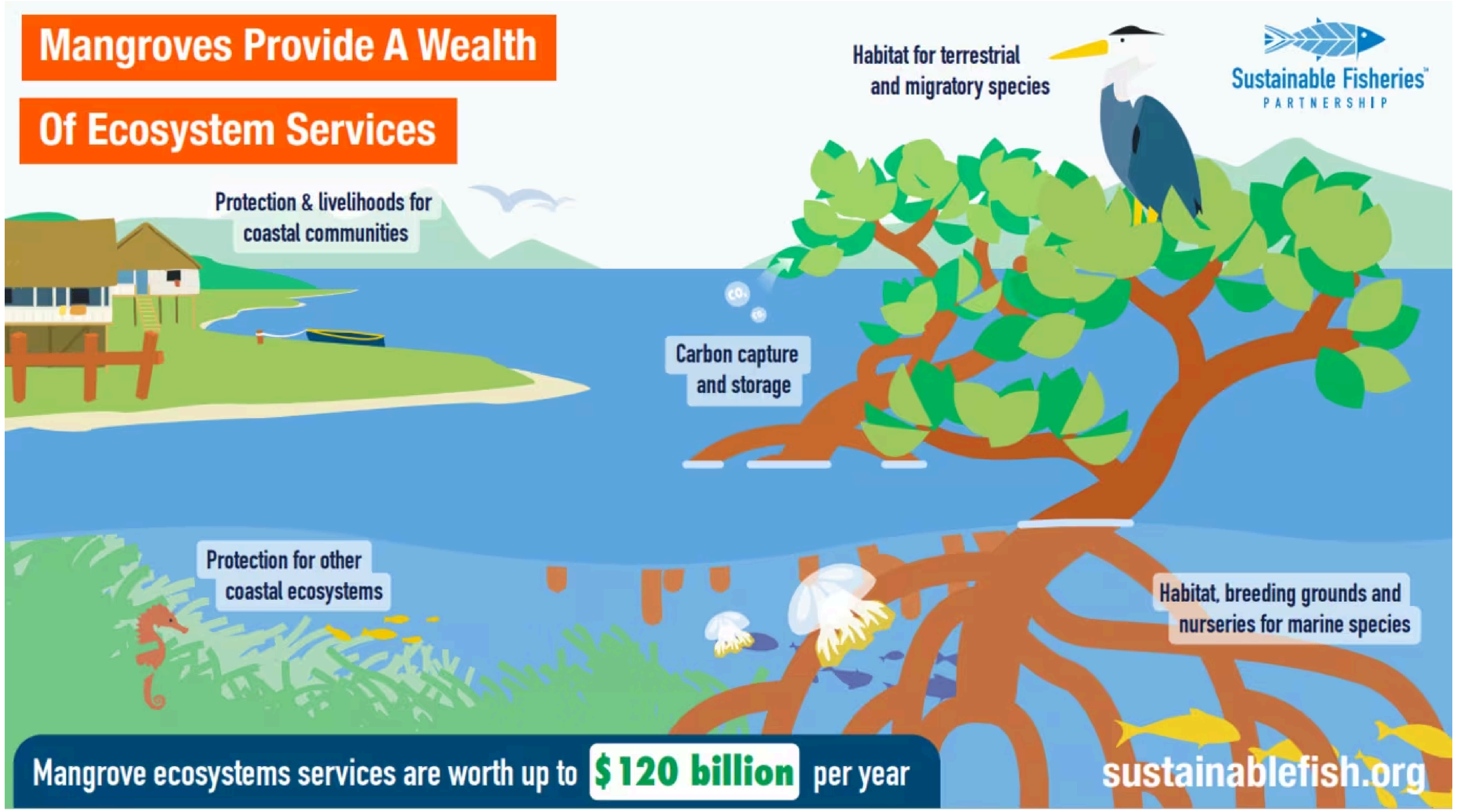
Loss of important habitats for fish, birds, and coastal protection; reduced biodiversity.



