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PERSPECTIVE

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Keeping Southeast Asia Afloat: Restorative Aquaculture Key to its Food Resilience

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Seaweed farmers carry a load from a harvest at Nusa Beach on Indonesia's resort island of Bali on March 18, 2021. Picture: SONNY TUMBELAKA/AFP.

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EXECUTIVE SUMMARY

- Aquaculture is key to Southeast Asia's food security as the region contributes nearly one quarter of global seafood production. However, commercial aquaculture has often resulted in aquatic ecosystem degradation.

- Restorative aquaculture, particularly by growing seaweed and shellfish, promotes aquatic farming while having a rehabilitative impact on marine and estuarine ecosystems.

- There are opportunities in Southeast Asia to adopt restorative aquaculture, not only in rapidly declining fishery zones, but also in areas soon to feel the effects of rising sea levels.

- Policies to transition to climate resilient, restorative aquaculture include the promotion of environmental rehabilitation alongside fishery development, promoting collective action towards restorative aquaculture, facilitating investment, infrastructure, and R&D, adopting food safety and sustainability certification, and improving regional cooperation.

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INTRODUCTION: TRANSITIONING TO RESTORATIVE AQUACULTURE

Fish protein is a key source of nutrition in Southeast Asia. On average, Southeast Asians consume 39.4kg/person/year, almost double the global average of 20.3 kg/person/year (2017 data).[1]

Southeast Asia is also a major contributor in fishery production. It produces 22% of the world's products (approximately 46.2 million tonnes in 2020), contributing US$49 billion to the Southeast Asian economy.[2] Indonesia is the largest producer in the region (49.4%), followed by Vietnam (16.7%), and Myanmar (12.6%). [3]

Demand for fish is expected to increase by 15% between 2020 to 2030.[4] Yet, the fishing industry is facing strong headwinds and quantities have been stagnating or declining (see Table 1).

The last few decades of overfishing, in part due to illegal, unreported, and unregulated (IUU) fishing, has resulted in 64% of the fisheries resource base in Southeast Asia being at risk of collapse.[5] Furthermore, the sector faces challenges of ageing fisherfolk, concerns over animal welfare, harmful chemical use, disease, parasites, and concerns over microplastic and heavy metal contamination. This is further exacerbated by climate change effects such as sea-level rise, ocean warming, acidification, change in sea-wave phenomena, and greater salinity.

An Intergovernmental Panel for Climate Change report[6] has highlighted that Southeast Asia, along with Northeast Asia, will experience the largest declines in fish stocks as ocean warming forces fish to move pole-wards towards cooler seas.

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Table 1: Fisheries production and value, by country, in Southeast Asia between 2018-2020, to note that 2020 decline may be due to COVID movement control orders

	2018			2019			2020		
Country	Total Fisheries* (MT)	Value of total fisheries* (US$1000)	Aquaculture only (MT)	Total Fisheries* (MT)	Value of total fisheries* (US$1000)	Aquaculture only (MT)	Total Fisheries* (MT)	Value of total fisheries* (US$1000)	Aquaculture only (MT)
Brunei Darussalam	14,712	44,061	1,146	14,658	60,138	933	16,575	81,580	3,501
Cambodia	943,205	n.a.	254,050	969,098	n.a.	307,408	936,300	n.a.	400,400
Indonesia	23,007,392	30,956,499	15,769,272	22,614,595	31,061,751	15,548,167	21,834,105	25,212,814	14,845,015
Lao PDR	179,100	n.a.	108,200	183,900	n.a.	113,000	200,021	n.a.	130,020
Malaysia	1,672,447	3,575,048	217,381	1,872,797	3,612,485	411,782	1,788,940	3,249,624	400,017
Myanmar	5,877,460	7,122,904	1,130,350	5,931,815	9,683,528	1,082,065	6,013,781	9,759,669	1,140,878
Philippines	4,613,074	4,849,394	2,304,365	4,413,129	5,053,999	2,358,238	4,398,589	5,238,534	2,322,831
Singapore	7,011	53,652	5,702	7,249	44,204	5,831	5,179	30,059	4,823
Thailand	2,456,294	5,209,759	919,538	2,488,833	5,529,289	961,703	2,393,971	5,077,904	959,907
Vietnam	7,768,500	n.a.	4,161,800	8,270,200	n.a.	4,492,500	8,635,686	n.a.	4,739,186
Total	**46,539,195**	**51,811,317**	**24,871,804**	**46,766,274**	**55,045,395**	**25,281,627**	**46,223,147**	**48,650,184**	**24,946,578**

