

A circular illustration depicting various aspects of aquaculture. At the top, a worker in a blue shirt and yellow apron tends to a conveyor belt of small fish. Above this, two orange cylindrical tanks with blue grates and digital displays are shown. To the right, a worker in an orange shirt and dark apron is preparing food in a bowl. At the bottom center, a worker in a white lab coat and orange gloves holds a test tube. Below the lab coat worker, a yellow building with solar panels sits on a platform, with two circular fish pens containing white fish. In the bottom left, a diver in a blue and orange suit is swimming. The entire scene is surrounded by stylized blue fish, coral, and seaweed. The title 'SINGAPORE AQUACULTURE PLAN' is centered in a white cloud-like shape.

SINGAPORE AQUACULTURE PLAN

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FOREWORD

Singapore's quest for food security is an important one. As a country that imports more than 90% of our food, Singapore is particularly vulnerable to global food supply chain disruptions caused by various factors such as disease outbreaks and geopolitical tensions. While import source diversification remains the cornerstone of our food security strategy, the volatility of global food supply chains today underscores the importance of having a local production buffer – serving as a form of insurance during food supply disruptions.

It has not been an easy journey for our agri-food sector despite some initial successes. It has faced developmental delays during the COVID-19 pandemic and strong headwinds due to inflationary pressures and higher costs. Global agri-tech companies have also not been spared from the challenging financing and investment environment. These macro conditions exacerbate the existing challenges that our aquaculture sector faces such as space and infrastructure limitations, the need to mitigate its environmental impact, and a limited domestic market with strong import competition. Nonetheless, aquaculture holds great potential for Singapore's food security needs, and we should harness the potential of becoming a leading research and innovation hub for sustainable tropical aquaculture.

The Singapore Aquaculture Plan (SAP) aims to address how the aquaculture industry can be transformed into a more productive and sustainable sector.



The path for this transformation is undergirded by several guiding principles. We will carefully consider competing sea space uses and ecological sensitivities when selecting sites, and root our approach in outcome- and science-based sustainable production methods. We will support industry growth through developing essential infrastructure, adopting progressive regulations, and leveraging science and technology. Throughout this process, we will emphasise collaboration across the ecosystem to foster innovative solutions.



For example, we are exploring potential sites in the Southern Waters for further studies on integrating closed containment aquaculture systems (CCAS) with open net cage systems for a new hybrid model for farming. CCAS represent a significant advancement in sustainable aquaculture by mitigating environmental risks to both the fishes and surrounding environment, while balancing cost considerations. By identifying suitable locations for hybrid models, we aim to optimise space utilisation, and enhance the productivity and sustainability of our aquaculture industry.

We are also strengthening the entire aquaculture value chain through the National Broodstock Centre, and Hatchery Development and Recognition Programme. This science and technology driven initiative aims to boost the local supply of genetically superior eggs and fingerlings – an important upstream input that significantly influences factors such as growth rates, disease resistance, and overall yield of aquaculture production. By fostering collaboration between research institutions, hatcheries, and farms, this initiative will reduce our dependence on imported upstream inputs, address key operational expenditures, and position Singapore as a potential exporter of high-quality aquaculture inputs in the region.

This paper presents a blueprint for the future of aquaculture in Singapore, designed to guide various stakeholders towards sustainable growth and a resilient food future for our nation. It is the result of extensive engagement with a broad spectrum of stakeholders including industry, researchers, nature groups, and Government agencies. Through open and collaborative discussions, we have identified innovative approaches to balance sustainability with productivity. These discussions have also been crucial in shaping our collective vision for the future of Singapore's aquaculture sector.

Let us continue to work together to build an aquaculture sector that is both productive and sustainable, ensuring our food security for generations to come.

Dr Koh Poh Koon

Senior Minister of State,
Ministry of Sustainability and the Environment,
Ministry of Manpower

EXECUTIVE SUMMARY

Objectives and Approach

The Singapore Aquaculture Plan (SAP) aims to develop the capability and capacity of Singapore's aquaculture industry to ensure sustainable and productive local seafood production. The SAP was developed through extensive stakeholder engagement via workshops, field trips, and overseas study visits to learn from global best practices and operational challenges.

State of Global and Singapore's Aquaculture Industry

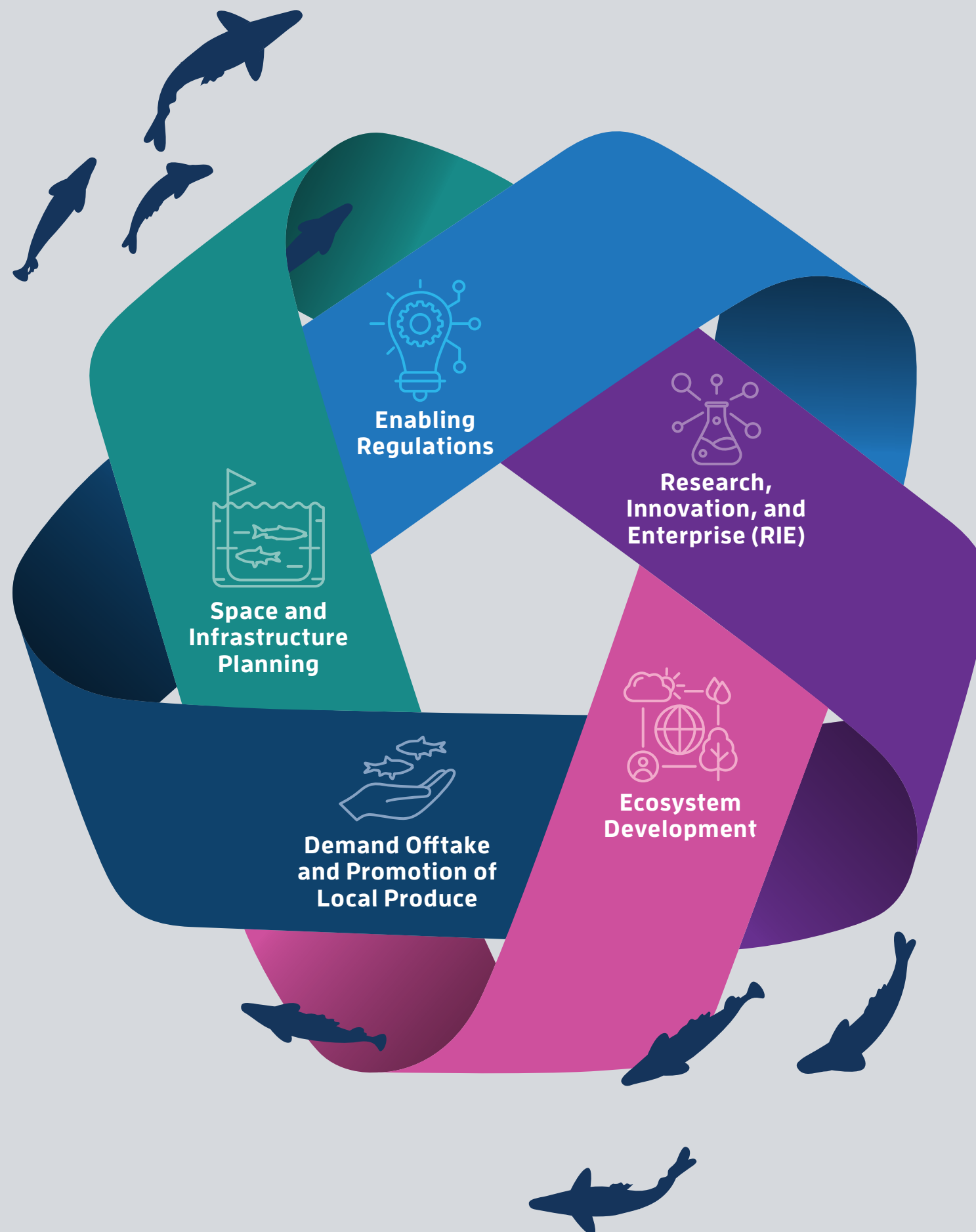
The 2022 global aquaculture production was valued at USD 313 billion. Aquaculture production is expected to grow rapidly and reach 111 million tonnes by 2032, representing a 17% increase compared to 2022. The industry is facing several key drivers of change, including climate change, more complex trade dynamics, increasing importance of sustainable farming practices and technological innovations. Southeast Asia, with key producers like Indonesia and Vietnam, contributes significantly to global aquaculture production.

Singapore's aquaculture industry is small, comprising 98 sea-based and 33 land-based seafood farms in 2023. It faces several challenges including limited sea space, suboptimal water quality, demands to mitigate its impact on the environment, and a limited domestic market with strong import competition.

To address the above challenges, the industry is increasingly adopting innovative and sustainable methods, while keeping to a mix of production systems that are suited to Singapore's unique constraints.

Strategic Pillars

To uplift the sector to its full potential, the SAP is structured around five pillars:



Space and Infrastructure Planning: Past efforts have included reviewing potential aquaculture sites, considering ecological sensitivity and multi-use planning. We will improve the robustness of site studies to ensure optimal site selection and develop key infrastructure, focusing on sustainable energy solutions and shared facilities to support aquaculture operations.

Enabling Regulations: Past efforts have fostered sector growth through longer leases that encourage farm investments in productivity and eco-friendly practices, while ensuring environmental stewardship through consults with technical agencies and environmental studies. We will continue refining regulations to be more outcome- and science-based. These evolved guidelines will support innovation while ensuring sustainability and simplify regulatory processes to facilitate industry growth.

Research, Innovation, and Enterprise (RIE): Leveraging the capabilities and solutions developed in the Marine Aquaculture Centre, the Singapore Food Story Research and Development Programme and AquaPolis, the industry has started to innovate and undertake collaborative research initiatives. To further enable technology translation, we will improve the access to intellect property from research programmes to local farms and launch the AquaPolis Industry Consortium Platform to strengthen research-industry partnership.

Ecosystem Development: Past efforts have focused on developing local talent, enhancing disease prevention, establishing good practice standards, providing financial support for farms' capability development, and fostering collaboration among stakeholders. We will continue to grow local champions, and foster partnerships, especially with technology firms, international aquaculture leaders, and the talent pipeline from institutes of higher learning. Additionally, we will establish a National Broodstock Centre, and Hatchery Development and Recognition Programme to boost the local supply of genetically superior eggs and fingerlings, given their significant impact on overall yield, particularly through improved growth rates and disease resistance.

Demand Offtake and Promotion of Local Produce: Efforts have been made to promote local aquaculture products through consumer education campaigns and partnerships with retailers and Food & Beverage establishments. We will continue our efforts to engage the public and key stakeholders, while refining our marketing and promotional strategies to boost demand for locally produced aquaculture goods.

OBJECTIVE OF PAPER AND APPROACH

OBJECTIVE

Singapore imports more than 90% of its food, which makes us vulnerable to food supply disruptions that may arise due to factors like climate change, geopolitics, and disease outbreaks. Alongside source diversification and stockpiling, local production enhances Singapore's food security by mitigating the impact of overseas supply disruptions. Consequently, building the capability and capacity of our agri-food industry for local production will contribute to our food security.

Seafood, being a nutritious source of protein that can be produced locally, presents a viable solution for food security. Therefore, we are working to transform our aquaculture sector to become a world leader in sustainable and productive urban tropical aquaculture.

The Singapore Aquaculture Plan (SAP) is a collaborative effort of the Singapore Food Agency (SFA) and key stakeholders to establish a comprehensive blueprint for the future of aquaculture in Singapore. It is designed to be a "living" document, providing guidance to stakeholders including industry players, researchers, Government agencies, nature groups, and consumers. The Plan will be regularly revised to ensure alignment with industry advancements and to facilitate ongoing coordination among stakeholders.

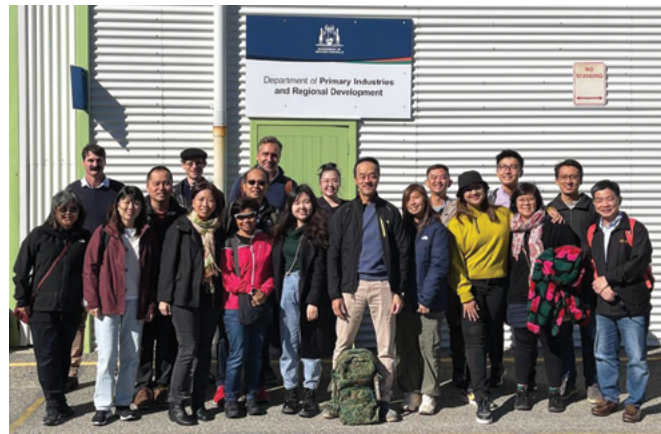
APPROACH

In developing the SAP, stakeholders were engaged in a series of meetings and workshops focusing on current regulations, principles of sea space planning, and global aquaculture trends. These engagements helped to foster collaboration and generate strategies for sustainable and productive aquaculture practices.

