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POLICY BRIEF
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Ensuring the Sustainable Future of the Rapidly Expanding Global Seaweed Aquaculture Industry – A Vision

Highlights

1. This policy brief highlights key challenges that must be addressed for the long-term sustainability of the global seaweed industry, ensuring its role in providing nature-based solutions within the sustainable ocean economy agenda and in contributing to the UN Decade of Ocean Science for Sustainable Development (2021 – 2030).

2. Seaweed production has grown rapidly over the past 50 years. It currently accounts for over 50 % of total global marine production, equating to ~35 million tonnes. In 2019, the industry's total value was estimated at USD 14.7 billion. The seaweed value chain supports the livelihoods of approximately 6 million small-scale farmers and processors, both men and women, many of whom live in coastal communities in low- and middle-income countries.

3. The aquaculture sector is increasingly interested in seaweed because of its potential for greater use in food, food supplements, animal feed, fertiliser and biostimulants, and in alternatives to fossil fuels and their derived products, such as plastics. Its cultivation can help restore degraded environments, increase ocean biodiversity and mitigate the effects of climate change and coastal acidification by capturing carbon and other nutrients. In low-, middle- and high-income countries, the seaweed industry has a wide-ranging potential to address the UN Sustainable Development Goals (SDGs) in particular, SDG 14 (life below water), SDG13 (climate action), SDG6 (decent work and economic growth) and SDG5 (gender equality).

4. The global seaweed industry, however, faces significant challenges. For future sustainability, improvements are urgently needed in biosecurity and traceability, pest and disease identification and outbreak reporting, risk analysis to prevent transboundary spread, the establishment of high quality, disease-free seed-banks and nurseries and the conservation of genetic diversity in wild stocks.

5. These improvements require technological innovation, capacity building and effective gender-responsive and co-ordinated policies, incentives and regulations. They will need to enhance occupational safety, whilst increasing the industry's resilience to the impacts of climate change and production hazards, such as pest and disease outbreaks. To align with the SDGs, particular attentions will need to be paid to small scale farmers and processors to ensure that the globalisation of seaweed aquaculture supports the development of sustainable, resilient and inclusive livelihoods.

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Seaweed farming in the Philippines benefits the entire community, including all ages and genders | © A.Q. Hurtado

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www.globalseaweed.org

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Finding the Right Balance

Global production of seaweeds is undergoing a rapid expansion, at a time of accelerating climate change, raising new challenges for producers and the environment (Fig. 1). Most seaweeds are currently produced for human consumption, hydrocolloids, animal feed and fertilisers. The seaweed industry has seen significant expansion since 2010, driven by commercial demands for higher value seaweed-derived products, such as cosmetics, pharmaceuticals, agricultural bio-stimulants and bio-packaging. Seaweed-derived products could also provide alternatives to those originating from fossil fuels (such as plastics) and seaweed cultivation offers a nature-based solution for restoring degraded coastal environments and increasing biodiversity by providing new habitats for aquatic species.

Seaweed cultivation offers opportunities for mitigating the effects of climate change through carbon capture, coastal deacidification, absorption of excess nutrients in eutrophic coastal environments, methane emission reduction and coastal protection. Its production can be integrated with other forms of extractive and fed aquaculture (Integrated Multi-Trophic Aquaculture) and with maritime activities, such as renewable energy generation. This means that seaweed production has good potential for enabling economic diversification in coastal and offshore marine environments in ways that can minimise conflicts over space and resources. As such, it helps support the UN's One Health Approach and contributes to several

