Axis: 3. Transforming Agriculture and Food Systems

Key objective: 9. More resilient, adaptive, and sustainable food systems -

Solution: Multiple benefits of algae aquaculture

Host Initiative: United Nations Global Seaweed Initiative (UNGSI)

Cooperating entities: UN Trade and Development (UNCTAD), UN Global Compact-Global Seaweed Coalition (UNGC-GSC), UN Industrial Development Organization (UNIDO), Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO-IOC), Food and Agriculture Organization of the United Nations (FAO)

Scope: Aquatic food and non-food production and value chains derived from marine and inland algae aquaculture, at global, regional and national level

#### Levers assessment:

Policy and regulatory frameworks: Low maturity

Rationale: Algae remains poorly defined in production, trade, regulation and standardisation systems, which are fragmented across food and non-food applications among different sectors. At the national level, seaweed is usually governed under fisheries, aquaculture, or food laws, with dedicated algae regulations mainly in Asian countries. At the regional level, efforts are limited and inconsistent with the exception of the European Union<sup>1</sup>. There is no dedicated multilateral agreement specifically covering algae. General technical guidance exists on adaptation and integration into NDCs/NAPs/NBSAP, but adoption is uneven. Countries are increasingly integrating fisheries and algae aquaculture into national policies, but coherence across climate, biodiversity, industrial development, marine and coastal zone management and food security agendas remains limited. UNCTAD's latest research reveals that SIDS have placed the ocean at the heart of their NDCs. Across 39 countries, a total of 606 ocean-related measures were found in NDCs: 54 per cent prioritize sustainable ocean economies, while 46 per cent target marine and coastal ecosystem conservation. About 85 per cent of the measures on sustainable use focus on fisheries and aquaculture, with only limited explicit attention to algae (UNCTAD, 2024).

<sup>1</sup> 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) 2023/915, replacing Regulation (EC) 1881/2006), specific thresholds for many seaweed species consumption have not yet been defined.

#### Risk and market decision-making: Medium maturity

Rationale: Genetic impoverishment poses a significant risk in seaweed farming, as it increases crop vulnerability to diseases and pests. This issue is particularly evident in tropical red seaweeds such as Eucheuma sp. and Kappaphycus sp., which were introduced from the Philippines to regions in East Africa and Central and South America. Although the sector has expanded rapidly and exponentially, production practices still rely heavily on monocultures and vegetative reproduction (cloning). To strengthen resilience and sustainability, greater emphasis should be placed on identifying local species and cultivating them within multi-culture systems.<sup>2</sup> Conservation and restoration of wild seaweed ecosystems are equally critical to maintain genetic diversity, safeguard ecosystem functions, and support the long-term sustainability of the sector. High climate vulnerability and safety risks to algae aquaculture are well recognized, but systematic use of climate data, early warning systems, and adaptive management tools for farmers remains limited, especially in developing countries and among small-scale producers and women. While new start-ups and small and medium enterprises (SMEs) are emerging in seaweed production and processing, informality in operations and decision-making is widespread. There is also a lack of international, regional and national intelligence and data systems on seaweed markets, product quality, limiting producers' ability to negotiate equitable contracts with sourcing companies and participate competitively in global value chains (UNCTAD, forthcoming).

#### • Technology shifts: Medium maturity

Rationale: Proven technologies for seaweed production and application exist - from mariculture and recirculating aquaculture systems to extraction of commercial biochemicals such as agar, alginate, and carrageenan. Successful organizational models are ready to be replicated in anticipation of technological shifts, particularly in the cultivation of red tropical seaweed. Community-based farming has already demonstrated its success, achieving an increase from 0 to 2,000 tons of dry seaweed in less than five years. UNCTAD reports that global exports of agar and alginate reached USD 260 million and USD 161 million, respectively in 2021 (UNCTAD, 2024). Technology transfer mechanisms are necessary to persuade adoption of climate resilient technologies by seaweed producers. Successful integration of small scale producers in industrial value chains is necessary to guarantee increased income by farmers (UNIDO 2019). In parallel, scalable nature-based technologies like integrated aquaculture (e.g., shrimp—tilapia—seaweed or finfish—bivalve—seaweed or abalone-seaweed or oyster-seaweed) support ecosystem services such as carbon absorption, pollution mitigation, habitat provisioning and coastal acidification mitigation. These innovations have shown clear adaptation and environmental benefits, however, scientific data still need to be replicated and