Some stakeholders also had the opportunity to attend overseas trips and farm visits to gain firsthand insights into the best practices of thriving aquaculture ecosystems, while understanding ground realities and operational challenges. Key visits included:

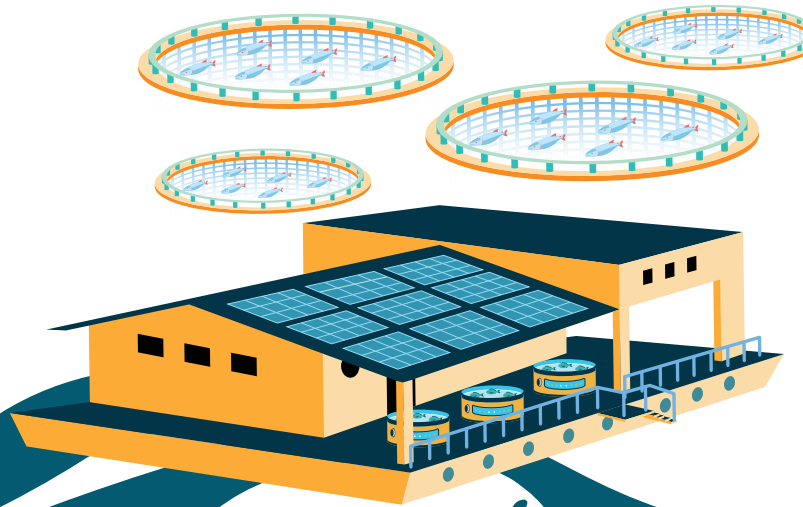
June 2023

Senior Minister of State Dr Koh Poh Koon led an aquaculture study trip to Australia with a delegation comprising representatives from Government agencies, industry, researchers, nature groups, and media. The objectives were to learn about South and Western Australia's regulatory practices and partnerships between the government, industry, and researchers in the development of sustainable aquaculture, and facilitate sharing of ideas across stakeholders.



February 2024

Representatives from Government agencies, industry and nature groups, visited Singapore Aquaculture Technologies, a sea-based barge farm, to better understand closed containment aquaculture system operations. Discussions centred around sustainable power, mitigative technologies, and disease monitoring with predictive diagnosis.



May 2024

Senior Minister of State Dr Koh Poh Koon led a trip to Hainan and Guangdong. The delegation, comprising representatives from Government agencies and industry, visited leading global aquaculture companies such as Haid Group, fishery industrial parks, universities, and research institutions. The visit involved engaging with industry executives and researchers about their efforts in selective breeding, hatchery technology, fish nutrition, and disease control. Additionally, the delegation learned how an integrated and supportive ecosystem such as the provision of superior fingerlings, fish health solutions, centralised facilities, and demand-supply aggregation services, contributed to enhancing the aquaculture sector in China.



OVERVIEW OF THE INTERNATIONAL AQUACULTURE INDUSTRY

(GLOBAL AND SOUTHEAST ASIA)



1 This refers to most farmed species of finfish, crustaceans, molluscs, other aquatic animals and aquatic plants. It excludes crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges).

2 This refers to data on aquatic animals. It excludes crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.

3 Food and Agriculture Organisation of the United Nations. (2024). The State of World Fisheries and Aquaculture 2024: Towards Blue Transformation. Rome, FAO.

GLOBAL AQUACULTURE INDUSTRY

The global aquaculture industry, which focuses on the cultivation of aquatic species¹ excluding wild-caught species, has seen remarkable growth. A significant milestone was achieved in 2022 when global aquaculture production surpassed wild-caught fish production for the first time.

The 2022 global aquaculture production was valued at

USD 313 billion.

Aquaculture production is expected to grow rapidly and reach

111 million tonnes by 2032, representing a

17% increase compared to 2022.

There are currently 731 species farmed worldwide, with whiteleg shrimp as the top species. The top 3 aquaculture producers² are China, India, Indonesia, at approximately 56%, 11%, 6% of the global total, respectively, in 2022³.



The industry is facing several key drivers of change, including climate change, more complex trade dynamics, increasing importance of sustainable farming practices and technological innovations.

Climate change

Climate change is increasingly recognised as a critical challenge to aquaculture, affecting the industry's productivity, sustainability, and long-term viability. Rising sea temperatures, ocean acidification, and extreme weather events are altering marine ecosystems and affecting marine species health, reproduction, and growth rates. Warmer waters can disrupt the optimal temperature ranges for farmed species, and lead to diseases and harmful algal blooms, which threaten both stock and economic stability.

Trade Dynamics

Geopolitical dynamics and the COVID-19 pandemic have exposed the vulnerabilities in aquaculture supply chains, causing disruptions and price volatility. Trade restrictions, conflicts, and pandemic-related workforce shortages have delayed shipments of essential inputs, driving up costs. In response, many countries, including Singapore, are prioritising localised production to build more resilient food systems.

Increasing importance of sustainable farming practices

The increasing need for environmental, social, and governance standards, ethical practices, and transparency in aquaculture is driven by growing consumer demand and concerns over environmental degradation, antibiotic use, and labour issues. Certifications such as the Aquaculture Stewardship Council (ASC) are gaining more recognition, with ASC-certified farms growing by 20% globally in 2021⁴. As consumers and businesses prioritise sustainability, adopting certified and responsible farming methods has become essential for the future of the aquaculture industry.

Technological innovations

Technological innovations are transforming aquaculture, with many farms already adopting advanced solutions for water quality management. Some studies show that these technologies can boost yield by 10-15% and reduce feed costs by 20-30%, driving both efficiency and sustainability⁵. The aquaculture technology sector is projected to exceed \$5 billion globally by 2030, signalling its rise as an industry⁶. A key development is the growing relevance of recirculating aquaculture systems and closed containment aquaculture systems, which optimise water usage, reduce environmental impacts, and improve biosecurity, making them a vital component of the future of sustainable aquaculture. While further research and development (R&D), and commercialisation is needed to make these systems cost-effective, they hold significant potential to enhance the sustainability of aquaculture.

4 Outram, R. (2023). ASC reports 20% increase in certified sites. Fish Farmer Magazine. Retrieved from <https://www.fishfarmermagazine.com/2022/11/01/asc-reports-20-increase-in-certified-sites/>

5 Obiero, K.O., Waidbacher, H., Nyawanda, B.O., et al. (2019). Predicting uptake of aquaculture technologies among smallholder fish farmers in Kenya. Aquaculture International, 27, 1689-1707.

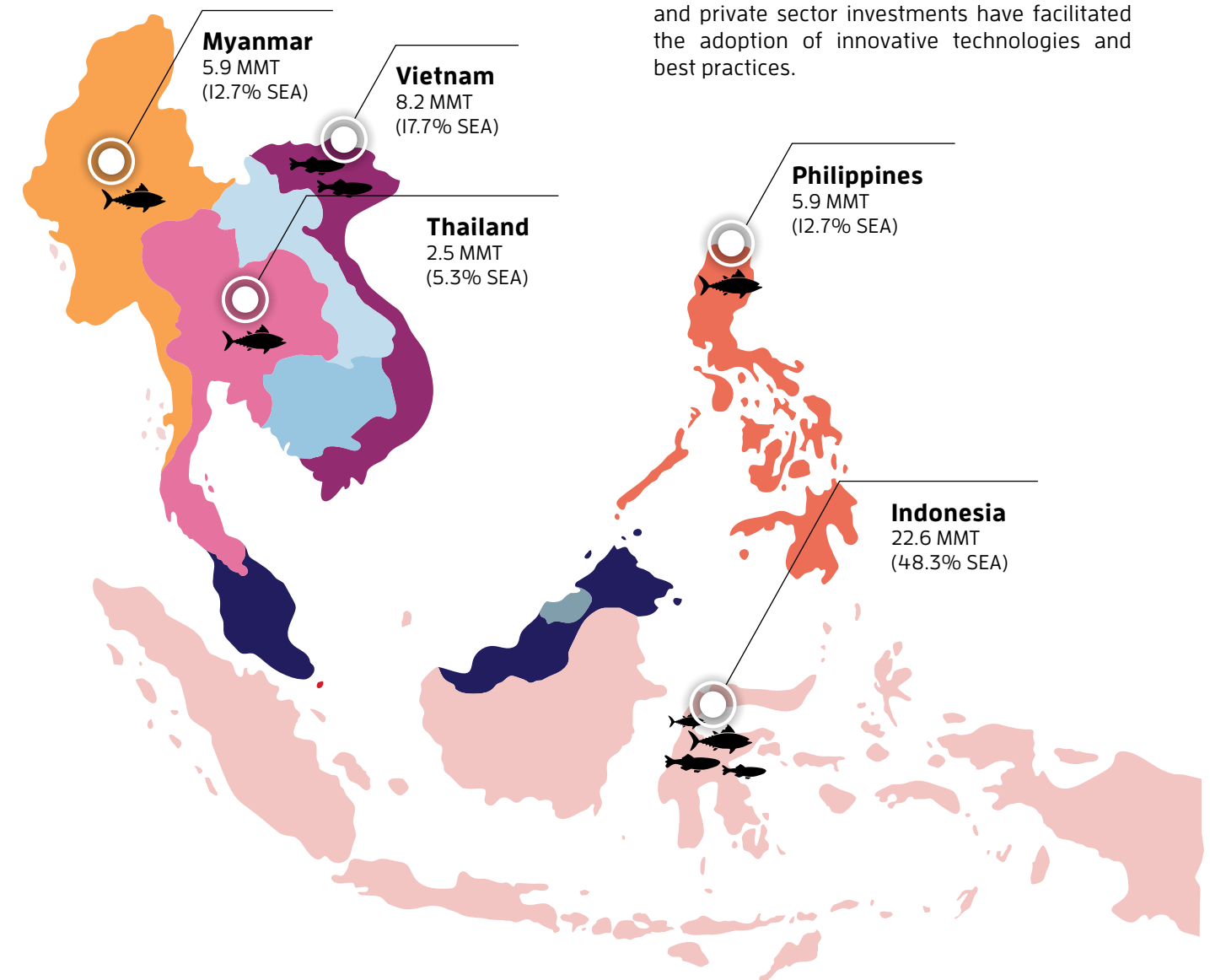
6 Global Market Insights. (2024). Aquaculture Equipment Market Size - By Equipment Type, By Application, By End Use & Forecast, 2024 - 2032. Retrieved from <https://www.gminsights.com/industry-analysis/aquaculture-equipment-market>

SOUTHEAST ASIA

The aquaculture industry in Southeast Asia is a significant contributor to global aquaculture production. Growth is projected to reach USD 107.3 billion by 2028, with a compound annual growth rate of 6.23%. This is almost double the output compared to 2018. Several countries in Southeast Asia are key players in the global aquaculture market. Notably, Indonesia, Vietnam, Myanmar, Philippines and Thailand (ranked in order of production) are among

the top 15 aquaculture-producing countries worldwide. Species farmed in Southeast Asia differ by region, but the top species across the area include tilapia, shrimp, pangasius catfish, and various carp species⁷.

The growth of aquaculture in Southeast Asia is supported by several factors, including government policies, international trade agreements, and investment in R&D. Governments in the region have implemented various initiatives to promote sustainable aquaculture practices, improve infrastructure, and enhance the competitiveness of their aquaculture industries. Additionally, collaborations with international organisations and private sector investments have facilitated the adoption of innovative technologies and best practices.



Aquaculture market of Southeast Asia. Figures reported are from 2019. Source: The Southeast Asian State of Fisheries and Aquaculture (SEASOFIA) 2022.

7 SEAFDEC. "Southeast Asian State of Fisheries and Aquaculture 2017." Southeast Asian Fisheries Development Center (2017): 167.

SINGAPORE'S AQUACULTURE INDUSTRY

Singapore's aquaculture industry is small in comparison to the global and regional scales, producing only 0.005% of global supply. Nonetheless, aquaculture has the potential to be more efficient and sustainable than traditional land-based protein sources, as it generally requires less space and can achieve a higher feed conversion ratio⁸. Furthermore, Singapore benefits from a vibrant technology and research and development ecosystem, which supports the development of innovative aquaculture solutions.

In 2023, Singapore had 98 sea-based seafood farms, and 33 land-based seafood farms⁹ producing 4,100 metric tonnes of seafood a year and contributing to 7% of our total local seafood consumption. Our sea-based farms cultivate tropical fish species, such as tilapia, barramundi, red snapper and grouper, to meet local demand.