* Total fisheries include from marine fisheries, inland fisheries and aquaculture
(Source: SEAFDEC)[7]

Recognising this, some in the fisheries community and farmers have turned to aquaculture which has been growing faster than captured fisheries in the last few years, particularly in Brunei, Cambodia, Lao, Malaysia, Thailand and Vietnam. Yet commercial aquaculture practices have often had a deleterious impact on the health of marine and estuarine ecosystems, including water pollution, eutrophication, habitat degradation, harmful harvesting practices, impacts on wild fish stocks, and disease.[8] This in turn harms the long-term sustainability of the industry and food security of the region, unless the situation reverses.

One promising solution is restorative aquaculture, which can simultaneously improve the health of aquatic environments and ensure food security for the region. A transition to restorative aquaculture is key to food and livelihood security for the hundreds of millions living along Southeast Asian coastlines.

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RESTORATIVE AQUACULTURE AND ITS BENEFITS

Aquaculture refers to cultivation of marine organisms. It can be carried out in netted environments or controlled environments, such as in ponds, tanks and open areas, for the purpose of food, pharmaceuticals and other products.

Aquaculture is already considered comparatively more environmentally sustainable[9] – it contributes only a tenth of the greenhouse gases (GHG) released, if measured against rearing terrestrial livestock farming.[10] Current estimates of annual emissions from global aquaculture are ~245-385 million metric tonnes (MT) of carbon dioxide equivalent (CO_2e) compared to 4-6 billion MT of CO_2e a year from livestock.[11] It is considered one type of climate resilient agriculture (CSA) – which achieves the three foundational pillars of CSA – boosting productivity, enhancing resilience, and lowering GHG.

Aquaculture becomes *restorative* when it contributes to ecological and environment health. The Nature Conservancy, a non-governmental organisation promoting climate action and conserving biodiversity, defines restorative aquaculture as occurring "when commercial or subsistence aquaculture provides direct ecological benefits to the environment, with the potential to generate net positive environmental outcomes."[12] It is one of the solutions under the umbrella of Nature-Based Solutions.

Among marine organisms, studies have found that seaweed and bivalves in particular, improve nearshore water quality and habitats.[13, 14] When combined with finfish production, it can result in the improved health of fish and production.[15] This has been proven in at least one study in northern Vietnam, when Tilapia, shrimp and seaweed were combined[16] Other marine organisms with restorative potential include sea cucumbers, sponges, snails, abalone, and sea squirts; these have been found to play important environmental roles in natural ecosystems and could provide restorative benefits in farmed settings.[17]

A summary of the benefits offered by seaweed and bivalves is described in the table below:

	Environmental benefits	Carbon contributions	End products[18]
Seaweed	• Provides refuge for juvenile fish and invertebrates, and promotes greater biodiversity when designed to enhance nature[19] • Biofiltration function removes nutrients (nitrogen, phosphorous and others) via uptake in tissues and cells • Moderate ocean acidification[20] • Co-culture with salmon and other finfish can reduce eutrophication risk[21]	• If biomass is sunken into deep sea, carbon is sequestered (if harvested, carbon is released up the value chain). Potential sequestration of 0.05 to 0.29 Gt of CO_2e annually, similar to restoring all the world's mangroves[22] • red macroalgae *Asparagopsis spp* in feed reduces methane from cattle.[23] • Does not require feed inputs therefore no GHG emissions	• Food/proteins (carrageenan, agar, iodine) • Pharmaceuticals • Animal feed • Biochar • Biofertiliser (*Chlorella vulgaris)* • Biofuels (biogas, biomethane) • Bioplastics
Bivalves	• Provides refuge for juvenile fish and invertebrates, and promotes greater biodiversity when designed to enhance nature[24] • Bivalve faeces act as fertiliser to enhance seagrass growth[25] • Absorbs nitrogen and phosphorus [26] • Filtration of organic and particulate matter to improve water clarity (mussels can filter 25 litres of seawater per day)[27] • Lowers likelihood of eutrophication[28]	• Can sequester carbon in shells, but due to respiration are net carbon emitters[29] • can improve environments for health of blue carbon habitats. [30] • When co-cultured with seaweed, it can be net carbon sink[31]	• Food/ proteins • Pharmaceuticals • Shells can be pulverised for building material

POTENTIAL FOR RESTORATIVE AQUACULTURE IN SOUTHEAST ASIA

Southeast Asia has 173,000 km of coastline[32] and has been identified as amongst the regions that have high opportunities for restorative aquaculture due to the need for rehabilitation.[33] According to the Nature Conservancy, all of Southeast Asia's seas has opportunity for restorative aquaculture, and those with higher opportunity to rehabilitate based on current levels of degradation and future risk[34] include the seas surrounding the Philippines, the Malacca Straits, and the coasts of northern Vietnam, and opportunity to rehabilitate.