<sup>2</sup>In Madagascar, a public–private partnership has been established to identify local *Kappaphycus* seaweed strains with enhanced resilience to climate change. This initiative, jointly funded by the Global Seaweed Coalition and USAID, now requires sustained government investment to maintain seaweed genebanks and safeguard the identified local strains.

harmonised to confirm their consistency. Additionally, there is a need to consider potential bottlenecks for technological uptake including licensing, energy requirements, and human capacity constraints. The Nature Conservancy (TNC) has developed a framework to measure the impact of seaweed farming (2024) has initiated this effort, which has since been followed by the Global Seaweed Coalition in developing approaches to assess biodiversity impacts. Still, advancement of sustainable seaweed solutions across food and non-food sectors remains hindered without enhanced access to investment and broader deployment.

## Knowledge & capacity building: Low maturity

Rationale: Around 600 million people rely on aquatic foods for livelihoods, yet many seaweed producers lack access to climate finance literacy and training on climate-resilient practices. Extension services remain uneven, and local and traditional knowledge must be mobilized to guide adaptation. Global seaweed production reached over 36.3 million tonnes (wet weight) in 2022, yet commercial cultivation is concentrated in only 10 species, limiting diversity and resilience (UNCTAD, 2024). These 10 species account for 99% of global seaweed production, according to the FAO's FishStat database (FAO Stats, 2025); three species represent 74% of global production. Seaweed contributes to food security, women's economic empowerment, and climate benefits, but producers often lack access to finance, training, and global markets (UNCTAD, 2024). UNCTAD's ongoing regulatory mapping of seaweed trade and standards also highlights uneven knowledge and fragmented approaches across regions. Building capacity for producers, especially women and small-scale farmers, and sharing best practices is essential to unlock these benefits (UNCTAD, forthcoming). Knowledge, skills and capacity of seaweed producers and processors in developing countries to supply to new markets such as biostimulants, animal feed, pet foods, non-plastic substitutes, and methane-reducing additives remain limited and need to be strengthened.

### Inclusive decision-making governance & design: Low maturity

Rationale: Co-management models show promise, yet small-scale and Indigenous actors remain underrepresented in decisions affecting their climate resilience. Women make up more than half of the seaweed workforce in several producing countries, but their participation in governance and policy processes remains limited (UNCTAD, 2024). UNCTAD's Ocean of Opportunities report stresses that small-scale producers are critical actors in farming and processing, yet often operate informally with limited institutional recognition (UNCTAD, 2024). The seaweed sector lacks gender-disaggregated production data, despite broad recognition that women constitute a significant proportion of the seaweed workforce. The UN Global Seaweed Initiative (UNGSI) seeks to address this by embedding inclusive governance structures that ensure women, youth, and small-scale producers help shape regulatory standards, trade access, and climate resilience strategies. Potential impacts will of course depend on the level of maturity of the governance structure. Seaweed is often grown in shallow coastal waters, an ecosystem that is among the most vulnerable to climate change and negative biodiversity loss. Seaweed cultivation should therefore be carefully designed and well integrated in coastal adaptation planning, in particular through locally-led adaptation.

### • Standards and Taxonomies: Low maturity

Rationale: There is no internationally agreed classification or taxonomy of edible industrialised algae species. FAO highlighted this in its State
of the World's Aquatic Genetic Resources (2019) and is currently working to gather further information with the support of the Global

Seaweed Coalition (GSC) through the global platform AquaGRIS (2024). There is no Codex Alimentarius guidance dedicated to seaweed at global level, as seaweed is not yet fully recognised as a food product, with the exception of one specie<sup>3</sup>. The Codex Alimentarius Commission and the International Organization for Standardization (ISO) only indirectly address certain species and production aspects. In trade statistics, seaweed and its derivatives are covered under a small number of HS codes: HS 1212.21 (raw seaweed for food use), HS 1212.29 (raw seaweed for non-food use), HS 1302.31 (agar-agar), and HS 3913.10 (alginic acid) (WCO, 2022; UNCTAD, 2024). This narrow classification constrains visibility in global trade data and hinders harmonisation of regulatory approaches. There is a need to create a working group to prepare a science and economic based taxonomy for commercial seaweed species. Private sustainability standards (e.g. ASC seaweed) exist but remain limited to primary production. Greenhouse gas inventory and life cycle assessment methods for seaweed farming also exist, but require further standardisation to fully capture carbon mitigation and biodiversity co-benefits.

