

SEAWEED REVOLUTION

A MANIFESTO FOR A SUSTAINABLE FUTURE

Lloyd's Register Foundation

> **“If we get this right, we are at the start of a great journey together in sustainably harvesting the potential of our largest common good – the ocean.”**



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FOREWORD

Secretary General of the United Nations, Antonio Guterres, has coined this the Decade of Action and Delivery for the 17 Sustainable Development Goals. Businesses, governments, academia, non-governmental organisations and the UN must act together and deliver solutions addressing key issues such as hunger, poverty and climate change, to name a few.

We are at a point where ocean health is rapidly deteriorating, caused by climate change, pollution and over-exploitation of its resources. At the same time, the ocean holds a huge potential to deliver on the global goals – with more healthy food, renewable energy and green transport for a growing world population.

The current global seaweed production is already a part of the solution. Going forward, we can scale up this industry to deliver safer and healthier food, renewable biofuel, low-carbon feed, as well as capturing and storing carbon dioxide to limit climate change, while also creating new sources of revenue to alleviate poverty in coastal communities. These are some of the direct benefits of seaweed production.

Examples of efforts that can ensure this industry accelerates to the next level:

- harmonizing rules and regulations;
- sharing science and safety best practices;
- enabling innovations;
- good marine spatial planning; and
- new investment efforts can ensure this industry accelerates to the next level.

This manifesto outlines the opportunities and barriers ahead of us. If we get this right, we are at the start of a great journey together in sustainably harvesting the potential of our largest common good - the ocean.

This Seaweed Manifesto will be available online at www.seaweedmanifesto.com, where you can also state your support to the manifesto and our common vision for the seaweed industry.

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INTRODUCTION

THE NEED FOR A MANIFESTO

This seaweed manifesto is a visionary document outlining how seaweed can contribute to delivering on the sustainable development goals. It defines a vision for the industry, explores the opportunities and benefits, as well as outlining the challenges and barriers for responsible development of the industry. The focus is on the untapped potential, which might notbe met without new thought-leadership and convening power to improve knowledge and expertise, develop new funding initiatives and influence policy makers, regulators and consumers.
Therefore, the manifesto proposes a set of success factors for all stakeholders, and provides the basis for different initiatives that will be required.

The collaborative development of the manifesto aims to create increased interest and active contributions to the responsible development of the industry from international donors, intergovernmental organizations, non-governmental organizations, research centres and international companies.

CONTRIBUTORS

The manifesto has been initiated by Lloyd's Register Foundation, an independent global charity that supports research, innovation and education with a mission to make the world a safer place. The work has been actively supported by the Sustainable Ocean Business Action Platform of the United Nations Global Compact. The Action Platform is taking a comprehensive view on the role of the ocean in achieving the 17 Sustainable Development Goals.

The editorial team consists of selected representatives from academia, business, non-governmental organizations and UN specialized agencies. The document is a consolidation of input from the participants, group discussions and relevant scientific reports and material, and so the content does not necessarily reflect the position of all participating and cited organizations.

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THE SEAWEED MANIFESTO AT A GLANCE

The figure below aims to give an overview of the content of the different chapters.

OPPORTUNITIES

- Unlock new seaweed value chains as drivers of the SDGs by exploring several applications and outcomes:
  - Food
  - Feed
  - Dietary supplements
  - Medicine
  - Bio-fuel
  - Crop nutrition
  - Packaging
  - Carbon sequestration
  - Ecosystem support
  - Ocean restoration
  - Poverty alleviation
  - Coastal community resilience

BARRIERS

- Fragmented industry outside of Asia
- Lack of aligned regulations or standards and insurability problems
- Technology barriers
- Need for social licence and spatial planning
- Limited understanding of potential and need for advocacy

SUCCESS FACTORS

- Global collaboration and knowledge-sharing
- Science-based decisions
- Positive environmental and occupational impact
- Harmonised standards, policies and regulations
- Coordinated investments

MILESTONES

- Market mapping
- Safe seaweed coalition
- Restoration of habitats
- Seaweed as carbon sinks
- Global blue farming platform
- Offshore production
- Integrated multi-trophic aquaculture
- Development of seaweed biorefineries

VISION

An upscaled, responsible and restorative seaweed industry playing a significant role in achieving the Global Goals by contributing to food safety and security, climate change mitigation, poverty alleviation and support to marine ecosystems.