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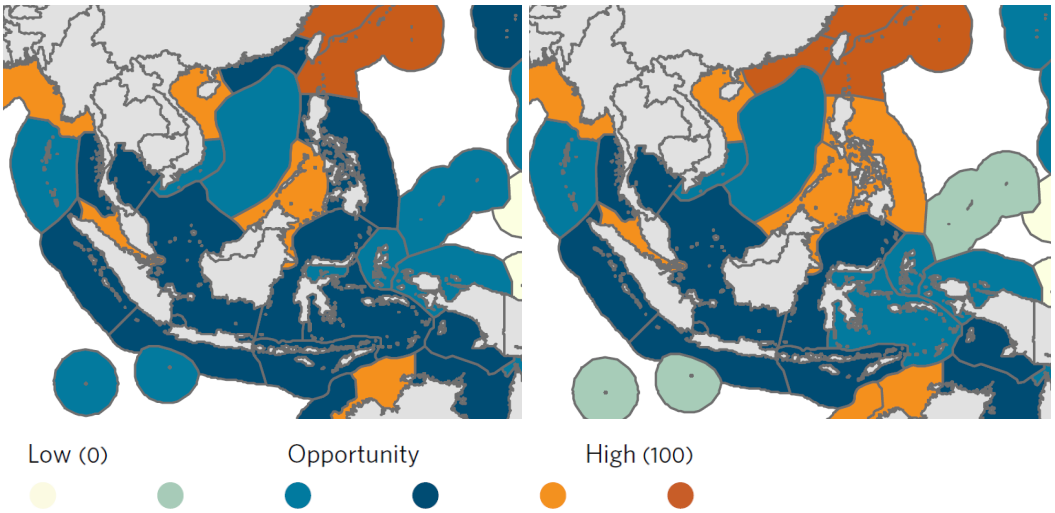

Figure 1: Nature Conservancy's assessment of Restorative Aquaculture Opportunity Index for Seaweed (left) and Shellfish (right)[35] (© The Nature Conservancy based on research by Theuerkauf et al, CC BY 4.0 licence)[36]

Due to the benefits of restorative aquaculture, it should also be prioritised in areas experiencing localised effects of climate change. For example, increased dissolved CO_2 will cause ocean pH to reduce by an average of 0.4-0.5, affecting fish embryo and larvae development.[37,38] Studies in the US, China and Chile have shown that seaweed can reduce acidity in surrounding waters and moderate ocean acidification, thus improving fish reproduction success. [39, 40, 41]

Furthermore, restorative aquaculture can be adopted by farmers facing submergence of farmland as a result of sea-level rise. Some of the key regions in Southeast Asia facing severe sea-level rise are the deltas of the Mekong River (near Ho Chi Minh City), Red River (near Hanoi), Chao Phraya River (near Bangkok), Yangon River (near Yangon), Barito River (in South Kalimantan), and the Selangor coastline (near Kuala Lumpur) (see maps below). Seaweed and bivalves can potentially soak up the inevitable contaminants released as urban land, farmland and infrastructure are submerged.