Picture from: https://thefishsite.com/articles/shrimp-farming-can-help-regenerate-mangroves

Source: FAO, n.d.

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Unsustainable feed

Source: Troell et al., 2014.

Aquaculture feed often contains fishmeal and fish oil made from wild-caught species like anchovies and sardines.

Reduction of fisheries harvests small pelagic fish to process into feed.

fishing pressure on wild stocks, threatening food security for communities relying on those species.

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Sustainable Practices

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- Aquaculture expansion must prioritize sustainability.
- Poor management can lead to pollution, habitat loss, and overuse of wild fish.
- Solutions include:

1) Integrated Multi-Trophic Aquaculture (IMTA)
2) Recirculating Aquaculture Systems (RAS)
3) Better feeds
4) Use of native species and optimal siting

- These practices protect ecosystems and support long-term productivity and food security.
- Sustainability ensures aquaculture benefits nutrition without harming the planet.

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1 What is IMTA?

- Integrated Multi-Trophic Aquaculture (IMTA) is a sustainable and innovative approach to aquaculture that involves cultivating multiple species of seafood in the same aquatic system.

Nutrient waste from monoculture systems (pollution and eutrophication)

Combines species at different trophic levels—e.g., fish, shellfish, and seaweed—so that waste from one species becomes input for another.

Reduces nutrient buildup and improves ecological balance in farming environments.

Source: Bamaniya et al., 2023.

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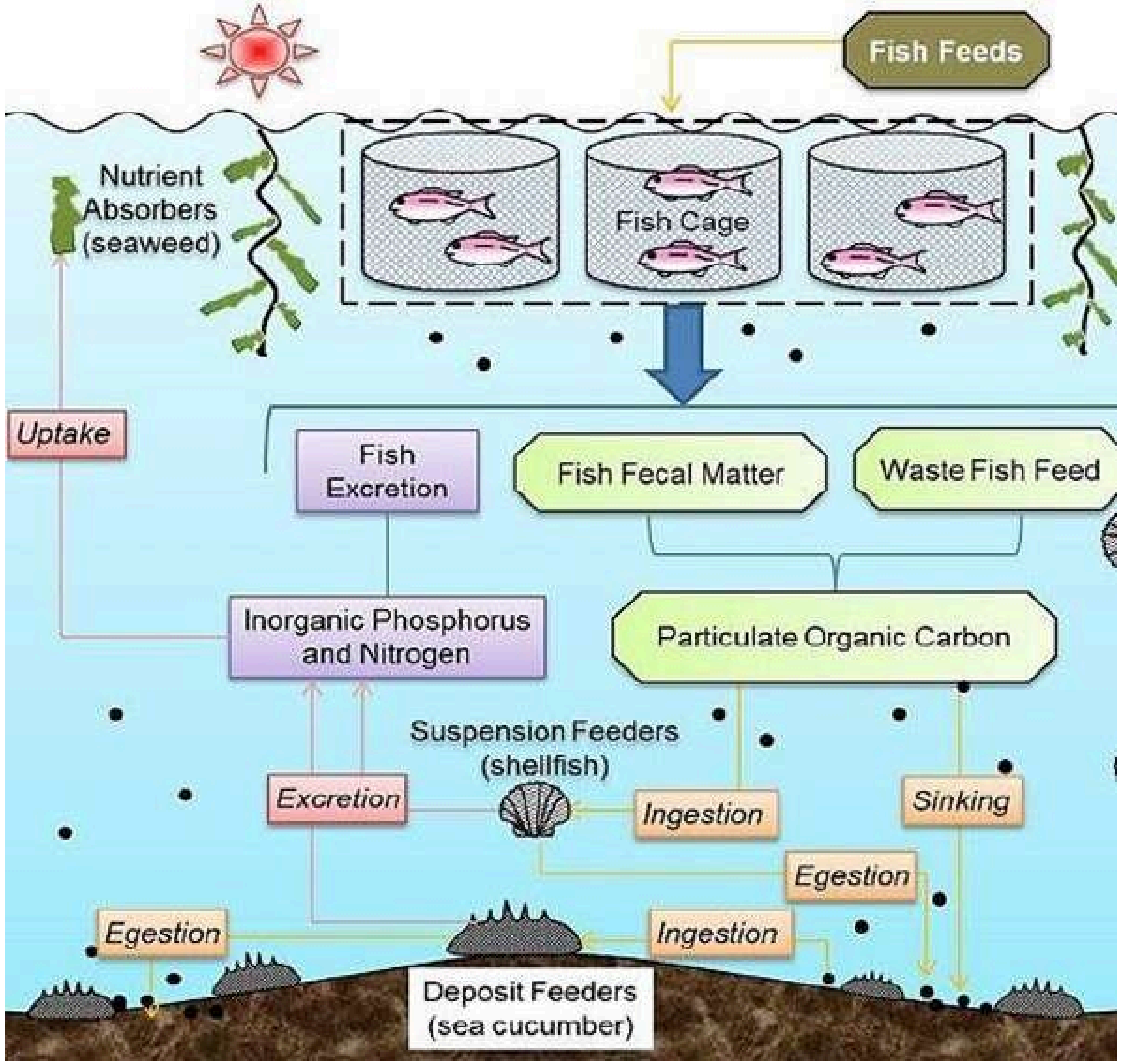
Integrated Multi-Trophic Aquaculture (IMTA)