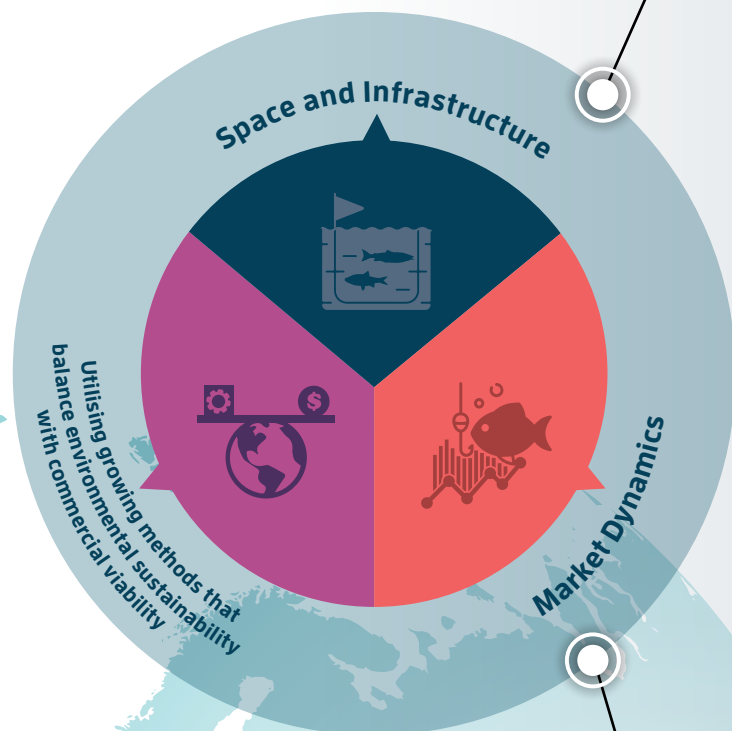


⁸ Ytrestøyl, T., Åsgård, T., & Håstein, T. (2018). Feed conversion efficiency in aquaculture: Do we measure it correctly? and Food Forward NDCs. (2023). Implementing Sustainable Aquaculture Management Systems.

⁹ Food and Agriculture Organisation of the United Nations. (2024). The State of World Fisheries and Aquaculture 2024: Towards Blue Transformation. Rome, FAO., and Singapore Food Agency. (2023). Singapore Food Statistics 2023. Singapore, SFA. The FAO report states that global aquaculture production of aquatic animals (without aquatic plants) was ~87.5 million tonnes in 2022.

KEY CHALLENGES

The aquaculture industry in Singapore, while promising, faces several key challenges that must be addressed to achieve our aspirations. They revolve around space and infrastructure, utilising growing methods that balance environmental sustainability with commercial viability, and market dynamics.



Space and Infrastructure

Singapore's dense population and limited geographic area result in a scarcity of land and sea space for aquaculture operations. This scarcity creates a significant hurdle in expanding aquaculture activities. Additionally, the available space is often subject to competing uses, such as coastal protection, shipping lanes, recreational activities, and conservation areas. Identifying and allocating appropriate sites for aquaculture requires meticulous planning and extensive stakeholder engagement.

Significant time and resources will also need to be invested to fully develop supporting infrastructure for sea-based farms. This includes electricity supply, and shared facilities such as sub-stations and waste management systems. Implementing shared facilities for sea-based farms presents greater challenges due to scattered locations and competing uses for sea space. These limitations can impede the growth and efficiency of sea-based farms.

Energy cost is a critical factor in the viability of sea-based farms. Access to reliable power is essential for farm operations, even though the overall demand is relatively low compared to other sea space uses. This low demand limits the feasibility of conventional energy solutions due to the high capital expenditure and maintenance costs involved, particularly if subsea cables are required for grid connection to a substation on the mainland. Non-intermittent and cheaper energy will also enable the use of more sustainable solutions such as closed containment aquaculture systems (CCAS) and recirculating aquaculture systems (RAS).

Utilising growing methods that balance environmental sustainability with commercial viability

Balancing environmental sustainability with commercial viability in Singapore's aquaculture sector presents significant challenges, particularly with limited coastal space and the presence of sensitive marine ecosystems. In addition, rising sea temperatures from climate change could also increase the risk of harmful algal blooms, which results in suboptimal water quality conditions for aquaculture. Unsustainable farming practices, such as the use of feeds that are unstable and pollutive, also exacerbate issues like water pollution and the degradation of site productivity. Hence, it is important that farms judiciously adopt appropriate production technology and husbandry practices to ensure an optimum balance.

Market Dynamics

With more than 90% of its food being imported, Singapore's local aquaculture producers face a significant market challenge. The domestic market for locally farmed seafood is relatively small, and local producers must compete with imported seafood, which is often cheaper due to factors such as economies of scale and lower production costs. To thrive, local producers must differentiate their products and create demand among consumers. This includes emphasising the freshness, quality, and sustainability of locally farmed seafood.

STATE OF PLAY: NAVIGATING AQUACULTURE IN SINGAPORE

To address the above challenges, the industry is increasingly adopting innovative and sustainable methods, while keeping to a mix of production systems that are suited to Singapore's unique constraints.

CCAS, envisioned to be the future of aquaculture, offers innovative solutions to increase productivity while safeguarding the environment. By controlling water quality and recycling water, CCAS ensures that fishes are protected from external environmental risks such as harmful algal blooms—an increasing concern due to climate change. These systems also allow for farming in areas that were previously unsuitable due to proximity to sensitive environmental zones, thus optimising sea space use while adhering to sustainability principles. Despite these benefits, CCAS comes with higher energy demands and significant capital expenditure. The adoption of CCAS is costly, and scaling this nascent but critical solution will require time, investment, and technological advancement.

While CCAS matures, traditional **open net cage farming systems** still play a significant role in Singapore's aquaculture landscape. Many farms with such systems continue to operate at a modest scale, contributing to local seafood supply. Some of these traditional farms are

also upgrading their practices to become **progressive open net cage systems**, moving away from the use of unstable and pollutive feeds such as confectionary waste towards more sustainable options like pelleted feed. Some farms are also exploring a **hybrid model, combining the benefits of both CCAS and open net cage farming systems**. Farms are also venturing into using superior upstream inputs and integrating downstream processing, which helps increase their productivity and market competitiveness.

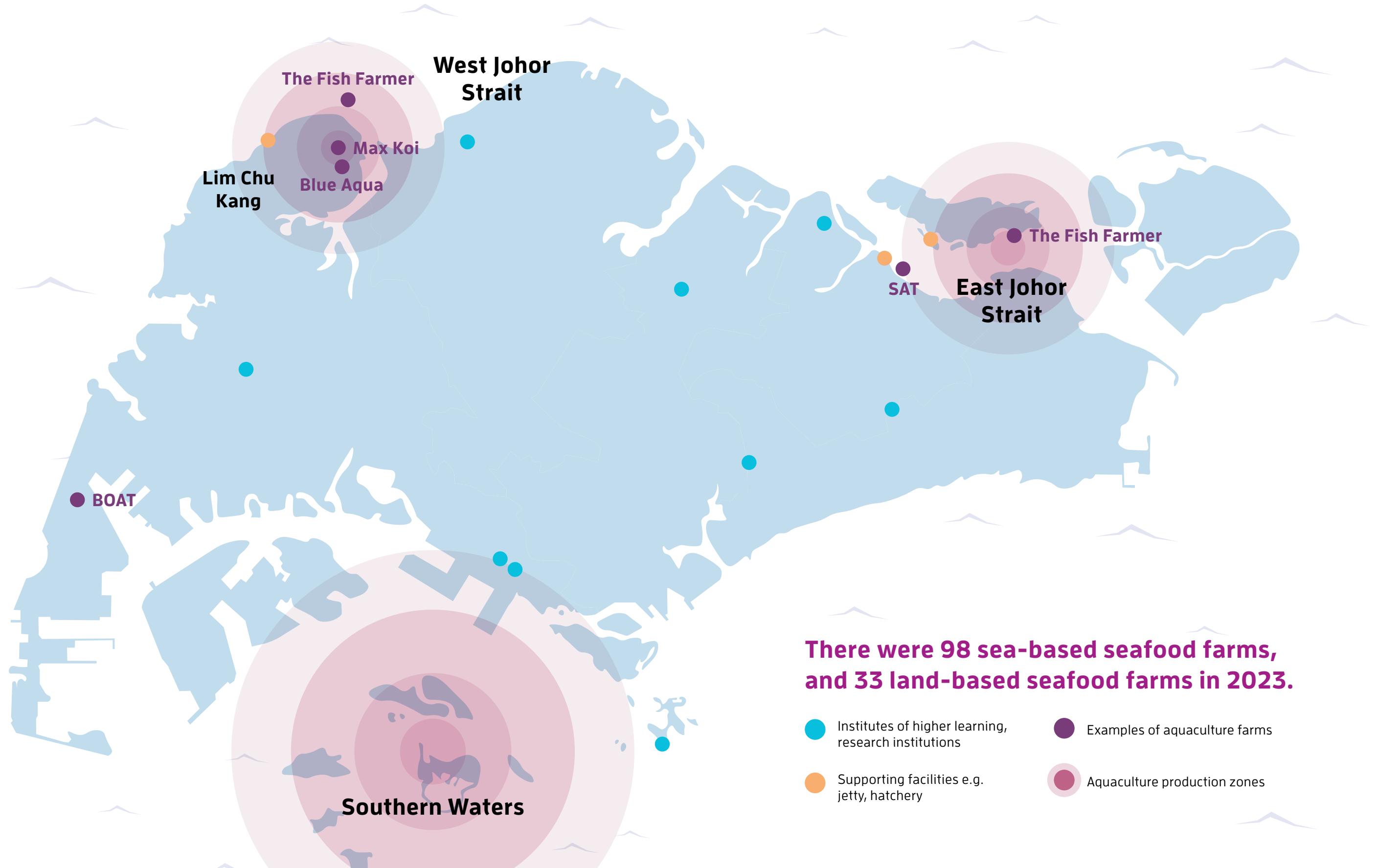
On land, **RAS** is gaining traction. RAS allows for controlled environment farming, where species that thrive in temperate climates – unsuitable for Singapore's tropical waters – can now be cultivated.

Ultimately, the adoption of a mix of production methods—ranging from traditional open net cages to advanced CCAS and land-based RAS—allows Singapore's aquaculture sector to grow sustainably while addressing the unique challenges of space, costs, and environmental concerns. As the sector continues to evolve, a focus on innovation, infrastructure development, and sustainability will be critical in ensuring that Singapore's aquaculture industry remains competitive and resilient in the face of future challenges.



Vertically integrated recirculating aquaculture system at the Blue Ocean Aquaculture Technology (BOAT) farm.

Overview of Aquaculture in Singapore



Here are some facts about some of our aquaculture farms

SEA-BASED FARMS



Singapore Aquaculture Technologies (SAT)

- Operates four sea-based farms in the East Johor Strait, producing barramundi and red snapper, with a production capacity of 500 tonnes annually.
- Uses CCAS with automated data collection, analytics, and AI - employing floating recirculating systems to avoid direct contact with seawater, minimising environmental risks. Transitioning to carbon-neutral operations using solar energy, with a focus on near-zero waste and circularity.
- Sells to hotels, restaurants under their retail branding 'BluCurrent'.



The Fish Farmer (TFF)

- Operates four sea-based farms off Lim Chu Kang and Changi, producing barramundi, golden pomfret, grey mullet, milkfish, and red snapper, with up to 1,000 tonnes of fish production annually.
- Utilises AI-based fish counting, Internet of Things (IoT) for dissolved oxygen, and solar energy to optimise production.
- Sells ready-to-cook fish fillets and soup via major supermarkets, online stores, and restaurants.

LAND-BASED FARMS

BLUE AQUA

Blue Aqua International

- Operates a land-based farm, producing shrimp, in Lim Chu Kang and plans to establish Singapore's first fully integrated land-based RAS trout farm, capable of producing up to 3,000 tonnes annually.
- The shrimp farm uses the patented Mixotrophic system to optimise water use and minimise waste.
- Sells products through their online retail store "Nature's Hug" to restaurants and supermarkets.



Max Aquaculture

- Operates a land-based farm in Lim Chu Kang, producing groupers and tilapia.
- Utilises RAS to reduce water usage and operates a two-storey hatchery for fingerling production. Also uses solar panels for renewable energy.
- Supplies via traders to hotels and restaurants.



Blue Ocean Aquaculture Technology (BOAT)

- Operates a land-based fish farm in Tuas, producing jade perch and grouper.
- Uses a vertically integrated RAS with CCTV, Internet-of-Things sensors, and nano-bubble technology to optimise space, treat water, and create oxygen-rich environments.
- Certified HALAL and ISO, with a co-located food processing facility producing fish noodles, fish bone collagen soup, and ready-to-eat grouper. Supplies to hotels, restaurants, and their online retail store "FINbyBOAT."

