UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

Seaweed for development

Trade, regulations and standards for inclusive growth

Technical cooperation outcome

UNCTAD/TCS/DITC/INF/2026/5

Acknowledgements

This study was prepared, under the supervision and guidance of Chantal Line Carpentier of the Division on International Trade and Commodities of UNCTAD, by a study team led by David Vivas-Eugui and Henrique Pacini, with substantive contributions from Ludovic Arnaud, as well as Yossra Larhlimi (UNCTAD intern).

UNCTAD gratefully acknowledges the substantive contributions of Mirko Dunner and Elizabeth Dewar and the valuable inputs of Maria Durleva, Glen Wilson and Lorenzo Formenti.

UNCTAD also expresses its appreciation to the following experts for the comments and ideas contributed: Atiq Zaman (Curtin University), Mélanie Cueff and Philippe Potin (French National Centre for Scientific Research, CNRS), Nichola Dyer (Global Seaweed Coalition, GSC), Alessandro Lovatelli, Marcio Castro de Souza, Shirlene Anthonysamy, Bhakti Anand and Hasan Abdullayev (Food and Agriculture Organization of the United Nations, FAO), Nima Bahramalian and Sudari Pawiro (United Nations Industrial Development Organization, UNIDO), Linda Jonsson (United Nations Environment Programme, UNEP), Saloni Sharma (Global Organization for PHA, Go!PHA), Craig Updyke (ASTM International) and Peter Schelstraete (Ubuntoo).

The study also benefited from interviews with Vincent Doumeizel (United Nations Global Compact), Flower Msuya (Zanzibar Seaweed Cluster Initiative, ZaSCI), Hamil Soud (C-weed Mwani), Narriman Jiddawi and Arthur Tuda (Western Indian Ocean Marine Science Association, WIOMSA), Alejandra Allendes (Quelp), Helena Abreu (International Seaweed Association, ISA), Emma Algotsson (Catchgreen), Margarida Eustáquio (PROALGA) and Devparna Archaya and Neha Jain (Zerocircle), and inputs from Maris Stulgis (DG MARE, European Commission) and Hélène Marfaing (Centre d'Etude et de Valorisation des Algues).

This study is a contribution to the United Nations Global Seaweed Initiative (UNGSI), supporting its work to strengthen the evidence base and inform global efforts on sustainable and inclusive seaweed governance. It was developed through the cooperation between the Ocean Economy and Fisheries Programme and the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme of UNCTAD. UNCTAD is grateful for the support of France and of the United Kingdom of Great Britain and Northern Ireland in producing this study.

Desktop formatting was undertaken by Lia Tostes.

Acronyms

ASEAN	Association of Southeast Asian Nations
AfCFTA	African Continental Free Trade Area
ASC-MSC	Aquaculture Stewardship Council and Marine Stewardship Council
EDB	WTO's Environmental Database
FAO	Food and Agriculture Organization of the United Nations
GAqP	good aquaculture practices
GSTP	Global System of Trade Preferences
HACCP	hazard analysis and critical control points
HS	harmonized system
ISO	International Organization for Standardization
JAS	Japanese Agricultural Standards
LDCs	least developed countries
MSMEs	micro, small and medium enterprises
NTMs	non-tariff measures
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SPS	sanitary and phytosanitary measures
TBT	technical barriers to trade
TRAINS	Trade Analysis Information System (UNCTAD)
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention for Climate Change
UNGSI	United Nations Global Seaweed Initiative
WTO	World Trade Organization

Table of contents

Executive summary **1**

Chapter I

Why seaweed matters: the case for scaling up sustainable production and trade **7**

Background and context 9

Objectives 12

Chapter II

Methodology: mapping trade amid fragmented data **14**

Data sources 17

Classification 18

Chapter III

Seaweed production and trade are rising, but remain concentrated and limited **20**

Global production patterns 22

Key exporters 25

Key importers 27

Trade in seaweed products 28

High-value derivatives: carrageenan, agar-agar and alginic acid 29

Economic potential and value chain opportunities 30

Chapter IV

Regulatory gaps holding back seaweed potential **32**

National regulations 35

Non-Tariff Measures (NTMs) and the UNCTAD Trade Analysis Information System (TRAINS) Database 35

Trade-related environmental measures
WTO Environmental Database 37

Selected national regulatory frameworks 39

Regional regulations 46

Multilateral agreements 48

Chapter V

Voluntary standards gaps limit quality assurance and market confidence in seaweed value chains 50

National standards 53

Regional standards 56

International standards 57

Public international standards 57

Private international standards 58

Chapter VI

Way forward: securing sustainable growth of the seaweed sector as part of the blue economy 61

Recognise seaweed as a distinct commodity and value-added product group in international trade and policy 63

Support convergence and mutual recognition of science-based and inclusive regionally and internationally recognised food safety regulations and standards for seaweed 64

Enable coherent and context-responsive development of regulations and regulatory approval processes for non-food seaweed applications 65

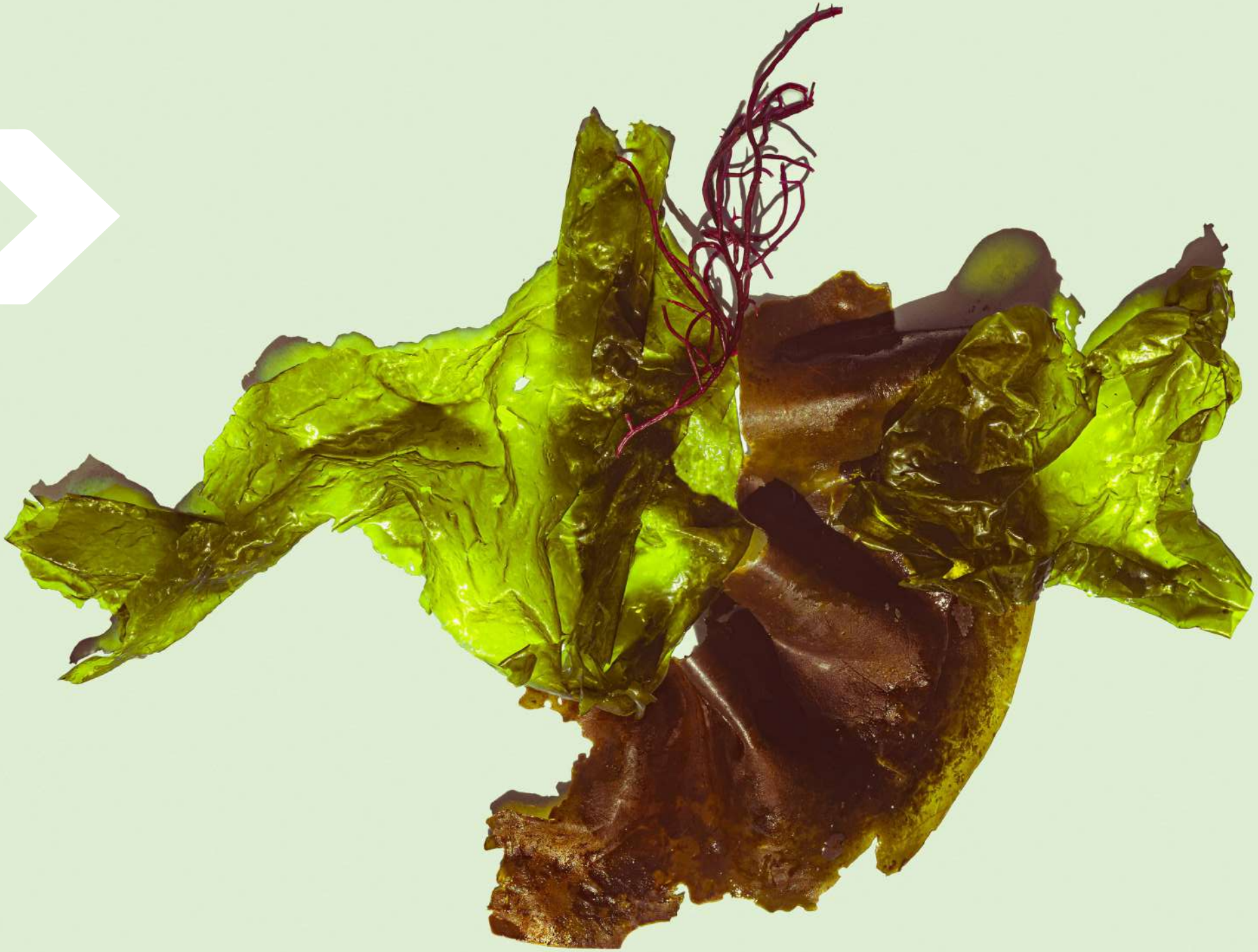
Build national and regional compliance capacity to expand developing country participation in global seaweed value chains... 66

Expand the collection and classification of non-tariff measures applicable to seaweed 66

Advance global governance and leadership through the UNGSI 67

Executive summary

© Kier Adair (Unsplash)



Executive summary

Seaweed holds vast potential to accelerate sustainable development, with applications ranging from food security and pharmaceuticals to bioplastics, cosmetics, fertilisers and other frontier materials that reduce pollution while supporting the shift toward sustainable and circular ocean-based/blue value chains. Although more than 12,000 seaweed species are known, commercial production remains concentrated in only ten, highlighting the huge scope for further innovative applications and diversification for many other species.

Between 2002 and 2022, global seaweed production tripled from 11.9 to 36.3 million tonnes (Mt, live weight), and could exceed 500 Mt by 2050, reflecting rising global demand for food and materials (FAO, 2024; UNCTAD, 2024c). Seaweed trade is growing even faster, nearly quadrupling from $1 to $3.9 billion during the same period. Of this $3.9 billion, 68 per cent came from seaweed derivatives such as carrageenan,[1] alginic acid,[2] and agar-agar[3] (UN Comtrade, 2025).

Trade-related regulatory frameworks and standards have not kept pace with the rapid growth of trade in seaweed. At the international level, seaweed remains poorly defined and fragmented across food and non-food applications. This lack of coherence creates uncertainty and persistent barriers for micro, small, and medium-sized enterprises (MSMEs) and exporters in developing countries, including least developed countries (LDCs) and Small Island Developing States (SIDS), limiting their access to export markets and their ability to move up in the seaweed value chain. These challenges are further compounded by widely varying food and safety standards, lengthy, inconsistent environmental licensing procedures, and regulatory "empty or grey zones" that leave non-food applications such as cosmetics, pharmaceuticals, biofuels, biostimulants, and bioplastics without clear market approval pathways.

This study provides a mapping of quantitative and qualitative regulations and standards for food and non-food seaweed applications and sets out the strategic case for promoting convergence and coherence in related approval processes. Such efforts can build trust among producers, traders, and consumers when they are science-based and inclusive, while avoiding the imposition of metrics developed in high-income countries that may not reflect the dietary habits, production conditions, or regulatory capacities of developing economies.

Using a mixed-methods approach that combined desk research, trade data analysis, non-tariff measure (NTM) mapping, legal and standards review, and expert interviews, this study maps the current regulatory, standards, and the sanitary and commercial approval landscape for seaweed trade. It also identifies key gaps and opportunities for designing a more sustainability-aligned, inclusive and context-specific framework for the growing seaweed sector. At the national level, seaweed is generally governed through sector-specific

Between 2002 and 2022, global seaweed production tripled from 11.9 to 36.3 million tonnes.

1 "Carrageenan" is a colloid extracted from various red algae (such as Irish moss) and used especially as a stabilizing or thickening agent. Carrageenan does not have its specific HS code, it but is instead included in the broader category HS130239 'Mucilages and thickeners derived from vegetable products'.

2 "Alginic acid" is an insoluble colloidal acid ($C_6H_8O_6$) that in the form of its salts is a constituent of the cell walls of brown algae. This versatile compound derived from brown seaweed, widely used in food, pharmaceuticals, and cosmetics for its thickening, stabilizing, and gelling properties.

3 "Agar agar" is a gelatinous colloidal extract of a red alga (as of the genera *Gelidium*, *Gracilaria*, and *Eucheuma*) used especially in culture media or as a gelling and stabilizing agent in foods.

As of October 2025, only 18 of the 109 technical measures related to seaweed recorded globally in the UNCTAD TRAINS database were seaweed-specific.

regulations, while at the regional and international levels, regulatory initiatives remain geographically limited and there is no dedicated multilateral agreement in place.

As of October 2025, 109 technical measures related to seaweed were recorded globally in the UNCTAD's Trade Analysis Information System (TRAINS) database, of which only 18 were seaweed-specific. Of these, just seven applied to seaweed intended for human consumption (hereafter referred to as food-grade). Around 70 per cent of the mapped measures were sanitary and phytosanitary (SPS) in nature, while 25 per cent were classified as technical barriers to trade (TBTs).

Although the Codex Alimentarius Commission and the International Organization for Standardization (ISO) address specific seaweed species or aspects indirectly, and private sustainability standards exist, their scope and guidance are limited (Zhou et al., 2023). The lack of comprehensive and cohesive international regulatory governance has significant consequences for innovation and trade. Without being recognised as a distinct commodity group or value-added product category in international trade, seaweed remains underrepresented in global trade and price statistics. Inconsistent food safety standards lead to costly shipment rejections and non-food applications are curtailed by the absence of clear production and composition guidance.

The study provides six main considerations for policymakers and other relevant stakeholders:

- **Define seaweed as a distinct commodity and value-added product group in international trade** to track detailed trade flows data and price of the most commercial species;
- **Support convergence, best practices, and mutual recognition in the development of science-based food safety standards**, in full consultation with developing economies, to facilitate market access and consumer protection;
- **Facilitate the coherent development of regulations, standards and approval processes for non-food seaweed applications**, ensuring inclusiveness and consideration of context-specific needs. This approach could assist in overcoming persistent challenges in meeting technical, quality, and environmental standards while fostering market creation, particularly for developing countries;
- **Build and strengthen national and regional compliance capacity** to expand developing country participation in the global seaweed value chain;
- **Strengthen NTMs compilation and reporting for seaweed products** and its by-products in UNCTAD and World Trade Organisation (WTO) databases;
- **Consolidate global leadership through the United Nations Global Seaweed Initiative** (UNGSI) as a driver for improved governance, coordination and development of the sector.

The establishment of the UNGSI,[4] first presented at the 3rd United Nations Ocean Conference[5] following recommendations[6] from the 5th UN Ocean Forum,[7] provides a critical platform to coordinate these efforts. The UNGSI was officially launched at the 80th UN General Assembly in September 2025. Its founding members include France, Indonesia, Madagascar. Chile and Brazil announced their membership at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) 30.[8]

The UNGSI aims to contribute to a science-based convergence of regulatory and standards setting processes, facilitate transparency and mutual recognition, and build technical and institutional capacity, particularly in SIDS, LDCs, and countries with large coastal areas holding potential for significant expansion of production. This study is UNCTAD's first contribution to the UNGSI, supporting the integration of seaweed within sustainability, production, and trade agendas of the UN System.

The United Nations Global Seaweed Initiative was officially launched at the 80th United Nations General Assembly in September 2025.

[4] For more details, see https://unctad.org/topic/trade-and-environment/united-nations-global-seaweed-initiative. Members at the time of the writing include the Republic of Madagascar, Republic of Indonesia, Republic of France, Chile, and Brazil, as well as UN Trade and Development (UNCTAD), UN Global Compact, Global Seaweed Coalition (GSC), Food and Agriculture Organization (FAO), UN Industrial Development Organization (UNIDO), Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO-IOC).

[5] For more details, see https://sdgs.un.org/conferences/ocean2025.

[6] UN Ocean Forum recommendations 4 a) and c). For more information, see 5unof-chairs-summary-format-v-final-rev.pdf.

[7] For more details, see https://unctad.org/meeting/5th-united-nations-ocean-forum-trade-related-aspects-sustainable-development-goal-14.

[8] Ministério da Pesca e Aquicultura. Brazil (2025). Brasil anuncia entrada na Iniciativa Global para as Algas Marinhas durante painel na COP30. For more details, see https://www.gov.br/mpa/pt-br/assuntos/noticias/brasil-anuncia-entrada-na-iniciativa-global-para-as-algas-marinhas-durante-painel-na-cop30.

Chapter I

Why seaweed matters

the case for scaling up sustainable production and trade

© Keegan Checks (Pexels)

Why seaweed matters:
the case for scaling up sustainable production and trade

Seaweed constitutes a high-potential blue bioresource for sustainable development, offering diverse applications across food, agriculture, and industrial sectors. However, its global production remains geographically concentrated and biologically narrow, limiting growth in international trade.

Background and context

Seaweed, which includes marine macroalgae, is increasingly recognised as a renewable resource of strategic importance for circular ocean-based value chains and a sustainable blue economy (UNCTAD, 2024c). Seaweed species are typically grouped into three categories: brown (e.g., kelp species), red (e.g., *Porphyra spp.* [nori]), and green (e.g., sea lettuce). Seaweed's prolific biomass production, low input and land-use requirements, and diverse applications across food and non-food sectors make it a vital asset for the development of a sustainable and circular ocean or blue economy. Seaweed contributes to coastal livelihoods, food and nutrition, climate resilience, waste reduction, and the development of renewable materials, aligning with Sustainable Development Goals (SDGs) related to poverty (SDG 1), food security (SDG 2), responsible consumption and production (SDG 12), climate action (SDG 13), and ocean health (SDG 14) (UNGC, 2020; UNCTAD, 2024c; Corrigan et al., 2025).

Applications range from food products and animal feed to biofertilisers, biodegradable packaging, pharmaceuticals and cosmetics (**Table 1**) (Anderson, 2017; IEA Bioenergy, 2017; European Union, 2021a; Lomartire et al., 2021; Sugumaran et al., 2022; World Bank, 2023; UNCTAD, 2024c). Seaweed farming can also support habitat restoration and carbon uptake, reinforcing its role in regenerative, ocean-based economies and further contributing to SDGs 13, 14, and, where applicable, 15 (UNDESA, 2023).

Realising its potential, however, requires a clearer understanding of how seaweed is produced and traded. Between 2002 and 2022, global seaweed production tripled, rising from 11.9 to 36.3 million tonnes (Mt) (FAO FishStat, 2025). Aquaculture now accounts for 97 per cent of global seaweed production,[9] with wild harvesting comprising the remaining three per cent (UNCTADstat, 2025). Production remains highly concentrated in Asia, accounting for 98 per cent of global output (World Bank, 2023: 2). China (21.6 Mt), Indonesia (9.1 Mt), and the Republic of Korea (1.8 Mt) together accounted for more than 90 per cent of global production in 2023 (FAO FishStat, 2025). However, contribution from other countries are growing, particularly through value-added exports such as hydrocolloids[10] and biotech ingredients, supported by rapid technological advancements (UNCTAD, 2024c; World Bank, 2023).

In 2022, Asia accounted for 98% of global seaweed production, underscoring the sector's high geographic concentration despite rapid global growth.

[9] Unless otherwise stated, all data and analysis in this study refer to macroalgae (seaweed) and exclude microalgae, such as those used in the nutraceuticals and food supplement markets (e.g., Spirulina, Chlorella).

[10] In this report, a hydrocolloid refers to a substance that formsforms a gel with water. For more details, see https://agris.fao.org/search/en/providers/122535/records/65df9bc10f3e94b9e5da71ba.

Table 1.
Applications of seaweed and its by-products: food and non-food use

Category	Application	Examples	Significance
Food	Human consumption	Whole foods (e.g., nori, wakame, kombu, *Caulerpa*, *Ulva*); food supplements	Rich in nutrients and proteins; supports plant-based and sustainable diets
	Food additives	Carrageenan, agar-agar	Natural thickeners, stabilizers, emulsifiers for food
	Animal feed	Aquafeed (fishmeal replacement); livestock/poultry feed additives	Reduces pressure on wild fish stocks; can lower methane emissions
Non-food	Agriculture	Biofertilizers and biostimulants	Improves soil health; reduces synthetic fertilizer use
	Packaging & materials	Biodegradable films; coatings; polyhydroxyalkanoates (PHA) feedstock	Alternatives to plastic; reduces pollution and fossil resource use
	Cosmetics	Skin and haircare products with bioactive compounds	Natural alternatives to synthetic chemicals
	Pharmaceuticals	Fucoidan, alginate dressings, agar-agar (culture media)	Natural thickeners, stabilizers, emulsifiers for medicines; also supports drug development, wound healing, and immune response
	Energy	Bioethanol, biodiesel from macroalgae	Renewable energy; circular economy; reduces land pressure
	Environmental services	Carbon uptake; wastewater treatment	CO_2 absorption; nutrient removal through bioremediation; ocean acidification mitigation
	Textiles	Seaweed-based fibres and fabrics	Sustainable, high-performance materials (e.g., moisture-wicking)

Source: UNCTAD (2025) compilation based on Anderson (2017); IEA Bioenergy (2017); European Union (2021a); Lomartire et al., (2021); Sugumaran et al., (2022); World Bank (2023); UNCTAD (2024b).

Innovations in offshore integrated multitrophic aquaculture (IMTA),[11] selective breeding, mechanised harvesting, bioprocessing, artificial intelligence (AI)-powered monitoring, and digital traceability platforms[12] are improving yields, reducing costs, and enabling high-value applications in biotechnology and biomaterials (UNCTAD, 2024c). These technologies also help expand domestic production, reduce import dependence, and support more resilient food systems (World Bank, 2023).

[11] IMTA combines the cultivation of fed aquaculture species (e.g., finfish, shrimp) with species that extract nutrients from the environment, such as seaweeds (inorganic nutrients) and suspension or deposit feeders (e.g., bivalves and sea cucumbers). This integrated approach enhances environmental sustainability, economic diversification and societal acceptability of aquaculture practices. FAO, AGROVOC Multilingual Thesaurus (accessed December 2025).

[12] Emerging AI-enabled digital platforms are increasingly used to support traceability and information sharing on sustainability-related solutions. For example, see Ubuntoo at https://ubuntoo.com/

Beyond its economic potential, seaweed cultivation delivers important social and livelihood benefits (FAO, 2023c). In 2021, the global seaweed market was valued at approximately $17 billion, with many coastal communities depending on it for income diversification, particularly in areas where opportunities are otherwise limited to tourism and fisheries (UNCTAD, 2024c). Many initiatives also build on traditional ecological knowledge of Indigenous Peoples and local communities, promoting more sustainable and locally adapted cultivation practices (FAO, 2018; UNCTAD, 2024c).

Just ten species account for 99 per cent of global seaweed output, and three species alone represent nearly three quarters of global output (Seaweed Insights, 2023; FAO FishStat, 2025). This reliance on a few monocultures increases vulnerability to pests, diseases, and climate shocks (Duarte et al., 2017; Valderrama et al., 2015). Moreover, many producers, particularly small-scale farmers and women, operate informally, with limited access to finance, training, technology and market intelligence (UNCTAD, 2024c). Such MSME and gender-based constraints are part of broader structural challenges that limit the resilience and inclusiveness of seaweed production systems.