Picture from: https://www.researchgate.net/publication/374449240_Integrated_Multi-Trophic_Aquaculture_System_IMTA

Source: Bamaniya et al., 2023.

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2

What is RAS?

- Recirculating Aquaculture Systems (RAS) are closed-loop aquaculture systems where water is filtered, treated, and reused within the facility instead of being continuously discharged.

Water pollution, disease spread, and land use

↓

Closed-loop systems where water is filtered and reused. Allows for control of waste, temperature, and pathogens.

↓

Minimizes environmental discharge, reduces antibiotic use, and can be sited inland.

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Source: Aquaculture ID, n.d.

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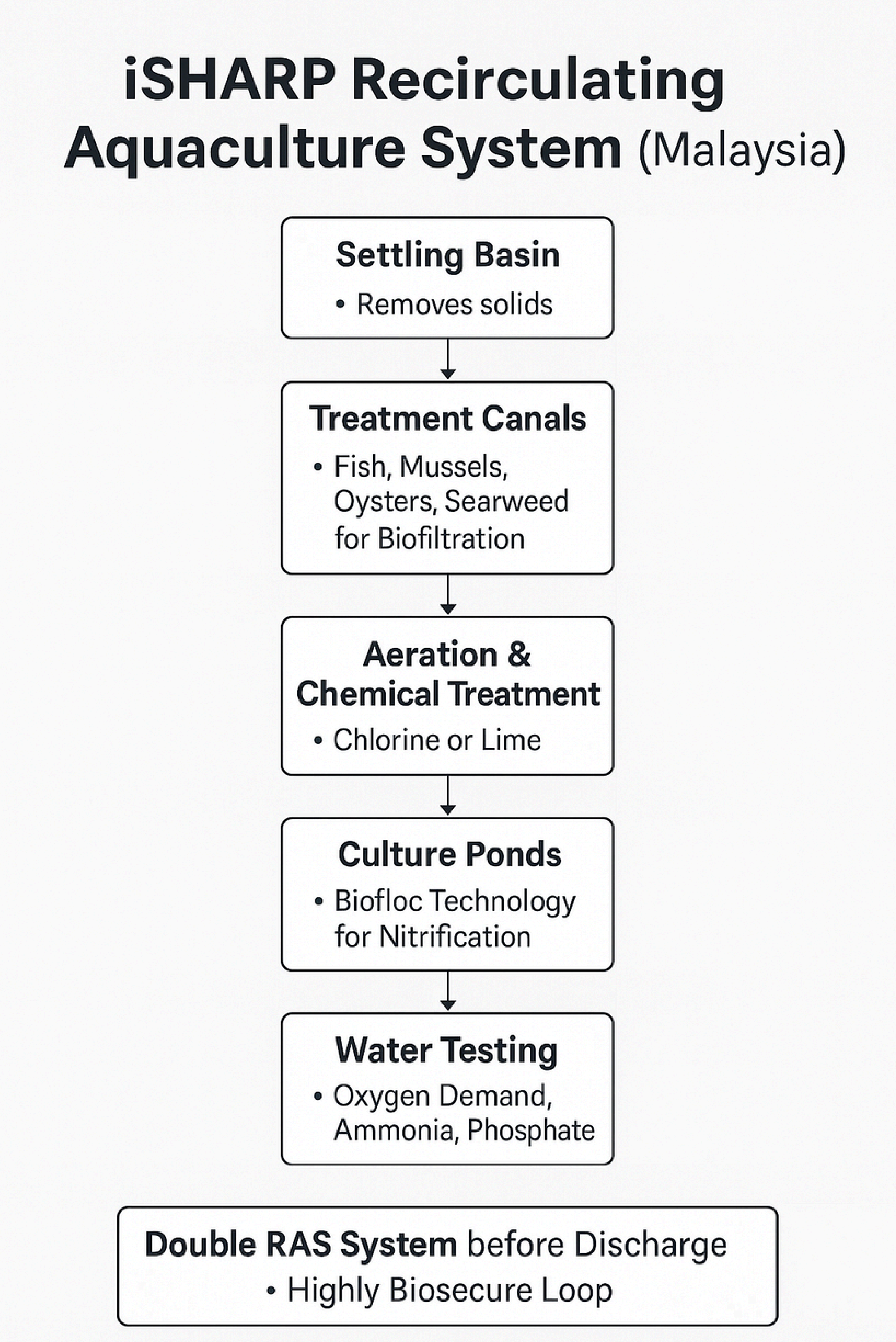
Case study: Recirculating aquaculture system (Malaysia)

- Initiated in 2011 as a response to the need for sustainable and biosecure shrimp farming, minimizing disease risk and environmental pollution.