FIVE PILLARS OF THE SINGAPORE AQUACULTURE PLAN

Against this backdrop of challenges and current state of play, there will be a need to develop the capability and capacity of Singapore's aquaculture sector. SAP stakeholders have hence identified five pillars to harness opportunities and mitigate challenges.

Each pillar maps out past efforts and outlines future measures that the industry should take to ensure sustainable growth and resilience. This structured approach provides a comprehensive roadmap for the future of aquaculture in Singapore.

> Space and Infrastructure Planning

How can we optimise our limited sea spaces for aquaculture while minimising impact on the environment, and provide for key infrastructure like cable networks to connect to energy grids and jetties? While optimising our limited land for land-based aquaculture remains important, the Space and Infrastructure Planning pillar in the SAP has been scoped to focus on sea space planning.

> Enabling Regulations

What regulations (e.g. approval processes, legislation, and guidelines) should be put in place to balance cost-effective farm practices, sustainable development and scaling up farm operations?

> Research, Innovation, Enterprise (RIE)

How will innovative science and tech initiatives be supported to anchor Singapore as a regional research and innovation hub for aquaculture, e.g. for genetics, feed development, close containment and recirculating aquaculture systems?

> Ecosystem development

How could the Government enable the farming industry in Singapore to become more competitive, with an enabling ecosystem that facilitates key operational expenditure such as feed, fingerlings, manpower?

> Demand offtake and promotion of local produce

What can be done to encourage the demand for local produce, including aggregation for economies of scale across branding/marketing but also logistics and packaging?

Space and Infrastructure Planning

With limited sea space that is further constrained by competing uses, this pillar focuses on providing greater certainty in the allocation of areas for aquaculture farming, while ensuring necessary infrastructure support to enhance productivity and scalability.

PAST/CURRENT

Tenders and Lease Tenure

Since 2022, SFA has launched tenders for new farm spaces, both on land and at sea. These tenders come with longer leases of 20+10 years, providing greater certainty and stability to farms. Longer leases support industry development by encouraging farms to invest in higher productivity solutions and facilitating their ability to secure bank loans.

To ease the transition for existing farms into this new lease arrangement, annual Temporary Occupation Licences (TOLs) are offered to existing sea-based farms starting for a 10-year transition period from January 2023. The annual renewal of TOLs is contingent on farms meeting the stipulated Minimum Production Levels in the TOL for each farm. Farms, both existing and new, could apply for upcoming sea space tenders as they are released.

Balancing Growth with Environmental Stewardship

For development projects within marine and coastal areas or land-based projects in ecologically sensitive zones, technical agencies such as the National Parks Board (NParks), National Environment Agency (NEA), Maritime and Port Authority of Singapore (MPA), and SFA are consulted. These agencies determine whether detailed environmental studies are necessary. To date, environmental studies have been completed for sea space aquaculture sites, such as Bukom in the Southern Waters. These studies enable SFA to determine the maximum production capacity for each site while considering existing biodiversity and other sensitive environmental receptors.

FUTURE

Despite past efforts, challenges persist. For instance, suitable sea space sites for aquaculture

in the Southern Waters are limited due to competing uses including shipping fairways and anchorages, industrial developments, and recreational activities. Furthermore, the presence of sites with high biodiversity value further restricts the available options for aquaculture development. Additionally, supporting infrastructure such as electricity supply and shared facilities are pending development or optimisation.

To address these challenges, a more holistic process will be embraced to optimise sea space use. This involves deconflicting uses, allowing for co-location, and integrating supporting infrastructure where possible. Such planning would foster a more forward-thinking approach to identifying potential sea space sites for aquaculture. This would ensure the sustained growth of the industry despite the increasing scarcity of land and sea space, while simultaneously prioritising environmental sustainability.

Site Selection Study

Government agencies will explore implementing a comprehensive site selection study at the early stages of planning. This preliminary study would take place before a full environmental

study and provide an overview of prioritisation and feasibility of potential sites for aquaculture development within a larger site or aquaculture zone. The preliminary study would consider factors such as environmentally sensitive areas and other planned sea space uses that could either negatively or positively impact aquaculture operations. The site selection study would also consider suitable environmental characteristics for aquaculture, which would determine the type of farming systems and the space requirements.

In conjunction with the site selection study, pre-engagements with selected stakeholders, not limited to Government agencies, industry representatives, nature groups, institutes of higher learning, and researchers would be carried out when necessary. These engagements aim to gather valuable stakeholder inputs and secure buy-in on potential sites identified for detailed environmental studies. Such pre-engagements can reduce the risk of abortive work by identifying environmentally feasible sites on which environmental studies need to be done, thereby reducing time and cost spent on environmental studies.

On 2 March 2024, SFA and JTC Corporation held a joint engagement session where participants shared perspectives and discussed environmental considerations for future development plans at the Northeastern Coast off Lorong Halus and East Johor Strait.



Reviewing potential Southern Waters sites for further studies for closed containment aquaculture systems (CCAS) farming



"Through collaboration and the adoption of innovative technologies, we are paving the way for a more strategic and sustainable approach to site selection, ensuring we protect vital ecosystems while addressing food security and industry needs."

Dr. Karenne Tun

This reflects Dr. Karenne Tun's experience during the SCI meeting on 21 November 2023, where key stakeholders discussed how CCAS could enable more optimised spatial buffer requirements that still met water quality parameters when compared to open net cage systems. Stakeholders then reviewed the potential of multiple aquaculture sites in Southern Waters, expressing preference to optimise existing brownfield sites (e.g. St John's Island and Semakau) before expanding to new sites in Southern Waters.

Infrastructure – Energy

As a short-term solution for farms' energy infrastructure, sea-based farms can deploy photovoltaic panels on farm structures and floating PVs (FPVs) with adequate battery storage capacity. Stakeholders have noted that FPVs deployed within aquaculture zones are unlikely to generate significant environmental impact, as the impact of shading from floating structures, including farm barges and FPVs, would already be accounted for within these zones.

SFA will collaborate with various ecosystem stakeholders, including industry players, Government agencies, and institutes of higher learning, to continue piloting viable renewable energy solutions. By leveraging renewable energy technologies, the aquaculture industry can reduce its reliance on conventional energy sources, thereby lowering operational expenditure and enhancing sustainability.

In planning for long-term power infrastructure, agencies need to work together with the industry to aggregate power demand from other users, such as harbour crafts. By pooling demand, they can achieve economies of scale, which would help to reduce energy costs for sea-based farms.

Infrastructure – Shared Facilities

We will explore how shared facilities can enhance the efficiency of the industry. Shared facilities, such as post-harvest processing, storage facilities, as well as waste processing and valorisation facilities, play a pivotal role in enhancing the value and branding of local aquaculture produce. Co-locating shared facilities with jetties is a potential solution to minimise logistics costs for sea-based farms.

Post-harvest processing facilities can process fresh produce in line with Singapore's food safety standards, potentially increasing consumer demand and the value-added of the product to the consumer. On the other hand, waste processing and valorisation facilities enable the conversion of farm waste into valuable products, thereby contributing to a more sustainable and circular economy.

Integration of aquaculture research with industry practices is another key aspect that can drive the sector forward. This integration can encourage the adoption of new technologies and foster industry participation in research activities, thereby enhancing the competitiveness of the industry.

Integrating research with industry

Marineholmen in Bergen, Norway, stands out as a significant model for aquaculture R&D. This innovation district synergistically combines a significant number of high impact research facilities including the University of Bergen, SINTEF Ocean and NORCE, and commercial aquaculture related enterprises such as Lerøy Seafood Group, Alltech Norway and MSD Animal Health group. With more than 150 businesses and 3500 employees, Marineholmen gathers several of the world's most competent professional marine communities to bridge and foster sustainable growth within the marine aquaculture sector. Singapore is studying the feasibility of such an approach for the future development of SFA's Marine Aquaculture Centre, as part of the goal of establishing Singapore as a premier hub for research and innovation in sustainable tropical aquaculture.

Enabling Regulations

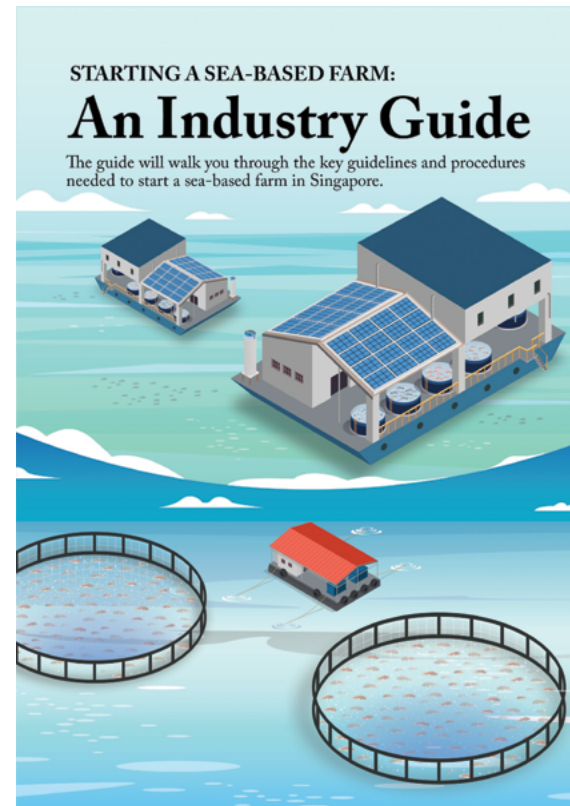
The enabling regulations pillar emphasises the need for outcome- and science-based guidelines to establish clear parameters for the formation and operations of farms within selected zones after detailed environmental studies are done, ensuring both long-term commercial viability and environmental sustainability.

PAST/CURRENT

Robust Collaboration with Technical Agencies

Singapore's regulatory framework for aquaculture is designed to ensure that development proposals align with national standards for safety, space optimisation, and environmental sustainability. Under the Urban Redevelopment Authority's (URA) Planning Act, any development proposal must secure planning approval from the Ministry of National Development (MND) and URA before proceeding. This approval process involves extensive consultation with technical agencies to address multiple aspects, including traffic management, fire safety, pollution control, and other environmental concerns.

The MND and URA evaluates the project based on its potential environmental impact identified from the detailed environmental studies before granting planning approval. The mitigation and monitoring measures are documented in a comprehensive Environmental Management and Monitoring Plan, which incorporates inputs from relevant stakeholders, including public and technical agencies, through engagement sessions.



The sea-based farm industry guide aims to help prospective farmers understand and navigate the regulatory requirements of setting up a sea-based farm in Singapore.

Supporting Industry to Navigate Regulations

To assist prospective farmers in navigating the regulatory landscape, an industry guide for sea-based farms has been developed with inputs from technical agencies and the Singapore Agro-Food Enterprises Federation Limited (SAFEF). This guide outlines the Whole-of-Government (WoG) regulatory processes and requirements for establishing a farm in Singapore. It covers procedures for bidding on sea spaces, submitting design and development plans, applying for farm licences from SFA, and meeting requirements from agencies concerning navigational safety, structural and building safety, trade waste and effluent management, and fire safety.

FUTURE

As sustainability has become increasingly important in aquaculture, the Government's regulatory approach should adapt to better encourage the industry in achieving both sustainable and productive practices.

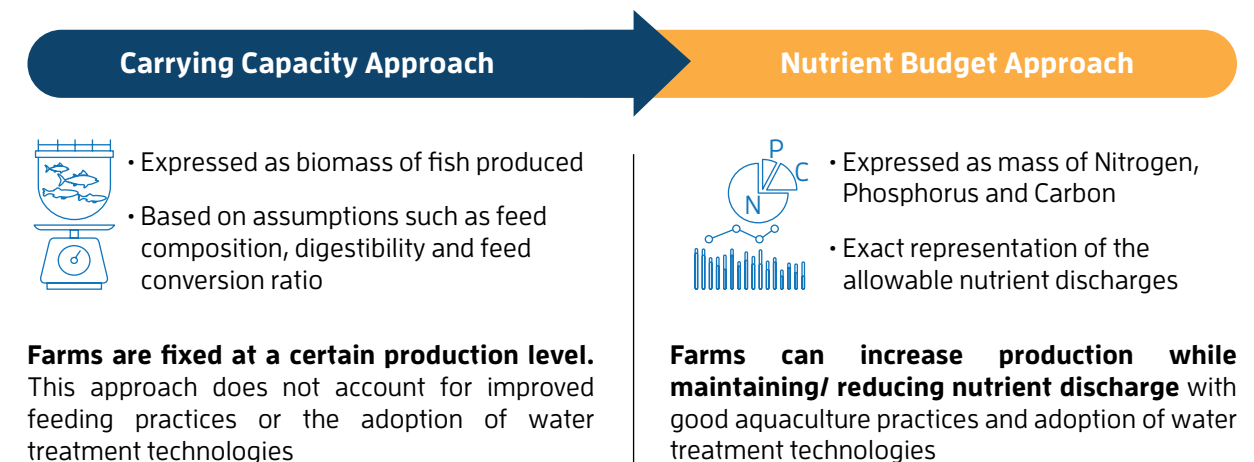
Transition to Nutrient Budget Approach in Regulations for Sea-Based Farms

To enhance the sustainability of sea-based farms, SFA will transition from the current carrying capacity model to a nutrient budget approach.