These constraints also contribute to inconsistent production and quality practices along the value chain. Climate change and rising demand have worsened quality issues across the sector. For example, premature harvesting has reduced the ability of seaweed extracts to form strong, stable gels, often used in food applications. Mixing seaweed from various origins and harvest ages, and attempts to accelerate drying with salt, further deteriorate product quality (UNIDO, 2025). Meanwhile, the growing use of chemical fertilisers to counteract warming-related productivity losses has raised concerns about ecological impact, quality deterioration, and long-term economic viability (Prasedya et al., 2022, 2023).

However, seaweed cultivation can bring environmental benefits. It requires no freshwater or arable land for cultivation, and can help absorb excess nutrients, mitigate ocean acidification and enhance marine biodiversity (UNCTAD, 2024c; Duarte et al., 2017). As natural carbon sinks, some seaweed species capture carbon at rates comparable to or exceeding those of terrestrial vegetation (Buck-Wiese et al., 2023; Sultana et al., 2023). Seaweed-based materials also offer promising alternatives to fossil fuel-derived plastics and other materials, and can generate by-products

Seaweed cultivation requires no freshwater or arable land and can function as a natural carbon sink while enhancing marine biodiversity.

Seaweed attached to cultivation lines, Diani, Kenya.

such as biochar,[13] contributing to carbon uptake and circular economy objectives.

Despite these advantages, the sector faces significant regulatory and market entry barriers, particularly in developing economies. Many producers encounter non-tariff measures (NTMs) that are not tailored to seaweed cultivation, harvesting, processing and trade. These include inconsistent SPS standards, unclear product classification, and complex certification requirements (UNCTAD, 2024c). Such barriers hinder innovation, trade, and the integration of small producers into formal markets.

Overcoming these challenges will require greater regulatory coherence, targeted investment, research, and global coordination. Key priorities are coordinated SPS measures, regional standards alignment, and capacity-building to strengthen quality infrastructure systems,[14] particularly for MSMEs. Efforts should also focus on enabling compliance with standards, certification, testing, inspection, and traceability systems. With the adequate policy support, seaweed can serve as a strategic sector for climate-smart export diversification and green and blue, inclusive industrial development, especially within national ocean economy/blue economy strategies and sustainable trade agendas.

Many seaweed producers face non-tariff measures that are not tailored to seaweed cultivation, harvesting, processing and trade.

Objectives

This study provides a preliminary overview of existing trade-related regulations and standards for both food and non-food seaweed products. It maps trade trends, key compliance areas and classification challenges; it also preliminarily assesses barriers faced by developing economies and identifies opportunities for regulatory coordination and investment, particularly within the evolving framework of the United Nations Global Seaweed (UNGSI). Promoting convergence, simplification and transparency in the development of regulations and relevant standards, in full consultation with developing economies, to reflect different production and institutional realities, can:

a) **Promote** the inclusion of smaller producers;

b) **Accelerate** the adoption of sustainability criteria within seaweed production;

c) **Facilitate** trade in sustainable seaweed; and

d) **Inform** consumers about product safety and quality necessary to drive demand.

The study aims to equip policymakers, industry stakeholders, producer groups, research and financial institutions, and international organisations with actionable recommendations for advancing sustainable seaweed production and trade.

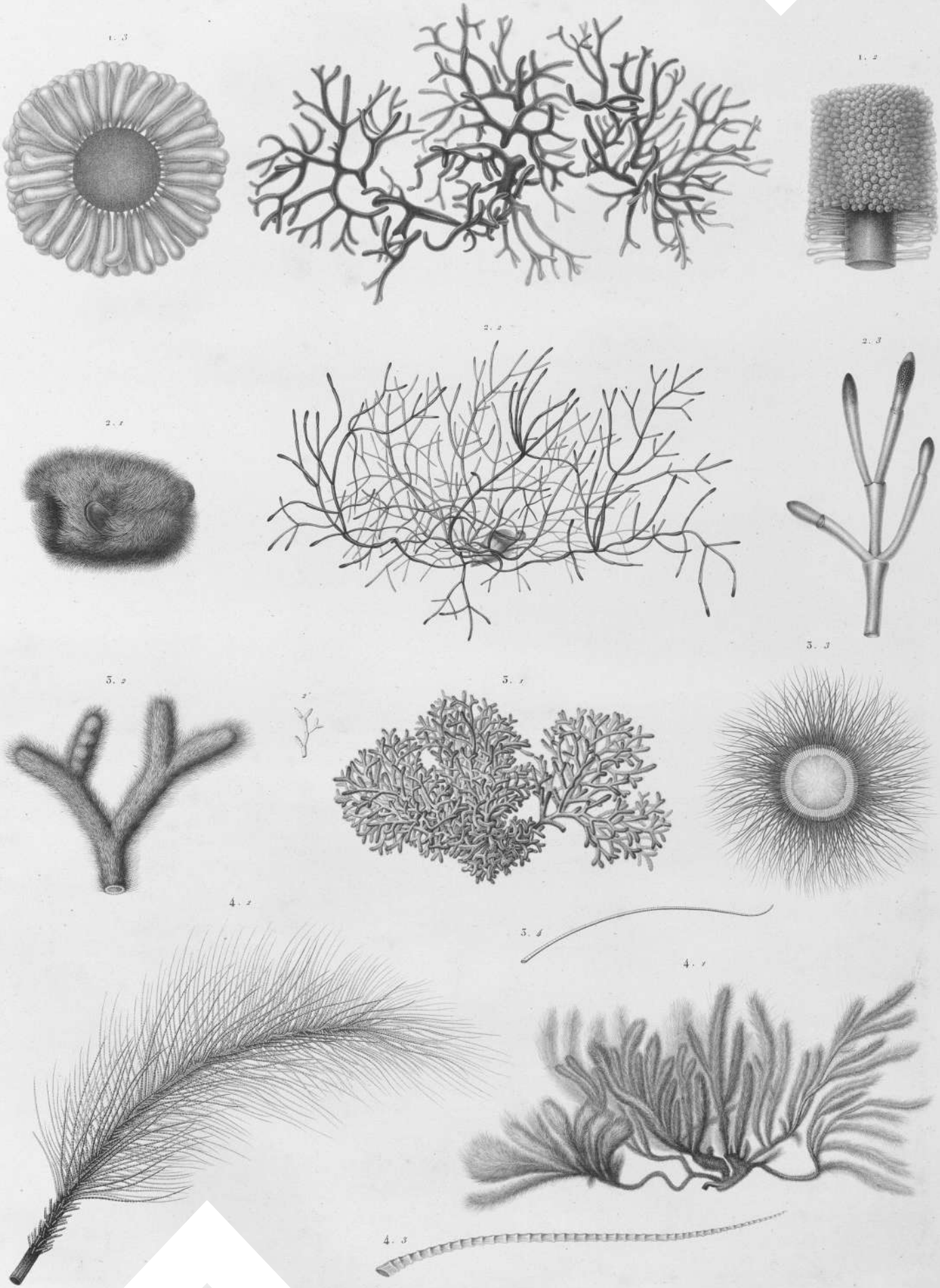
[13] Biochar is a carbon-rich, stable material produced by heating biomass (such as seaweed) in low-oxygen conditions. It can be used to enhance soil fertility and sequester carbon, supporting climate mitigation efforts.

[14] The national quality infrastructure system comprises the organisations (public and private) together with the policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety and environmental soundness of goods, services and processes.

Chapter II

Methodology

mapping trade amid fragmented data



Methodology:
mapping trade amid fragmented data

Global seaweed trade, regulations and standards suffer from classification gaps and inconsistent data gathering. This study applies a mixed-methods approach combining UN Comtrade, FAO, and WTO data with stakeholder interviews to map production and trade-related standards.

Drawing on the agreements on TBTs and SPS measures of the WTO, the study distinguishes between three key categories:

- **Technical regulations:** mandatory rules that establish product characteristics or production methods, often including labelling, packaging, or marking requirements. Under the WTO TBT Agreement, Members are required to ensure that technical regulations (i) are applied in a non-discriminatory manner, meaning that imported products are not treated less favourably than comparable domestic products (Article 2.1); and (ii) do not create unnecessary obstacles to international trade (Article 2.2).[15] Additionally, regulations are required to be based on legitimate objectives such as health, safety, or environmental protection, and where relevant international standards exist and are appropriate, to use them as a basis (Article 2.4). Trade-related regulations are also subject to transparency, information-sharing and notification requirements under the TBT.[16] In practice, these measures are mostly applied to non-food uses of seaweed and their by-products.
- **Sanitary and phytosanitary measures:** these are measures applied to protect human, animal, or plant life or health from risks arising from pests, diseases, disease-causing organisms, additives, contaminants, toxins, or other substances in food or feed.[17] These measures must be based on scientific principles and sufficient scientific evidence, must not arbitrarily or unjustifiably discriminate or serve as disguised restrictions on international trade, and must be applied only to the extent necessary to protect human, animal and plant life.[18] In practice, these measures are mostly applied to food and animal feed uses of seaweed and their by-products.
- **Standards:** voluntary documents developed for repeated use, specifying rules or characteristics for products or processes. Core principles set in the WTO TBT Agreement's Code of Good Practice[19] for developing international standards include inclusiveness, transparency, impartiality, consensus, and the avoidance of unnecessary overlap or duplication by using existing relevant international standards.

[15] For more details, see Article 2 (on technical regulations and standards) of the Agreement on Technical Barriers to the World Trade Organization (WTO).
[16] In addition to obligations in Article 2, Article 10 of the WTOWTO TBT Agreement contains further provisions on transparency, information-sharing and assistance, including through enquiry points, such as designated national TBT focal points.
[17] For more details, see, Annex A (1) of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS measure) of the WTO.
[18] For more details, see Article 2 of the WTO SPS Agreement.
[19] For more details, see Annex 3 of the WTO TBT Agreement.

© Quang Nguyen Vinh (Pexels)

Data sources

The study adopts a mixed-methods approach, combining quantitative and qualitative data to assess global seaweed production and trade-relevant regulations and standards. While the analysis is global in scope, it focuses primarily on Asia,[20] which accounts for more than 90 per cent of global seaweed output (FAO FishStat, 2025).

The quantitative analysis drew on international databases, including UN Comtrade[21] and FAO FishStat[22] for trade flows and production volumes, respectively, UNCTAD's TRAINS[23] and the WTO Environmental Database (EDB)[24] for regulations including NTMs. These sources were selected for their broad coverage and standardised reporting formats, enabling cross-country comparisons. While there is some overlap between TRAINS and the WTO EDB, findings are not affected as the analysis is concerned with broader regulatory trends rather than precise policy counts.

The qualitative data were gathered through a literature review and a series of key informant interviews (KIIs) with stakeholders across the seaweed value chain. Interviewees were identified through targeted outreach, expert referrals, and a review of recent publications. The sample aimed to balance geographic representation with institutional diversity, including voices from the private sector, academia, civil society, and international organisations. The final selection was based on subject-matter expertise, regional experience, and active engagement in seaweed value chains, governance, or trade.

International datasets, including UN Comtrade, FAO FishStat, UNCTAD TRAINS and the WTO Environmental Database, **underpin the mapping of global seaweed trade and regulatory trends.**

[20] This regional focus reflects not only production scale, but Asia's role in shaping global value chains, innovations in cultivation practices, and emerging regulatory models. Insights from Africa, Small Island Developing States (SIDS), and other regions are included where available, particularly to highlight policy innovations and value chain diversification. However, due to limitations in data availability and stakeholder access, some regional perspectives (particularly from underrepresented Pacific Island contexts) may not be fully captured.

[21] UN Comtrade is the United Nations international trade statistics database, based on official country data. For more information, see https://comtradeplus.un.org/.

[22] FAO FishStat provides data on global fisheries and aquaculture production. For more information, see https://www.fao.org/fishery/en/fishstat.

[23] TRAINS is an UNCTAD database on non-tariff measures and trade-related regulations (1937–2022). For more information, see https://trainsonline.unctad.org/home.

[24] WTO EDB compiles environment-related trade measures notified by WTO members (2010–2023). For more information, see https://edb.wto.org/.

Classification

Seaweed classification in this study follows the 2022 edition of the Harmonised System (HS) Nomenclature[25] (World Customs Organization, 2022). The analysis focuses on HS codes with direct relevance to seaweed and its derivatives, as outlined in **Table 2**.

The HS classification has several limitations. Notably, HS 130239 (mucilages and thickeners derived from vegetable products) covers carrageenan along with several other compounds. It is included due to the importance of carrageenan in the seaweed market. A few countries have developed specific national subheadings for carrageenan within their trade classification systems,[26] an example that other countries could follow. Another limitation is that the HS system does not yet capture many value-added seaweed derivatives, such as bio-based materials, nutraceuticals,[27] or biotech intermediates. A more detailed HS code classification, especially for tracking non-food and high-value applications, is therefore needed (UNCTAD, 2025a). To reduce potential biases, the study triangulated and cross-checked trade data against national production data, expert interviews, and relevant literature.

Table 2.
Seaweed-specific HS codes selected for analysis of trade in seaweed and its derivatives

HS Code	Application	Product	Description
1212.21	Food	Raw seaweed	Fit for human consumption; fresh, chilled, frozen or dried
1212.29	Non-food	Raw seaweed	Not fit for human consumption; used in agriculture, feed, bioproducts, etc.
1302.31	Food, pharmaceutical, laboratory	Agar-agar	Gelling agent used in food, microbiology, and pharmaceuticals
1302.39 NOT LIMITED TO SEAWEED	Food, cosmetic, pharmaceutical	Carrageenan	Thickener from red seaweed
3913.10	Industrial, cosmetic	Alginic acid	Thickener from seaweed; used in cosmetics, food, industrial processes

Source: World Customs Organisation (2022).

Note: HS Code 1212.20 is not recognised as a distinct international category and is typically consolidated under 1212.21 (WCO, 2022). It has limited commercial relevance for global seaweed trade data.

[25] Harmonised System (HS) codes are internationally standardised product classification codes maintained by the World Customs Organization (WCO) for use in customs and trade statistics. For more information, see https://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2022-edition.aspx.

[26] Including the United States, China, India and Brazil. However, data is not always collected. For the United States, for example, as of December 2025, the US International Trade Commission does not provide data for this code (see https://dataweb.usitc.gov/trade/search/TotExp/HTS).

[27] Nutraceuticals are foods, or components of foods, that provide medical or health benefits, including the prevention and treatment of disease, a term first coined in 1989 by Stephen L. DeFelice. See https://pharmaceutical-journal.com/article/ld/1-what-is-a-nutraceutical.

Chapter III

Seaweed production and trade are rising but remain concentrated and limited

© Henrique Pacini (UNCTAD)

Seaweed production and trade are rising, but remain concentrated and limited

Global seaweed production and trade tripled and quadrupled in value, respectively, between 2002 and 2022. Growth is led by value-added derivatives such as carrageenan and agar-agar. However, production remains concentrated in a few economies.

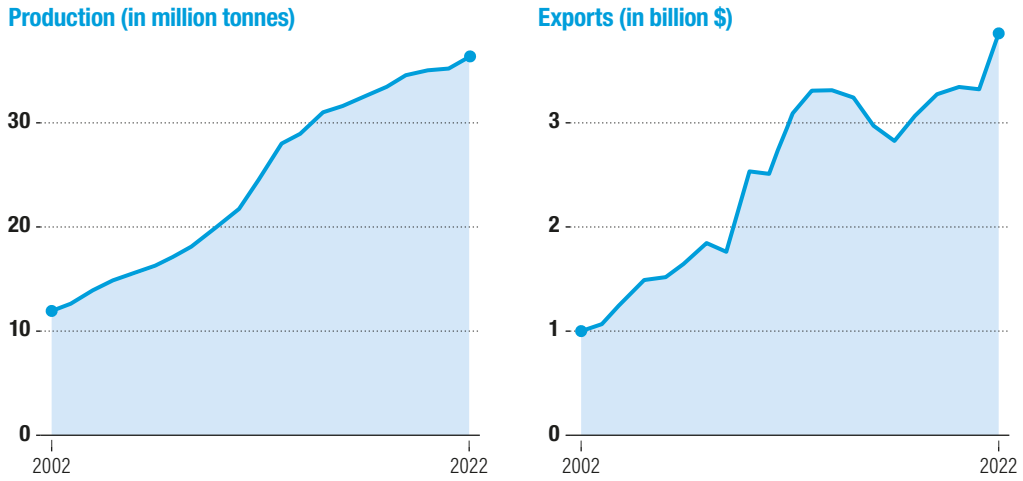
Global production patterns

Global seaweed production expanded significantly over the past two decades, driven by the growth of aquaculture and increased demand for seaweed-based products across food, industrial and biomaterial sectors (UNCTAD, 2024c). Between 2002 and 2022, total output rose from approximately 11.9 to 36.3 million Mt, a threefold increase that reflects the rapid commercialisation of the sector (**Figure 1**) (FAO FishStat, 2025).

This growth has been supported by advances in cultivation techniques, seed and farm technology, and processing innovation alongside growing market demand for sustainable, plant-based inputs in food systems, cosmetics, biofertilisers, and packaging (FAO, 2023c; Froehlich et al., 2019). Policy incentives and export-oriented strategies in key producing countries such as China, Indonesia, and the Republic of Korea have further accelerated investment and expansion (World Bank, 2023; FAO, 2022). Asian countries represent 98 per cent of global output (World Bank, 2023: 2).

In 2023, China (21.6 Mt), Indonesia (9.1 Mt), and the Republic of Korea (1.8 Mt), together accounted for over 90 per cent of global seaweed production (FAO FishStat, 2025). These figures (typically reported in wet or live weight) require further validation, as data accuracy and consistency at the country level remain limited and would benefit from stronger collection methodologies (UNIDO, 2025).

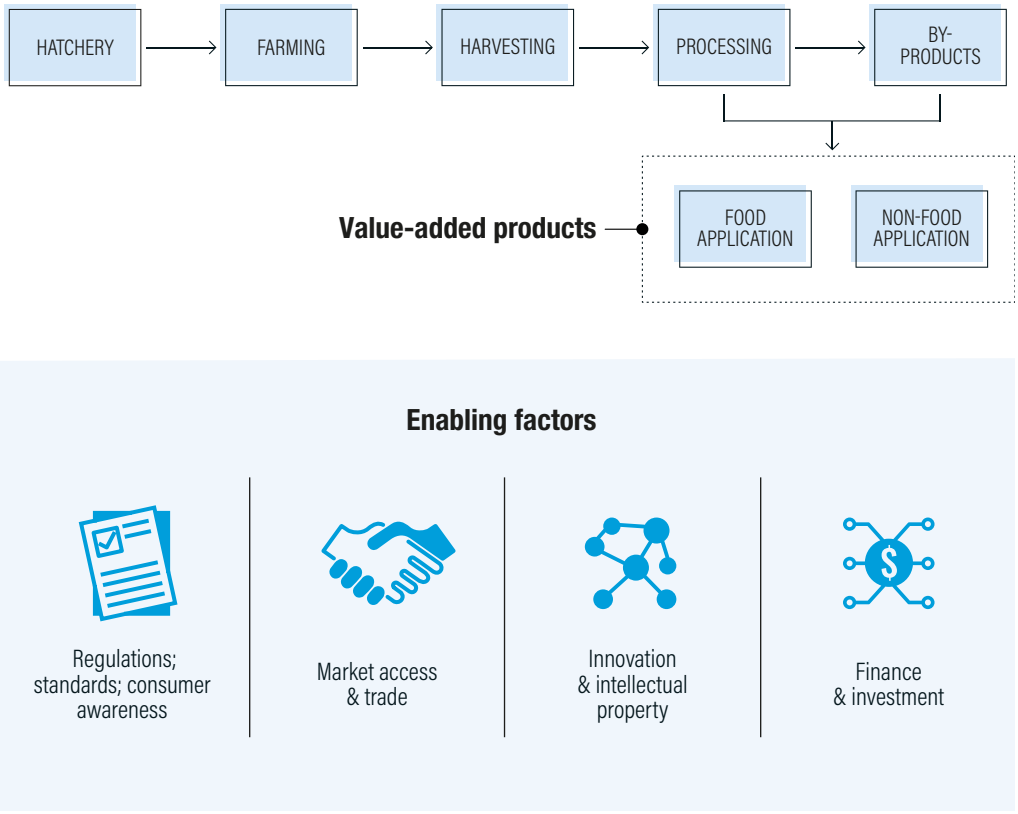
Figure 1.
Global seaweed production tripled, while trade quadrupled
Global seaweed production and exports, 2002–2022



Source: UNCTAD (2025) analysis based on FAO FishStat (2002-2022) and UN Comtrade (1 October 2025).

Figure 2.
The seaweed value chain includes industrial processing of derivatives for both food and non-food uses

The seaweed value chain and its enabling environment



Source: UNCTAD (2025) based on UNIDO, n.d.; Galgo, 2014; Zhang et al., 2022.

The seaweed supply chain (**Figure 2**), comprising hatchery, farming, harvesting, processing, and by-product development, is transforming under growing demand for sustainable ocean economy/blue economy products (Galgo, 2014; UNIDO, n.d.; Zhang et al., 2022). However, most technological innovation has focused on cold-water seaweed species. Tropical seaweed production continues to be limited by weaker investment and technical capacity.

Hatchery activities are increasingly focused on improving seed quality and diversifying cultivated species, while farming faces constraints related to climate change, labour availability, and seasonal variability (Sultana et al., 2023). Harvesting and primary processing are often localised, but scaling is hindered by limited post-harvest infrastructure for cleaning, drying and stabilising raw seaweed (Zayed et al., 2024).

Processing innovations, particularly biorefinery models, are unlocking new value streams by extracting secondary compounds such as fucoidan,[28] laminarin,[29]

[28] Fucoidan is a sulfated polysaccharide found in brown seaweeds, characterised by a high fucose content and structural diversity. They are widely studied for their functional properties and emerging applications in food, cosmetic and other bio-based industries, although their structures and mechanisms of action are not yet fully understood (Jeon Y.J., 2021).

[29] Laminarin is a water-soluble polysaccharide found in various brown algae and is increasingly explored for use

and polyphenols[30] (World Bank, 2023). These feed into high-value applications and value chains, including cosmetics, nutraceuticals, and pharmaceuticals (Hurtado et al., 2021). Seaweed by-products such as biochar, fertilisers, and animal feed additives are also gaining traction, especially within circular bio-based economy frameworks.