System Design



Source: Taw, 2010

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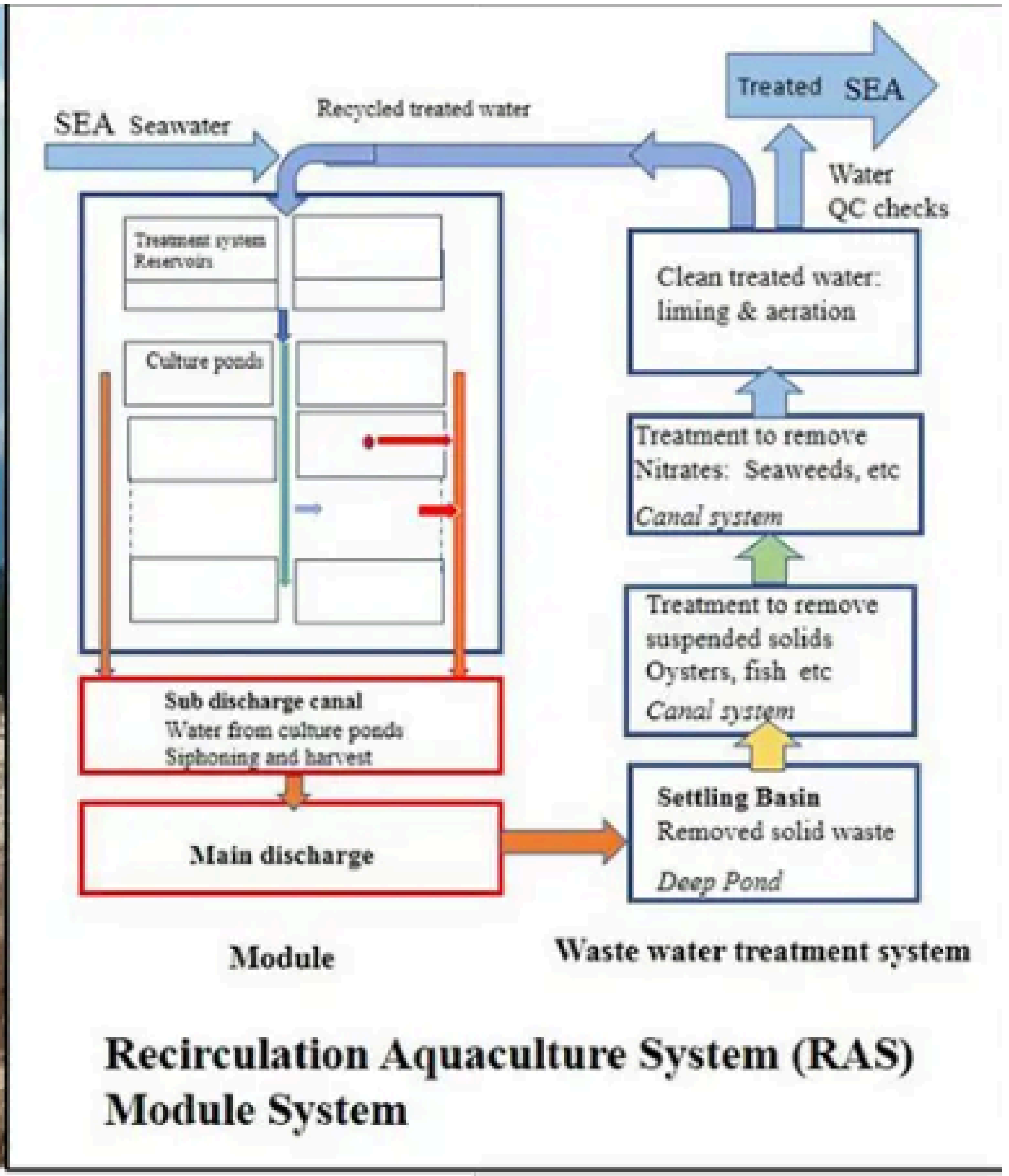

Fig. 6: View of the iSHARP Project RAS shrimp farm, Malaysia (Taw et al. 2013).