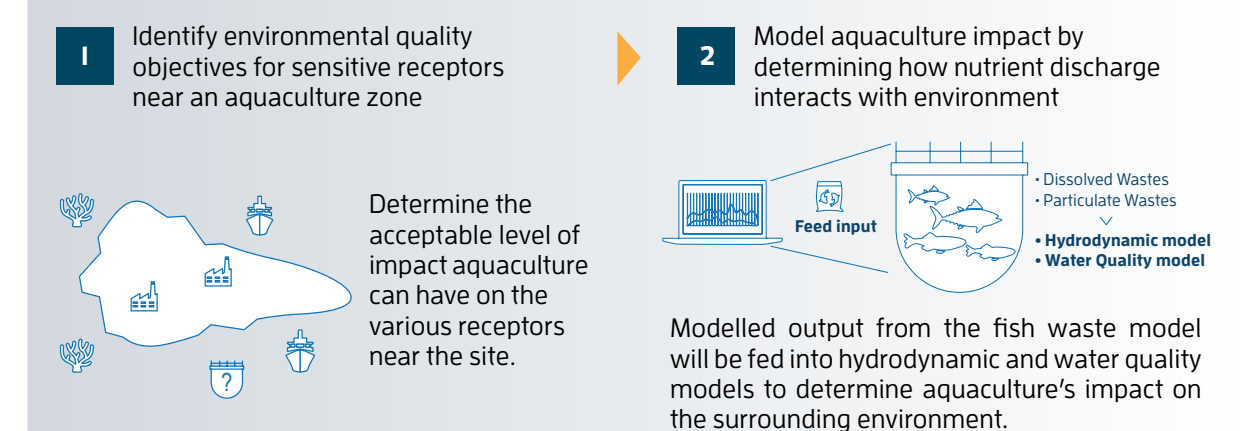
The carrying capacity model defines the maximum allowable production from a farming area within the accepted environmental quality objectives - specific, measurable targets set for various environmental indicators - to minimise environmental impact on sensitive habitats such as coral reefs and seagrass meadows, and to maintain water quality standards. While similar to how a site's carrying capacity is derived, the nutrient budget instead defines the maximum allowable nutrient (i.e. Nitrogen, Phosphorus and Carbon) discharge from a farming area. This approach prioritises moderating nutrient discharge, rather than imposing controls on production levels or prescribing specific farming models (such as open cage, close containment aquaculture systems, or hybrid systems), as a means to achieve sustainability.

This would encourage farms to adopt good farming practices and new technologies, to reduce their nutrient discharge so that more fishes can be farmed within a production site while ensuring other sensitive receptors are not adversely impacted. This outcome- and science-based approach provides SFA with the flexibility to plan production targets based on farming systems and practices, and bolsters the branding of the local aquaculture industry. Active monitoring of the nutrient budget will be conducted at an aquaculture zonal level via the Aquaculture Sensing Network (see page 34) to ensure compliance, and that optimal farming conditions are kept and safeguarded.

Transitioning to the Nutrient Budget Approach for Sea-Based Farms



What is the science behind these approaches?



Strengthening Farm Management and Animal Husbandry

We will also strengthen farm management and animal husbandry practices. Under the planned Food Safety and Security Bill, every farm licence application must be accompanied by a Farm Management Plan. The Farm Management Plan is designed to mitigate risks related to food safety, disease spread, and sustainable production. It will include nutrient management and biosecurity measures that the farm operator commits to implementing during farm operations. Farms must also appoint trained personnel to oversee implementation of the Farm Management Plan. To support this, subsidised training for

an "Appointed Personnel" will be conducted by SFA and Temasek Polytechnic's Aquaculture Innovation Centre, focusing on how to develop and implement a Farm Management Plan. SFA will provide guidance documents to help sea-based farms understand the requirements, thereby minimising administrative burdens. Additionally, SFA will periodically update the industry on the latest regulations and collaborate with other agencies to contextualise regulations, such as foreign worker quotas and structural regulations applicable to farms.

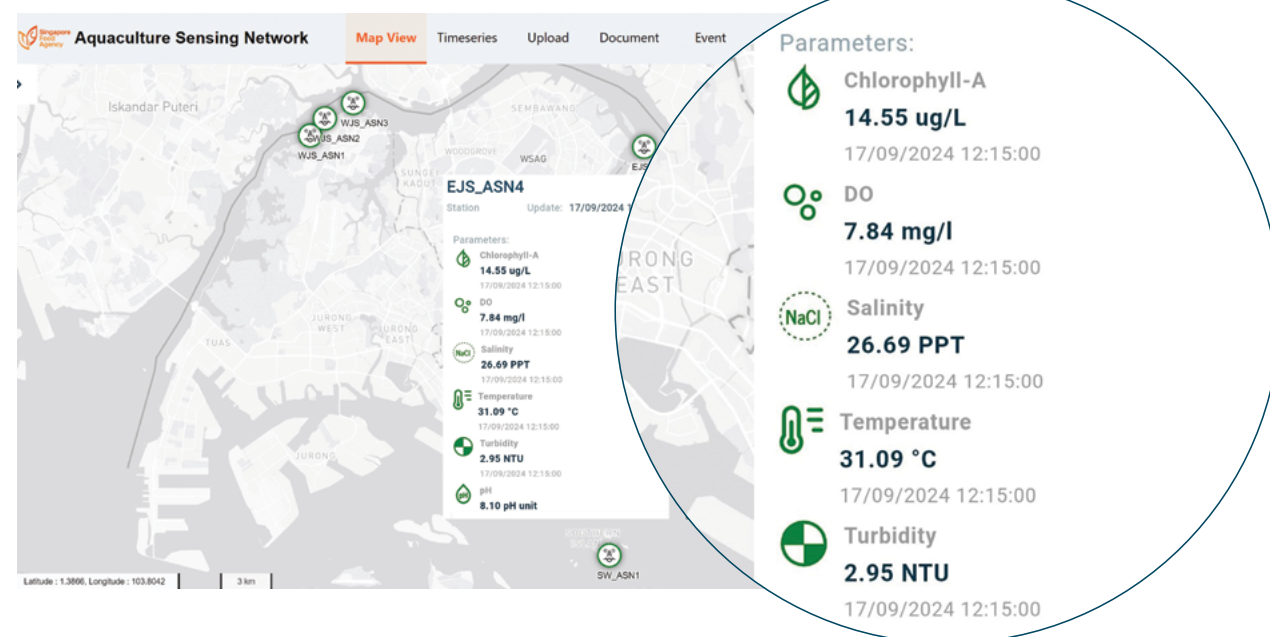
Deployment of the Aquaculture Sensing Network

The Aquaculture Sensing Network (ASN), a network of water quality sensors at aquaculture zones, has been deployed to monitor and provide operational insights on various water quality parameters. This is also complemented by water and sediment sampling to gather other important information on the state of aquaculture sites.

This monitoring of nutrient and sediment levels will help establish baseline measurements and provide early warning against environmental risks such as harmful algal blooms.

ASN data will support sea-based farming operations, regulation, and compliance, and can be shared across agencies and with farms for the sustainable management of aquaculture sites. SFA plans to integrate ASN data with the Maritime and Port Authority of Singapore's (MPA) GeoSpace-Sea system, which combines geospatial information from various sources to provide deeper insights for environmental management.

Snapshot of the Aquaculture Sensing Network Dashboard



Leveraging Citizen Science and Community Surveillance



To optimise monitoring while balancing manpower considerations, environmental monitoring should adopt a risk-based approach and could be complemented by the promotion of citizen science, where the community would be involved in monitoring and collection of data, as the "eyes and ears" on the ground.

Beyond parameters like dissolved inorganic nitrogen or phosphorous, we will explore collecting data on other indicative parameters (e.g. behavioural patterns of aquatic animals, ecotoxicology, hormone disruption and presence of marine wastes), when collecting data on water and sediment quality.

We will also collaborate with institutes of higher learning and the industry to integrate data collection and sampling efforts as field work for part of their ongoing programmes. Their involvement could also help to strengthen the sense of joint responsibility and develop the future talent pool for sustainable aquaculture to better support the development of the aquaculture industry.

Intertidal watch volunteers surveying at Coney Island. Photo credit: NParks.

The zonal nutrient budget will be operationalised as part of the Environmental Management and Monitoring Plan frameworks. This will be applied as part of the Environmental Impact Assessments for: the repurposed St. John's Island site, the East Johor Strait site, and the West Johor Strait site. The Farm Management Plan, which will be required by farms under the planned Food Safety and Security Bill, will form the basis for Environmental Management and Monitoring Plan actions at the farm and operator level, and SFA's levers to ensure adequate compliance.

Government agencies will review policies and regulations while considering wider global trends to balance enterprise and sustainability issues. By continuously adapting to new realities and emerging challenges, Singapore aims to create a resilient and adaptive regulatory framework that supports the sustainable growth of its aquaculture industry while safeguarding environmental and public health.

Research, Innovation, and Enterprise (RIE)

The RIE pillar focuses on harnessing emerging technologies to drive innovation and bolster the competitive edge of the aquaculture industry. This entails aligning research efforts with industry needs, leading to practical applications and operational efficiencies, thereby facilitating the industry's transformation and enhancing its competitiveness.



PAST/CURRENT

Marine Aquaculture Centre and Singapore Food Story Research and Development (SFS R&D) Programme

The Marine Aquaculture Centre (MAC), established in 2003 on St John's Island, has been a pioneer in local aquaculture research. With near commercial-scale tank systems, MAC has achieved several significant breakthroughs. A notable achievement is the improvement of growth rates for Asian Seabass through a long-term selective breeding program in partnership with Temasek Life Sciences Laboratory (TLL). This was attained through a significant increase in average body

weight from the initial generation compared to the latest selectively bred line¹⁰. Additionally, MAC has developed large-scale indoor RAS technology for Asian Seabass fry production and has pioneered husbandry techniques to combat disease, such as low salinity culture methods to address Big Belly Disease in Asian Seabass hatchery production.

The SFS R&D Programme was launched in 2020 to drive research and plug technological gaps in agri-food domains, including aquaculture. This programme supports a range of aquaculture-related projects that cover critical areas such as disease and health, nutrition, genetics, production systems, and farming environments. The programme has already yielded promising results such as in improving Asian Seabass growth rate, and survivability against bacterial and virus infections.

| Combinatorial Supplementation of Fish Feeds through Encapsulation for Enhanced Growth Rates in Aquaculture | Multipronged approach toward vaccine development against Scale Drop Disease Virus (SDDV) in Asian Seabass |
|--|--|
| <p>Key findings:</p> <ul style="list-style-type: none"> Encapsulated fish feed with nutraceutical ingredients (probiotics and curcumin) improving growth rate of Asian Seabass fingerlings by up to 25% and improving survivability against bacterial infection Potential value capture in Singapore as regional producer and supplier of high quality feed related products  | <p>Key findings:</p> <ul style="list-style-type: none"> Cost-effective peptide-based vaccine conferred up to 75% relative percentage survivability for Asian Seabass against SDDV Potential to build a vaccine development platform for other aquaculture diseases aside from SDDV  |
| <p>Researcher: Nanyang Technological University Singapore</p> <p>Collaborator: OPAL</p> | <p>Researcher: Infectious Diseases Labs</p> <p>Collaborator: UVAXX</p> |

Under the SFS R&D Programme, we have made good progress in developing superior fish feed (by Prof Joachim Loo, Nanyang Technological University) and vaccines against Scale Drop Disease Virus in Asian Seabass (by Prof Laurent Rénia, A*STAR Infectious Diseases Lab).

- “Main R&D” funding is allocated to the AquaPolis industry consortium (see page 39) to maximise research outcomes at mid-TRL levels; and
- “Research Translation” funding focuses on translational R&D of promising agri-food projects at higher TRL levels.

SFS R&D Programme 2.0

To further accelerate capabilities in agri-food domains to address food security challenges, fresh funding under the second phase of the SFS R&D Programme (SFS 2.0) was allocated in 2022. The SFS 2.0 aquaculture domain aims to achieve several key outcomes:

- Develop superior fry/fingerlings for tropical aquaculture species, which contribute to an increase in productivity;
- Improve the feed conversion ratio, making feed more cost-effective, as it constitutes more than half of aquaculture production costs; and
- Reduce fish mortality from key diseases.