Enabling factors across the seaweed supply chain include rising consumer awareness of seaweed's potential environmental and health benefits, though this awareness remains limited, especially in high-income markets (Nakhate and van der Meer, 2021). Harmonised, or mutually recognised, standards and regulations are critical for building consumer trust and reducing compliance costs for producers, especially MSMEs, including women-led enterprises.

Finance and investment are also essential to develop infrastructure, support research and development, expand access to credit for MSMEs and smallholders, and advance ecosystem services monetisation (e.g., emerging blue carbon and other ecosystem services) (Duarte et al., 2017). However, market and trade access remains uneven, with numerous and uncoordinated NTMs continuing to create barriers for producers and exporters.

Trade flows and market access

The volume and value of global seaweed trade have grown in recent years, supported by increased demand for processed and functional seaweed products. Based on UN Comtrade (2025) data available at the time of writing, total trade in seaweed products increased from $2.2 to $3.9 billion between 2012 and 2022. Primary and processed seaweed exports reached 0.75 million tonnes (net weight), up from 0.54 million tonnes (net weight) in 2012 (UN Comtrade, 2025; FAO FishStat, 2025). By contrast, total seaweed production reached 36.3 million tonnes (live weight) in 2022. This indicates that most seaweed is produced for domestic use (even when indicative conversion factors between live weight and net weight are considered).[31]

A small number of countries dominate global exports, while small-scale and medium-sized producers elsewhere continue to face major barriers to accessing international markets (UN Comtrade, 2025). These include high compliance costs, limited access to certification schemes, and underdeveloped quality infrastructure, all of which hinder participation in premium markets (UNCTAD, 2025b). With their small and geographically dispersed production, small-scale producers face difficulties to aggregate supply, ensure consistent quality, and meet certification and testing requirements.

Moreover, in regions such as Africa, Latin America and SIDS, trade is further constrained by inconsistent product classifications and non-transparent regulatory procedures (FAO, 2023c). In these contexts, collective action, such as forming producer associations or cooperatives to pool efforts and resources, can be key to overcoming scale-related and regulatory barriers. Producer associations do by enabling collective requests for testing and certification, generating economies of scale for the same product or by-products.

In 2022, only 0.75 million tonnes of seaweed were traded internationally, indicating that most global production is consumed domestically.

in functional foods, nutraceuticals, and other bio-based applications due to its favourable properties such as biodegradability, biocompatibility and low toxicity (Karuppusamy et al., 2022).

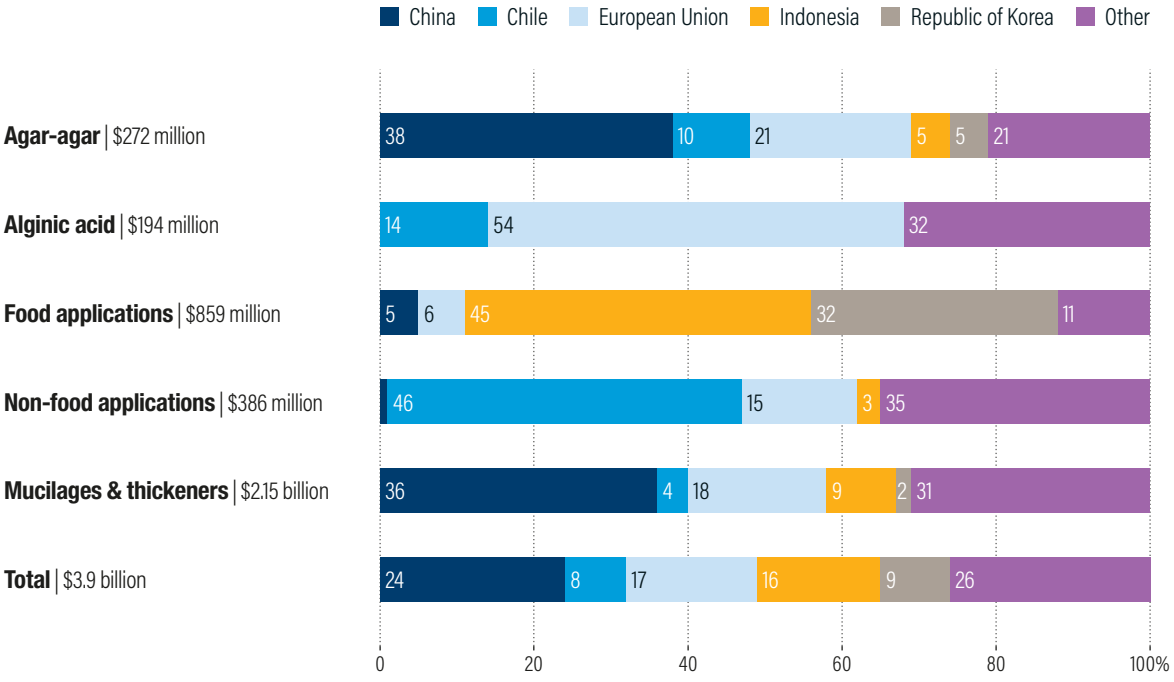
30 Polyphenols are plant-derived secondary metabolites composed of multiple phenol units, produced as part of plants' natural responses to environmental and biological stress, and valued for their functional properties in food, cosmetic and industrial applications (Ciupei et al., 2024).

31 Live seaweed typically has an 80–90 per cent water content (Good et al., 2021). If dried for export, the conversion from live to net weight can be a factor of 0.1 (i.e., 1 tonne live weight becomes 0.1 tonne net weight).

Key exporters

In terms of value, China is the largest exporter of seaweed (accounting for 24 per cent of global exports), followed by the European Union (17 per cent) and Indonesia (16 per cent) (**Figure 3**) (UN Comtrade, 2025). The European Union primarily exports processed derivatives such as alginic acid, while China and the Philippines are major seaweed derivatives exporters,Indonesia and the Republic of Korea mainly trade in primary seaweed (food and non-food applications). Chile has emerged as a key player in non-food applications, particularly *Gracilaria* and *Durvillaea*, which are used in industrial polysaccharides,[32] feed supplements, and biofertilisers (Zhang et al., 2022). In terms of export volume, Indonesia leads by a significant margin, followed by China, the European Union, and Chile (UN Comtrade, 2025).

Figure 3.
Several developing economies are leading exporters of at least one seaweed-based product
Share of global exports by country for selected seaweed products and derivatives, 2022



Source: UNCTAD (2025) analysis based on UN Comtrade (2022).

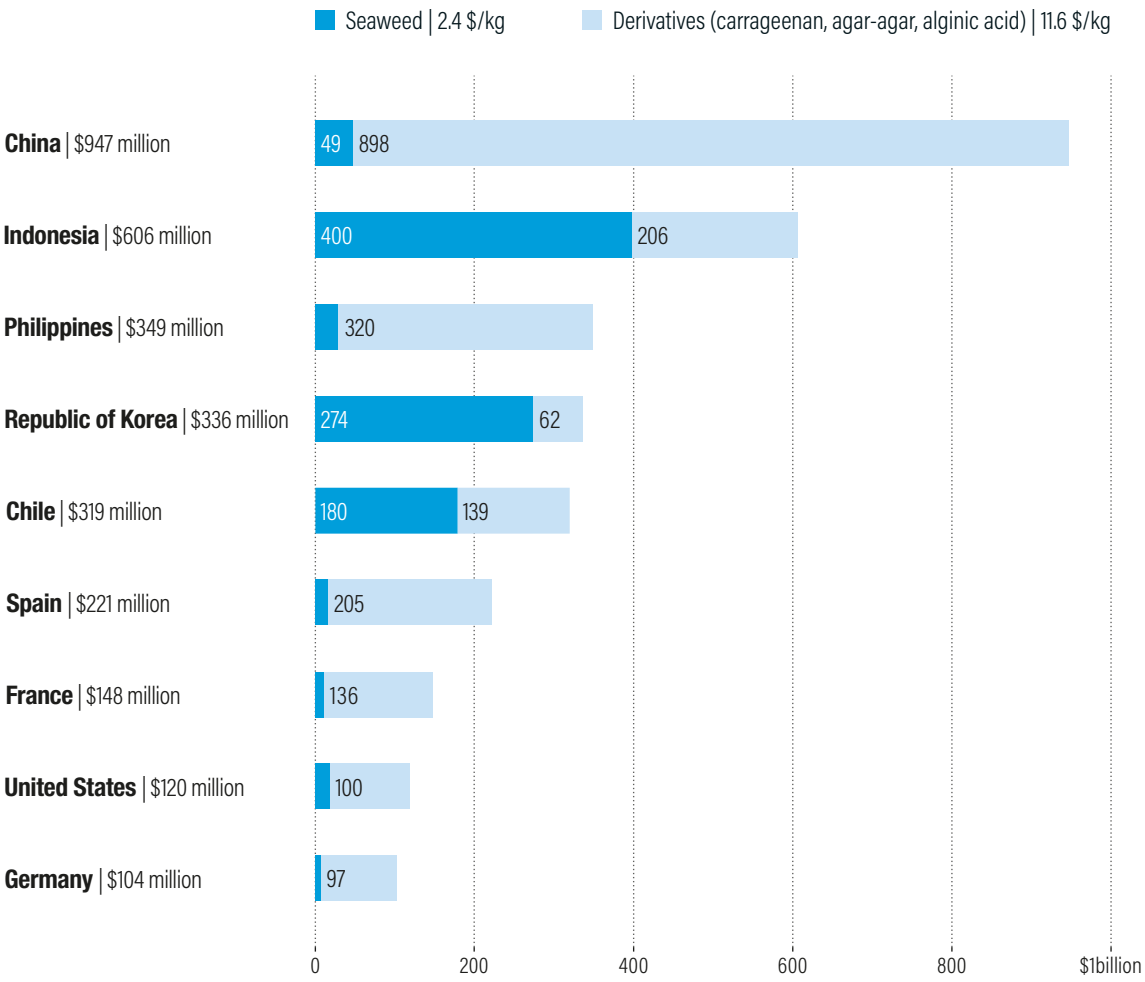
Note: HS Code 1212.20 is not recognised as a distinct international category and is typically consolidated under 1212.21 (WCO, 2022). It has limited commercial relevance for global seaweed trade data.

[32] "Polysaccahrides" are complex carbohydrates composed of linked sugar units, commonly found in plants and marine organisms and used for their structural and functional properties in food and industrial applications. For more information, see https://www.sciencedirect.com/topics/chemical-engineering/polysaccharide.

Among the top ten exporters by value, China leads in seaweed derivatives, which represent approximately 95 per cent of its total seaweed exports (**Figure 4**). Within developing countries, Indonesia and Chile largely specialise in primary seaweed, while the Philippines primarily exports processed derivatives by value. All high-income countries among the top ten exporters, except for the Republic of Korea, focus on seaweed derivatives. Governments seeking to increase their share of the global seaweed market may benefit from supporting investments in infrastructure for derivative extraction, which is associated with higher prices and substantial growth potential (World Bank, 2023).

Figure 4.
Seaweed exports show contrasting specialisations: commodities versus high-value derivatives

Top 10 exporters of seaweed in million $, 2022



Source: UNCTAD (2025) analysis based on UN Comtrade (2022).

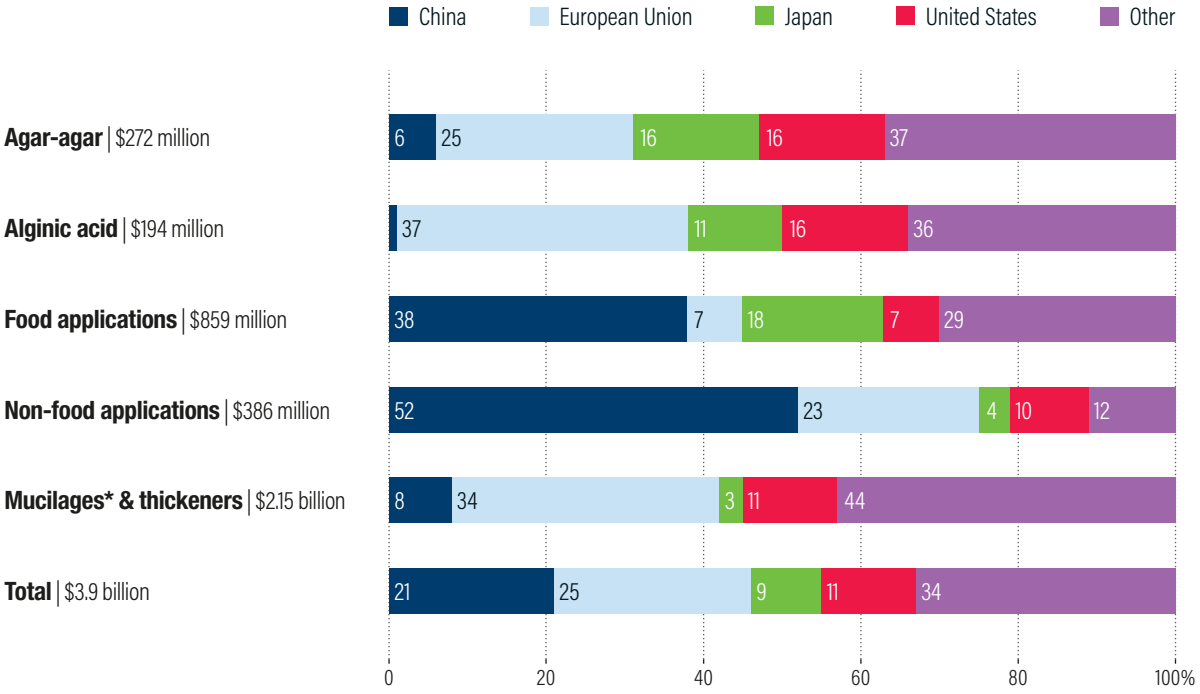
Note: Seaweed refers to HS121221 (food-grade seaweed) and HS121229 (non-food grade seaweed). Seaweed derivatives refer to HS130231 (agar-agar), HS130239 (carrageenan) and HS391310 (alginic acid). HS130239 also includes non-seaweed mucilages and thickeners such as tara gum, xanthan and konjac but was included given the importance of carrageenan exports in total seaweed exports. Average prices are calculated by dividing total export values by total net weight.

Key importers

In 2022, four importers, namely, China, the European Union, Japan, and the United States of America accounted for 66 per cent of total global demand (**Figure 5**). The European Union was the largest overall importer of industrial derivatives such as mucilages and thickeners (i.e., carrageenan), agar-agar and alginic acid. China followed closely, driven by its dominant imports of food-grade and non-food seaweed, importing more than half of all non-food grade seaweed, while Japan and the United States showed relatively diversified imports across both industrial and non-food grade categories (UN Comtrade, 2025).

Dependence on a small number of importing countries presents a vulnerability for global market resilience. South-South trade in seaweed for food and non-food uses represented half of total trade in 2022 (UNCTAD, 2025c). Inter-regional and regional initiatives such as the Global System of Trade Preferences among developing countries (GSTP),[33] the African Continental Free Trade Area (AfCFTA) and the Association of Southeast Asian Nations (ASEAN), could help scale seaweed and other marine species trade by promoting regulatory alignment and investment in regional value chains (AfCFTA, 2025; ASEAN, 2025; UNCTAD, 2024a).

Figure 5.
The European Union and China are leading importers of seaweed derivatives and seaweed, respectively
Share of global imports by country for seaweed and seaweed derivates, 2022



Source: UNCTAD (2025) analysis based on UN Comtrade (2022).

Note: Thickeners and mucilages (HS 130239) includes seaweed-based derivate carrageenan, as well as non-seaweed based products.

[33] For more details, see https://unctad.org/topic/trade-agreements/global-system-of-trade-preferences.

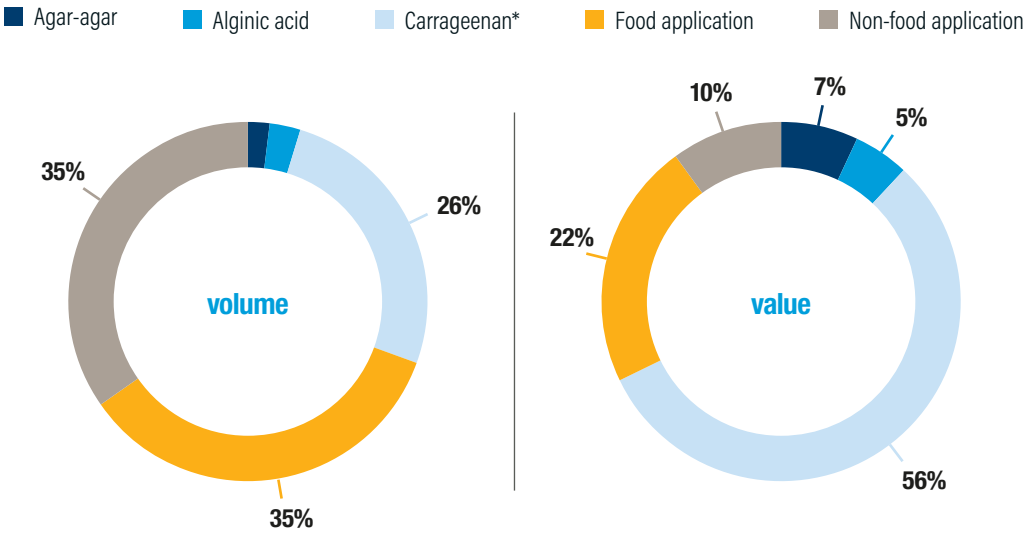
Trade in seaweed products

In 2022, food-related seaweed exports (**Figure 6**) accounted for 35 per cent of total trade in volume but 22 per cent in value. However, this figure underrepresents the true extent of seaweed use in food, as key derivatives such as carrageenan, agar-agar and alginic acid, widely used in culinary applications like dairy alternatives, confectionery, and processed meats are classified under separate HS codes.[34] These compounds also have significant non-food applications, for example, in pharmaceuticals (e.g., wound dressings), cosmetics (e.g., emulsifiers in creams), and industrial processes (e.g., paper coating and textile printing) (World Bank, 2023).

Moreover, many seaweed-based products are incorporated into multi-ingredient formulations, further complicating their trade classification. Although alginic acid and agar-agar each represent only about 2 per cent of seaweed trade by volume, they account for a disproportionately larger share by value, roughly five and seven per cent, respectively, highlighting the higher prices associated with processed seaweed derivatives.

The current HS coding system lacks the granularity needed to accurately capture the diversity of seaweed derivatives and their end uses, as discussed in Chapter II. This highlights the need for clearer and more detailed classification standards that reflect the growing role of seaweed within bio- and circular-economy value chains.

Figure 6.
Seaweed derivatives represent 30 per cent of seaweed trade by volume but 68 per cent by value
Percentage share, global seaweed exports by volume (kg) and value ($), 2022



Source: UNCTAD (2025) analysis based on UN Comtrade (2022).

Note: Seaweed refers to HS121221 (food-grade seaweed) and HS121229 (non-food grade seaweed). Seaweed derivatives refer to HS130231 (agar-agar), HS130239 (carrageenan) and HS391310 (alginic acid). * HS130239 also includes non-seaweed mucilages and thickeners such as tara gum, xanthan and konjac but was included given the importance of carrageenan exports in total seaweed exports. Average prices are calculated by dividing total export values by total net weight.

[34] The absence of a specific HS code for algae-based carrageenan presents a major drawback for accurately estimating seaweed trade volumes. The analysis of seaweed trade is based on data for HS121221 (food-grade seaweed), HS121229 (non-food grade seaweed), HS130231 (agar-agar), HS130239 (carrageenan) and HS391310 (alginic acid). HS130239 includes non-seaweed mucilages and thickeners such as tara gum, xanthan and konjac, but was included given the importance of carrageenan exports in total seaweed exports.

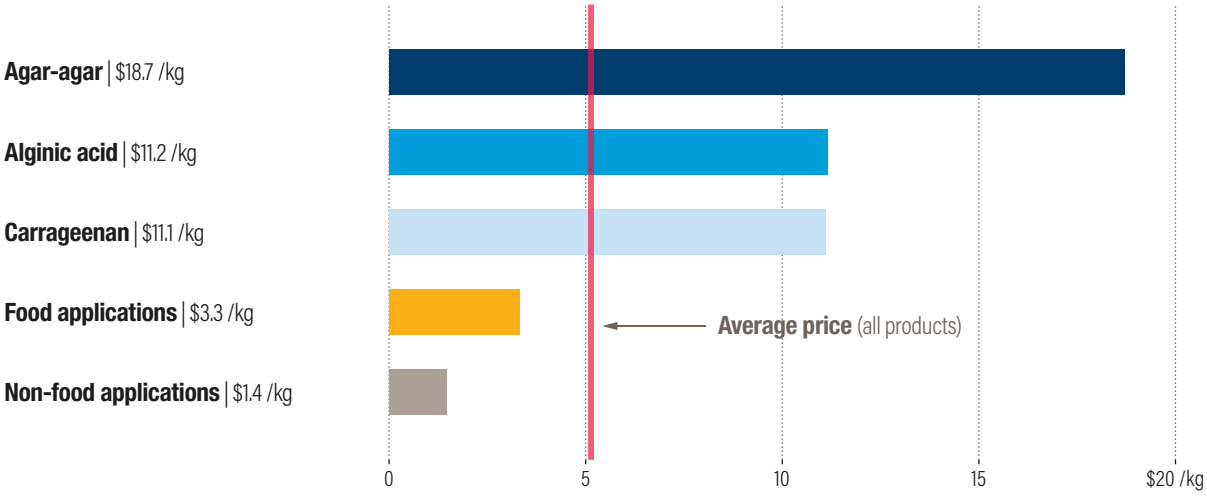
High-value derivatives: carrageenan, agar-agar and alginic acid

Seaweed-derived compounds such as carrageenan, agar-agar and alginic acid play an outsized role in international trade due to their high value, specialised applications, and regulatory relevance (FAO, 2023a). Carrageenan is extracted from red seaweed and is widely used in the food industry for its gelling, stabilising and thickening properties. It is estimated to represent one-third of seaweed production by volume (Zhang et al., 2022).

In 2022, agar-agar had the highest average export price, about $19/kg, nearly four times the average for all seaweed products, while the average export price for alginic acid and carrageenan was about $11/kg (**Figure 7**) (UN Comtrade, 2025). This reflects their limited supply, complex processing, and specialised applications in microbiology, pharmaceuticals, and premium food products. China accounts for 37 per cent of global mucilages and thickeners (i.e., carrageenan) exports, followed by the Philippines (15 per cent) and Indonesia (nine per cent). China also leads in agar-agar exports (38 per cent), while the European Union and Chile account for 21 and ten per cent respectively (see Figure 3).