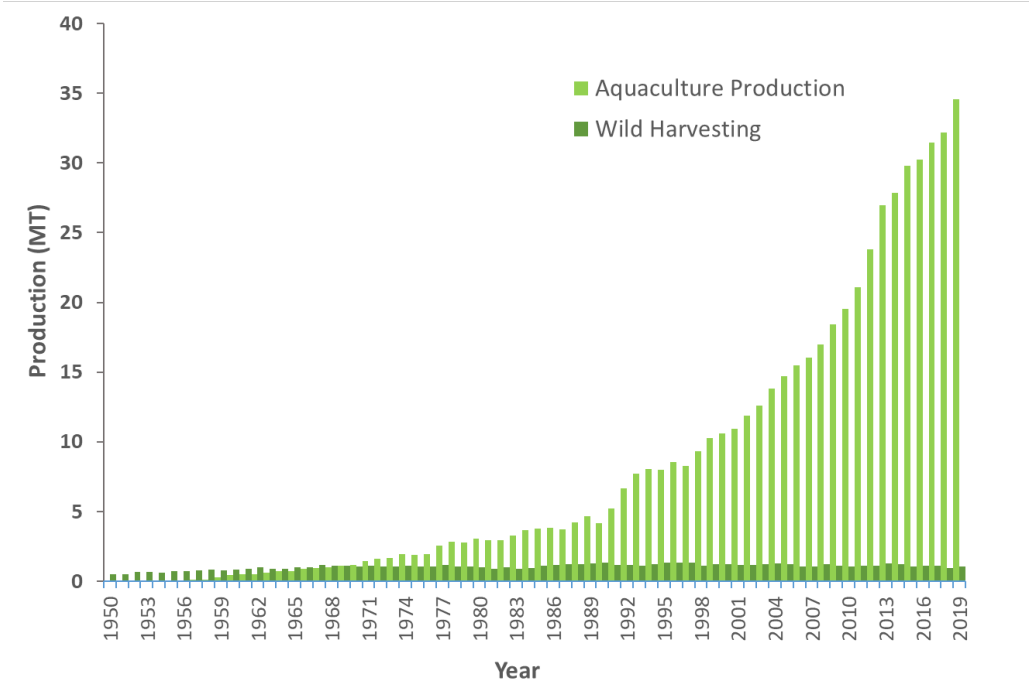

Figure 1. Global seaweed aquaculture production and wild harvest (1950 – 2019).

Sustainable Development Goals, notably SDG14 – Life Below Water, SDG13 – Climate Action, SDG8 – Decent Work and Economic Growth and SDG5 – Gender Equality.

However, the rapid expansion of the seaweed industry poses significant challenges. Like terrestrial crops, seaweed stocks are susceptible to a wide variety of hazards. Reliance on a very limited number of commercially grown species and their inter-breeding with wild native stocks has reduced the genetic diversity of seaweed cultivars used by the industry. Overharvesting of wild stocks has meant that limited resources are available to reinvigorate the gene pool; and the unintentional introduction and spread of pests (including grazers) and disease by unregulated stock movements and other non-aquaculture related pathways has led to outbreaks – whose severity is increased by the effects of climate change. Physical and regulatory conflicts with other users of the marine environment, such as fisherfolk and tourists can affect production and there are few transparent national and international policies and standards for ensuring quality, fair pricing, traceability and effective biosecurity, including reporting of outbreaks and quarantine procedures.

Socio-economically, a pest or disease outbreak can have devastating economic consequences on farmers, families and their wider communities. The seaweed industry supports the livelihoods of approximately 6 million small scale farmers and processors, both women and men, in over 48 countries. Whilst high income countries are increasingly interested in cultivating seaweeds, particularly kelps, most seaweed production takes place in predominantly low- and middle- income countries, where it can make a significant contribution to incomes in impoverished coastal communities . Entire multi-generational families can be employed on seaweed farms and risk losing their livelihoods due to major pest and

Philippine seaweed farmer with their newly harvested crop | ©I. Campbell

disease outbreaks. Seaweed farmers typically restock their farms with seedlings from their remaining crop or those of neighbouring farmers and/or buyers, which increases the risk of re-introducing diseased stock. Compared with shrimp and finfish diseases, biosecurity farm-level biosecurity measures for seaweed have been largely neglected in almost all farming countries.

This policy brief highlights the challenges facing the global seaweed industry and provides recommendations to incentivise it to balance economic profitability with environment, human and organism health. Taken together, these recommendations will help ensure the industry's long-term resilience and sustainability; promoting seaweed cultivation as a nature-based solution within the 'Blue' or sustainable ocean economy agenda and as a key contributor to the UN Decade of Ocean Science for Sustainable Development (2021 – 2030).