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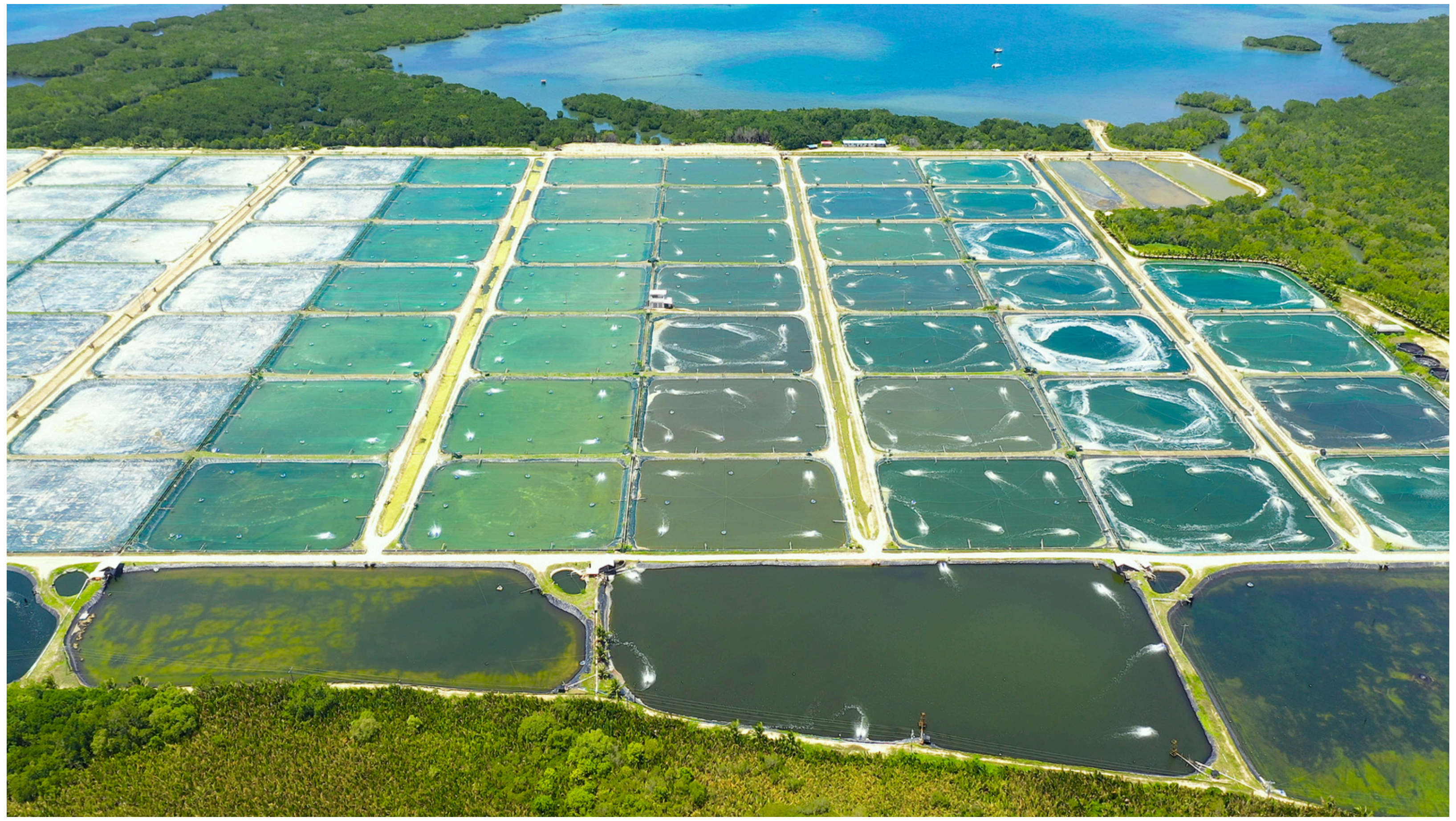
Source: Taw, 2010

Sustainable Practies

- The project is very fortunate to have the two systems (double RAS) combined to make the farm a more biosecure and sustainable shrimp facility than many other typical farms.
- The project started its first stocking in two modules in October 2011, and, since then, the farm has been operating without any reported incidents of shrimp diseases.



Source: Taw, 2010

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Sustainable Practies

3

Better feeds

- plant-based
- insect meal

"Increased use of terrestrial crops and the rise of alternative ingredients such as insect meals can help shift aquaculture towards sustainability." (Troell et al., 2014)

4

Use of native species and optimal siting

- Reduces the risk of ecological disruption if fish escape. They are also more likely to thrive in local environmental conditions.
- Using zoning tools, environmental impact assessments (EIA), and hydrological modeling to identify appropriate locations that minimize harm and conflict with other coastal users.

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Certification & Policy

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- One of the most effective tools developed to meet these expectations is certification schemes. These frameworks help regulate practices, monitor compliance, and inform both consumers and retailers about the sustainability of aquaculture products.

1. **Certification: Aquaculture Stewardship Council(ASC)**
2. **National aquaculture zoning and licensing**
3. **Monitoring and Environment Standard**
4. **Role of Consumer Choice In Sustainability**

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Activity

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Aquaculture Design Challenge

1. Design a sustainable shrimp or fish farm.
2. Consider: site, waste management, species choice.

Present your farm concept to class or forum.

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Summary

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Sustainable aquaculture helps meet protein demand.

Innovations and good practices reduce impacts.

Policy and certification ensure responsible development.

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