Alginic acid, derived from brown seaweed, is widely used in both food and industrial applications due to its natural thickening, stabilizing, and gelling properties (FAO, 2023a). In 2022, it comprised five per cent of all seaweed-related trade, with exports valued at $194 million (UN Comtrade, 2025). The European Union led both exports (54 per cent) and imports (37 per cent), followed by Japan and Chile (UN Comtrade, 2025). Regulatory approval by agencies such as the European Food Safety Authority (EFSA) and the United States Food and Drug Administration (FDA) has further supported its commercial integration (EFSA Panel on Food Additives and Nutrient Sources added to Food (ANS) et al., 2017; UNCTAD, 2024c).

Figure 7.
Seaweed derivatives' price per kg is up to 13 times higher than that of non-food grade seaweed
Average price of seaweed products traded (in $ per kg), 2022



Source: UNCTAD (2025) analysis based on UN Comtrade (2022).

Note: The figure covers HS121221, 121229, 130231, 130239 and 391310. *HS130239 includes non-seaweed thickeners but is retained due to the significance of carrageenan exports.

© Adobe Stock

Economic potential and value chain opportunities

Expanding domestic processing capacity represents a key opportunity for producer countries to move up the seaweed value chain. Transitioning from raw biomass exports to higher-value processed products such as powders, extracts, or biostimulants can significantly increase export revenue, support local development, and reduce dependence on commodity markets (UNCTAD, 2024c; World Bank, 2023). The World Bank estimates the global seaweed market could expand by an additional $11.8 billion by 2030, with short-term growth expected in biostimulants ($1.9 billion), animal feed ($1.1 billion), and pet food ($1.1 billion) (World Bank, 2023). Medium-term opportunities include nutraceuticals ($4 billion), fabrics ($862 million), bioplastics ($733 million), and alternative proteins ($448 million), while emerging applications such as seaweed-based construction materials could add $1.4 billion to the market (World Bank, 2023).

In parallel, circular economic approaches are gaining attention, particularly the valorisation of seaweed waste streams, which remains an unexplored source of economic and environmental value. Residual biomass, including offcuts, degraded algal thalli,[35] and post-extraction slurries, often retains valuable polysaccharides, proteins, and minerals (Pardilhó et al., 2022). These waste materials can be repurposed into secondary products such as biofertilisers, animal feed, bioplastics, biochar or inputs for anaerobic digestion (Singh et al., 2022; Chojnacka et al., 2022). However, uptake remains limited, especially in low- and middle-income countries, due to poor infrastructure, limited technology access, and unclear standards governing the use of waste-derived inputs (Mahjoub and Domscheit, 2020). A more circular approach to seaweed value chains, grounded in supportive regulation, investment in waste-to-value infrastructure, and clearer market incentives, could reduce environmental pressure, create rural employment and improve resource efficiency (Pardilhó et al., 2022; Mahjoub and Domscheit, 2020).

Together, these trends, from greater value capture through product diversification to innovations with a circular economic approach, highlight seaweed's potential to drive industrial upgrading, support climate-friendly development and job creation, and build more resilient value chains. However, realising this potential depends on overcoming trade-related barriers, which are addressed in the next section. Chapter IV reviews seaweed regulation at the national, regional and international levels, with a focus on relevant trade instruments.

The global seaweed market could expand by an additional $11.8 billion by 2030, driven by growth in biostimulants, nutraceuticals, bioplastics and other emerging applications.

[35] Thallus is the main body of a seaweed, i.e., the visible biomass that is grown and harvested, rather than separate roots, stems or leaves. For more information, see https://www.dcceew.gov.au/science-research/abrs/online-resources/glossaries/algae.

Chapter IV

Regulatory gaps holding back seaweed potential

© Rohit Kumar (Unsplash)

Regulatory gaps holding back seaweed potential

Despite rapid market growth, regulatory frameworks remain fragmented and generic. Only 17 per cent of NTMs affecting seaweed apply specifically to seaweed, while most apply generically across wider product groups. A lack of clarity raises compliance costs and deters investment, especially in non-food and high-value applications.

As seaweed production expands into new applications and sectors, the need for clear, consistent, and seaweed-specific regulatory frameworks has become increasingly critical. Regulations play a critical role in shaping market access and sustainability safeguards; however, most remain national in scope and treat seaweed indirectly, typically, as part of aquaculture, fisheries, or food additives (UNCTAD, 2024c; Cai et al., 2021). This limits coherence and adds complexity and compliance costs for producers and exporters, particularly when dealing with novel uses or emerging species.

At the multilateral level, seaweed is generally covered by WTO trade disciplines, particularly the SPS and TBT Agreements. However, the sector's rapid expansion into diverse food, industrial, and bio-based applications has exposed limitations in applying these general disciplines without clearer classification and regulatory coherence. Seaweed is also not recognised as a distinct commodity group in trade classification or policy monitoring. Unprocessed seaweed is often grouped under broader categories such as "fisheries/aquatic foods", despite being entirely plant-based. To be considered a distinct commodity group, a product typically needs to originate from the primary sector, involve minimal processing, be fungible, and be widely traded.

This regulatory gap partly reflects the biological and commercial characteristics of the sector. Although a relatively small number of species dominate global production, they serve diverse and often non-interchangeable markets from food and cosmetics to industrial applications (FAO FishStat, 2025 and Seaweed Insights, 2023). This variability means the sector often fails to meet the criteria for recognition as a distinct commodity group, resulting in higher compliance costs, lower investment, and uneven regulatory enforcement (FAO and WHO, 2022). At the same time, some countries, such as Indonesia, have moved ahead nationally by designating seaweed as a strategic commodity,[36] highlighting its growing economic and policy importance even in the absence of dedicated international recognition.

This chapter provides a tiered review of seaweed regulation across three levels: first, under national statutes (sub-section 4.1), then within regional trade regimes (4.2) and finally through broader international instruments (4.3).

[36] MMAF (2020). Regulation No. 26/2020 on Strategic Commodities in Aquaculture. For more details, see 50 PERMEN-KP 2020 ttg Penerapan KKNI Bid.Industri Pengolahan Rumput Laut.pdf.

Sorting and handling dried seaweed prior to processing.

© Henrique Pacini (UNCTAD)

Seaweed is not recognised as a distinct commodity group in international trade classification or policy monitoring systems.

National regulations

National regulations are legally binding rules that govern seaweed production, processing, and trade. They are enforced by national authorities and vary widely in scope, clarity, and enforcement. While some countries, such as the Republic of Korea, offer integrated oversight (**Tables 3 and 4**), most countries govern seaweed under general laws for larger product groups (e.g., for food, fisheries, aquaculture or cosmetics), rather than through seaweed-specific legislation. A few countries have begun to address food safety risks associated with seaweed by establishing specific regulatory thresholds and issuing consumer guidance on safe consumption, handling and preparation methods (FAO and WHO, 2021, 2022).

Non-Tariff Measures (NTMs) and the UNCTAD Trade Analysis Information System (TRAINS) Database

NTMs are defined as policy measures other than ordinary customs tariffs that may affect international trade in goods by altering quantities traded, prices, or both (UNCTAD, 2010). Under WTO disciplines (the SPS and TBT Agreements), NTMs must be non-discriminatory, transparent, and in the case of SPS measures, based on best available scientific evidence.

In practice, however, they often exert greater impact on trade than traditional tariffs and disproportionately affect exports from low-income countries and smaller-scale producers due to high assessment and compliance costs (UNCTAD, 2025b).

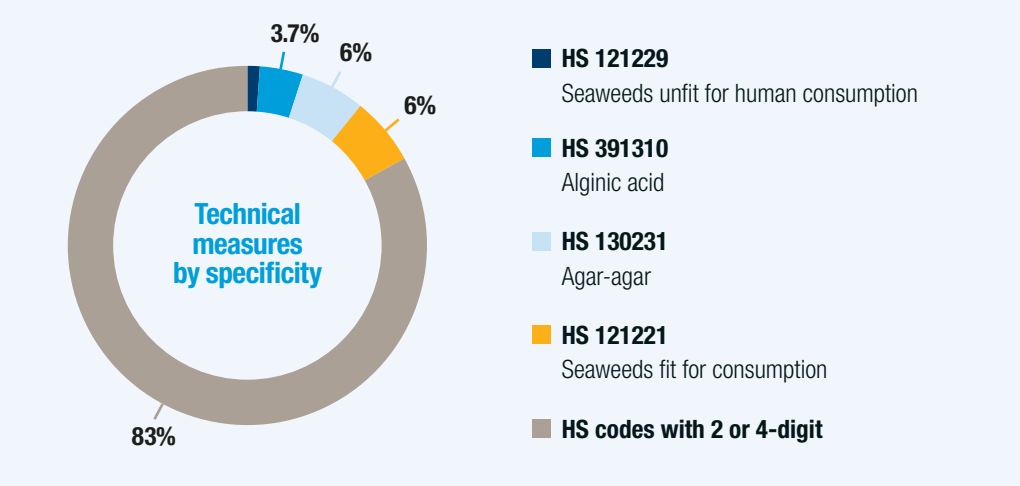
Of the 109 technical measures identified in the UNCTAD TRAINS database that apply to seaweed, only 18 (17 per cent) explicitly apply to seaweed's associated 6-digit HS codes, namely 121221, 121229, 130231, 130239 and 391310 (**Figure 8**). The remaining 91 (83 per cent) apply to 2- or 4-digit HS codes (e.g., HS12 or HS 1302), making it difficult to distinguish seaweed from other products in trade data and policy analysis, and increasing compliance challenges for producers and exporters. Also, the absence of targeted regulations, especially distinguishing between food- and non-food grade seaweed, contributes to market uncertainty and discourages investment.

Most measures are SPS-related (70 per cent), followed by TBT (25 per cent) and pre-shipment formalities (5.5 per cent) (**Figure 9**). The majority aim to protect human health (78 per cent) or plant health (17 per cent).[37] In addition, indirect NTMs such as customs delays, port congestion, and administrative inconsistencies further burden producers in developing countries.

Box 1 provides an illustrative example of these challenges through a Tanzanian exporter case.

[37] The analysis of policy objectives is based on a review, by UNCTAD, of each technical measure.

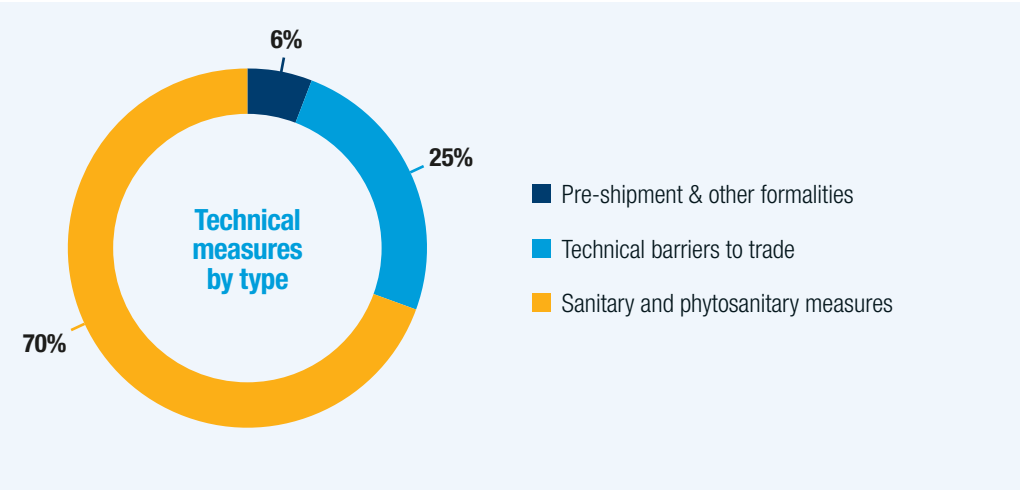
Figure 8.
Most technical measures affecting seaweed trade apply to broader product categories
Share of technical measures affecting seaweed trade, by level of specificity



Source: UNCTAD analysis based on TRAINS Database (2025).

Note: Technical measures are a subcategory of NTMs consisting of SPS, TBTs, and pre-shipment inspections and other formalities. Other NTMs are not considered here as they are often applied for horizontal on all products and for non-seaweed specific reasons (for instance, export controls). Only technical measures affecting several economies are considered. NTMs affecting all products are also not included.

Figure 9.
70 per cent of technical measures affecting seaweed are sanitary and phytosanitary
Percentage share of technical measures affecting seaweed trade, by type



Source: UNCTAD (2025) analysis based on TRAINS Database (2025).

Box 1.
Navigating barriers and building value: a Tanzanian seaweed enterprise's export challenge

The United Republic of Tanzania exports over 90 per cent of its seaweed, primarily raw, to international markets including the United States of America, France, Spain, Chile and China. By exporting most production without processing, producers capture little added value and remain exposed to global price volatility (UNCTAD, 2024b).

Interviews with the United Republic of Tanzania's largest seaweed firm highlight key challenges to capturing higher value. Climate change has reduced productivity of sea moss (Eucheuma cottonii), forcing a shift to heat-tolerant spiney seaweed (Eucheuma spinosum). However, because many regional producers have also shifted to this variety, the market has become saturated, leading to increased competition and price volatility (H. Soud, personal communication, March 11, 2025).

Trade barriers include high shipping costs, port congestion, HS code classification issues, customs delays, and unclear bureaucratic processes. In early 2025, customs delay held up critical packaging materials for the United Republic of Tanzania's seaweed sector. Overlapping taxes and unclear policies further discouraged investment.

Still, there are signs of progress. The United Republic of Tanzania's Liner Shipping Connectivity Index (LSCI)[1] reached 64 in February 2025,[2] indicating improved maritime connectivity. Private investments have also been made in a domestic seaweed powder facility, modelled after the Republic of Korea's processed seaweed sector, aiming to boost domestic value addition, employment and resilience (H. Soud, personal communication, March 11, 2025).

Source: Interviews with selected stakeholders, UNCTAD (2025), 2nd training workshop for communicators on circular economy. See: https://unctad.org/meeting/2nd-training-workshop-communicators-circular-economy.

[1] The Liner Shipping Connectivity Index (LSCI), developed by UNCTAD, measures a country's integration into global liner shipping networks based on six components capturing the availability, capacity, diversity, and reach of container shipping services. Higher values indicate stronger maritime connectivity and greater potential integration into international trade. For more information, see https://unctadstat.unctad.org/datacentre/reportInfo/US.LSCI and https://unctadstat.unctad.org/datacentre/dataviewer/US.LSCI.

[2] UNCTAD (2025). Maritime profile: United Republic of Tanzania. For more details, see https://unctadstat.unctad.org/CountryProfile/MaritimeProfile/en-GB/834/index.html.

Trade-related environmental measures
WTO Environmental Database

The WTO Environmental Database (EDB) offers a more focused view of the trade-policy landscape by cataloguing trade-related environmental measures[38] that have been notified by Members or identified by the WTO Secretariat. As of 2025, it records 41 seaweed-related measures, and only one explicitly targeting seaweed as a product, namely an SPS notification by the Philippines. The remaining 40

[38] In WTO terms, trade-related environmental measures refer to non-tariff measures adopted for environmental objectives, e.g., SPS, subsidies, quantitative restrictions, licensing requirements, or technical regulations. These may aim to support sustainable resource management, ensure food and feed safety, or align with multilateral environmental agreements (MEAs) such as the Convention on Biological Diversity (CBD) or the Basel Convention. The seaweed-related measures identified in the database typically involve import/export licenses, quotas, technical standards or labelling schemes.

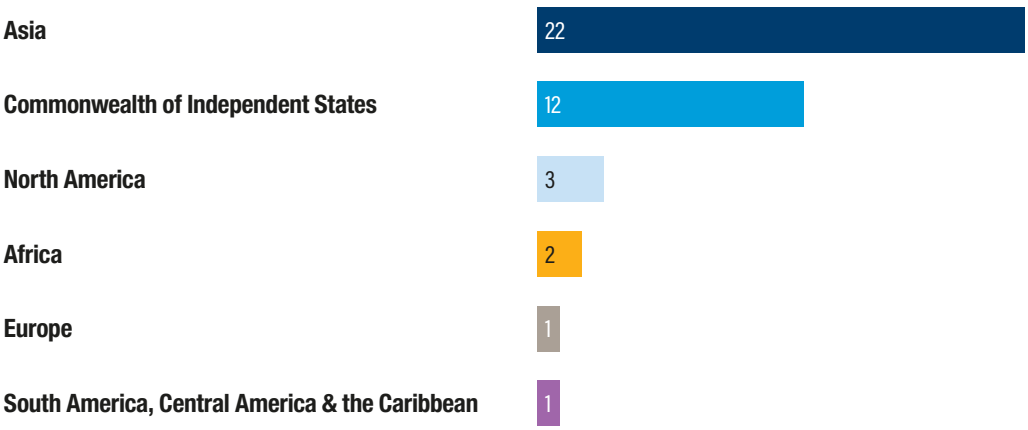
© Benjamin Jones (Unsplash)

measures apply horizontally to broader product categories such as fisheries, marine plants, or aquatic organisms. This pattern suggests both under-notification and the limited visibility of seaweed within multilateral trade governance (WTO EDB, 2025). As a result, the full scope of seaweed-relevant environmental regulations is likely broader than reflected in the database but remains institutionally diffuse at the multilateral level.

Geographically, Asia and the Commonwealth of Independent States (CIS) account for the majority of seaweed-related entries: 22 measures from Asia (53.7 per cent) and 12 from CIS countries (29.3 per cent) (WTO EDB, 2025). Other regions report significantly fewer entries, namely, North America (3), Africa (2), and one each for Europe, South America, Central America and the Caribbean which limits their visibility in global regulatory mapping and may reduce their influence in future international discussions on seaweed-relevant governance and standard-setting discussions (**Figure 10**) (WTO EDB, 2025).

Overall, the EDB reinforces the finding that seaweed is not yet recognised as a distinct product category in environmental trade regulation, limiting transparency and constraining the development of sustainability-linked standards.

Figure 10.
Asia leads in the development of seaweed-specific trade regulations
Number of trade-related environmental regulations referencing seaweed, by region



Source: UNCTAD (2025) analysis based on WTO's Environmental Database as of May 2025.

"Sea grapes" *Caulerpa lentillifera* for sale at the Bagting Fish Market in Dapitan City, Philippines.

© FAO

Selected national regulatory frameworks

Nine national regulatory frameworks were selected for deeper review, namely Chile, China, Brazil, Indonesia, Japan, the Philippines, the Republic of Korea, the United States and the Bolivarian Republic of Venezuela, based on their global relevance and diversity of legal systems. Across these cases, two cross-cutting policy objectives emerge: food safety and environmental management. These affect both food and non-food applications of seaweed and shape compliance costs, scalability, and innovation.

Food safety

Food safety emerges as a central concern in all jurisdictions due to seaweed's propensity to bioaccumulate certain contaminants such as arsenic, cadmium and persistent organic pollutants (POPs)[39] during cultivation and processing. Additionally, high iodine content found in most brown seaweed can pose health risks if consumed in large quantities (Mukhia et al., 2024). These risks make regulatory oversight essential to public health protection (for both human and animal consumption) and consumer trust. However, countries differ in how they regulate these issues, particularly in setting composition and contaminants thresholds, which often reflect varying levels of population sensitivity to dietary iodine intake.

China applies general mandatory hygiene standards for aquatic foods (GB 2733-2015)[40] and maximum contaminant levels for food that also cover seaweed (GB 2762-2022/XG1-2025)[41]). In the Republic of Korea, an integrated system combining HACCP certification with strong

[39] Persistent organic pollutants (POPs) are toxic, long-lasting chemical substances that resist environmental degradation, accumulate in the food chain, and can cause adverse effects on human health and the environment. In marine settings, POPs may accumulate in aquatic organisms, including seaweed, raising food and feed safety concerns. POPs are regulated globally under the Stockholm Convention on Persistent Organic Pollutants. For more information, see https://www.pops.int/.

[40] National Health Commission of China (2015). GB 2733-2015 Hygienic Standard for Algae Products. For more details, see https://www.agsiq.net/pdf/China_GB_2733-2015_National_Food_Safety_Standard_Fresh_Frozen_Aquatic_Products.pdf. This is a mandatory standard.

[41] China, National Health Commission and State Administration for Market Regulation, National Food Safety Standard – Maximum Levels of Contaminants in Foods, GB 2762-2022/XG1-2025 (Beijing, 16 January 2025), English version, including Amendment 1. Available at: 2762-2022/XG1-2025 English Version, GB 2762-2022/XG1-2025 National Food Safety Standard - Maximum Levels of Contaminants in Foods, includes Amendment 1 (English Version) – Code of Chin (accessed 21 August 2025). This is mandatory standard.

traceability requirements provides targeted and consistent oversight (MFDS, n.d.). In Indonesia, seaweed's strategic importance has led to multi-agency involvement; however, overlapping mandates among competent authorities have been reported to raise costs for producers (Waldron et al., 2023). Under Act No 45/2009,[42] seaweed is also classified as a fishery product, meaning that its trade and certification rules are treated in the same regulatory category as other fishery products, which places additional compliance burdens on processors and exporters.

In Japan, food safety authorisations and implementation vary across prefectures, creating uncertainty for exporters (MHLW, 2022; METI, 2025), while in the Philippines, aquaculture and fisheries laws provide a basic framework for aquatic food safety, but they pay little attention to novel or imported species (BAFPS, 2017; Mateo et al., 2020). In the United States, seaweed is Generally Recognised as Safe (GRAS) under the Federal Food, Drug, and Cosmetic Act, which offers flexibility; however, uneven implementation across states leads to inconsistent enforcement (FDA, 2023). **Table 3** summarises the main national regulations governing seaweed for food use across the nine selected countries.

Only 17% of technical measures recorded in UNCTAD TRAINS as applying to seaweed **target seaweed-specific HS codes.**

Table 3.
National food regulations for seaweed

Country	Regulation	Competent authority	Scope & description
Brazil	**Portaria No.147, de 17 de novembro de 1997** LICENSING FOR EXTRACTION AND CULTIVATION – APPLIES HORIZONTALLY	Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA)	Establishes guidelines for licencing the installation and operation of seaweed extraction, cultivation and harvesting
Chile	**Law 21651** (2024) General law on fishing and aquaculture in the field of Benthic resources EXTRACTION – APPLIES HORIZONTALLY	Undersecretariat of Fishing and Aquaculture National Institute for the Sustainable Development of Artisanal Fishing and Small-Scale Aquaculture (INDESPA)	Regulates the extraction of algae and other benthic resources, defining management standards, differentiating extraction techniques, and establishing protected zones and species.
China	**GB 2733-2015** Hygiene standards **GB 2762-2022/XG1-2025** Maximum contaminant levels for food	National Health Commission (NHC) Provincial Food and Drug Supervision Bureaus	Establishes hygiene requirements and permissible contaminant levels for edible seaweed
Indonesia	**Permen KKP No. 19/2010** Export procedures for fishery products including seaweed **Permen KKP No. 16/2024** Quality assurance and inspection for fisheries products including seaweed	Ministry of Marine Affairs and Fisheries (MMAF) National Agency for Drug and Food Control (BPOM)	Regulates quality assurance system for processing and export requirements for food-grade fisheries products including seaweed

[42] Law of the Republic of Indonesia Number 45 of 2009 on Amendment to Law Number 31 of 2004 on Fisheries. For more details, see https://peraturan.go.id/files2/uu-no-45-tahun-2009_terjemah.pdf.