The Globalisation of the Seaweed Industry

In the last decade, the rapid expansion of the seaweed industry has continued unabated, predominantly in Asia. This growth has been fuelled by the accessibility of non-indigenous seedlings intentionally moved between countries and regions with no or minimal biosecurity checks, and the ease of vegetative

FACT BOX

In 1969, global annual seaweed production reached 2.2 million tonnes fresh weight (mt FW), evenly split between cultivated and the harvest of natural populations. After 50+ years, the quantity derived from harvesting has remained static (<3% of total seaweed production), whilst production of cultivated seaweeds has increased 15 fold reaching ~35 mt FW in 2019. **Seaweed aquaculture now contributes ~51% by weight to global mariculture production and the industry is worth over US$14.7 billion.** Countries, such as China, Indonesia, the Republic of Korea, the Philippines, Japan and Malaysia produce the vast majority of seaweeds in farm sites ranging from less than one hectare to several thousand. In 2019, China alone produced 20.3 mt FW of seaweed (57% total global production), followed by Indonesia at 9.96 mt FW (27.9%). The main global crop, by weight, is the kelp *Saccharina japonica,* which is largely produced in China, though the algae *Neopyropia* spp. and *Neoporphyra haitanensis*, the carrageenophytes *Kappaphycus* spp. and *Eucheuma* spp. and the agarophytes *Gracilariopsis* and *Gracilaria* spp. are grown in East and South-east Asia; predominantly Indonesia, the Philippines and Malaysia.

out-planting. Governments and industry keen to support economic development have promoted seaweed production in coastal communities, helped by the short production cycle and its need for only basic technology, unskilled labour, and minimal capital investment.

There is an increasing demand, however, for contaminant-free seaweeds and their products, with high levels of traceability or chains of custody, greater economies of scale and higher standards of occupational and environmental safety. Policies and guidelines are needed to support governments to resolve conflicts for finite coastal marine resources and to safely produce high quality seaweeds. Valuable lessons should be drawn from other aqua- and agricultural sectors about the need to look carefully at nutrient budgets in the coastal environment and for stringent biosecurity policies to prevent the introduction and spread of pests and disease (Fig. 2).

The contributions made by women and informal workers to seaweed farming are significant, but under-recognised. There is considerable diversity in who can be considered to be a 'seaweed farmer'. Seaweed farming is often a whole-family operation, with women and men fitting the different tasks around their various family responsibilities. However, capacity building and other types of support programmes are often targeted towards men: women's