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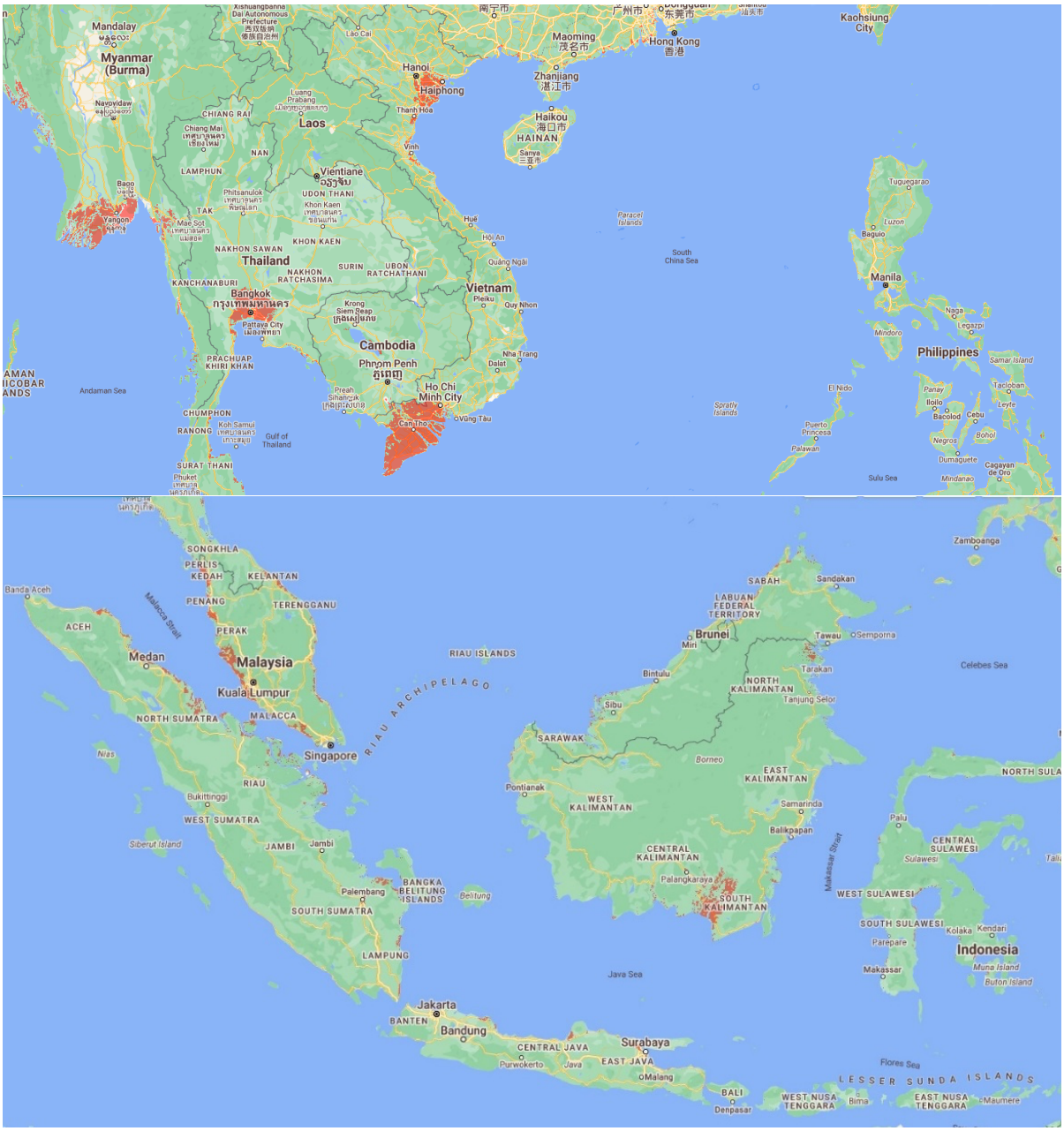

Figure 2: Major regions (shown in red) projected to be below annual flood level in 2050, based on IPCC 2021 report that may benefit from restorative aquaculture practices (Source: Climate Central)[42]

Restorative aquaculture is potentially a market-based solution. Seaweed alone is a US$16.7 billion industry globally, and 98% of it is already farmed in Asia.[43] Initial costs and set up barriers, however, can be substantial. The key to successful restorative aquaculture is understanding the ecosystem enough to create localised solutions. Each site may require unique design and implementation strategies. Fortunately, with its long history in farming of seaweed and shellfish, Southeast Asia's fishery communities, particularly within indigenous communities, may hold localised resource management experience and expertise. Institutionalising this knowledge and expanding it to a science-based approach would require

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facilitative policies, structures and capital support by governments, the civil sector, the private sector or the carbon markets.

KEY RECOMMENDATIONS TO ENHANCE RESTORATIVE AQUACULTURE

While restorative aquaculture practices have the potential to ameliorate or even reverse the ecological and biodiversity damage, more experience is needed to realize its projected benefits. The dividends from success, however, has the potential to reduce the number of livelihoods detrimentally affected by environmental degradation and climate impacts in coastal areas, while contributing to local, regional and global food security.

Some policies that can propel the region to reap the benefits of restorative aquaculture include:

1) *Promotion of environmental rehabilitation alongside food production in the fishery sector.*

The fishery sector's development is a major development area for Southeast Asian nations. However, environmental rehabilitation policies are often carried out by different government departments. Integrated government departments need to shift focus from solely reducing the negative impacts and environmental risk management, to one that promotes environmental net benefits that can not only support lowering carbon emission goals, but also improving the health of aquatic environments. Combining food production with environmental rehabilitation would also identify and address the barriers and uncertainty in regulatory frameworks and guidelines. Aquaculture practices should also be paired with adequately resourced monitoring, management and enforcement programmes.