Table 3. (cont.)
National food regulations for seaweed

Country	Regulation	Competent authority	Scope & description
Japan	**Act No. 233 (1947, amended 2018)** Food Sanitation Act General food law for hygiene, additives, labelling and import controls	Ministry of Health, Labour and Welfare (MHLW)	General food law covering hygiene, additives, labelling, and import controls for food products including seaweed
Philippines	**Fisheries Administrative Order No. 210-01** (2001) Export procedures for fresh seaweed	Bureau of Fisheries and Aquatic Resources (BFAR) Food and Drug Administration (FDA)	Governs seaweed aquaculture and traceability. RA 10611 governs overall food safety and labelling
	Republic Act 10611 (2013) General food safety and traceability law		
Republic of Korea	**Food Sanitation Act** (2002) General food hygiene and safety law	Ministry of Food and Drug Safety (MFDS)	Requires HACCP certification and import controls for edible seaweed, while also ensuring traceability and hygiene and regulating its use in health and wellness products.
	Law on the Promotion and Support of the Laver Industry Industrial seaweed support		
	Functional Health Foods Act Supplements, nutraceuticals		
	Special Act on Imported Food Safety Management (amended 2023) Import safety and traceability framework		
United States	**Federal Food, Drug, and Cosmetic Act** (1938) General food law for labelling, adulteration, and GRAS status	Food and Drug Administration (FDA)	Seaweed is generally recognised as safe (GRAS); facilities must implement preventive controls, hazard analysis, and sanitation if processing food-grade seaweed
	FSMA – Preventive Controls Rule (21 CFR Part 117) Food safety planning and controls for facilities processing seaweed products		
Bolivarian Republic of Venezuela	**Resolutions DM/N° 023-23** and **DM/N° 089-23** Cultivation – applies horizontally	Ministry of Fisheries and Aquaculture Ministry for Ecological Socialism	Regulates algae cultivation, in a broad sense (macroalgae, microalgae, and cyanobacteria)

Source: UNCTAD analysis (2026).

Non-food regulation

Non-food regulation is similarly fragmented. Cosmetics, pharmaceuticals, fertilisers and industrial applications are usually governed under separate sectoral laws, which ensures coverage and product-specific safety requirements but complicates compliance. In Japan, responsibilities are spread across several ministries with distinct mandates, which can create overlaps and red uce regulatory predictability for innovation. In the Philippines, there is an absence of non-food regulations specific to seaweed (Mateo et al., 2020). In the United States oversight is divided between the Food and Drug Administration (FDA), Environmental Protection Agency (EPA), and the Department of Agriculture (USDA) depending on the product and intended use. In the Republic of Korea, clearer frameworks for seaweed use for cosmetic provide stronger support for innovation. **Table 4** summarises the main non-food regulations across six national frameworks where information was found.

On the **environmental side**, sustainable seaweed extraction and farming, whether for food or non-food purposes, are often celebrated for their positive ecosystem services, including water filtration, nutrient and carbon uptake, habitat provision, and their regenerative effects. Yet regulations are promulgated to ensure environmental integrity in both wild extraction and aquaculture. In the case of ***in situ* extraction**, the so-called Chile "Benthic" law (Law 21651 of 2024)[43] regulates the extraction of wild algae and other benthic resources (e.g., animal and plant species on the sea bottom), while recognising the role of artisanal fishers and gatherers and incorporating both environmental and social considerations. In Brazil, the Portaria No. 147 (1997)[44] regulates licenses for wild seaweed extraction as well as the installation and operation of seaweed cultivation and harvesting.

In **aquaculture**, seaweed cultivation in France falls under maritime spatial planning and is subject to environmental impact assessments (EIAs) required by the European Union Environmental Impact Assessment Directive (Directive 2011/92/EU, as amended by 2014/52/EU).[45] Licences are issued following reviews of biodiversity impacts, conflicts with other marine activities, and water quality; producers may also have to undertake complex management studies to maintain their license (**Table 4**) to operate. In the Bolivarian Republic of Venezuela, Ministerial Resolutions DM/N° 023-23 and DM/N° 089 of 2023[46] establish a novel framework for algae cultivation, broadly defined to include not only macroalgae but microalgae and cyanobacteria.

Elsewhere, licensing and approval processes vary dramatically, taking anywhere from a few months to several years. While such safeguards are essential for protecting ecosystems, they should ensure lengthy or costly regulatory approval process does not discourage investments and industry development (Falconer et al., 2023). Some countries have also developed species-specific systems; for example, the Philippines' Fisheries Administrative Order No. 250-2 of 2018[47] regulates the collection, harvesting, gathering, selling and exporting of *Sargassum spp.* along their multiple-use

Non-food seaweed regulation is split across multiple sectoral frameworks and authorities in many countries, creating overlaps and regulatory complexity.

[43] Chile, Ley Bentónica [Benthic Law], Law No. 21651 (2024). For more details, see https://www.bcn.cl/leychile/navegar?idNorma=1200828&idParte=10488632&idVersion=2024-02-07.

[44] Brazil, Ministry of the Environment, Portaria No. 147 (1997). For more details, see https://www.ibama.gov.br/sophia/cnia/legislacao/IBAMA/PT0146-181001.PDF.

[45] European Union (2014) Directive 2014/52/EU amending Directive 2011/92/EU on environmental impact assessments, OJ L 124. For more details, see https://eur-lex.europa.eu/eli/dir/2014/52/oj/eng#:~:text=Directive%202011%2F92%2FEU%20of%20the%20European%20Parliament%20and%20of,of%20protection%20of%20the%20environment%20and%20human%20health.

[46] Bolivarian Republic of Venezuela, Ministry of Aquatic and Air Transport, Resolutions DM/N° 023-23 and DM/N° 089 (2023). For more details, see https://badellgrau.com/gaceta-oficial-no-42-787-ordinaria-de-fecha-28-de-diciembre-de-2023/?print=pdf&utm

[47] Philippines, Bureau of Fisheries and Aquatic Resources (BFAR), Fisheries Administrative Order No. 250-2, Series of 2018: Rules and Regulations on the Collection, Harvesting, Gathering, Selling and Exporting of Sargassum Species (2018). (No longer available online).

Table 4.
National non-food regulations for seaweed

Country	Regulation	Competent authority	Scope & description
China	**Provisions for Registration and Filing of Cosmetics** (2021) Covers seaweed-based cosmetic ingredients	National Medical Products Administration (NMPA)	Regulates cosmetic products and ingredients derived from seaweed, part of general safety and labelling law
Indonesia	**Permen-KKP No. 50/2020** Strategic commodity designation for seaweed **Permen-KKP No. 7/2013** Certification of seaweed origin **Permen-KKP No. 1/2024** Workforce qualifications for seaweed sector	Ministry of Marine Affairs and Fisheries (MMAF) National Agency for Drug and Food Control (BPOM) Ministry of Manpower	Recognises seaweed as a strategic commodity; governs traceability, cross-sector development, and human resource capacity in industrial seaweed applications
Japan	**Act on Securing Quality, Efficacy and Safety of Products Including Pharmaceuticals, Medical Devices and Cosmetics Law** Covers health and cosmetic uses of seaweed	Ministry of Health, Labour and Welfare (MHLW) Pharmaceuticals and Medical Devices Agency (PMDA)	Covers seaweed-based ingredients in cosmetics, nutraceuticals, and pharmaceuticals under a unified safety and efficacy law
Philippines	**Fisheries Administrative Order No. 250-2** (2018) While several *Sargassum spp.* are edible, main uses of sargassum include biorefining, biofuels, cosmetics, and fertilizers	Department of Agriculture	Regulates the collection, harvesting, gathering, selling and exporting of *Sargassum spp.* along their multiple use value chains Non-food seaweed uses (e.g., in cosmetics, fertilisers) fall under general product or environmental regulation frameworks
Republic of Korea	**Cosmetic Act** Seaweed-derived cosmetic products	Ministry of Food and Drug Safety (MFDS) Ministry of Ocean and Fisheries (MOF)	Supports seaweed industry research and development and industrialisation, especially for laver (*Porphyra spp.*)
United States	**Federal Food, Drug, and Cosmetic Act** Covers cosmetics and supplements **Environmental Protection Agency (EPA) rules** Seaweed-based agricultural inputs under general pesticide and environmental laws **United States Department of Agriculture (USDA) Organic Program** Organic certification of seaweed inputs	Food and Drug Administration (FDA) U.S. Environmental Protection Agency (EPA) U.S. Department of Agriculture (USDA)	Covers seaweed in cosmetics, fertilisers, supplements and organic products by sector-specific rules from multiple agencies

Source: UNCTAD analysis (2026).

© Henrique Pacini (UNCTAD)

value chains – an approach particularly relevant for countries affected by large-scale Sargassum influxes in the Caribbean.

By contrast to these more structured approaches, fragmented mandates, inconsistent thresholds, and lengthy licensing processes raise costs and creates barriers, particularly for MSMEs. In response, several governments have adopted national policies, strategies, and initiatives to address these challenges and support sectoral development (see **Box 2**). However, most of these regulations have not yet been compiled and notified under UNCTAD's TRAINS database or the WTO EDB. Their systematic compilation and inclusion in these databases would support the creation of a comprehensive global repository of seaweed-relevant regulations.

To date, most regulatory examples analysed originate from Asian countries, reflecting the region's dominance in global seaweed production and processing, rooted in long-standing production and consumption practices. As the Codex Alimentarius covers only a limited number of species and the International Organization for Standardization (ISO) only has a small number of private guidelines applicable, most national regulations identified have not been developed based on international standards. FAO-WHO Expert Meetings (from 2021–22)[48] found these were significant regulatory gaps, identified food safety hazards such as inorganic arsenic, cadmium, organic pollutants, microplastics, and pathogens that remain insufficiently regulated at international level, and recommended the development of International and Regional Codex standards where relevant (see section on international standards below).

Given the diversity in scope, modalities, stages of production or product development, thresholds applied, and the existence of diverse regulatory approaches, there is value in **an expanded comparative analysis to identify areas of regulatory distance and convergence across countries**. Such analysis should cover the entire value chain for food and non-food seaweed, from cultivation and harvesting, to processing, and downstream products and by-products, drawing on national experiences of regulatory approval processes before competent authorities.

This analysis could help identify **good regulatory practices** that other countries may consider adopting and support the gradual development of **mutual recognition schemes** in areas such as risk assessment, sanitary and safety testing, verification, commercial and sanitary approval, and relevant certifications, where fundamental regulatory objectives and requirements in food, non-food uses align. International harmonisation may be considered at a later stage, once tangible progress has been made in mapping and addressing existing regulatory and standards gaps.

Most national **seaweed regulations have not been developed based on international standards.**

[48] FAO/WHO (2022). Report of the expert meeting on food safety for seaweed: current status and future perspectives. Available at: https://www.who.int/publications/i/item/9789240058538.

Box 2.
National policy instruments supporting seaweed sector governance

In addition to regulations, several countries have adopted strategic policy instruments such as strategies, roadmaps, national visions, or high-level executive initiatives to guide the development of their seaweed sectors. These frameworks are typically non-binding, but they play a critical role in aligning cross-sectoral efforts, setting investment priorities, and promoting coherence across government mandates.

China | The Blue Granary Initiative (2023)

Introduced in the 2023 No.1 Central Document (State Council of China, 2023), the Blue Granary Initiative promotes large-scale marine food production, including seaweed, through offshore aquaculture, marine pastures, and ecological planning (State Council of China, 2024). It aims to transform marine resources into a national protein reserve while advancing innovation and food security goals.

France | Roadmap for Seaweed (2025)

Launched in March 2025, France's national roadmap aims to triple domestic seaweed productionn by 2027 and strengthen the sector's resilience and competitiveness (Government of France, 2022). The plan focuses on adapting regulations to the specific needs of seaweed producers, improving governance, supporting R&D and training, and enhancing market transparency. It promotes interprofessional coordination and integration of seaweed activities into maritime planning, while encouraging innovation and international visibility for French companies.

Indonesia | Presidential Regulation No. 33/2019

Indonesia's national roadmap for seaweed industry development (2018-2021) outlines a comprehensive strategy, including measures for seedling supply, post-harvest handling, MSME empowerment, and improved access to finance (Government of Indonesia, 2025). Building on this, Indonesia is preparing an Integrated National Action Plan for Seaweed Development (2025-2029), led by BAPPENAS and other stakeholders within the next two years (Bappenas, 2025). As part of this Action Plan, the Ministry of Marine Affairs and Fisheries (KKP), with the support of UNIDO, is developing a dedicated certification scheme for seaweed and seaweed products, distinct from other fisheries products.

Madagascar | Five-Year Plan for Seaweed (2021)

Adopted in 2021, Madagascar's five-year plan targets expansion of red seaweed production through new farming zones, certified seed banks, and public-private partnerships (Government of Madagascar, 2021). It prioritises regulatory reform, streamlining permits, biosafety, and export procedures, while supporting training, R&D, and anti-theft measures. The plan aims to boost exports and rural livelihoods, with a €1.4 million budget and strong institutional coordination.

Source: UNCTAD analysis (2026).

Regional regulations

Regional trade agreements and supranational institutions are beginning to shape aspects of seaweed regulation, yet most frameworks remain general or indirect. Some bodies incorporate seaweed under broader food, aquaculture or additive safety rules, but few have developed targeted frameworks.

The European Union is currently the only regional bloc with a relatively comprehensive system, particularly in relation to food and organic aquaculture. Seaweed food safety is overseen by the European Food Safety Authority (EFSA), which provides risk assessments and scientific advice on toxicological risks. While general EU food law sets maximum contaminant levels – most recently Regulation (EU) No 2023/915, replacing Regulation (EC) No 1881/2006,[49] specific thresholds for many seaweed species consumption have yet to be defined.

Pesticide residues in seaweed are regulated under Regulation (EC) No 396/2005,[50] which establishes maximum residue levels (MRLs) for pesticides in or on food and feed of plant and animal origin, (including seaweed) where relevant substances are authorised. However, there are no comprehensive EU-wide maximum levels specifically applicable to all seaweed species for heavy metals such as cadmium, lead, arsenic, or iodine. Regulation (EU) No 2023/915[51] sets maximum limits for certain contaminants in food, e.g., cadmium in seaweed-based food supplements and for nickel in seaweed, but broader contaminant limits remain under discussion following EFSA's 2023 scientific report (EFSA, 2023). In the absence of harmonised European Union thresholds, Member States may apply national maximum levels or guidance values. A 2018/2019 EU-FORA risk assessment[52] found generally low health risks from mercury, cadmium, and lead in seaweed, but highlighted excessive iodine intake as a potential concern for vulnerable groups such as pregnant women and individuals with thyroid disorders. Access to the European market is also influenced by the European Union's Novel Food Regulation (Regulation EU No 2015/2283).[53] Under this framework, seaweed species that were not consumed to a significant degree in Europe before 15 May 1997 require pre-market authorisation and an EFSA risk assessment (EU, 2015). Species with a documented history of safe consumption before that date, such as nori and dulse, are exempt. The authorisation process can, depending on the case, be lengthy and expensive, often discouraging investment and slowing product innovation (EU, 2021b).

Non-food regulation in the European Union is handled through sectoral frameworks. The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (EC) No 1907/2006[54] applies to seaweed-derived chemicals, the Cosmetics Regulation (EC) No 1223/2009[55] covers personal care products, and the Fertilising Products (Regulation EU No 2019/1009)[56] also applies to seaweed-based inputs. These instruments strengthen consumer and environmental protection but rarely offer seaweed-specific guidance for producers or exporters, such as tailored registration procedures, safety testing protocols, or labelling requirements. Implementation also varies across Member States, creating some level of compliance uncertainty for exporters to the European market.

Outside the European Union, **regional trade frameworks affecting seaweed remain limited in scope and specificity**, resulting in divergent national standards.

[49] Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. For more details, see https://eur-lex.europa.eu/eli/reg/2006/1881/oj.
[50] Regulation (EC) No 396 2005. For more details, see https://eur-lex.europa.eu/eli/reg/2005/396/oj/eng.
[51] Regulation (EU) 2023/915. For more details, see https://eur-lex.europa.eu/eli/reg/2023/915/oj/eng.
[52] For more details, see https://www.efsa.europa.eu/sites/default/files/corporate_publications/files/190917_eu-fora-serie-2.pdf.
[53] Regulation (EU) 2015/2283. For more details, see https://eur-lex.europa.eu/eli/reg/2015/2283/oj/eng.
[54] Regulation (EC) 1907/2006. For more details, see https://eur-lex.europa.eu/eli/reg/2006/1907/oj/eng.
[55] Regulation (EC) 1223/2009. For more details, see https://eur-lex.europa.eu/eli/reg/2009/1223/oj/eng.
[56] Regulation (EU) 2019/1009. For more details, see https://eur-lex.europa.eu/eli/reg/2019/1009/oj/eng.

© Adobe Stock

Environmental regulation is another cross-cutting issue. The Environmental Impact Assessment Directive (2011/92/EU, amended by 2014/52/EU)[57] establishes minimum procedural requirements for environmental impact assessment across the European Union, including the content of the assessment report (e.g., the baseline scenario). However, licensing and marine spatial planning are handled nationally, leading to widely varying timelines ranging from a few months to several years (Falconer et al., 2023). This variation illustrates both the strength and complexity of the European Union framework: while the Directive establishes a common procedural baseline for environmental risk assessment, national implementation may create administrative burdens that deter investment.

Outside the European Union, regional regulatory frameworks affecting seaweed remain limited in scope and specificity. Regional groupings such as the Association of Southeast Asian Nations (ASEAN), United States-Mexico-Canada Agreement (USMCA), and Mercado Común del Sur (MERCOSUR) largely defer to national laws, resulting in divergent standards (Devadason et al., 2018; Lauria, 2023; Mulyaman et al., 2023; Eum, 2023) and approaches across member states.

Regulatory convergence and transparency tend to decrease transaction costs, enable trade predictability, and make it easier for producers to meet multiple market requirements. According to (OECD, 2013), each additional transparency commitment in a regional trade agreement (RTA) leads to over 1 per cent increase in bilateral trade—with comprehensive RTAs (typically a dozen such clauses) yielding double-digit trade gains overall.

While regional regulatory harmonisation could further facilitate broader market access and reduce compliance burdens, it may also entail significant adaptation and implementation costs for producers, especially in developing economies, who must align with complex and often resource-intensive regulatory frameworks in import markets. As such, regional blocs often opt for the adoption of basic regulatory objectives, principles, mutual recognition, cooperation frameworks, or soft coordination mechanisms to balance trade facilitation with the preservation of domestic regulatory autonomy (Prado and Bertrand, 2015).

[57] European Union (2014) Directive 2014/52/EU amending Directive 2011/92/EU on environmental impact assessments, OJ L 124. For more details, see https://eur-lex.europa.eu/eli/dir/2014/52/oj.

Multilateral agreements

Seaweed is not governed by any dedicated multilateral agreement. Instead, it falls under a patchwork of trade, environmental and phytosanitary frameworks that apply to seaweed only indirectly. These instruments establish important baselines for safety, traceability, and benefit-sharing, but none were designed with the multifunctional, fast-evolving nature of the seaweed sector in mind.

Food-related regulations to safeguard human, animal, and plant life and health are addressed under the WTO's SPS Agreement, which governs how countries apply food safety and animal/plant health measures without creating unjustified trade barriers. Seaweed, however, is rarely identified as a distinct product in SPS notifications, limiting transparency and coordination.

As the sector evolves, there is a growing need for multilateral frameworks that are both science-based as well as contextualised. Regulations should be informed by robust scientific evidence and tailored to the specific species cultivated, needs and capacities of different countries. For example, iodine thresholds may vary depending on dietary habits (EFSA, 2023; Lee et al., 2025), and cultivation standards must reflect local environmental conditions. A one-size-fits-all approach risks excluding or imposing unrealistic constraints on producers in developing economies and undermining sustainability goals. Instead, flexible, consultative, and evidence-driven approaches should guide future regulatory development.

Non-food regulation is even more fragmented. In general, regulations for cosmetics, pharmaceuticals, and fertilisers are typically covered under the WTO TBT Agreement, sectoral treaties or national legislation, but no multilateral agreements provide seaweed-specific regulatory guidance. Environmental governance is similarly indirect. The FAO Code of Conduct for Responsible Fisheries and its Guidelines for Sustainable Aquaculture[58] apply to seaweed farming in principle, but they are non-binding. The Convention on Biological Diversity (CBD) and its Nagoya Protocol on Access and Benefit-sharing apply to seaweed when it is utilized as genetic resource,[59] establishing global norms for access and equitable benefit-sharing. In practice, however, marine implementation remains inconsistent (CBD, 2011, n.d.).

R&D on seaweed genetic resources is increasing under the CBD and the Nagoya Protocol. Since 2014, 46 Internationally Recognised Certificates of Compliance (IRCCs) have directly referenced seaweed species or mixtures: 44 issued by India and one by Viet Nam and South Africa each.[60] Of these, 27 were requested for commercial purposes, 13 for non-commercial purposes, and 6 have already expired.

In response to these gaps, industry-led initiatives are emerging to promote more coherent governance. For example, UNCTAD's BioTrade Principles and Criteria, updated in 2020 to include Blue BioTrade, promotes sustainable trade and equitable benefit-sharing for marine biodiversity, including macroalgae (UNCTAD, 2020). The Global Seaweed Coalition also advocates for clearer international regulations on safety, sustainability, and labour conditions (Global Seaweed Coalition, 2025). and its use is growing (Babayemi, et al., 2019; Boateng, et al., 2022).

Seaweed is not governed by any dedicated multilateral agreement and is regulated only indirectly under existing trade and environmental frameworks.

[58] FAO Code of Conduct for Responsible Fisheries and its Guidelines for Sustainable Aquaculture. For more details, see https://openknowledge.fao.org/server/api/core/bitstreams/93a383cb-a675-4909-8ada-dacf89247de5/content/v9878e.htm.