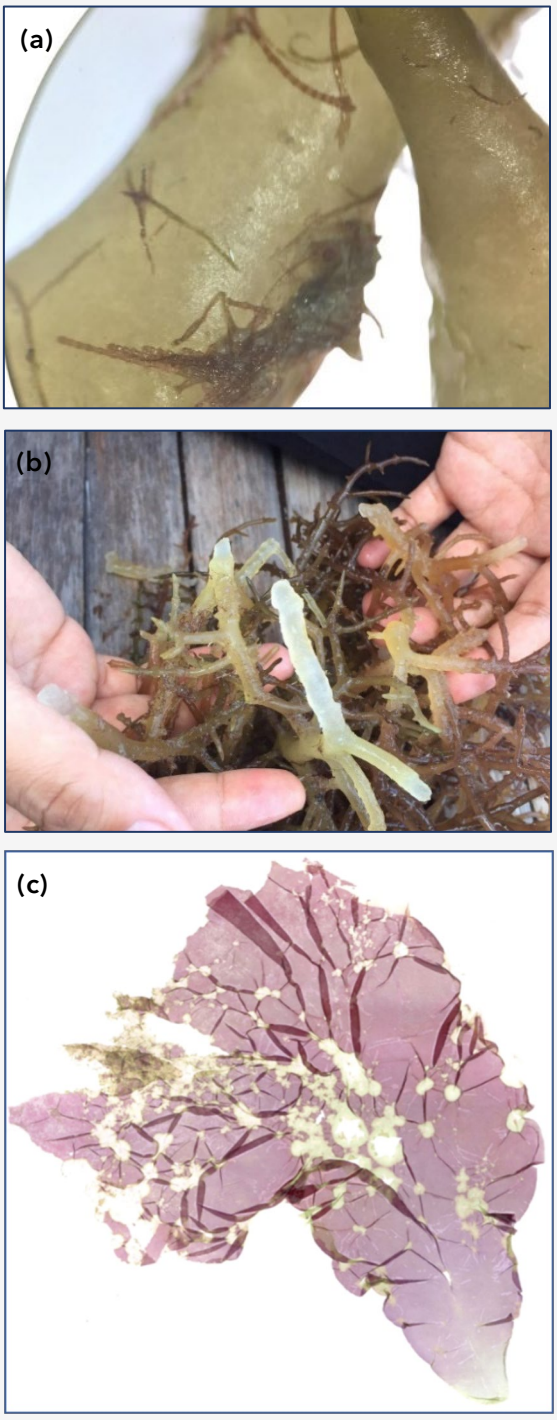

Figure 2. Examples of (a) epiphytic filamentous algae on *Kappaphycus* spp.; (b) Ice-ice disease syndrome in *Kappaphycus* spp; (c) Red Rot disease

specific needs for information and their particular resource constraints tend to be overlooked. Formal support programmes can also fail to recognise that a large proportion of the seaweed produced is farmed informally, as part of a mixed income generation strategy, by people who are already poor and who might struggle to access government support because of language or other barriers. More attention needs to be paid to reaching all seaweed farmers, with messages that help them develop more sustainable seaweed farming activities in their specific contexts.

A sustainable seaweed industry requires effective biosecurity and genetic diversity

As with any form of cultivation, the introduction and spread of seaweed pests and disease poses a major and increasing threat to production. Biosecurity helps minimise the risk of outbreaks and mitigates adverse impacts, thus protecting public health, ensuring the sustainability of the industry and safeguarding the environment. Biosecurity needs to be incorporated into government policies and regulations, as well as farm operational plans. In the context of the Progressive Management Pathway for Improving Aquaculture Biosecurity (PMP/AB), a new initiative of FAO and partners, biosecurity refers to the cost-effective management of risks posed by pathogenic agents to aquaculture through a strategic approach at enterprise, national and

Tanzanian seaweed farmer overseeing seedlings deployment

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international levels with shared public-private responsibilities. A PMP specifically for seaweed biosecurity (PMP/AB-Seaweed) has also been developed to guide stakeholders, from farmers to governmental agencies and NGOs, in how to respond to, and contain, emerging exotic and endemic pest and disease outbreaks.

The movement of live seaweeds is acknowledged as a major vector for the introduction of Transboundary Aquatic Seaweed Diseases (TASDs). A number of seaweed pests and diseases have been identified and science-based innovations for their early detection are available. Risk analysis and early warning systems though are weak: training in pest and disease identification needs to be delivered widely, reporting systems need to be developed and stronger incentives are needed to implement prevention, practical control and environmentally safe treatment measures.

Introduced, non-indigenous macroalgae can also alter ecosystem structure and function, by changing food webs, monopolising space, developing into ecosystem engineers, removing excessive quantities of nutrients and spreading far beyond their point of introduction, if the cultivars are allowed to escape from the farm. For example, in certain regions of the Philippines and Tanzania, only introduced farmed varieties of *Kappaphycus* spp and *Eucheuma denticulatum* can be found in the wild. The inter-breeding of farm 'escapees' with indigenous species may also lead to the impoverishment in the genetic resources of wild stocks, impacting on ecosystem resilience and reducing the potential for future breeding programmes.

Early career researchers examine seaweed for pests and disease in Tanzania | © F. Msuya

Reducing national dependence on introduced seaweeds and their cultivars from other countries and regions, whenever possible, will minimise the importation of pests and disease and support the conservation of indigenous species. This can be achieved by investing in research to assist in the development of local, national and regional seed banks and nursery facilities, ideally based on indigenous seaweeds. Such developments would strengthen national capacity to identify and breed disease and pest resistant strains for restocking, where the crop has been lost to outbreaks or natural hazards. It is imperative that the biosecurity practices of seed producers ensure that disease and pest-free stock is guaranteed prior to transboundary trade.

As the global seaweed aquaculture industry grows and diversifies, the risk of introducing known and emerging pests and diseases to the new regions will escalate. Ensuring a resilient and sustainable industry will require the implementation of effective local, regional, and trans-boundary biosecurity measures, including quarantine procedures and the rapid detection of pests and diseases. International research centres have been established for terrestrial agriculture (e.g., rice, maize, wheat) and some aquaculture (e.g., fish, shellfish) to develop new production techniques and inform policymaking. International, national, and regional biosecurity policies also exist for terrestrial crops and terrestrial and aquatic animals. However, there is no co-ordinated global effort to support seaweed research, to build and transfer technical capacities and to protect wild seaweed populations. In addition, there are few biosecurity-related policies for seaweed production: where such policies exist for the movement of aquaculture stock, implementation and enforcement can be problematic, particularly when the origin of the stock is unclear and traceability measures are lacking.