VISION

Seaweed has the potential to address some of the world's most pressing challenges. Our vision is an upscaled, responsible and restorative seaweed industry, playing a globally significant role in food security, climate change mitigation, and support to the marine ecosystem, as well as contributing to job-creation and economic growth.

The vision goes beyond being sustainable. The aim is to restore abundance to the ocean while solving some of the world's biggest societal challenges. About 50 per cent of the photosynthesis on Earth occurs in seaweeds and microscopic algae floating in the oceans contributing to the uptake of carbon dioxide and the release of oxygen. The seaweeds provide shelter for marine life and are an important part of the food chain.

> Seaweed refers to about 11,000 different species that grow in the world's saltwater environments.

A globally thriving and connected seaweed industry has unmatched potential. Below are some examples of how seaweed can contribute to the UN Sustainable Development Goals (SDGs).

The list is not exhaustive. Supporting facts and figures can be found in related articles in the annex under References and further reading.



While covering 71 per cent of Earth's surface, the ocean contributes only 2 per cent to the world's food supply on a caloric basis (Schubel and Thompson, 2019). Low in fat and rich in proteins, carbohydrates, minerals, vitamins (B12, A, K) and essential micronutrients (iodine, zinc, iron), seaweed and other algae hold an untapped potential to contribute to the food system by being a nutritional source of food for humans, feed for aquaculture and land animals, and fertilizers for crops.



Seaweed research is also focusing on potential medicinal applications and its use as a specific dietary supplement.



Development of the industry could be a new source of revenue, especially for emerging economies and vulnerable people. The new industry could help to alleviate hunger and poverty. Ultimately, we get more resilient coastal communities and reduced inequalities.



Innovation projects are exploring the potential of using seaweed extracts as a source of packaging to replace single-use plastic and substitute oil-based adhesives, to move toward plastic reduction and a more environment-friendly chemistry in consumer goods.



Seaweed cultivation does not require any land, while agriculture contributes to around 24 per cent of global greenhouse gas emissions (Bellarby et al., 2008), with land-use change (for example, deforestation) being the largest contributor. Seaweed production for food and feed could contribute to avoiding land-use change. Seaweeds also naturally sequester carbon and could help to mitigate the effects of ocean acidification.

There are some investigations into the carbon storage potential of seaweeds, although so far this is relatively unexplored. The potential for seaweed to help combat the effects of climate change could be largely underestimated (Gough, 2015).



Seaweed also provides marine ecosystem support by contributing to increased fish habitat and marine biodiversity, as well as ocean restoration. Seaweed could potentially serve as the basis of a new integrated multi-trophic aquaculture with fish and shellfish to increase production while decreasing environmental impact.

OPPORTUNITIES

A GLOBAL BUSINESS

Seaweed farming is a global business carried out in at least 56 countries worldwide in 2018 (12 in Africa, 12 in the Americas, 14 in Asia, 11 in Europe and 7 in Oceania) (FAO, 2020). Farms vary from large industrial enterprises to smaller family-run businesses (Hoegh-Guldberg et al., 2019). More than 99 per cent of the production is found in Asian countries.

In 2018, OECD countries accounted for over 60 per cent of the total export value (close to USD 1 billion) of seaweeds traded for direct human consumption or as raw materials to produce other food or non-food products, and Europe accounted for nearly half of the world import value (USD 1.3 billion) of seaweed-based thickeners (United Nations, 2020).

Although seaweed businesses are established globally, it is still an emerging industry at the start of a growth phase. Coordinated action now is needed to ensure we are not missing out on opportunities, and potentially cause unintended harm.

> Seaweed has the potential to contribute to many of the solutions for a more sustainable world.

The following section outlines some of the opportunities and benefits of seaweed cultivation, before looking at the market potential.

HEALTHY FOOD AND FEED

Whilst we are feeding more people safely than ever before, more than 800 million people around the world are undernourished, and 2 billion people are suffering from micronutrient deficiencies (FAO, IFAD and WFP, 2015).

The population is expected to increase by around 2 billion persons in the next 30 years, to 9,7 billion in 2050 (United Nations Department of Economic and Social Affairs, 2019). Compared with 2010, the world needs 56 percent more food by 2050 (WRI, 2018). This must be done without using more land, and while lowering emissions.

The ocean accounts for 70 per cent of the Earth's surface and seafood could play a much more important role in global food provision. According to the Food and Agriculture Organization of the United Nations (FAO), aquaculture (the farming of fish, shellfish, micro and macro algae, and other organisms) is one of the world's fastest growing food-producing sectors and now accounts for 50 per cent of the world's fish that is used for food (FAO, 2020).