The aquaculture domain under SFS 2.0 is structured into three sub-funding categories to ensure a targeted approach:

- “Seed” funding supports lower Technology Readiness Level (TRL) R&D to foster research innovation and drive development of disruptive technologies;

To strengthen collaboration between local and international aquaculture researchers and industry partners, the AquaPolis Programme was established under SFS 2.0. This initiative aims to harness technical, operational, and research expertise to develop innovative and sustainable solutions while nurturing talent for the industry's workforce. In November 2023, the AquaPolis Agreement was signed between SFA, NUS and TLL, to formalise the structure of the AquaPolis Board, which sets strategic directions and operationalises AquaPolis R&D initiatives.

The MAC will play a key role in AquaPolis research efforts, offering expertise in breeding and hatchery production. MAC's shared infrastructure and expertise will enable collaborative partnerships that drive research advancements. Researchers can tap and build on MAC's resources, including test-bedding facilities, shared facilities (e.g., replicated tank systems and biological materials such as eggs, larvae, rotifers, and microalgae), and expertise through synergistic partnerships to develop innovative solutions.



¹⁰ Yue, Gen Hua & Wang, Le & Sun, Fei & Yang, Zituo & Wong, J. & Wen, Y. & Pang, H. & Lee, M. & Yeo, S. & Liang, B. & Chen, K. & Lim, H. & Jiang, J.. (2023). Improving growth, omega-3 contents, and disease resistance of Asian Seabass: status of a 20-year family-based breeding program. Reviews in Fish Biology and Fisheries. 34. 1-20. 10.1007/s11160-023-09810-6.

Collaboration between AquaPolis Stakeholders to identify problem statements to enhance R&D efforts

AquaPolis stakeholders are actively involved in identifying key problem statements to enhance R&D efforts and ensure industry relevance. The inaugural AquaPolis R&D Workshop, held on 3-4 October 2023 and attended by 40 scientists from local institutes of higher learning, is one of the platforms which gathers researchers and industry players to challenges faced by the aquaculture industry.

As a result, a research proposal titled "Optimising Asian Seabass Research and Production in Singapore through an Integrated Approach" was developed. It aims to address critical production bottlenecks in Singapore's main farmed fish species, Asian Seabass, using three approaches: (1) improving fish fingerling quality and robustness, (2) boosting survival rates at grow-out stage from diseases, and (3) achieving distinctive quality for locally farmed Asian Seabass. This project is co-led by Dr Richard Le Boucher from TLL and A/P Christoph Winkler from NUS.

It brings together multidisciplinary expertise from eight institutes of higher learning and research institutions to lower production costs, enhance market value, and strengthen the resiliency and sustainability of local aquaculture farming operations.



FUTURE

As emerging technologies continue to reshape the aquaculture landscape, there is an increasing need to capitalise on these advancements to drive innovation and enhance the industry's competitive edge.

Access to Intellectual Property





To foster closer alignment between researchers and industry, Intellectual Property (IP) developed under the AquaPolis Programme will be free for a set period for local farms to use in pilot trials and/or local production. This approach ensures that research translates into practical and farm-scale applications - supporting both operational efficiencies and commercial food production within the industry. Where necessary, IP protection measures may be adopted to prevent potential infringement from competing interests.

Enhancing Capabilities

AquaPolis will continue to engage the industry through their industry consortium platform, launched in October 2024. This platform aims to close the gap between academic research and industry needs, translating AquaPolis R&D outcomes into practical solutions that boost production and add economic value. It will also facilitate discussions to identify industry challenges and pain points, guiding the development of scalable translational R&D projects in collaboration with farmers, institutes of higher learning, and research institutions.

The long-term vision of AquaPolis is to transform the local aquaculture industry into a stable, mature, and self-sustaining sector by developing

a sustainable funding model for co-investing in R&D initiatives. We will continue to work with the industry closely to build new R&D capabilities to better capture new growth opportunities. Potential opportunities include:

-  **Selective breeding programme for other species:** Building on our existing efforts on Asian Seabass, we are looking into other species such as red snapper, marine tilapia, and shrimps. This would open new opportunities and improve business viability of farms in Singapore.
-  **Feed and Nutrition:** To enable faster fish growth and better health, research into feeds that are species-specific and optimised for nutritional benefits are critical. Key areas include developing functional feed additives to enhance fish health and quality, and exploring cost-effective, sustainable fishmeal alternatives to reduce production costs.
-  **Optimising closed containment aquaculture systems (CCAS) and recirculating aquaculture systems (RAS):** With increasing environmental considerations, CCAS/RAS is expected to see greater adoption. Research into integrating automation and AI technologies can optimise production and improve affordability.
-  **Environmental Impact:** Research into aquaculture's interactions with the environment to better develop solutions for risks such as harmful algal blooms and oil spills.

Ecosystem Development

A collaborative ecosystem that optimises key operational expenditures such as feed, fingerlings, and manpower will enhance the competitiveness of Singapore's aquaculture industry. This strategic pillar involves fostering closer partnerships with upstream input suppliers and enabling farms to integrate vertically into upstream activities, such as hatchery operations.

PAST/CURRENT

Developing a Local Talent Pipeline

Local institutes of higher learning such as the National University of Singapore, Republic Polytechnic, Temasek Polytechnic, and the Institute of Technical Education offer a range of Pre-Employment Training and Continuing Education Training programmes that are relevant to the aquaculture industry. These programmes include short courses, diplomas, and degrees designed to equip local talents with the necessary skills to support various roles within the industry. These efforts ensure that the aquaculture industry has a skilled workforce capable of driving innovation and maintaining high standards.

Proliferating Sustainable Aquatic Health Practices

The rollout of Aquatic Animal Health Services (AAHS) to sea-based farms, which began in August 2023, has enhanced disease prevention and control measures within the aquaculture industry. In the first year, 19 farms signed up for the service and received funded veterinary consultations which assisted in farm management, disease diagnoses, prevention and control, which are essential for improved farm biosecurity and management across the sector. Additionally, the development and launch of Standards on Good Aquaculture Practices (GAqP) in collaboration with industry stakeholders has established benchmarks for sustainable and responsible aquaculture practices. This is vital for ensuring food safety and the commercial competitiveness of local products.

Financial Support and Co-Funding

Providing financial support and co-funding assists local farms in their capability development and drives higher productivity in a sustainable and resource-efficient manner. The \$60 million Agri-Food Cluster Transformation Fund, launched in 2021, is an example of such support. This fund has enabled farms to reduce operating costs, for example by adopting sustainable energy solutions such as solar panels. Other supported pre-qualified equipment includes aeration/oxygenation systems, automated feeding systems, automated harvesting systems, feed processing machines, pelleting machines, water treatment systems, and monitoring and control systems¹¹.

Fostering Collaboration and Knowledge Sharing

Various initiatives have been undertaken to facilitate collaboration and knowledge sharing, including regular engagement sessions, workshops, and collaborative projects. This collaborative approach has been instrumental in driving the industry's growth and innovation.

One notable example is the collaboration with industry associations such as the Singapore Agri-Food Enterprise Federation Limited (SAFEF). SAFEF has played a crucial role in the ecosystem by helping to aggregate production costs, such as logistics and packaging, and by interfacing with offtakers and retailers to aggregate demand. Aggregation significantly streamlines operations and has the potential to reduce operating expenditure and capital expenditure for the industry.

FUTURE

While significant progress has been made, there is still opportunity to enrich the ecosystem by strengthening partnerships and fulfilling gaps in the value chain. This strengthened ecosystem will reduce operating expenditure

and capital expenditure, and ensure the industry remains at the forefront of technological and scientific advancements.

Growing a Vibrant Industry Ecosystem

To foster a dynamic aquaculture industry in Singapore, we will nurture local champions and attract top-tier global farming companies. We will empower local champions to scale up and innovate, ensuring they can compete on the global stage. By bringing in international expertise and best practices, we will also elevate the standards of our local industry.

Additionally, SFA can facilitate strategic partnerships that connect the local aquaculture industry with technology firms, international aquaculture leaders, and the talent pipeline from institutes of higher learning. These collaborations will drive the adoption of advanced technologies and innovative farming methods - enhancing efficiency and sustainability. By fostering these innovations and partnerships, we aim to strengthen our ties with key countries, creating a more resilient and interconnected aquaculture industry.

Enhancing the Aquaculture Ecosystem Across the Value Chain

As farms collaborate closely with other players in the value chain, such as upstream genetics

and fingerlings providers and downstream food processors, it is crucial to enhance the entire aquaculture ecosystem. This includes bolstering solution providers in genetics, feed and food processors - to support the anchoring and growth of best-in-class farms.

Under the Agri-Food Cluster Transformation Fund, dedicated funding will be allocated to facilitate the development and deployment of closed containment aquaculture systems across sea spaces, such as St John's Island and Bukom, to bolster sustainable aquaculture practices.

Eggs and fingerlings are vital components in the aquaculture production value chain, as their quality directly influences the entire downstream process. Currently, our farms rely heavily on overseas sources, which often results in inconsistent quality and higher mortality rates. Hatcheries are essential for producing healthy, high-quality fingerlings that form the foundation of successful aquaculture operations.

To address these gaps, SFA will launch the National Broodstock Centre, and Hatchery Development and Recognition Programme. This initiative aims to boost the supply of locally produced genetically superior eggs and fingerlings from our research programme, as well as upgrade local hatchery capabilities to enhance the overall productivity and resilience of our aquaculture sector. These upstream inputs also offer significant export potential, driving economic growth from new international markets and positioning Singapore as a leading tropical aquaculture hub.

Improving growth rates for Asian Seabass via the use of marker-assisted selective breeding project

In 2004, a breeding program aimed at improving traits such as growth rates for Asian Seabass was initiated. Founding stocks were sourced from neighbouring countries such as Indonesia, Malaysia and Thailand to start the selective breeding program with a diverse genetic pool and to avoid inbreeding in future generations.

Three distinct and elite lines were successfully established after four generations of family-based selection. The selection utilised a combination of conventional selective breeding, molecular parentage analysis, marker assisted selection and genomic selection techniques.

The breeding programme will continue to improve important traits such as robustness in response to changing water conditions due to climate change. The programme will also be expanded to support the upcoming National Broodstock Centre, and Hatchery Development and Recognition Programme.

¹¹ Systems for environment, water, and nutrient sampling.

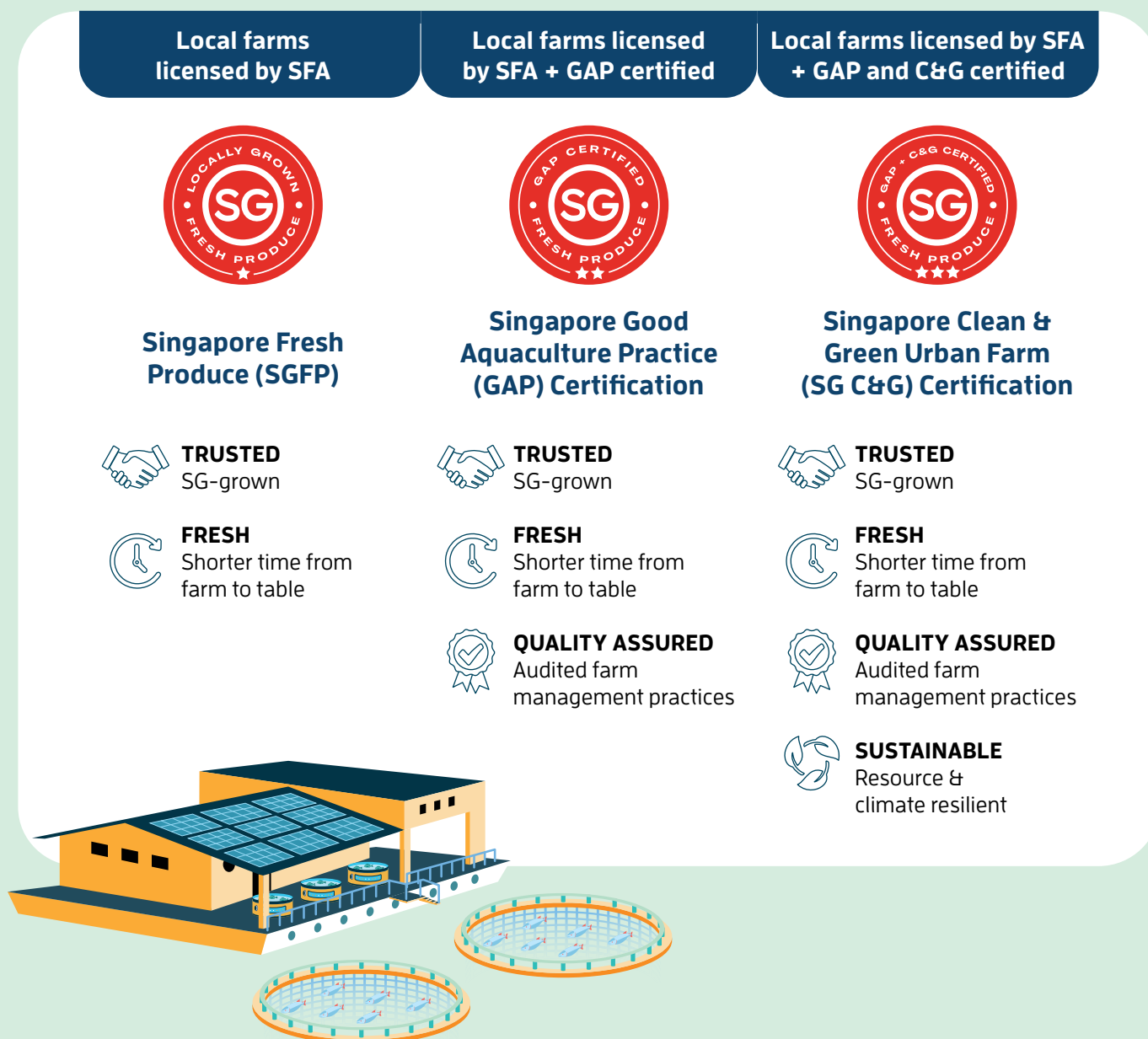
Demand Offtake and Promotion of Local Produce

The demand offtake pillar underscores the critical role consumer demand plays in driving the growth of the aquaculture industry. A holistic approach is needed to address demand at individual, industry, and national levels, given the multi-faceted nature of driving consumer demand and industry growth. Key strategies include expanding marketing and consumer education initiatives to raise awareness about the benefits of local seafood and promote its consumption.