2) Promotion of collective action on restorative aquaculture through partnerships with multilevel stakeholders.

The sheer scale of the fishery problem in Southeast Asia necessitates the engagement and collective action of all stakeholders including communities (particularly indigenous communities), private, public, and civil sectors, and regional institutions. Public institutions could work together with communities and environmental organisations to develop the science, monitoring approaches and tools to measure and prove the benefits from restorative aquaculture. Investment could be made into sensors, technology and tools that can assist in the data collection and monitoring needs that can reduce the regulatory costs of newly growing aquaculture sector. Once known, clear and effective communication must be fostered among stakeholders on relevant tools and practices that can expand restorative aquaculture.

Furthermore, collaborative and in-field capacity building programmes would also build confidence in participants to adopt new solutions and help finetune management and monitoring practices. These need to be inclusive of women, who already play important roles in the processing phase (drying, packaging) of the aquaculture industry.[44] Such programmes can also promote solutions that reduce loss and waste.

3) Facilitate investment, infrastructure and R&D into restorative aquaculture interventions

Evidence of the economic and environmental value of restorative aquaculture is still in development. Proof depends on experimentation, having access to data, expert analysis, monitoring, and further solutions development. This requires investment in trials, research, and technology, which could be undertaken by the public sector, research institutions, the private sector (for example, through accelerator programmes and incubators). Carbon markets are an additional source of capital when combined with blue carbon projects, such as mangrove or seagrass rehabilitation initiatives.

Beyond establishing new programmes, support and extension services could contribute to success. Localised climate-smart and resilient seeding facilities, breeding programmes, hatcheries, disease management facilities, biorefineries or cold chain facilities are some enabling infrastructures that could significantly reduce the risk and cost of setting up and scaling up restorative aquaculture programmes.

4) Adoption of food safety and sustainability certification

Certification and labelling are key to distinguishing products resulting from restorative aquaculture practices from others, especially from fisheries resulting from IUU. Certification should not only be made available for food products, but also non-edible products such as for biofertiliser, biofuel etc. Without this, few are incentivised to adopt what may seem to be more onerous and risky restorative aquaculture practices.

Meeting the requirements for certification is often out of the reach of the millions of smallholders in the sector. It requires fees, access to facilities such as sensors and laboratories, and third-party assistance to facilitate the process. Public agencies and other stakeholders could invest in the technology and tools to assist in data collection and ameliorate costs and encourage greater participation for certification and monitoring.

5) Shore up regional cooperation on restorative aquaculture.

Southeast Asia has longstanding agreements and frameworks for protection of coastal and marine environments through the Association of Southeast Asian Nations (ASEAN), its working groups and its technical centres. The ASEAN Working Group on the Coastal and Marine Environment (AWGCME), the ASEAN Sectoral Working Group on Fisheries (ASWGFi), the ASEAN Centre for Biodiversity and the Southeast Asian Fisheries Development Centre (SEAFDEC) are among the crucial platforms and institutions promoting the sustainable management, conservation and economic development of the marine and fishery sector.

The policy frameworks that are associated with restorative aquaculture include the Regional Code of Conducts on Responsible Fisheries (RCCRF), the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN region Towards 2020, and the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region. Currently, the ASWGFi has been tasked to develop a common fisheries policy, named the ASEAN General Fisheries Policy (AGFP). It would be ideal if the AGFP could also adopt

principles, frameworks and targets to promote restorative aquaculture to achieve region-wide cumulative benefits.

Southeast Asia has among the most biodiverse marine habitats on the planet. [45] With dedicated action, Southeast Asian nations could lead the way to identification of beneficial marine species to contribute to the global field of restorative aquaculture. However, time is short. Recent IPCC reports has reinforced that our marine biodiversity and its habitats are in rapid decline. [46] Rehabilitative actions are urgently needed to stay its degradation, and restorative aquaculture is one of the foremost tools for doing so.

Restorative aquaculture is not only an economic option that can support the millions reliant on fisheries for their livelihoods, in the long term it is also a more sustainable food-secure option. To do so requires not only dedicated efforts of governments individually and collaboratively throughout Southeast Asia, but also collaboration and engagement at all segments of the value chain. Only then can we keep the fishery sector afloat, through the rising tides ahead.

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