[59] Meaning subject to research and development on the genetic and/or biochemical composition of the seaweed, including through the application of biotechnology.

[60] See Access and Benefit Sharing Clearance House Mechanism: https://absch.cbd.int/en/search?currentPage=1&tab=nationalRecords (last accessed 15 December 2025).

Chapter V

Voluntary standards gaps limit quality assurance and market confidence in seaweed value chains

Voluntary standards gaps limit quality assurance and market confidence in seaweed value chains

Voluntary standards complement regulation by guiding quality and sustainability practices, but in the seaweed sector they remain fragmented and uneven. Most focus on food-grade seaweed, with limited benchmarks for non-food uses. International guidance is generic and private certification schemes have low uptake, particularly among small producers, hindering market access and investor confidence.

As international seaweed markets evolve, standards are playing an increasingly important role in shaping production, trade and sustainability practices (WTO, 1995). Standards help ensure product quality, address safety and interoperability considerations, reduce transaction costs, and support environmental and social objectives. However, like the regulatory landscape, the standardisation framework for seaweed remains scattered and jurisdiction-specific, with considerable variation in subject matter, coverage, enforcement, and with low levels of international alignment.

Unlike technical regulations, standards are typically voluntary specifications developed by national, regional, or international bodies. These may be public, such as national standardisation agencies or intergovernmental organisations, or private, including industry associations and certification schemes. In certain jurisdictions, standards can become legally binding when they are incorporated into laws or regulations, or when used as criteria in public procurement processes. Additionally, standards may become *de facto* mandatory when required by dominant market actors such as processors, retailers, or global supply chains as a condition for market access. Even when not formally mandated, standards can influence compliance indirectly through buyer requirements, certification programs, or conformity assessment procedures.

This section reviews national, regional and international seaweed standards, highlighting key instruments, responsible authorities, and critical coverage gaps.

Divergent national contaminant standards, including on iodine and heavy metals, **complicate compliance for seaweed exporters.**

© Henrique Pacini (UNCTAD)

National standards

At the national level, seaweed-related standards vary widely in scope, legal status and enforcement. A few countries, particularly those with established seaweed industries such as China, Indonesia, Japan, the Republic of Korea, and France have developed relatively structured national standards that set out product definitions, quality benchmarks, and contaminant thresholds. These standards differ in legal status and precision, but all aim to ensure human, plant and animal health, food and product safety and to facilitate sustainable harvesting, production and commercialisation processes.

For example, in China, product-specific standards such as GB 19643-2016[61] complement the broader regulatory framework by providing more detailed benchmarks for producers. Indonesia's Standard Nasional Indonesia (SNI) system also defines species- and product-specific criteria, including standards for *Eucheuma cottonii* and dried seaweed that establish drying methods and packaging requirements Badan Standardisasi Nasional, 2017; MMAF, 2019). Additional SNIs apply to seaweed-based products, such as SNI 2690:2015[62] (Badan Standardisasi Nasional, 2015). Japan's Japanese Agricultural Standards (JAS) system offers voluntary grading and labelling guidance for products such as nori and wakame, while the Republic of Korea integrates mandatory food safety requirements into HACCP-based certification schemes, particularly for laver (MFDS, n.d.).[63]

In Europe, France has issued detailed compositional guidance through the French Agency for Food, Environmental and Occupational Health and Safety (ANSES), including recommended limits for inorganic arsenic, lead, cadmium, mercury, tin, and iodine. ANSES has also issued consumption recommendations for species with high iodine levels, reflecting a precautionary approach. Currently, 43 seaweed species are officially recognised as edible in France, based on national risk assessments and aligned with European Union novel food authorisations and exemptions, and this list could serve as the basis for a broader catalogue (ANSES, 2025). Germany illustrates intra-regional divergence, applying much stricter iodine limits than its neighbouring countries (BfR, 2007).[64] In contrast, the United States relies largely on its National Organic Program, which certifies seaweed for organic production but does not provide broader compositional standards at federal level (USDA, 2018). Together, these differing approaches complicate compliance, particularly for exporters navigating varying requirements across jurisdictions.

Standards for non-food seaweed applications remain less developed and are often embedded in general product categories rather than tailored frameworks. For example, Japan and the Philippines lack dedicated non-food seaweed standards, while the United States applies an Organic Program to fertilisers and the EPA's guidelines to biopesticides (USDA, 2018). The Republic of Korea provides somewhat clearer requirements for cosmetics, though these remain part of wider product regimes rather than seaweed-specific standards (MFDS, n.d.). In Europe, France has also issued technical recommendations on the use of seaweed in cosmetics, providing additional voluntary guidance to complement existing product regulations. Emerging producers such as Chile and United Republic of Tanzania have begun issuing

[61] China, National Health Commission and State Administration for Market Regulation, National Food Safety Standard – Algae and Algae Products, GB 19643-2016 (Beijing, 2016).
[62] Indonesia, Badan Standardisasi Nasional, Pemesanan Online (PESTA Online) (n.d.a). SNI 2690:2015. For more details, see https://pesta.bsn.go.id/.
[63] See footnote 75.
[64] According to the German Federal Institute for Risk Assessment (BfR), a maximum iodine concentration of 20mg/kg dry weight in dried seaweed is recommended (BfR, 2007), whereas France permits levels up to 2000mg/kg dry weight for all edible species (ANSES, 2018).

harvesting and farming standards, but these are partial and still evolving (Ministry of Agriculture, United Republic of Tanzania, 2021). Overall, fragmented standards create uncertainty for producers and weaken buyer confidence, slowing progress toward higher-value applications (UNIDO, n.d.).

Three key trends stand out from these national frameworks. Like technical regulations, food standards are generally more developed than those for non-food applications, especially in countries with mature aquaculture and processing industries. This can indirectly constrain the development of seaweed-based inputs for cosmetics, packaging, fertilisers and animal feed, particularly where access to markets or buyers depends on meeting recognised quality or certification standards. Second, non-food standards tend to be embedded within broader sectoral norms rather than tailored to seaweed, resulting in fragmented oversight and inconsistent quality benchmarks. Third, many emerging producing countries only have draft or partial standards in place. While these efforts reflect growing recognition of seaweed's economic potential, the absence of clear and widely accepted standards create uncertainty for investors and makes it harder for producers to access international markets. As with regulations, internationally and regionally applicable standards that could guide national policy and regulatory-making remain very limited as will be shown in **Sub-sections Regional** and **International Standards**.

Tables 5 and **6** illustrate these patterns, providing a comparative overview of selected national standards for food and non-food seaweed applications.

Table 5.
National standards governing food applications of seaweed

Country	Standard	Issuing authority	Scope & description
China	**GB 19643-2016** Edible algae and algae products	National Health Commission (NHC) State Administration for Market Regulation (SAMR)	Binding thresholds for hygiene, heavy metals, and contaminants in edible algae
	GB/T 23596-2024 Good practices for seaweed		
Indonesia	**SNI 7579:2:2010** *Eucheuma cottonii*	Badan Standardisasi Nasional (National Standardisation Agency)	Defines species-specific quality, drying methods, and packaging protocols for export readiness
	SNI 2690:2015 Dried seaweed		
	SNI 8391:1:2021 Refined carrageenan		
	SNI 7688:2022 Semi refined carrageenan		
	SNI 2802:2021 Agar-agar		
	SNI 9110:2022 ATC Alkali treated cottonii		
Japan	**Japanese Agricultural Standards (JAS)** Applied to seaweed products	Ministry of Agriculture, Forestry and Fisheries (MAFF)	Voluntary grading and labelling standards for products like *nori* and *wakame*

Table 5. (cont.)
National standards governing food applications of seaweed

Country	Standard	Issuing authority	Scope & description
Philippines	**PNS/BAFS 85:2021** Raw dried seaweed	Bureau of Agriculture and Fisheries Standards (BAFS)	Defines moisture content, quality classes, and contaminant thresholds
Republic of Korea	**HACCP certification** Applied to seaweed processing	Ministry of Food and Drug Safety (MFDS)	Mandatory food safety management system applied to edible seaweed, especially laver
United States	**USDA National Organic Program**	U.S. Department of Agriculture (USDA)	Organic certification criteria for seaweed-based food products
United Kingdom	**BS EN 17399:2024** Algae and algae products	British Standards Institution (BSI)	Terminology, sampling, and testing standards for algae in food and feed
France	**ANSES List of Algae for Human Consumption**	French Agency for Food, Environmental and Occupational Health & Safety (ANSES)	Hygiene and safety recommendations for processed seaweed
	AFNOR Technical Guidance	French Standardisation Association (AFNOR)	
India	**IS 12342:1988 Part 1** Agarophytes	Food Safety and Standards Authority of India (FSSAI)	Proposes standards for safety and compositional benchmarks for edible seaweed
	IS 12342:1988 Part 2 Alginophytes		
	IS 16877:2020 Processed *Eucheuma*		
	IS 19196:2025 Good aquaculture practices for seaweed cultivation		

Source: UNCTAD analysis (2026).

Note: Rows shaded in grey indicate emerging or partial seaweed standards.

Table 6.
National standards governing non-food applications of seaweed

Country	Standard	Issuing authority	Scope & description
China	—	—	No seaweed-specific non-food standard; relevant practices guided by general industrial policies
Indonesia	**SNI 2690:2015** *Food and non-food*	Badan Standardisasi Nasional (BSN)	Covers drying, quality, and packaging for food and selected industrial applications
	SNI 2690:2023 Partial coverage for industrial uses	Ministry of Marine Affairs and Fisheries (MMAF)	

Table 6. (cont.)
National standards governing non-food applications of seaweed

Country	Standard	Issuing authority	Scope & description
Japan	—	—	JAS only applies to food and agricultural products
Philippines	—	—	Defines moisture content, quality classes, and contaminant thresholds
Republic of Korea	—	—	No specific standard; covered under regulations (e.g., Cosmetic Act, Functional Health Foods Act)
United States	**USDA National Organic Program** Seaweed in fertilisers **EPA Biopesticide Registration Guidelines**	U.S. Department of Agriculture (USDA) U.S. Environmental Protection Agency (EPA)	Certification for organic inputs; safety protocols for seaweed-based fertilisers
Chile	**TDL: Technical norm under "Benthic" Law 21.651** (2014) Standard applicable to harvesting	National Fisheries and Aquaculture Service (SERNAPESCA)	Applied harvest sustainability standards for wild seaweed under aquaculture law
United Republic of Tanzania	**TZS 2750:2022** Dried seaweed specification	Tanzania Bureau of Standards Ministry of Agriculture	General best practices for farming *Eucheuma* and *Kappaphycus* in coastal areas

Source: UNCTAD analysis (2026).
Note: Rows shaded in grey indicate emerging or partial seaweed standards.

Regional standards

At the regional level, standardisation efforts are emerging but remain uneven. The most advanced initiative is in the European Union, where the European Committee for Standardization (CEN), particularly through Technical Committee CEN/TC 454, is developing voluntary standards for algae and algae products (CEN/TC 454, 2024). These cover terminology, classification, analytical methods and quality requirements across food, feed, cosmetics, and industrial uses, but so far primarily address unprocessed and or minimally processed algae and algae products. The European Union also applies product-specific compositional specifications under food additives regulation for seaweed-derived additives, notably E407 (carrageenan) and E407a (processed *Eucheuma* seaweed),[65] which focuses on extracts rather than whole algae (EU, 2012). Other technical instruments, such as the EN 13432 standard on Biodegradable Packaging Certification[66] are indirectly relevant for seaweed-based bioplastics but

[65] European Commission. (2012). Commission Regulation (EU) No 231/2012 of 9 March 2012 laying down specifications for food additives listed in Annexes II and III to Regulation (EC) No 1333/2008 of the European Parliament and of the Council. Official Journal of the European Union.
[66] European Committee for Standardization (CEN) (2000). EN 13432:2000: Packaging – Requirements for packaging recoverable through composting and biodegradation – Test scheme and evaluation criteria for the final acceptance of packaging. Brussels: CEN.

operate as horizontal packaging standards and do not address cultivation, sourcing or biomass composition (CEN, n.d.; EU, 1994).

Outside the European Union, regional trade and cooperation agreements such as ASEAN, MERCOSUR, and USMCA have not established dedicated seaweed standards, relying instead on national-level systems, and in some cases, limited regulatory cooperation or selective mutual recognition mechanisms.

International standards

International standards for seaweed remain limited, with significant gaps in composition, contaminant thresholds and sustainability criteria.

At the international level, standards provide only a partial framework for seaweed, leaving significant gaps in composition, contaminant thresholds, additives and sustainability criteria. Public standards offer a potential foundation for an eventual regulatory convergence but remain generic and only partially applicable to seaweed. Private standards have partly filled this gap, especially in sustainability and social responsibility, but their uptake remains uneven due to cost and capacity barriers (Ferdouse et al., 2018).

Public international standards

Among public instruments, the Codex Alimentarius provides the main international benchmark for food safety and hygiene (FAO/WHO, 2025).[67] To date, only one seaweed-specific standard exists: Codex Standard CXS 323R-2017[68] for laver (*Pyropia*),[69] which specifies compositional, safety, and labelling requirements, but applies mainly to Asian markets.

More recently, the Global Organization for EPA and DHA Omega-3s (GOED) has proposed a new Codex standard for algae-based omega-3 oils,[70] reflecting growing commercial interest. However, no equivalent Codex standards exist for whole seaweed or seaweed extracts.

Beyond Codex, general ISO standards such as the ISO 22000[71] series on food safety management systems and ISO 14001[72] on environmental management systems can be applied to seaweed production. FAO and WHO also provide guidance on aquaculture, offering broad principles for responsible practices (FAO, 1995; FAO/ILO, 2011; FAO/WHO, 2024; Waqas et al., 2024). Yet these frameworks are generic and do not address seaweed's specific risks and characteristics.

[67] FAO-WHO (2021). Codex Alimentarius: Code of practice for fish and fishery product. For more details, see https://iris.who.int/bitstream/handle/10665/336524/9789240013179-eng.pdf?sequence=1.

[68] Codex Alimentarius Commission. (2017, amended 2023-4). Regional Standard for Laver Products (CXS 323R-2017). For more details, see https://www.fao.org/fao-who-codexalimentarius/sh-proxy/it/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXS%2B323R-2017%252FCXS_323Re.pdf.

[69] "Laver product" is defined by this Regional Standard XS 323R-2017 as "those prepared mainly with raw laver, which belongs to the genus *Pyropia*. All products are dried and after drying, the products may be further roasted and/or seasoned".

[70] GOED (2024). GOED Proposal for Development of a Microbial Omega-3 Oil Standard Approved by Codex. For more details, see https://goedomega3.com/news/post/goed-proposal-development-microbial-omega-3-oil-standard-approved-codex#:~:text=A%20proposal%20for%20new%20work%20to%20develop%20a,move%20forward%20by%20the%20Codex%20Alimentarius%20Commission%20%28CAC%29.

[71] ISO 22000. Food safety management. For more details, see https://www.iso.org/iso-22000-food-safety-management.html.

[72] ISO 14001:2014. Environmental management systems – Requirements with guidance for use. For more details, see https://www.iso.org/iso-22000-food-safety-management.html.

Coverage under the American Society for Testing and Materials (ASTM International) is also limited. One withdrawn standard (ASTM E1498-2012)[73] focused on seaweed production tests, while only a few niche standards exist for carrageenan, agar, and alginate (e.g., ASTM F2459, D8068, E2471) (ASTM, 2022, 2021). Other initiatives, such as the PEGASUS guidelines[74] developed under the Phycomorph COST Action, provide technical recommendations for sustainable aquaculture in Europe, functioning as advisory guidance.

In sum, public international standards and guidelines play only a limited role in providing broad coverage and/or facilitating seaweed markets expansion and trade. They offer useful reference points but fall short of providing a coherent global framework.

Private international standards

In the absence of comprehensive public codes, private initiatives have emerged as important governance tools. To ensure legitimacy and effectiveness, voluntary standards need to be developed through bottom-up processes that enable meaningful participation by producers and institutions from developing countries. This includes enabling access to standard setting bodies, incorporating scientific input from diverse regions, and ensuring that standards reflect the realities of tropical and temperate production systems. Without such inclusivity, standards risk being perceived as externally imposed and may fail to gain traction among key producer communities.

To date, **only one seaweed-specific Codex standard exists for laver** (*Pyropia*), CXS 323R-2017

[73] ASTM E1498-92(2012): Standard Guide for Conducting Sexual Reproduction Tests with Seaweeds (Withdrawn 2021). For more details, see https://store.astm.org/e1498-92r12.html.

[74] The PEGASUS Guidelines (Phycomorph European Guidelines for a Sustainable Aquaculture of Seaweeds) were developed under the EU-funded COST Action PHCOMORPH and coordinated by the European Commission's Joint Research Centre. They are advisory best-practice guidance rather than a formal standard or certification scheme. For more details, see https://publications.jrc.ec.europa.eu/repository/handle/JRC117543.

The Aquaculture Stewardship Council (ASC) Seaweed Standard, jointly developed with the Marine Stewardship Council (MSC), is the most comprehensive private international standard to date, covering environmental performance, labour rights, and stakeholder engagement for both farmed and wild-harvested seaweed (ASC and MSC, 2018). Its scope is limited to primary production, although downstream traceability can be demonstrated via the MSC Chain of Custody Standard.[75] While the ASC standard provides an important reference point for sustainability assurance, its uptake remains uneven, particularly among small-scale producers.

Organic certification systems also play a significant role in private governance. Schemes recognised under EU Regulation (2018/848)[76] and the USDA National Organic Program are widely applied to seaweed production. Commercial examples, such as Nordic Seafarm in Sweden, demonstrate that large-scale kelp farming can comply with organic benchmarks (Sub Mariner Network, n.d.; USDA, 2022; EU, 2018). However, organic standards focus primarily on production inputs and processes and do not address broader social, labour, or ecosystem considerations in a seaweed-specific manner.

Industry-led schemes add further diversity to the private standards landscape. Cargill's Red Seaweed Promise, for instance, promotes responsible sourcing of *Eucheuma* and *Kappaphycus* (Cargill, 2021). These initiatives provide reference points for sustainability, transparency, and market assurance, but their uptake, cost, enforcement and credibility vary.

The ASC Seaweed Standard is currently the most comprehensive private international standard.

Many private international, including voluntary sustainability standards (VSS) depend on voluntary participation or corporate implementation. Many firms in developing countries, particularly MSMEs, often have limited or no representation in international standard-setting fora. This constrains their capacity to influence standards design and ensure that requirements reflect the local ecological, technical, and socio-economic realities in developing country contexts. Furthermore, many developing countries producers particularly in Africa and Latin America where the seaweed sector in less developed countries face additional knowledge, capacity and financial constraints to apply, assess, verify and certify compliance with the international standards in place.

While private standards can help address regulatory and standardisation gaps, they also contribute to fragmentation in the assurance landscape. This often exacerbates inequities in access to certification and the resulting market benefits, as compliance costs and complex certification processes may exclude many smallholders from global value chain (UNFSS, 2022).

Therefore, the challenge is not to impose uniform standards, but to foster greater coherence and operability among existing initiatives while expanding and normalising meaningful participation, by developing countries in standard-setting and governance processes. This includes reducing the cost and complexity of application, verification and certification, and ensuring that standards remain adaptable to different species, context-sensitive and flexible to different production systems and national capacities.

[75] MSC (2025). For more details, see https://www.msc.org/standards-and-certification/chain-of-custody-standard.
[76] Regulation (EU) 2018/848. For more details, see https://eur-lex.europa.eu/eli/reg/2018/848/oj/eng.

Chapter VI

Way forward

securing sustainable growth of the seaweed sector as part of the blue economy

© Juraté Čia (Pexels)

Way forward:
securing sustainable growth of the seaweed sector as part of the blue economy

The seaweed sector is expanding faster than the systems designed to regulate and support it. Fragmented governance, uneven standards, and limited institutional capacity continue to hinder producers, especially in developing economies, from accessing global markets and moving up the value chain to and capturing a fair and equitable share of its value. Addressing these constraints does not require uniform global rules but rather greater visibility, comparability and cooperation, anchored in national and regional development priorities and context.

Recognise seaweed as a distinct commodity and value-added product group in international trade and policy

A fundamental gap lies in the absence of seaweed as a recognised commodity group in international trade. Most national and multilateral databases still classify seaweed under broad categories such as "aquatic foods" or as part of "fisheries products",[77] rather than as a distinct set of aquatic plant species and derivatives (UNCTAD TRAINS, 2025; WTO EDB, 2025). To date, Indonesia is the only country that formally recognises seaweed as a separate commodity. This lack of visibility and recognition complicates product classification, limits analytical capacity in trade negotiations, and hinders the design and development of targeted support measures. Given that seaweed production and trade have grown at double-digit rates over the past decade, there is a strong case for establishing systematic monitoring of production volumes, trade flows, prices, qualities, uses and market trends across commercially important species.

Uncertainty is particularly significant for innovative seaweed value-added products, where exporters face difficulties in identifying applicable HS codes, determining regulatory obligations, and clarifying institutional oversight. Collaboration with the private sector such as through the newly established UNGSI[78,79] could support the development of a more detailed international HS classification system at the commercial species level and for their most direct by-products based on market realities. This would provide a clearer regulatory baseline and reduce transaction costs for exporters, especially in developing countries.

[77] For example, Japan regulates seaweed through its Food Sanitation Act, classifying it alongside other marine products such as fish and crustaceans (WTO EDB, 2025). By contrast, the Philippines has introduced a GAqP for Seaweed, addressing food safety as well as environmental sustainability and socio-economic considerations (BAFPS, 2017) under a value chains approach.

[78] For more information, see https://unctad.org/topic/trade-and-environment/united-nations-global-seaweed-initiative.

[79] For more information, see https://unctad.org/topic/trade-and-environment/united-nations-global-seaweed-initiative.

In parallel, compiling an indicative international reference list of both food and non-food species used for trade, along with information on their processing, and defining their levels of fungibility for by-product development, would help ensure consistent production of species, product homogeneity, as well as greater transparency in pricing, monitoring of traded volumes and overall trade practices, and better informed policy design without constraining national regulatory autonomy.

Support convergence and mutual recognition of science-based and inclusive regionally and internationally recognised food safety regulations and standards for seaweed

Food-grade seaweed represents a critical area of regulatory and standards misalignment. Although around 80 per cent of global seaweed production is destined for human consumption, regulatory guidance on safety and composition remains limited (FAO, 2023b). While the Codex Alimentarius has standards for specific products such as laver, it has yet to provide a comprehensive coverage of the diversity of seaweed species now traded internationally.[80] As a result, contaminant thresholds for iodine, arsenic, cadmium and other compounds can vary widely across jurisdictions (Banach et al., 2022), forcing producers to fragment supply chains to meet multiple standards.[81] Shipments that meet domestic safety standards are frequently rejected in importing countries with more stringent rules, undermining predictability and deterring investment (Doumeizel, 2022).