### • Supply: Medium maturity

Rationale: Over the past two decades, the global seaweed industry has tripled in size and doubled in value, reaching more than 36.3 million tonnes (wet weight). Today, seaweed accounts for half of global marine aquaculture production by volume. Main producers of primary algae are in Asia, with China and Indonesia generating 87 per cent of global seaweed production in 2022 (UNCTAD, 2025). In the short-term, the most promising new markets are projected to reach \$4.4 billion by 2030, including biostimulants, animal feed, pet foods, and methane-reducing additives. Medium-term opportunities, including nutritional supplements, alternative proteins, bioplastics, and fabrics could reach a potential value of \$6 billion. Long-term emerging markets are projected to reach \$1.4 billion, for pharmaceuticals and construction materials, but with significant regulatory challenges and a high cost of product development (World Bank, 2023). FAO production data are considered as not fully accurate by external experts, and are not disaggregated. National focal points to obtain those data are not designated clearly. In preparing data on the supply side, there is a need to consider climate risks that could generate quite different output levels depending on the climate and other environmental factors.

## • Demand: Medium maturity •

 Rationale: Algae demand has been mainly driven by aquaculture growth; increased low-calorie, nutritious. low carbon and plant-based diets, and new non-food uses including in cosmetics, animal feed, fertilizers, biopacking and bioplastics, but this trade is currently subject to significant tariff and geopolitical uncertainty that will affect trade flows (UNCTAD 2024 and 2025). Demand should grow organically with the

<sup>&</sup>lt;sup>3</sup>Regional standard for laver products, *Pyropia sp.*, Asia, CXS 323R-2017

rise of food demand globally. Using UN population estimates for the next few decades, we would expect total dry-weight seaweed demand to increase by 20% between now and 2050 (Standard Chartered report, 2023). Finally, demand is expected to grow through increased awareness and education, which remain limited at present and are not yet integrated into national policies.

#### • Trade: Medium maturity •

Rationale: Trade in seaweed and other algae, whether fit for human consumption (HS 121221) or other uses (HS 121229), nearly doubled between 2012 and 2022, rising from \$677 million to \$1.2 billion. In terms of exports, Asia and Latin America are the top actions. Many countries are now exploring options for South-South and regional trade as the way out to deflect impacts of tariff uncertainty and to find new markets (UNCTAD, 2025). Seaweed has not yet been fully recognised as a plant-based commodity in international markets. The 5th United Nations Ocean Forum on Trade related aspects of SGD 14 "call for the creation of a UN wide system Task Force on Seaweed and a Technical Advisory Body on sustainable biomaterials, within UNCTAD, to fill regulatory and standard gaps and scale-up marine-based innovation and related product development" (UNCTAD, 2025). The national quality infrastructure system (standards, metrology, conformity assessment services) are often underdeveloped to service the seaweed sector. As a result, verification of compliance of products with quality, safety and sustainability requirements becomes difficult and costly, thus hindering trade.