PAST/CURRENT

Individual

Since 2020, SFA has proactively launched a series of marketing campaigns aimed at building and strengthening awareness and demand for local produce. Central to these efforts has been educating the public about the series of red and white SG Fresh Produce (SGFP) logos, helping consumers easily identify local produce.




The 2-star and 3-star SGFP logos are accorded to products sourced from local farms certified for quality assurance or sustainable practices. There are two key certifications: the Singapore Good Aquaculture Practice (SG GAqP) and Singapore Clean and Green (SG C&G) certifications. These certifications aim to recognise high-quality local produce, enhance branding, and promote responsible farming practices.


To drive awareness and demand for local produce, SFA has partnered with various industry players and media outlets. Key initiatives include:

 **Collaborations with Supermarket Retailers:** SFA works closely with supermarket retailers on marketing campaigns, advertisements, and fairs. Additionally, the agency supports events such as farmers' markets organised by the Singapore Agro-Food Enterprise Federation Limited (SAFEF) and the Kranji Countryside Association.

 **Programmes and Events:** SFA has collaborated with suitable programmes and events, including popular television shows like MasterChef Singapore and King of Culinary, as well as supported national events such as the National Day Parades. These collaborations help to increase the visibility and appeal of local produce among a wider audience.

 **Community Engagement through Culinary Initiatives:** In collaboration with the Singapore Chefs' Association (SCA) and People's Association (PA), SFA launched the "Food Resilience Cooking in the Community" initiative in November 2023. This programme involved masterclasses on recipes that include local produce and food alternatives, conducted by SCA for PA culinary trainers. These masterclasses were followed by community classes in the second half of 2024, aimed at educating the public on the benefits of using local produce.

In addition to these initiatives, SFA has also collaborated with various partners to promote food security messages and highlight the importance of supporting local produce. Notable efforts include:

 **Educational Talks in Schools and Pre-Schools:** SFA has organised talks to educate young students about the importance of food security and the role of local produce in ensuring a stable food supply.

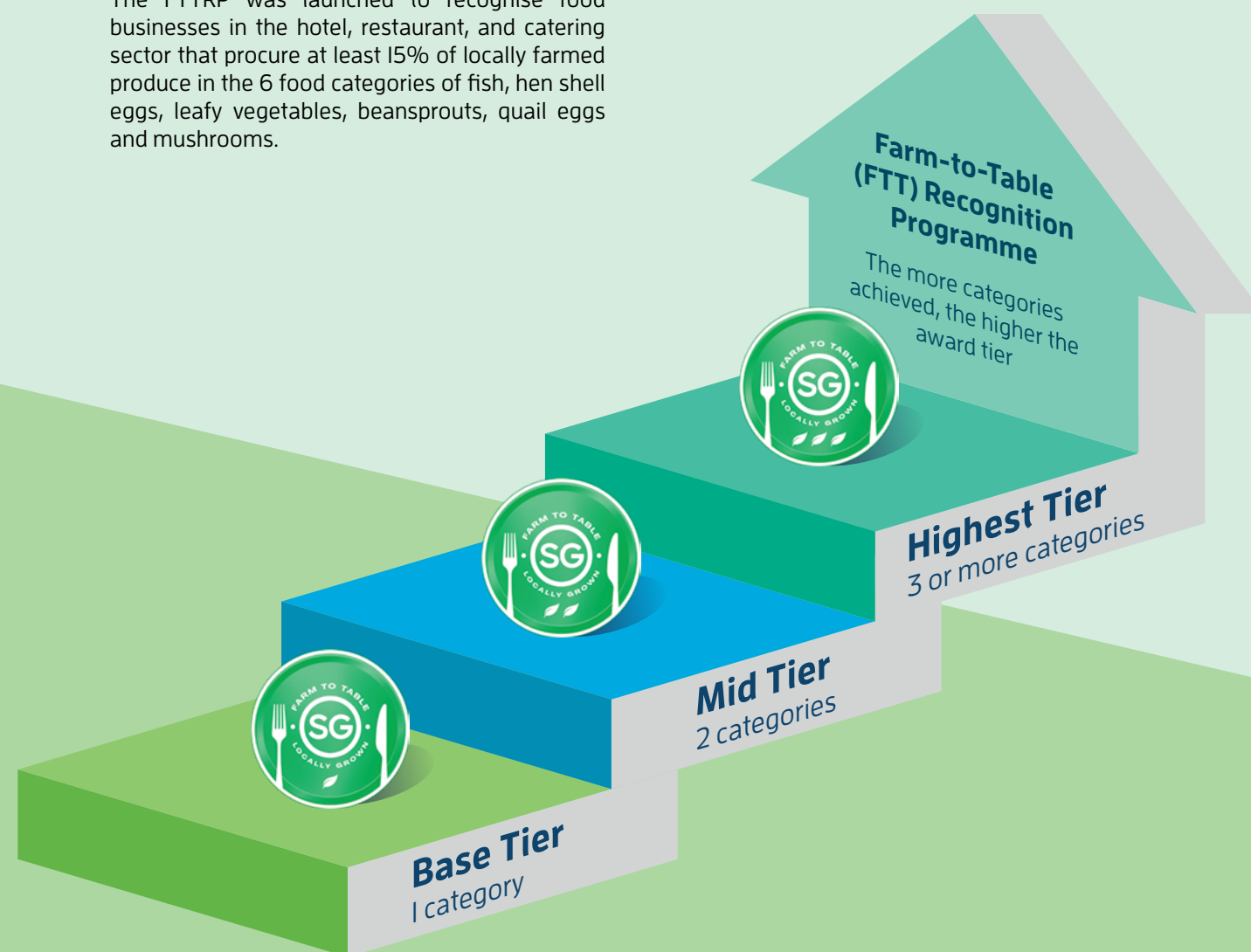
 **Innovative Digital Engagement:** In partnership with the Ministry of Digital Development and Information, SFA rolled out an innovative game called SG Farm Tycoon on Roblox in October 2023. This game was designed to teach young Singaporeans about food security and the significance of local production.

There remains a need to further promote the nutritional and sustainability benefits of local aquaculture products to build consumer trust and preference for these products. This could be underpinned by science-based research and studies. Strengthening the supply chain and distribution networks is also crucial to ensure that local aquaculture products reach a wider audience - supporting the growth and sustainability of the industry.

Industry

SFA has been in close collaboration with the HoReCa (Hotels, Restaurants, and Cafes) sector to increase the offtake of local produce. In March 2023, SFA launched the Farm-To-Table Recognition Programme (FTTRP) to recognise HoReCa food businesses that support local produce by procuring at least 15 per cent of their fresh produce ingredients, including fishes from local farms. Food businesses recognised under the programme can brand and market themselves as being sustainable, using fresher produce, and supporting Singapore's food resiliency.

The FTTRP was launched to recognise food businesses in the hotel, restaurant, and catering sector that procure at least 15% of locally farmed produce in the 6 food categories of fish, hen shell eggs, leafy vegetables, beansprouts, quail eggs and mushrooms.

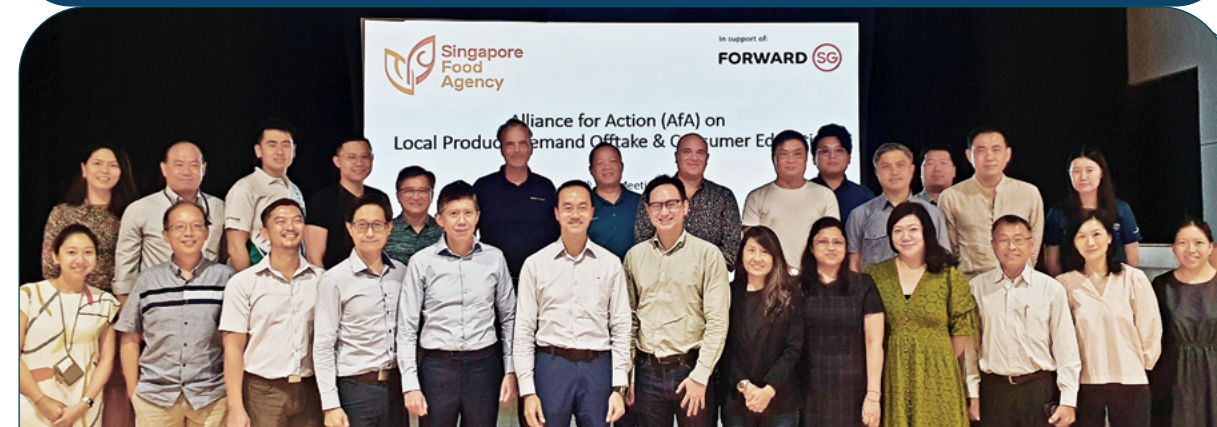


6 Food Categories



Furthermore, in February 2023, the industry formed an Alliance for Action (AfA) on "Local Produce Demand Offtake and Consumer Education" to increase the demand offtake of local produce. The AfA discussed and implemented strategies aimed at increasing the commercial offtake of local agriculture and aquaculture produce. This initiative also seeks to encourage consumers to support local produce. One of the key takeaways from the AfA was the importance of an industry-led supply and demand aggregator role, which was assumed by SAFEF. This aggregator aims to help producers secure longer-term sale contracts with retailers, while providing retailers a consistent supply of high-quality produce.

Bringing industry cohesion to the next level



As part of the ForwardSG conversations, an **Alliance for Action (AfA) on "Local Produce Demand Offtake and Consumer Education"** to increase the demand offtake of local produce was formed in Feb 2023. The AfA was chaired by Mr Stanley Goh/CEO of Food Solutions, SATS and co-chaired by Mr Jack Moy/CEO of Sustenir Group and Mr Vincent Tan/Group Executive Director, Shin Tai Ho & Co (Rong Yao Fisheries). The AfA comprised key industry representatives from our farms, offtakers including the HoReCa businesses, retailers, and trade associations. The collective achievements included:

- Formation of an industry-level supply and demand aggregator, spearheaded by SAFEF, that will partner farmers, traders and food processing companies via commercial aggregator contracts to better match demand and supply.
- Onboarded 70 food businesses onto the FTTRP to date. SFA will continue to expand the FTTRP to more food businesses, and plan to onboard at least 100 food establishments over the next year.
- Since October 2023, government procurement has incorporated a weighted criterion for sustainability into its catering contract. By using locally produced ingredients, interested food caterers can fulfil the sustainability criterion, amongst others. The new contract, effective from 1 Feb 2024 to 31 Jan 2027, comprises 11 FTTRP caterers.
- SFA also helps to organise farm tours for HoReCa businesses to increase awareness and adoption of local produce.

"This platform has facilitated beneficial engagement among diverse stakeholders, who might not have otherwise come together, empowering us to collectively discuss and tackle our shared challenges. The outcomes from the AfA continue to have meaningful impact beyond the platform's completion. For instance, the aggregator role spearheaded by SAFEF has led to transformative branding initiatives like "The Straits Fish" and "SG Farmers' Market". These efforts are reshaping collaboration between the local producers and markets, creating a progressive model that was previously unattainable, setting new standards for cooperation and innovation within and beyond the industry."