There is therefore a strong case to promote regional and international convergence and the development of science-based, inclusive food safety standards for major commercial food-grade seaweed species while respecting national policy space and differing dietary, environmental, and production contexts. Such initiatives can help reduce regulatory fragmentation, enhance food safety and consumer protection, lower transaction costs, and improve market access, thereby supporting the sector's integration into global food systems. A menu of potential actions in this regard may include:

- **Comparative analysis of existing national and regional regulations** and standards to identify areas of overlap, equivalence and divergence with the support of the UNGSI members and partner institutions;
- **Mapping of good food safety practices** applicable across major commercial food grade species and key by-products, considering different production systems and ecological conditions; and
- **Exploring options to enable sectoral mutual recognition agreements** or equivalence arrangements for risk assessment methodologies, food safety testing, and sanitary and commercial approvals with the support of FAO and the World Health Organization (WHO).

While international harmonisation may represent a possible long-term pathway, it should not be viewed as a prerequisite for progress. An incremental

[80] The Codex Alimentarius Commission, at its 48th Session (14 November 2025), agreed to keep the Committee on Fish and Fishery Products (CCFFP) active and tasked it with converting the Regional Standard for Laver Products (Asia) (CXS 323R-2017) into a worldwide standard, considering new work on other seaweed species, and reviewing existing standards for fish and fishery products.

[81] For example, iodine limits in the European Union and United States are significantly lower than in Japan or the Republic of Korea, where culturally embedded consumption patterns justify more flexible thresholds (Doumeizel, 2022), reflecting differing consumption patterns rather than unified safety science. Likewise, *Eucheuma denticulatum*, a widely consumed seaweed in Asia, remains classified as "novel food" under the European Union's Novel Food Regulation, pending further safety assessments (EC, 2025; MAFF, 2022). This divergence forces exporters into lengthy and duplicative approval process, restricting streamlined market access despite longstanding scientific and traditional evidence of safe consumption.

approach building on tangible progress in closing regulatory and standards gaps and fostering convergence where appropriate can be more sensible.

For any future international food-grade seaweed standard-setting process to be both legitimate and effective, its development would need to be firmly grounded in science, inclusive by design, and supportive of bottom-up engagement by developing countries, particularly within the FAO/WHO Codex Alimentarius framework. This implies facilitating effective and meaningful participation in standard-setting fora, integrating scientific perspectives from a wide range of regions, and ensuring that any guidance is adaptable to different species, consumption patterns and conditions of both tropical and temperate aquaculture systems. Absent such inclusive and context-sensitive approaches, international standards risk being perceived as externally driven, limiting their uptake and effective adoption by producers and small-scale operators in developing countries, limiting their market access.

Enable coherent and context-responsive development of regulations and regulatory approval processes for non-food seaweed applications

There are very few national and regional regulations explicitly applicable to non-food applications. Where regulations exist, approval processes are typically managed by multiple agencies, such as those responsible for product safety, environment, or trade. This fragmented approach limits transparency, increases compliance costs, and creates uncertainty for producers. Emerging uses of seaweed in pharmaceuticals, cosmetics, packaging, fertilisers and textiles face equally fragmented frameworks (World Bank, 2023).

Regulations are usually embedded within sectoral laws, but without cross-referencing or dedicated standards for seaweed inputs. As a result, producers often operate in regulatory "grey zones" where approval pathways are unclear, and no reference standards exist for lifecycle impacts or product safety (World Bank, 2023).

To support responsible commercialisation and innovation, clearer approval pathways are needed that specify testing requirements for human, animal and environmental safety as well as methodologies for assessing lifecycle impacts, nutrient leakage, and carbon accounting (Campbell et al., 2020). In cosmetics and pharmaceuticals, this includes clearer guidance on toxicology, efficacy, side effects, dosage and safety testing; while in packaging and biomaterials, it involves recognised criteria for food-contact safety, composability, biodegradability and bio-based characteristics and environmental risk.

In the short term, regulatory development should prioritise coherence, transparency, and operability, while remaining adaptable to national circumstances, species diversity, and stages of industrial development. Extending regulatory coverage should therefore balance the benefits of greater regulatory clarity with the need to preserve policy space for learning, innovation and inclusive participation by developing countries in emerging seaweed applications. Such an approach is essential to unlocking seaweed's potential contribution to the development of sustainable ocean, bio-based and circular ocean/blue value chains economic sectors in developing countries.

Although **around 80% of global seaweed production is destined for human consumption,** regulatory guidance on food safety and composition remains limited.

Build national and regional compliance capacity to expand developing country participation in the global seaweed value chains

Developing countries, which account for most global production, continue to face structural obstacles in meeting regulatory and quality requirements. These include limited laboratory and testing infrastructure, constrained assessment and verification capacities and complex and sometimes burdensome regulatory approval and certification processes. Targeted investment in accredited laboratories for contaminant analysis, dry and cold storage, and certified processing facilities, is essential to enable producers to comply with applicable manufacturing practices and reduce avoidable rejection at borders (UNCTAD, 2025a). Capacity-building should also extend to customs and trade authorities to streamline procedures and reduce delays. South-South trade frameworks such as the Global System of Trade Preferences (GSTP)[82] alongside regional platforms such as the AfCFTA and ASEAN can play a catalytic role by promoting mutual recognition of standards, pooling certification resources, and supporting South-South knowledge and learning exchange.

Such initiatives would help small-scale producers diversify exports, reduce dependence on volatile raw biomass markets, and capture greater value through processed products such as functional foods, sustainable fertilisers, and biomaterials (FAO, 2018). Strengthening innovation ecosystems, including support for legal access and benefit-sharing, R&D, product development, testing, and sustainable processing, is also critical to enabling producers in the Global South to participate in higher-value segments of the seaweed economy.

Expand the collection and classification of non-tariff measures applicable to seaweed

The number of seaweed-related regulations captured in UNCTAD's TRAINS database and the WTO EDB remains limited. There is a need to support member States in systematically identifying, collecting, classifying, and where relevant, notifying seaweed-related regulations applicable to commercially traded species, for both food and non-food uses.

For UNCTAD, a dedicated analytical and technical assistance initiative could be developed to identify and classify NTMs relevant to seaweed value chains, improving the reliability and comprehensiveness of the data even where official notifications are incomplete or absent.

In the case of the WTO EDB, which relies primarily on member government notifications, strengthening national reporting capacity is crucial. Donor support to expand and refine the coverage of seaweed-related NTMs in the TRAINS database using UNCTAD's 2019 International Classification of NTMs[83] could enhance transparency, regulatory predictability, and evidence-based policymaking across seaweed value chains.

[82] The Global System of Trade Preferences (GSTP), negotiated under UNCTAD and signed in 1988, promotes South–South trade through preferential tariff concessions. It includes 42 participants, including least developed countries and MERCOSUR. UNCTAD provides technical support, and the Committee of Participants serves as its highest decision-making body.

[83] For more details, see https://unctad.org/system/files/official-document/ditctab2019d5_en.pdf.

Advance global governance and leadership through the UNGSI

Finally, global leadership in seaweed governance remains limited. Despite the sector's growing economic, social and environmental importance, no international framework comprehensively addresses the sector across food and non-food applications. Public standards are limited in scope, private standards are fragmented, compliance and opportunity costs are rising, and institutional coordination across trade, environment, and development areas is minimal (World Bank, 2023). These gaps reduce regulatory clarity and predictability, slowing innovation and deepening inequities between advanced industrial producers and small-scale coastal producers, particularly in the Global South.

The establishment of the UNGSI at the 3rd UN Ocean Conference in 2025 marks an important step, but its potential impact will depend on how effectively it can coordinate standards, mobilise partnerships, and support capacity-building at scale. The UNGSI is mandated to lead the development of coherent regulatory frameworks, convene multi-stakeholder working groups, and facilitate the integration of seaweed into global sustainability, trade, and climate agendas. Against this background, several initiatives by the UNGSI are currently being supported and coordinated:

The UNGSI has recently deposited a Plan to Accelerate Solutions on the Multiple Benefits of Algae Aquaculture (Algae PAS)[84] as part of the Climate Action Agenda[85] of the 30th session of the United Nations Framework Convention on Climate Change (UNFCCC COP30) and plans to further develop a road map for the UNGSI action for 2027-2030 on the road to the 4th UN Ocean Conference foreseen for 2028.

The Algae PAS aims, by 2030, to:

1. **Increase** uptake of best climate mitigation, adaptation and resilient practices and technologies;
2. **Strengthen** regulatory governance and inclusive participation; and
3. **Mobilize** finance for aquatic food systems transformation.

Furthermore, the UNGSI will also serve as a platform to:

- **Facilitate coordination** and support for the development of globally aligned seaweed regulations and standards by supporting dialogues among developed and developing countries, relevant producer associations and international bodies, in collaboration with FAO/WHO Codex Alimentarius Secretariat, ISO, and WTO SPS/TBT committees;
- **Support alignment**, where appropriate, of classification systems, risk assessment protocols, contaminant benchmarks, and options for mutual recognition across jurisdictions;
- **Set clear deliverables** for the next 2–3 years, including a detailed commercial seaweed species and by-products registry, sustainability standard guidance, and a digital knowledge hub to support regulators and producers to navigate relevant regulations and standards;
- **Support the development of regional ocean economy** and seaweed centres of excellence as shared infrastructure and expertise to facilitate joint research, risk assessments, commercial and safety approvals, certification, and capacity-building, particularly for SIDS, LDCs, and emerging producer countries; and

[84] For more information, see https://climateaction.unfccc.int/assets/documents/78_.pdf.
[85] For more details, see https://unfccc.int/documents/652935.

Chantal Line Carpentier (UNCTAD) on the potential of seaweed

© Giuseppe Carotenuto (FAO)

- **Mobilise financing and partnerships** to expand technical cooperation, support pilot initiatives, and facilitate access to commercial approval, verification, and certification processes for small-scale producers, including through Blue BioTrade[86] and circular economy approaches.

By anchoring global leadership in a transparent, inclusive, and action-oriented platform, UNGSI can help ensure that sustainability, equity, and innovation remain at the core of seaweed sector governance while it quickly expands.

Taken together, these measures can help address persistent classification gaps, reduce regulatory fragmentation, and improve market transparency, thereby enabling seaweed's full potential across food and non-food uses in an environmentally sound and socially inclusive manner. By embedding seaweed more firmly within global sustainability, trade, and innovation frameworks, while supporting differentiated capacities and contexts, the international community can position the sector as a cornerstone of resilient, inclusive and sustainable ocean and blue economies and deliver tangible benefits for climate action, food security, equitable development, and circular value chains.

[86] For more information, see https://unctad.org/publication/blue-biotrade-harnessing-marine-trade-support-ecological-sustainability-and-economic.

References

AfCFTA (n.d.). *African Continental Free Trade Area*. Available at: https://au-afcfta.org/.

Andersen, M. (2017). *Opportunities and risks of seaweed biofuels in aviation*. Bellona Europa. Available at: https://bellona.org/publication/opportunities-and-risks-of-seaweed-biofuels-in-aviation.

ANSES (n.d.). *Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail*. Available at: https://www.anses.fr/fr.

Aquaculture Stewardship Council (ASC) and Marine Stewardship Council (MSC) (2017). ASC-MSC Seaweed (Algae) Standard. Version 1.0. Available at: https://www.asc-aqua.org/seaweed-standard.

ASEAN (n.d.). Association of Southeast Asian Nations. Available at: https://asean.org/.

ASTM International (2021). *ASTM E1498-92(2012): Standard guide for selection and documentation of existing data for environmental site assessments*. Available at: https://store.astm.org/e1498-92r12.html.

ASTM International (2022). *ASTM D6400-21: Standard specification for labeling of plastics designed to be aerobically composted in municipal or industrial facilities*. Available at: https://store.astm.org/d6400-21.html.

Badan Standardisasi Nasional (BSN) (2015). *SNI 2690:2015: Rumput laut kering (dried seaweed)*. Available at: https://pesta.bsn.go.id/produk/detail/10148-sni26902015.

Bureau of Agriculture and Fisheries Standards (BAFS) (2017). *PNS/BAFS 208:2017: Code of Good Aquaculture Practices (GAqP) for Seaweed*. Department of Agriculture, Philippines. Available at: https://www.globalseaweed.org/wp-content/uploads/2019/02/GAqP_PNSBAFS_208_2017.pdf.

Banach JL, Koch SJI, Hoffmans Y and van den Burg SWK (2022). *Seaweed Value Chain Stakeholder Perspectives for Food and Environmental Safety Hazards.* Foods. 11(10):1514, Multidisciplinary Digital Publishing Institute.

Bappenas (2024). *Coordinating Ministry for Food Affairs, and FAO Promote Aquatic Food Sources to Support Indonesia's Food Security.* Available at: https://www.bappenas.go.id/index.php/en/berita/bappenas-kemenkopangan-dan-fao-dorong-pangan-akuatik-dukung-ketahanan-pangan-indonesia-vC10v.

Brazil. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) (1997). *Portaria IBAMA, No. 147*. Available at: https://www.ibama.gov.br/sophia/cnia/legislacao/IBAMA/PT0146-181001.pdf.

Bureau of Fisheries and Aquatic Resources (BFAR) (2022). *The Philippine Seaweed Industry Roadmap (2022–2026).* Department of Agriculture, Philippines. Available at: https://pcaf.da.gov.ph/wp-content/uploads/2022/06/Philippine-Seaweed-Industry-Roadmap-2022-2026.pdf.

Buck-Wiese, H., Andskog, M.A., Nguyen, N.P., Hehemann, J.-H. et al. (2022). *Fucoid brown algae inject fucoidan carbon into the ocean*. Proceedings of the National Academy of Sciences, 120(1), e2210561119. Available at: https://doi.org/10.1073/pnas.2210561119.

Bolivarian Republic of Venezuela. Ministry of Fisheries and Aquaculture and Ministry for Ecosocialism (2023). *Resolutions on the sustainable use, cultivation and related activities of algae and cyanobacteria, DM/N° 023-23 and DM/N° 089-23*. Available at: https://svacuicultura.org/noticia/capitulo-3/.

Cai, J. and Lovatelli, A. (2021). Seaweeds and microalgae: An overview for unlocking their potential in global aquaculture development. Rome: Food and Agriculture Organization of the United Nations. Available at: https://doi.org/10.4060/cb5670en.

Campbell, I., Kambey, C.S.B., Mateo, J.P. et al. (2020). *Biosecurity policy and legislation for the global seaweed aquaculture industry.* Journal of Applied Phycology, 32, 2133–2146. Available at: https://doi.org/10.1007/s10811-019-02010-5.

Cargill (2021). *Sustainable seaweed: Red seaweed promise progress report.* Available at: https://www.cargill.com/doc/1432198890865/sustainable-seaweed-red-seaweed-promise-progress-report.pdf.

European Committee for Standardization (CEN) and European Committee for Electrotechnical Standardization (CENELEC) (n.d.). *CEN and CENELEC standards development platform.* Available at: https://standards.cencenelec.eu/.

European Committee for Standardization (CEN) (n.d.). *CEN/TC 454: Algae and algae products*. Available at: https://standards.iteh.ai/catalog/tc/cen/716626c7-934a-467a-b1bb-6ccad1e57d61/cen-tc-454.

Chile. Government of Chile (2024). *Ley que modifica la Ley General de Pesca y Acuicultura en el ámbito de los recursos bentónicos, No. 21.651*. Available at: https://www.bcn.cl/leychile/navegar?idNorma=1200828&idParte=10488632&idVersion=2024-02-07.

China. National Health Commission (2015). *Hygienic Standard for Algae Products, GB 2733-2015*. Available at: https://www.aqsiq.net/pdf/China_GB_2733-2015_National_Food_Safety_Standard_Fresh_Frozen_Aquatic_Products.pdf.

China. National Health Commission and State Administration for Market Regulation (2016). *National Food Safety Standard – Algae and Algae Products, GB 19643-2016*. Available at: https://www.chinesestandard.us/products/gb19643-2016.

China. State Administration for Market Regulation (2021). *Provisions for Registration and Filing of Cosmetics, Order No. 35*. Available at: https://english.nmpa.gov.cn/2022-06/30/c_785637.htm.

China. State Administration for Market Regulation and Standardization Administration of China (2024). *General Quality Requirements for Instant Seaweed and Its Products, GB/T 23596-2024*. Available at: https://openstd.samr.gov.cn/bzgk/std/newGbInfo?hcno=BEFF4C5AF2C1AAB220BA74C4214F7E9F.

China. National Health Commission and State Administration for Market Regulation (2025). *National Food Safety Standard – Maximum Levels of Contaminants in Foods, GB 2762-2022/XG1-2025*. Available at: https://www.codeofchina.com/standard/GB2762-2022XG1-2025.html.

Chojnacka, K., Moustakas, K. and Mikulewicz, M. (2022). Valorisation of agri-food waste to fertilisers is a challenge in implementing the circular economy concept in practice. *Environmental Pollution*, 312, 119906. Available at: https://doi.org/10.1016/j.envpol.2022.119906.

Convention on Biological Diversity (CBD) (n.d.). *Convention on Biological Diversity.* Available at: https://www.cbd.int/.

Convention on Biological Diversity (CBD) (2011). *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization.* Available at: https://www.cbd.int/abs.

Corrigan, S., Cottier-Cook, E.J., Lim, P.-E. and Brodie, J. (2025). *The state of the world's seaweeds*. London: Natural History Museum. Available at: https://doi.org/10.5519/4ln9oqk7.

Devadason, E.S., Chandran, V.G.R. and Kalirajan, K. (2018). Harmonization of food trade standards and regulations in ASEAN: The case of Malaysia's food imports. *Agricultural Economics*, 49(1): 97–109. Available at: https://doi.org/10.1111/agec.12398.

Doumeizel, V. (2022). *La Révolution des algues*. Paris: Éditions des Équateurs.

Duarte, C.M., Wu, J., Xiao, X., Bruhn, A. and Krause-Jensen, D. (2017). Can seaweed farming play a role in climate change mitigation and adaptation? *Frontiers in Marine Science*, 4, 100. Available at: https://doi.org/10.3389/fmars.2017.00100.

European Food Safety Authority (EFSA) (2023). Dietary exposure to heavy metals and iodine intake via consumption of seaweeds and halophytes in the European population. *EFSA Journal*, 21(1): e07798. Available at: https://doi.org/10.2903/j.efsa.2023.7798.

EFSA ANS Panel et al. (2017). Scientific opinion on the re-evaluation of alginic acid and its sodium, potassium, ammonium and calcium salts (E 400–E 404) as food additives. *EFSA Journal*, 15(11): 5049. Available at: https://doi.org/10.2903/j.efsa.2017.5049.

European Union (1994). *Directive 94/62/EC on packaging and packaging waste*. Available at: https://eur-lex.europa.eu/eli/dir/1994/62/oj.

European Union (2012). *Commission Regulation (EU) No 231/2012 of 9 March 2012 laying down specifications for food additives listed in Annexes II and III to Regulation (EC) No 1333/2008 of the European Parliament and of the Council*. Available at: https://eur-lex.europa.eu/eli/reg/2012/231/oj.

European Union (2015). *Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on novel foods*. Available at: https://eur-lex.europa.eu/eli/reg/2015/2283/oj.

European Union (2018). R*egulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on Organic Production and Labelling of Organic Products and Repealing Council Regulation (EC) No 834/2007*.

European Union (2021a). *The EU Blue Economy Report 2021*. Available at: https://op.europa.eu/en/publication-detail/-/publication/518896b1-f983-11eb-b520-01aa75ed71a1/language-en.

European Union (2021b). *Commission Implementing Regulation (EU) 2021/1165 of 15 July 2021 authorising certain products and substances for use in organic production and establishing their lists*. Available at: https://eur-lex.europa.eu/eli/reg_impl/2021/1165/oj.

Eum, J. (2023). Non-tariff measures along global value chains: Evidence from ASEAN countries. *Asian-Pacific Economic Literature*, 37(2): 27–53. Available at: https://doi.org/10.1111/apel.12402.

Falconer, L. (2023). Planning and licensing for marine aquaculture. Reviews in Aquaculture, 15(4): 1374–1404. Available at: https://doi.org/10.1111/raq.12765.

FAO (1995). *Code of conduct for responsible fisheries*. Available at: https://www.fao.org/iuu-fishing/international-framework/code-of-conduct-for-responsible-fisheries/en/. (accessed 2 July 2025).

FAO (2018). *The global status of seaweed production, trade and utilization*. Rome: Food and Agriculture Organization of the United Nations.

FAO (2022). *The state of world fisheries and aquaculture*. Rome: Food and Agriculture Organization of the United Nations.

FAO (2023a). *Recognizing and enhancing the contribution of algae to global aquaculture development*. Rome: Food and Agriculture Organization of the United Nations. Available at: https://knowledge4policy.ec.europa.eu/publication/recognizing-enhancing-contribution-algae-global-aquaculture-development_en.

FAO (2023b). *Seaweed trade and market potential*. Rome: Food and Agriculture Organization of the United Nations.

FAO (2023c). *Recognizing and enhancing the contribution of algae to global aquaculture development*. Twelfth Session, Sub-Committee on Aquaculture. Rome: Food and Agriculture Organization of the United Nations.

FAO (2024). *GLOBEFISH special feature: Seaweed trade and market potential*. Rome: Food and Agriculture Organization of the United Nations. Available at: https://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1644723/.

FAO FishStat (2025). *FishStat: Global fishery and aquaculture production statistics database*. Rome: Food and Agriculture Organization of the United Nations. Available at: https://www.fao.org/fishery/en/topic/fishstat.

FAO and ILO (2011). *Guidance on addressing child labour in fisheries and aquaculture.* Rome: Food and Agriculture Organization of the United Nations; Geneva: International Labour Organization. Available at: https://www.fao.org/3/i2238e/i2238e.pdf.

FAO and WHO (2021). *Report of the expert meeting on food safety for seaweed – Current status and future perspectives*. Rome: Food and Agriculture Organization of the United Nations; Geneva: World Health Organization.

FAO and WHO (2022). *Report of the expert meeting on food safety for seaweed – Current status and future perspectives*. Rome: Food and Agriculture Organization of the United Nations; Geneva: World Health Organization.

FAO and WHO (2024). *Evaluation of certain food additives: Ninety-ninth report of the Joint FAO/WHO Expert Committee on Food Additives*. Rome: Food and Agriculture Organization of the United Nations; Geneva: World Health Organization.