## Public/private finance: Low maturity

- Rationale: Seaweed aquaculture remains critically underfinanced compared to its potential. While global seaweed exports were valued at around USD 1.2 billion in 2023, the overall market is estimated at USD 17-19 billion, revealing a major investment gap (UNCTAD, 2024a AND unctad 2025). Despite its role in food security, climate mitigation, and sustainable materials, seaweed receives only marginal attention from global adaptation and agrifood finance flows (Global Seaweed Coalition, financing opportunities in seaweed sector EU, 2025). UNCTAD's Blue Deal initiative highlights the need to mobilise blue finance for emerging ocean sectors, including seaweed, through instruments such as blended finance, blue bonds, and sustainable trade facilitation. Unlocking this financing is essential to expand production, foster innovation, and ensure inclusive participation in seaweed value chains. Blended funds have been identified as one solution by the Global Seaweed Coalition in de-risking investment. Indeed, seaweed producers and SMEs have difficulty fundraising to kick start projects with long term return on investment and are cost intensive in the situation of in-land production. A scoping study is being initiated at EU level with identified partners which would deserve to be upscale at global level if funds are available. In parallel, public funding is needed to safeguard national seaweed resources and support restoration efforts. Unlike terrestrial plants, seaweed moves and can be transferred across borders, as recognized as genetic resources under the Nagoya Protocol. Countries therefore need to secure their national resources through the establishment of seaweed genebanks both to preserve biodiversity and, more importantly, to protect and sustain their growing seaweed industries, which currently rely on a limited number of species.
- Partnerships and collaboration: Low maturity

Rationale: Collaboration among science, finance, policy, and communities, as well as multi-stakeholder initiatives are growing, though continued co-design and scaling are needed for greater impact. The UNGSI demonstrates this lever by bringing together Member States (Madagascar, Indonesia, France and Chile), UN entities (UNCTAD, UNGC-GSC, FAO, UNIDO, UNESCO-IOC), and civil society partners. This coalition provides a foundation for scaling joint research, knowledge exchange, and investment in algae aquaculture. In science, UNGSI supports the emergence of regional seaweed research centers (e.g. tropical seaweed research center in Indonesia covering research for SE Asia and East Africa).

#### • Public opinion: Medium maturity

Rationale: Recognition of seaweed as a low-carbon, nutritious, and versatile resource is growing, but its role as a climate and development solution remains underrepresented in public narratives. Despite its potential to provide food security, substitutes and alternatives to plastics, and ecosystem services, seaweed is still perceived as a niche commodity rather than a strategic sector. In the particular case of substitutes and alternatives to fossil fuel-based plastics, seaweed is already being used to develop and produce biomaterials such as PLA and PHA, with no microplastics in the case of the latter. UNCTAD has helped shift narratives by framing seaweed as both a climate and development solution at the 5th UN Ocean Forum (March 2025) and the 3rd UN Ocean Conference (June 2025). The UN Global Seaweed Initiative builds on this momentum by offering a platform for awareness-raising, advocacy, and public engagement on seaweed's role in food security, livelihoods, and climate action. At the same time, negative public opinion persists around invasive species (sargassum, algal blooms), which is widely associated with beach fouling and coastal damage, rather than recognized for its potential uses if managed sustainably.

Expected impact of this plan on the 2035 targets (if any): High

**Policy and regulatory frameworks:** Strengthen coherence across national, regional, and global levels by advancing international classifications (HS codes), regulations (national laws) and standards (e.g. Codex Alimentarius, ISO and ASC). Mapping existing regulations and standards and providing technical assistance for dedicated improvement, refinement and compliance. Algae will be better integrated into NDCs, NAPs, and NBSAPs, particularly in SIDS and coastal states, ensuring alignment across climate, biodiversity, and food security agendas.

**Finance and investment:** Unlock capital flows for seaweed aquaculture through blended finance models, blue bonds, and sustainable trade facilitation. Scale up the EU-led scoping study on blended funds into a global initiative to de-risk private investment and expand opportunities for SMEs and small-scale producers. Mobilize public financing to establish national seaweed genebanks, ensuring biodiversity conservation and long-term resilience of the industry, which currently relies on a narrow range of species. Clarification of more suitable and sustainable cultivation methods, safety, job creation and technological needs could facilitate the leverage of impact capital opportunities.

**Knowledge, capacity, and inclusion:** Expand training and extension services, with a focus on climate finance literacy, trade-related policies, resilient practices, and mobilizing traditional knowledge. Replicate successful organizational and community-based farming models that have already demonstrated rapid scaling potential, such as red tropical seaweed cultivation. Strengthen inclusive governance, ensuring meaningful participation of women, youth, and Indigenous producers in shaping policies, accessing markets, and benefiting from investment.