Mr Vincent Tan/Group Executive Director, Shin Tai Ho & Co (Rong Yao Fisheries), Co-Chair of Alliance for Action (AfA) on "Local Produce Demand Offtake and Consumer Education".



Locally sourced marine tilapia marketed under "The Straits Fish" was sold at selected FairPrice supermarkets, further promoting the availability and appeal of local seafood.

The AfA also recognised the importance of marketing and consumer education initiatives to raise awareness about the benefits of locally produced seafood and encourage its consumption. Efforts were initiated to enhance the visibility and appeal of local agriculture and aquaculture products through branding campaigns, such as the SGFP logos used by local producers selling at supermarkets, participation in food fairs, and collaborations with retailers and restaurants. For instance, SAFEF partnered with NTUC FairPrice to pilot the sale of locally farmed produce under distinct brands: "SG Farmers' Market" for leafy vegetables at 44 stores, and "The Straits Fish" for marine tilapia at 20 stores. Dedicated retail shelf spaces were created in-store at FairPrice Xtra outlets to raise the visibility of local produce.

National

At the national level, SFA has partnered with the Ministry of Education (MOE) and Singapore Airport Terminal Services (SATS) to pilot the Food Resilience Preparedness Programme (FRPP) in secondary schools. This initiative aims to educate and empower young Singaporeans about food security and introduce them to the concept of Ready-to-Eat (RTE) meals, which include local fishes and other ingredients, as well as food alternatives, for emergency preparedness.

The first phase of the pilot was rolled out in October 2023 across 10 secondary schools, where 2,800 students and teachers were introduced to the RTE meals. Phase 2 of the pilot took place in February 2024, in conjunction with the commemoration activities for the 40th anniversary of Total Defence. This phase saw the participation of 40 schools, involving approximately 50,000 students and teachers.

Through these educational initiatives, SFA seeks to cultivate a culture of food resilience among young Singaporeans, ensuring that future generations are well-informed about the significance of supporting local produce and the broader implications for national food security. This holistic approach not only promotes the consumption of local aquaculture products but also underscores the importance of sustainable and responsible food practices in Singapore.

FUTURE


Future efforts will need to build upon these foundational efforts to drive demand offtake. We will expand marketing and consumer education initiatives, and continue raising awareness about consumers' responsibility in food security and the benefits of local produce. This will be a long-term effort, and we envision that these messages will gradually resonate over time, especially with the increasing significance of climate change.

Promoting the nutritional and environmental benefits of local aquaculture products will remain a priority to build consumer trust and preference for these products. SFA will work with the industry on:

-  **Continuing with Citizen Engagement:** Working alongside schools and the community to raise awareness and support for local produce.
-  **Developing Targeted Marketing Strategies:** Creating marketing strategies that cater to different demographic groups and preferences will help to broaden the appeal of local aquaculture products.
-  **Differentiation from imports:** Labelling imports and local produce with measurable quality indicators to improve the value proposition of consuming local produce.

The industry will continue to enhance the visibility and appeal of local aquaculture products through branding campaigns, participation in food fairs, and collaborations with retailers and restaurants. As price remains a limiting factor, it is important to strengthen the supply chain and distribution networks to ensure that local aquaculture products reach a wider audience, supporting the growth and sustainability of the industry. SFA will work with the industry to explore:

-  **Consolidating Demand via SAFEF's Neutral Aggregator Efforts:** Leveraging SAFEF's role as a neutral aggregator to consolidate demand and secure longer-term contracts with retailers.

-  **Breaking into Export Markets:** Processing local aquaculture produce into value-added products, such as ready-to-eat meals and fillets, and marketing them internationally to reap

economies of scale. One approach could be expanding initiatives like SAFEF's "The Straits Fish" to the scale of Australis' "The Better Fish"¹²

SAFEF's efforts, e.g. The Straits Fish pilot, with aggregated logistics, packaging, branding

SAFEF is an industry-led, not-for-profit organisation representing the agri-food enterprises in Singapore. SAFEF has been supporting the industry through various initiatives to drive aggregation of offtake and farm services, such as providing advisory support in areas like business development, financing, branding and marketing, as well as conducting workshops and networking events to facilitate knowledge sharing on farming and enterprise.

Following the conclusion of the Alliance for Action (AfA), SAFEF continued to link up producers and offtakers. SAFEF signed a Memoranda of Understanding (MOUs) with At Fresh Pte Ltd and Seafood Industries Association Singapore in October 2023 to look into aggregating the commercial supply of locally farmed vegetables and fish, both fresh and processed, for distribution to local HoReCa establishments. This includes exploring longer-term purchasing contracts to provide producers with certainty of demand and pricing while ensuring constancy of supplies of good quality produce to retailers.

Since May 2024, locally farmed leafy vegetables and marine tilapia have been sold at FairPrice supermarkets under the brand names "SG Farmers' Market" and "The Straits Fish" respectively. The pilot was progressively rolled out to a total of 44 outlets for the "SG Farmers' Market" vegetable products, and 20 outlets for "The Straits Fish" products. Since the launch, consumer response has been positive, with steady growth in sales of locally farmed vegetables and marine tilapia. To streamline consumers' shopping experience and raise visibility of local produce, dedicated retail shelf spaces have also been created in-store at 7 Hyper FairPrice outlets.



¹² The Better Fish® by Australis Aquaculture is a brand that prioritises sustainability and ethical practices in seafood production. It specialises in ocean-farmed barramundi, which is known for its mild flavor and high nutritional value. The brand is committed to reducing the environmental impact of food production while ensuring the highest quality standards.

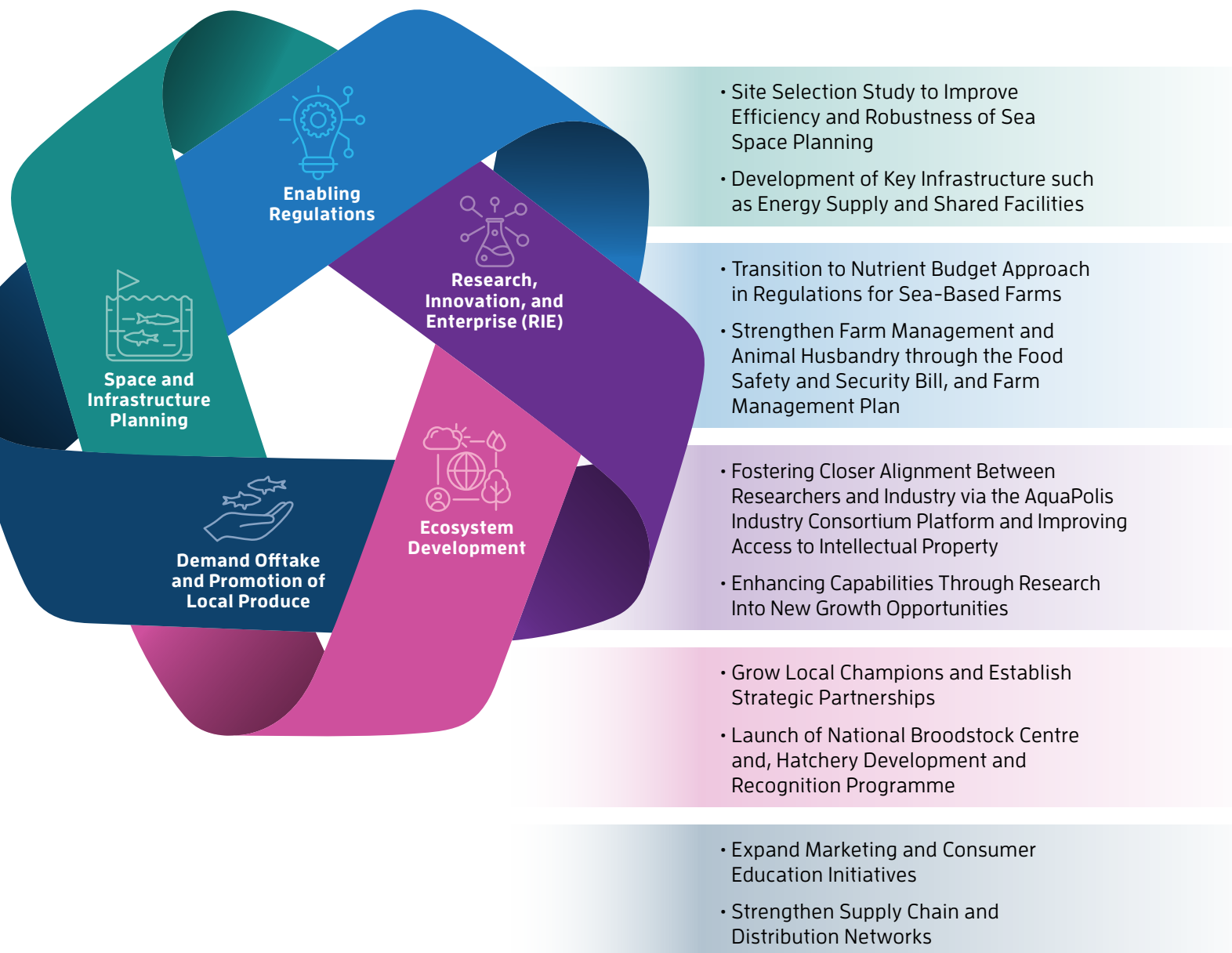
CONCLUSION

The SAP charts a course for our nation's aquaculture future, with its five pillars addressing the complex challenges and opportunities ahead. SFA is committed to developing a sustainable and productive tropical aquaculture industry, while recognising that success will require strong collaboration and adaptability from all stakeholders.

Designed as a 'living document', the SAP will evolve with the industry to remain relevant and responsive to new developments. Its realisation hinges on joint responsibility -

while the industry innovates and builds capacity, Singaporeans must also step up to support local produce and make sustainable food choices. The collaborative spirit that shaped this plan must continue, as the synergy between government, industry, researchers, nature groups, and consumers is crucial for creating a resilient and sustainable food system.

Our united effort will ensure a thriving aquaculture sector, vital to Singapore's food security and sustainable future.



GLOSSARY

Aquaculture Sensing Network (ASN): A system for monitoring water and sediment quality in aquaculture areas.

Aquaponics: A system combining aquaculture with hydroponics, where fish waste provides nutrients for plants.

Biosecurity: Measures to prevent the incursion, contain the spread and management of disease in aquaculture systems.

Broodstock: Adult fishes used for breeding purposes in aquaculture.

Carrying Capacity Model: A method to determine the maximum allowable production from a farming area.

Closed Containment Aquaculture Systems (CCAS): Farming systems where fish are cultured in a controlled environment that isolates and protects stock from external environmental factors.

Denitrification: The process of converting nitrates in water into nitrogen gas, important to reduce nutrient discharge from aquaculture activities.

Environmental Impact Assessment: A study to evaluate the potential environmental effects of proposed developments.

Environmental Management and Monitoring Plan: A comprehensive plan for managing environmental impacts of developments in Singapore.

Environmental Quality Objectives: Specific targets typically comprising of hydrodynamic impact, water and sediment quality and biodiversity indicators to ensure that the proposed development do not impact sensitive receptors in the vicinity.

Environmental, Social, and Governance standards: Criteria used to evaluate the sustainability and ethical impact of aquaculture businesses.

Farm Management Plan: A document written by the farm detailing their measures to mitigate risks on food safety, disease spread and sustainable production.

Feed Conversion Ratio: A measure of the efficiency with which fishes convert feed into body mass.

Fingerlings: Young fishes used to stock aquaculture farms.

Grow-out: The phase in aquaculture where juvenile fishes are raised to market size.

Harmful algal blooms: Algae that can grow out of control and produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds.

Hatchery: A facility where fish eggs are hatched and reared in their early life stages.

Nutrient Budget: An approach defining the maximum allowable nutrient discharge from a farming area within accepted environmental quality objectives.

Offtake: The purchase or acquisition of aquaculture products by consumers or businesses.

Pelleted Feed: Processed fish feed in the form of pellets, made from formulaions typically optimised for better nutrition and reduced waste.

Recirculating Aquaculture Systems (RAS): A type of closed containment aquaculture system for fish culture where the incorporation of water treatment processes allows the water to be reused for fish culture.

Selective Breeding: The practice of mating individuals with desired traits as a means of increasing the frequency of those traits in a population.

Sensitive Receptors: Environmental or anthropogenic features such as coral reefs, seagrass meadows, mangroves, marine intakes, jetties, aquaculture facilities etc.

SG Fresh Produce (SGFP) logos: Labels indicating locally grown produce in Singapore.

Technology Readiness Level (TRL): A measure of the maturity of a technology or innovation.

Vertical Integration: When a company owns or controls its suppliers, distributors, or retail locations in the same industry.

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The development of the SAP has been a collective effort, and we look forward to continuing this collaboration as we work towards a sustainable and productive aquaculture industry for Singapore.

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