Promoting wider environmental, gender-responsive and socially inclusive approaches to upscaling the seaweed industry: policy recommendations

The previous UNU-INWEH/SAMS policy brief (2016) outlined eight recommendations to ensure the global seaweed sector is supported by **evidence-informed decision making. The further recommendations below will help policymakers incentivise the seaweed industry to address UN SDGs 5, 8, 13 and 14;** balancing socially-inclusive and gender-equitable economic growth, ocean health and occupational safety.

1. **Develop clear international seaweed-related policies and regulations to improve biosecurity and genetic diversity**, that are integrated with marine planning frameworks at local, national, and regional levels. At national level, where appropriate, seaweed should be

included as an important commodity in national strategies on health management and biosecurity; as such proactive measures such as disease prevention, responsible movement (introduction and transfer), emergency preparedness and contingency planning and maintaining good husbandry and biosecurity governance should be normal practice. Ensuring that regulations can be enforced will improve traceability throughout the industry. Regional specified bodies should preferably rely on existing structures and organisations, but clear communication and coordination mechanisms between local, national, regional, and global governance levels should be put in place to ensure regulatory consistency.

2. **Develop global, regional, and national technology transfer and capacity building initiatives, focusing on biosecurity and genetic diversity.** Face-to-face and online training programmes in biosecurity, farm management practices, and early diagnostic procedures for exotic and emerging pests and disease, to enable effective management. Such programmes should be inclusive of all seaweed farmers (women and men, formal and informal), and others along the seaweed value chain, such as collectors, traders, processors and international buyers, who can reinforce the messages.

3. **Develop regional and national seed stocks and biosecure nurseries**, to review indigenous biodiversity, support the selection and diversification of seaweed varieties for cultivation, and provide a reliable source of healthy, disease and pest-free seedlings to farmers, when required.

4. **Maintain the genetic diversity in wild stocks** by conserving wild seaweed populations through encouraging conservation zones, minimising the introduction of non-indigenous species, and encouraging the development of indigenous strains/varieties for commercial cultivation.

5. **Further develop assessment tools** for balancing environmental and economic risks with the potential benefits of seaweed production (e.g., cost-benefit analysis) and to enable risk-based analysis of management options at multiple scales.

6. **Incentivise the integration of seaweed production with other extractive and fed-aquaculture species and maritime activities** where possible, to reduce eutrophication and harmful algal blooms, enable economic diversification, control the impacts related to major pest and disease outbreaks, and minimise potential conflicts over space and resource use in the marine environment.

7. **Channel support for long-term investments to promote the beneficial aspects of the industry.** Innovative finance and insurance schemes could incentivise seaweed producers to adopt and implement sustainable farm

management and biosecurity practices, which support carbon and nutrient capture initiatives, biodiversity enhancement, traceability, diversification, fair access and distribution of seaweed products; and which facilitate decent and safe working conditions for all throughout the value chain.

8. **Establish international seaweed research networks**, to conduct further innovative, interdisciplinary research spanning the natural and social sciences. These would support the development and implementation of industry-wide standards for seaweeds that are gender-responsive and applicable to both large- and small-scale producers. Research could include work on genetic resource mapping and conservation and on seaweed-microbiome interactions, working with local knowledge as appropriate. It could cover breeding and expansion of nursery capacity to improve the use of pest and disease/stress-resistant stocks, integrated pest and disease identification and development of locally-appropriate treatment measures; and early warning systems for pest and disease outbreaks. Occupational safety should be combined with work on the wider more immediate and longer-term environmental impacts of upscaling seaweed production. Studying the family and community networks that underpin the early stages of the seaweed value chain would help devise policies that enhance equity, particularly for women and informal seaweed farmers.

Such research networks would also contribute to policy improvements, alignment of policies with the One Health Aquaculture Approach, and aid countries in the implementation of national initiatives, such as the introduction of their PMP/AB-Seaweed.

Seaweed farming in Tanzania | © F. Msuya

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