**Data and evidence:** Improve the quality, harmonisation, and accessibility of seaweed production and trade data to support evidence-based policymaking and investment. FAO's FishStat provides global production statistics, though coverage is limited to a handful of species. UNCTAD and UN Comtrade track trade flows in values and volumes on existing raw materials and by products. Building on these foundations, the plan will seek to enhance global monitoring systems, ensuring that SIDS, LDCs and small-scale producers are visible in statistics and able to leverage opportunities in a sustainable ocean economy, particularly in the algae sector.

By 2035, the plan aims to deliver measurable progress through three impact pathways:

- 1. Increasing uptake of best climate mitigation, adaptation and resilient practices and technologies:
  - By expanding sustainable cultivation and processing, deploying innovations such as methane-reducing feed additives, biostimulants for agriculture, disease-resistant strains, improved farming systems, and digital monitoring tools.
- 2. Strengthening governance and inclusive participation:
  - By integrating seaweed into NDCs, NPAs, NBSAPs and national ocean, food and climate strategies, while ensuring active involvement of smallholders, women, youth, and Indigenous producers in policy, market access, and benefit-sharing.
- 3. Mobilizing finance for aquatic food systems transformation:
  - By scaling public and private investment, de-risking SME participation through blended finance, and supporting infrastructure for new value chains in bioplastics, fertilisers, pharmaceuticals, and other innovative applications. Fund the "Blue deal" proposal by UNCTAD to provide a sector wide support to the implementation of trade-related aspects of SDG 14 and action by the UNGSI.

## **Expected contributions to global processes:**

- Global Stocktake (GST): highlights seaweed's role in mitigation (carbon sequestration, methane reduction, plastic alternatives) and adaptation (ecosystem regeneration, coastal protection), filling a current gap in climate reporting on blue carbon ecosystems.
- 2030 climate solutions targets: demonstrates how seaweed can support nutrition security, resilient coastal livelihoods, and low-carbon materials for billions in climate-vulnerable regions, while attracting new flows of green and blue investment.
- **SDGs**: directly contributes to SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 5 (Gender Equality), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action) and SDG 14 (Life Below Water).

• UN ocean and climate processes: builds on its announcement at the 3rd UN Ocean Conference (June 2025) and responds to the recommendations of the 5th UN Ocean Forum (March 2025), providing a global platform to strengthen governance and finance for seaweed. It will continue this trajectory at COP30 (November 2025), positioning seaweed within sustainable ocean economies and trade contributions to national climate action and biodiversity frameworks, with strong relevance for SIDS, LDCs, and emerging producer countries.

Output	Action Scope	Action	Type of action	Implementation Lever	Responsible	Time horizon	Stakeholder engagement	Committed Stakeholders
1.Ensure that global data on production and trade is accurate, cover all commercial species and producing and trading countries	Global aquatic plant systems	Strengthen FAO fish Stats, UNCTAD Trade and UNIDO Stats systems for notification and data compilation	New action •	Supply Demand Trade	FAO, UNCTAD amd UNIDO	Novem •	Countries Companies Regulators & Multi-stakehol Technical insti	UNGSI
2.Achieve 100% growth in global seaweed aquaculture output by 2030 is compared with previous decade	Global aquatic plants systems	Promote adoption of climate-resilient production and technologies, pluri-culture practice and sustainable seaweed aquaculture models (ex: community based farming models). Facilitate the use of area-based management tools such as marine spatial planning (MSP) and marine protected areas (MPAs)	Existing a	Supply Technology sh Knowledge &	FAO, UNIDO, UNCTAD, UNGC- GSC	Novem	Countries Companies Investors Technical insti	UNGSI
3. A preliminary map of algae and seaweed trade regulations and standards is available	Global aquatic plant trade	Undertake a preliminary mapping of trade regulations and standards	New action •	Trade Policy & regul Knowledge & Standards & T	UNCTAD-led, with the support of GSC, UNIDO, FAO	Novem •	Countries Companies MDBs Technical insti Regulators & Multi-stakehol	UNGSI
4.Increased number references in NDC 3.0, NAPs, and NBSAPs or associated implementation plans that explicitly include algae-related actions and priorities	Global aquatic plant aquaculture and carbon sinks contribution to climate,	Further develop technical guidance and evidence on the climate mitigation and adaptation potential of aquatic food systems, and support countries to integrate algae in NDCs, NAPs and NBSAPs. No	Existing a	Policy & regul  Trade  Technology sh  Knowledge &	UNFCCC-led with the support of UNCTAD, FAO, UNIDO, UNESCO-IOI, GSC	Novem •	Countries Technical insti Multi-stakehol	UNGSI