FAO and WHO (2025). *Codex Alimentarius Commission*. Rome: Food and Agriculture Organization of the United Nations; Geneva: World Health Organization. Available at: https://www.fao.org/fao-who-codexalimentarius/about-codex/en/.

Ferdouse, F., Lovstad Holdt, S., Smith, R., Murúa, P. and Zhengyong, Y. (2018). The global status of seaweed production, trade and utilization. *GLOBEFISH Research Programme,* vol. 124. Rome: Food and Agriculture Organization of the United Nations.

France. ANSES (2020). *List of Algae Authorized for Human Consumption*. Available at: https://www.anses.fr/en/system/files/ERCA2017SA0070EN.pdf.

France. AFNOR (n.d.). *Technical guidance documents on seaweed and algae*. Available at: https://www.chambre-syndicale-algues.org/afnor/.

Froehlich, H.E., Afflerbach, J.C., Frazier, M. and Halpern, B.S. (2019). Blue growth potential to mitigate climate change through seaweed offsetting. *Current Biology*, 29(18): 3087–3093.e3. Available at: https://doi.org/10.1016/j.cub.2019.07.041.

Galgo, C.R. Jr. and Abamo, A.P. (2015). *Profitability analysis of seaweed (Eucheuma denticulatum (N.L. Burman) F.S. Collins & Hervey) enterprise in Dawahon Island, Bato, Leyte: A green value chain approach*. Available at: https://api.semanticscholar.org/CorpusID:234369954.

Global Seaweed Coalition (2025). *Safe Seaweed Coalition*. Available at: https://www.safeseaweedcoalition.org/.

Good, M., Sannito, C. and Meyer, L. (2021). *Seaweed handling and processing guidelines for Alaska*. Fairbanks, Alaska: Alaska Sea Grant, University of Alaska Fairbanks. Available at: https://doi.org/10.4027/shpga.2021

Government of France (2022). *Feuille de route nationale pour le développement des filières algales françaises.* Available at: https://www.mer.gouv.fr/feuille-de-route-nationale-pour-le-developpement-des-filieres-algales-francaises.

Government of Indonesia (2019). *Presidential Regulation No. 33 of 2019 on the development of the seaweed industry.* Available at: https://peraturan.bpk.go.id/Details/108806/perpres-no-33-tahun-2019

Government of Madagascar (2021). *Plan de développement de l'algoculture.*

Hurtado, A.Q. et al. (2021). *Extracts of seaweeds used as biostimulants on land and sea crops—an efficacious, phyconomic circular blue economy: with special reference to Ascophyllum (brown) and Kappaphycus (red) seaweeds.* In: Gupta, S. and Van Staden, J. (eds.), Biostimulants for crops from seed germination to plant development. Academic Press, pp. 263–288.

IEA Bioenergy (2017). *State of technology review: Algae bioenergy*. Available at: https://www.ieabioenergy.com/blog/publications/state-of-technology-review-algae-bioenergy/.

India. Bureau of Indian Standards (1988). *Raw Seaweeds, Part 1: Agarophytes; Part 2: Alginophytes, IS 12342:1988*. Available at: https://archive.org/details/gov.in.is.12342.1.1988 and https://law.resource.org/pub/in/bis/S06/is.12342.2.1988.pdf.

India. Bureau of Indian Standards (2020). *Processed Eucheuma Seaweed, Food Grade – Specification, IS 16877:2020*. Available at: https://standardsbis.bsbedge.com/BIS_SearchStandard.aspx?Standard_Number=IS%2016877&id=33496.

India. Bureau of Indian Standards (2025). *Good Aquaculture Practices for Seaweed Cultivation – Requirements, IS 19196:2025*. Available at: https://standardsbis.bsbedge.com/search_redirect.aspx?id=33374.

Indonesia. Badan Standardisasi Nasional (2010). *Produksi rumput laut kotoni (Eucheuma cottonii) – Bagian 2: Metode long-line, SNI 7579.2:2010*. Available at: https://pesta.bsn.go.id/produk/detail/8179-sni757922010.

Indonesia. Ministry of Marine Affairs and Fisheries (2010). *Pengendalian Sistem Jaminan Mutu dan Keamanan Hasil Perikanan, Permen KKP No. 19/2010*. Available at: https://peraturan.bpk.go.id/Details/158023/permen-kkp-no-per19men2010-tahun-2010.

Indonesia. Ministry of Marine Affairs and Fisheries (2013). *Sertifikasi Asal Rumput Laut, Peraturan Menteri Kelautan dan Perikanan No. 7/PERMEN-KP/2013*. Available at: https://peraturan.bpk.go.id/Details/158250/permen-kkp-no-7permen-kp2013-tahun-2013.

Indonesia. Badan Standardisasi Nasional (2015). *Rumput Laut Kering, SNI 2690:2015*. Available at: https://www.globalseaweed.org/wp-content/uploads/2019/02/SNI_2690_Tahun_2015_Dry_seaweed.pdf.

Indonesia. Ministry of Marine Affairs and Fisheries (2020). *Penerapan Kerangka Kualifikasi Nasional Indonesia Bidang Industri Pengolahan Rumput Laut, Peraturan Menteri Kelautan dan Perikanan No. 50/PERMEN-KP/2020*. Available at: https://peraturan.bpk.go.id/Details/187011/permen-kkp-no-50permen-kp2020-tahun-2020.

Indonesia. Badan Standardisasi Nasional (2021). *Tepung agar-agar murni, SNI 2802:2021*. Available at: https://pesta.bsn.go.id/produk/detail/13807-sni28022021.

Indonesia. Badan Standardisasi Nasional (2021). *Karaginan Murni – Bagian 1: Kappa Karaginan – Syarat Mutu dan Pengolahan, SNI 8391-1:2021*. Available at: https://legalcentric.com/content/view/173837.

Indonesia. Badan Standardisasi Nasional (2022). *Karagenan Semi Murni (Semi Refined Carrageenan), SNI 7688:2022*. Available at: https://pesta.bsn.go.id/produk/detail/14273-76882022.

Indonesia. Badan Standardisasi Nasional (2022). *Alkali Treated Cottonii (ATC), SNI 9110:2022*. Available at: https://bsn.go.id/uploads/download/laporan_kinerja_direktorat_ps_akkh_2022.pdf.

Indonesia. Badan Standardisasi Nasional (2023). *Dried Seaweed, Quality and Processing Conditions, SNI 2690:2023*. Available at: https://www.bsn.go.id/pemesanan-online.

Indonesia. Ministry of Marine Affairs and Fisheries (2024). *Penerapan Kerangka Kualifikasi Nasional Indonesia Bidang Budidaya Rumput Laut, Peraturan Menteri Kelautan dan Perikanan No. 1 Tahun 2024*. Available at: https://peraturan.bpk.go.id/Details/280241/permen-kkp-no-1-tahun-2024.

Indonesia. Ministry of Marine Affairs and Fisheries (2024). *Kewenangan Pembinaan dan Pengendalian dalam Rangka Penerbitan Sertifikat Jaminan Mutu dan Keamanan Hasil Perikanan, Permen KKP No. 16/2024*. Available at: https://peraturan.bpk.go.id/Details/306095/permen-kkp-no-16-tahun-2024.

Japan. Government of Japan (1947). *Food Sanitation Act, Act No. 233*. Available at: https://www.cas.go.jp/jp/seisaku/hourei/data/fsa.pdf.

Japan. Ministry of Justice (n.d.). *Act on Securing Quality, Efficacy and Safety of Products Including Pharmaceuticals, Medical Devices and Cosmetics*. Available at: https://www.japaneselawtranslation.go.jp/en/laws/view/3213.

Japan. Ministry of Agriculture, Forestry and Fisheries (n.d.). *JAS – Specific Organic Standards, including Organic Algae, JAS 0018*. Available at: https://www.maff.go.jp/e/policies/standard/specific/organic_JAS.html.

Republic of Korea. Ministry of Food and Drug Safety (2002). *Food Sanitation Act*. Available at: https://www.mfds.go.kr/files/upload/eng/FOOD_SANITATION_ACT.pdf.

Republic of Korea. Ministry of Food and Drug Safety (2014). *Health Functional Foods Act*. Available at: https://www.kca.go.kr/down/eng/laws/15_Health%20Functional%20Foods%20Act.pdf.

Republic of Korea. Ministry of Food and Drug Safety (2015). *Special Act on Imported Food Safety Control*. Available at: https://elaw.klri.re.kr/eng_service/lawView.do?hseq=63626&lang=ENG.

Republic of Korea. Ministry of Oceans and Fisheries (2020). *Act on the Promotion and Support of the Laver Industry*. Available at: https://law.go.kr/LSW/lsInfoP.do?lsiSeq=224663#0000.

Republic of Korea. Ministry of Food and Drug Safety (2020). *Cosmetic Act*. Available at: https://elaw.klri.re.kr/eng_service/lawView.do?hseq=38953&lang=ENG.

Republic of Korea. Ministry of Food and Drug Safety (2020). *Hazard Analysis and Critical Control Point (HACCP) for Food and Livestock Products*. Available at: https://www.mfds.go.kr/eng/brd/m_15/view.do?seq=72430.

Lauria, L.B. de M. (2023). Non-tariff protectionism in Mercosur: Analysis and recommendations on the last three decades. *Contexto Internacional*, 45: e20210067. Available at: https://doi.org/10.1590/S0102-8529.202345e20210067.

Lee, Y., Park, H.J., Jo, M., Ha, K.S. and Mok, J.S. (2025). Analysis and risk assessment of total iodine content in edible seaweeds in South Korea. *Foods*, 14(16): 2865. Available at: https://doi.org/10.3390/foods14162865.

Lomartire, S., Marques, J.C. and Gonçalves, A.M.M. (2021). An overview of the health benefits of seaweeds consumption. *Marine Drugs*, 19(6): 341. Available at: https://doi.org/10.3390/md1906034.

Mahjoub, B. and Domscheit, E. (2020). Chances and challenges of an organic waste-based bioeconomy. *Green and Sustainable Chemistry*, 10: 25–38. Available at: https://doi.org/10.4236/gsc.2020.101003.

Mateo, J.P. et al. (2020). Analysis of biosecurity-related policies governing the seaweed industry of the Philippines. *Journal of Applied Phycology*, 32(3): 2009–2022. Available at: https://doi.org/10.1007/s10811-020-02123-1.

METI (2025). *Industrial science and technology policy*. Available at: https://www.meti.go.jp/english/policy/economy/industrial_technology/index.html.

MFDS (n.d.). *Ministry of Food and Drug Safety regulatory information*. Available at: https://www.mfds.go.kr/eng/wpge/m_9/denofile.do.

MHLW (2022). *Food import procedures under the Food Sanitation Act: Article 27 requirements.* Tokyo: Ministry of Health, Labour and Welfare.

Ministry of Agriculture, Tanzania (2021). *Agricultural sector development programme phase II (ASDP II)*. Dodoma: Government of Tanzania.

MMAF (2019). *Keputusan Menteri Kelautan dan Perikanan Republik Indonesia Nomor 1/KEPMEN-KP/2019*. Jakarta: Ministry of Marine Affairs and Fisheries.

Mukhia, D.J. et al. (2024). Sea vegetables: An alternative food source – a review. *Agricultural Reviews*. Available at: https://doi.org/10.18805/ag.R-2590.

Mulyaman, D., Djaya, J.R.S. and Pradono, B.A. (2023). Blue economy transformation and seaweed industry development in Indonesia. *Journal of Sustainable Transformation*, 1(2): 39–53.

Nakhate, P. and van der Meer, Y. (2021). A systematic review on seaweed functionality: A sustainable bio-based material. *Sustainability*, 13(11): 6174. Available at: https://doi.org/10.3390/su13116174.

National Health Commission (NHC) and State Administration for Market Regulation (SAMR) (2022). *Catalogue of approved "Three New Foods" (including novel food ingredients)*. Available at: https://www.cirs-group.com/en/food/china-issued-a-full-catalogue-including-approved-new-food-raw-materials-new-food-additives-and-new-food-related-products-for-public-comments.

Pardilhó, S., Cotas, J., Pereira, L., Oliveira, M.B. and Dias, J.M. (2022). Marine macroalgae in a circular economy context: A comprehensive analysis focused on residual biomass. *Biotechnology Advances*, 60: 107987. Available at: https://doi.org/10.1016/j.biotechadv.2022.107987.

Philippines. Bureau of Fisheries and Aquatic Resources (2001). *Rules and regulations on the exportation of fresh, chilled and frozen fish and fishery/aquatic products, Fisheries Administrative Order No. 210-01*. Available at: https://elibrary.judiciary.gov.ph/thebookshelf/showdocs/11/44103.

Philippines. Government of the Philippines (2013). *Food Safety Act of 2013, Republic Act No. 10611*. Available at: https://lawphil.net/statutes/repacts/ra2013/ra_10611_2013.html.

Philippines. FAOLEX (2018). *Regulations on the collection, harvesting, gathering, selling and exporting of Sargassum spp., Fisheries Administrative Order No. 250-2*. Available at: https://leap.unep.org/en/countries/ph/national-legislation/fisheries-administrative-order-no-250-2-s-2018-amending-fao-no.

Philippines. Department of Agriculture – Bureau of Agriculture and Fisheries Standards (2021). *Philippine National Standard – Seaweeds: Code of Good Aquaculture Practices (GAqP), PNS/BAFS 208:2021*. Available at: https://www.scribd.com/document/550711493/2021-10-19-PNS-BAFS-208-2021-Seaweeds-Code-of-Good-Aquaculture-Practices-GAqP.

Prado, M.M. and Bertrand, V. (2015). Regulatory cooperation in Latin America: The case of Mercosur. *Law and Contemporary Problems*, 78(4): 205–230.

Prasedya, E.S. et al. (2022). Seaweed fertilizer prepared by EM-fermentation increases abundance of beneficial soil microbiome in paddy (Oryza sativa L.) during vegetative stage. *Fermentation*, 8(2): 46. Available at: https://doi.org/10.3390/fermentation8020046.

Prasedya, E.S. et al. (2023). Sustainable use of organic seaweed fertilizer improves the metagenomic function of microbial communities in the soil of rice plants. *Sustainability*, 15(23): 16328. Available at: https://doi.org/10.3390/su152316328.

Seaweed Insights (2023). *Global seaweed production*. Available at: https://seaweedinsights.com/global-production/.

Singh, P., Mohanty, P., Mishra, S. and Adhya, T. (2022). Food waste valorisation for biogas-based bioenergy production in circular bioeconomy: Opportunities, challenges and future developments. Biofuels, *Bioproducts and Biorefining*, 16(6): 1750–1773. Available at: https://doi.org/10.1002/bbb.2405.

State Council of China (2023). *No. 1 Central Document 2023.* Available at: https://leap.unep.org/en/countries/cn/national-legislation/no1-central-document-2023.

State Council of China (2024). *No. 1 Central Document 2024*. Available at: https://www.gov.cn/zhengce/202401/content_6924934.htm.

Submariner Network (n.d.). *KosterAlg: EU organic-certified Swedish cultivated seaweed.* Available at: https://2020.submariner-network.eu/alliance/87-alliance-cases/778-kosteralg-eu-organic-certified-swedish-cultivated-seaweed.

Sugumaran, R. et al. (2022). A retrospective review of global commercial seaweed production: Current challenges, biosecurity and mitigation measures and prospects. *International Journal of Environmental Research and Public Health*, 19(12): 7087. Available at: https://doi.org/10.3390/ijerph1912708.

Sultana, F. et al. (2023). Seaweed farming for food and nutritional security, climate change mitigation and adaptation, and women empowerment: A review. *Aquaculture and Fisheries*, 8(5): 463–480. Available at: https://doi.org/10.1016/j.aaf.2022.09.003.

UN Comtrade (2025). *UN Comtrade database*. Geneva: United Nations Conference on Trade and Development. Available at: https://comtradeplus.un.org/.

UNCTAD (2010). Non-tariff measures: Evidence from selected developing countries and future research agenda. *SSRN Electronic Journal*. Geneva: United Nations Conference on Trade and Development. Available at: https://doi.org/10.2139/ssrn.1549003.

UNCTAD (2020). *BioTrade principles and criteria*. Geneva: United Nations Conference on Trade and Development. Available at: https://unctad.org/topic/trade-and-environment/biotrade/principles-and-criteria.

UNCTAD (2024a). *South-South trade in the marine fisheries and aquaculture sectors.* Geneva: United Nations Conference on Trade and Development.

UNCTAD (2024b). *Review of maritime transport 2024*. Geneva: United Nations Conference on Trade and Development.

UNCTAD (2024c). *An ocean of opportunities: The potential of seaweed to advance food, environmental and gender dimensions of the SDGs*. Geneva: United Nations Conference on Trade and Development.

UNCTAD (2025a). *Leaving the shore: Marine-based substitutes and alternatives to plastics.* Geneva: United Nations Conference on Trade and Development.

UNCTAD (2025b). *Making sense of non-tariff measures: A user's guide to accessing and analysing the data.* Geneva: United Nations Conference on Trade and Development.

UNCTAD (2025c). *Ocean trade database.* Geneva: United Nations Conference on Trade and Development. Available at: https://unctadstat.unctad.org/datacentre/dataviewer/US.OceanTradeIndividualEconomies.

UNCTAD TRAINS (2025). *TRAINS Online database*. Geneva: United Nations Conference on Trade and Development. Available at: https://trainsonline.unctad.org/.

UNCTADstat (2025). *UNCTADstat database.* Geneva: United Nations Conference on Trade and Development. Available at: https://unctadstat.unctad.org/.

UNDESA (2023). *Global sustainable development report 2023*. New York: United Nations Department of Economic and Social Affairs.

UNGC (2020). *UN Global Compact ocean principles.* New York: United Nations Global Compact. Available at: https://unglobalcompact.org/library/5743.

UNIDO (n.d.). *From ocean to market: Advancing a sustainable seaweed value chain for coastal prosperity in Indonesia.* Vienna: United Nations Industrial Development Organization. Available at: https://sdgs.un.org/partnerships/ocean-market-advancing-sustainable-seaweed-value-chain-coastal-prosperity-indonesia.

UNIDO (2023). *Indonesia's seaweed industry as a key source of sustainable blue growth. Policy brief.* Vienna: United Nations Industrial Development Organization. Available at: https://hub.unido.org/news/policy-brief-indonesias-seaweed-industry-key-source-sustainable-blue-growth.

United Kingdom. British Standards Institution (2024). *Algae and Algae Products: Vocabulary, BS EN 17399:2024*. Available at: https://knowledge.bsigroup.com/products/algae-and-algae-products-vocabulary-1.

United Republic of Tanzania. Tanzania Bureau of Standards (2022). *Dried Seaweed — Specification, TZS 2750:2022*. Available at: https://www.tbs.go.tz/catalogues.

United States. United States Department of Agriculture (2018). *National Organic Program – Seaweed in Fertilisers*. Washington, DC: United States Department of Agriculture. Available at: https://www.ams.usda.gov/sites/default/files/media/MSMarineMaterialsDiscDocOct2018Web.pdf.

United States. United States Department of Agriculture (n.d.). *National Organic Program, 7 CFR Part 205*. Washington, DC: United States Department of Agriculture. Available at: https://www.ecfr.gov/current/title-7/subtitle-B/chapter-I/subchapter-M/part-205.

United States. Environmental Protection Agency (2022). *Response to Comments Received on the Draft Guidance for Plant Regulator Label Claims, Including Plant Biostimulants*. Washington, DC: United States Environmental Protection Agency. Available at: https://downloads.regulations.gov/EPA-HQ-OPP-2018-0258-0172/content.pdf.

United States. Environmental Protection Agency (n.d.). *Biopesticide Registration*. Washington, DC: United States Environmental Protection Agency. Available at: https://www.epa.gov/pesticide-registration/biopesticide-registration.

United States. Food and Drug Administration (2015). *Code of Federal Regulations, Title 21, Part 117 – Current Good Manufacturing Practice, Hazard Analysis and Risk-Based Preventive Controls for Human Food*. Washington, DC: United States Food and Drug Administration. Available at: https://www.ecfr.gov/current/title-21/part-117.

United States. Food and Drug Administration (2024). *Federal Food, Drug, and Cosmetic Act*. Washington, DC: United States Food and Drug Administration. Available at: https://www.govinfo.gov/content/pkg/COMPS-973/pdf/COMPS-973.pdf.

USDA (2018). *National Organic Standards Board materials subcommittee discussion document: Marine materials in organic crop production.* Washington, DC: United States Department of Agriculture.

USDA (2022). *National Organic Program handbook*. Washington, DC: United States Department of Agriculture. Available at: https://www.ams.usda.gov/rules-regulations/organic/handbook.

Valderrama, D. et al. (2015). The economics of Kappaphycus seaweed cultivation in developing countries: A comparative analysis of farming systems. *Aquaculture Economics & Management*, 19(2): 251–277. Available at: https://doi.org/10.1080/13657305.2015.1024346.

Waldron, S. (2023). *The Indonesian seaweed industry.* In: Globalisation and livelihood transformations in the Indonesian seaweed industry. London: Routledge, pp. 51–76.

Waqas, M.A., Hashemi, F., Mogensen, L. and Knudsen, M.T. (2024). Environmental performance of seaweed cultivation and use in different industries: A systematic review. *Sustainable Production and Consumption*, 48: 123–142. Available at: https://doi.org/10.1016/j.spc.2024.02.001.

World Bank (2023). *Global seaweed new and emerging markets report 2023*. Washington, DC: World Bank.

World Customs Organization (2022). *Harmonized system nomenclature 2022 edition*. Brussels: World Customs Organization.

WTO (1995). *Agreement on Technical Barriers to Trade.* Geneva: World Trade Organization. Available at: https://www.wto.org/english/docs_e/legal_e/17-tbt_e.htm.

WTO Environmental Database (2025). *WTO environmental database.* Geneva: World Trade Organization. Available at: https://edb.wto.org/.

Zayed, A., El-Seadawy, H.M., Attia, E.Z., Rushdi, M.I. and Abdelmohsen, U.R. (2024). Adopting biorefinery and a circular bioeconomy for extracting and isolating natural products from marine algae. *Frontiers in Natural Products*, 3. Available at: https://doi.org/10.3389/fntpr.2024.1360343.

Zhang, L. et al. (2022). Global seaweed farming and processing in the past 20 years. *Food Production*, Processing and Nutrition, 4(1): 23. Available at: https://doi.org/10.1186/s43014-022-00112-7.

Zhou, L., Ren, S., Du, L., Tang, F. and Li, R. (2023). Is environmental labeling certification a “green passport” for firm exports in emerging economies? Evidence from China. *International Business Review*, 32(5): 102171. Available at: https://doi.org/10.1016/j.ibusrev.2023.102171.

unctad.org