Output	Action Scope	Action	Type of action	Implementation Lever	Responsible	Time horizon	Stakeholder engagement	Committed Stakeholders
	adaptation and biodiversity goals	baseline report specifically in algae, only a report of UNCTAD on oceans measures in SIDS						
5.Mapping of existing industrialised seaweed species globally at country level and associated genebanks. Taxonomy clarification is needed to enable the work.	Global aquatic information system	Strengthen FAO AquaGRIS platform, create or identify genebanks at national level to secure seaweed production facing risks (climate event, pest & disease outbreak)	Existing a	Knowledge & Standards & T	FAO, GSC			UNGSI
6.Develop and present scientific sound reports to the Commission of the Codex Alimentarius to support the algae based standards for food and food contact	Global aquatic food systems	Compile information of food grade species, food safety, nutrition, contaminants and other risks of relevant algae varieties. Further research might be needed to achieve this work.	New action -	Standards & T Risk-informed	FAO, UNCTAD, UNIDO, GSC	Novem	Investors Countries Regulators &	UNGSI
7.Assessment of various seaweed value chains and mapping value addition opportunities, compliance challenges and quality infrastructure needs for producer countries to be able to benefit from market opportunities.		Assessment of readiness of national quality infrastructure systems including institutional capacity (standardization body, metrology institution, accreditation body) and services (testing, certification, calibration, surveillance) to support development of seaweed industry and facilitate exports and trade. Assessment of markets and value chains to identify market and investment opportunities.	New action -	Trade Policy & regul Supply Demand	UNIDO-led with the support of UNCTAD, FAO, UNGC-GSC	June 2	Countries Investors Regulators & Companies Technical insti	UNGSI
8.Global Innovation, Incubation and Accelerator		Launch of global innovation challenge, connecting north	New action •	Technology sh •	UNGC-GSC, UNCTAD,	Decem	Countries Companies	UNGSI

Output	Action Scope	Action	Type of action	Implementation Lever	Responsible	Time horizon	Stakeholder engagement	Committed Stakeholders
programme for development, pilot application and upscaling new seaweed based products and/or technologies		and south actors for joint technology and product development, pilot testing and upscaling. Design and implementation of incubation and accelerator programme in collaboration with academia, industry and financial institutions.		Knowledge &	UNIDO, FAO		Investors -	
9.Enhancing education, training, sustainability, trade capacity and competitiveness of seaweed industries globally		Seaweed to be included as part of the educational curriculum. Design and implementation of a global technical cooperation programme aiming at 1) enhancing performance of all value chain actors through training, good practices, technology upgrading, up-skilling etc., 2) strengthening the technical and non-technical support institutions and services to the seaweed sector and 3) fostering a conducive policy environment for transformation of the seaweed sector in supported countries. The Seaweed Breakthrough, currently under development for COP31, could serve as one of the key policy instruments to advance this last objective.	New action •	Knowledge &  Partnerships  Public opinion	UNESCO-IOC, GSC, UNIDO, FAO, UNCTAD	Decem	Countries Technical insti Youth & Indig Multi-stakehol Companies	UNGSI
10.Leverage blue finance to enable small-holders, producers and SMEs to develop and innovate, at		Develop blended finance to de-risk seaweed investment. Enable micro-credit and social business model.	New action -	Technology sh Public/private	UNGC-GSC, UNIDO, UNCTAD	Novem	Investors Countries MDBs	UNGSI

Output	Action Scope	Action	Type of action	Implementation Lever	Responsible	Time horizon	Stakeholder engagement	Committed Stakeholders
production level and downstream valorisation.								

<sup>\*</sup>All of these actions depend on funding availability and support. Outputs 3,5 and 7 are partially funded and already started.