For the growth to be sustainable, the focus must not only be on species at the top of the food chain, such as tuna and salmon, but also be on smaller fish, shellfish and, crucially, seaweed and other algae.

Seaweed is a promising source of food and feed and provides important habitats that help to underpin crucial marine ecosystem. It is estimated that by 2050, 0.1 per cent of the ocean could be dedicated to producing seaweed as a food source, materials and chemicals. This would provide 15 times more seaweed than current production (Duarte et al., 2017; Froehlich et al., 2019).

Seaweed is currently not high in non-Asian consumer preferences. A shift in western diets would be needed for an increase in direct consumption of seaweed as food, and there is an opportunity to increase consumer awareness regarding the benefits. An increase in animal-based diets would drive the demand for seaweed for feed.

CLIMATE CHANGE MITIGATION AND ECOSYSTEM SUPPORT

To meet carbon emissions targets, more than 30 countries have committed to increasing production of renewable resources from biological materials and converting them into products such as food, animal feed and bioenergy (Hoegh-Guldberg et al., 2019). In a post-fossil-fuel world, an increasing proportion of chemicals, textiles, alternatives to plastics, and plant boosters will have to come from biomass, which may include marine plants.

In addition, and though further research is needed to confirm this, some seaweed used as feed additive appears to reduce the release of methane from cows and sheep, which accounts for a substantial part of greenhouse gas emissions from agriculture (Walter, J., 2020; Roy, E. A., 2019). Offshore seaweed production could potentially contribute at scale towards climate mitigation via long-term storage of carbon in the ocean sedimentation (Cage, 2018). In addition, recognition of the role of vegetated coastal ecosystems (including seaweed) as sites of carbon sequestration has led to blue carbon strategies.

The blue strategies aim to mitigate and adapt to climate change through the conservation and restoration of these ecosystems as well as through seaweed farming. Seaweed is vital support for marine ecosystems, helping to clean the ocean, provide habitats for other species and support the overall health of the marine environment.

JOB-CREATION AND IMPROVED LIVELIHOODS

Seaweed farming could create jobs and improve livelihoods in coastal communities. In low- and middle-income countries, more local capacity building for safe and sustainable production, as well as effective marketing is needed.

Major investment will be needed to scale up production, increase research on local seaweed communities, strengthen value chains and improve resilience in these areas whilst supporting the livelihood opportunities for coastal communities.

Specific attention should be given to a shared-value approach. Experience in some emerging countries (such as Tanzania and Indonesia) has shown that these new revenues could be generally directed to women and contribute to gender equality.

MARKET OUTLOOK

In 2018, the global seaweed production was 33 million tonnes (wet weight), of which 97 per cent was farmed, and 3 per cent came from wild seaweed. Global seaweed production accounted for around 28 per cent of the total aquaculture tonnage.

Plant-based consumption is growing in industrialized countries. The main drivers are health, the environment and animal welfare. In addition, demand for Kosher and Halal production will soon be nearing USD 2 trillion. Seaweed is an alternative solution for the food industry to replace meat as a source of protein and gelatin.

However, the development of farmed seaweed is not without its risks. Creating new types of food production could potentially also lead to new types of risks and pathogens, especially in places that lack experience in seaweed farming. Many governments, IGOs, NGOs and private initiatives have initialized ambitious projects to scale up seaweed production outside the major producing areas in Eastern and South-Eastern Asia. Natural conditions (currents, continental shelves, tidal waves, nutrients) look promising for offshore or onshore farming in various parts of Africa, North Europe, South Asia, North West Australia and the Americas. Small Island Developing States (SIDS) are also potential growth areas that have the attention of donors.

The industry doubled in size between 2005 and 2015 (FAO, 2018a). However, the seaweed industry can still be considered nascent. For the potential benefits of seaweed to be realized, those involved in the industry need to come together to overcome the hurdles.

BARRIERS

Below are examples of the factors that may slow down the expansion of the seaweed industry.

FRAGMENTED INDUSTRY OUTSIDE OF ASIA

Outside of Asia, the global seaweed industry is relatively underdeveloped, fragmented and regionalised in many places. Different initiatives and applications are perceived as disconnected. Pioneering companies might experience competitive relationships and there is limited sharing of good practices.

LACK OF ALIGNED REGULATIONS OR STANDARDS AND INSURABILITY PROBLEMS

Data on the safety of seaweed for feed and food purposes in the world outside Asia is scattered. Claims about the safety and sustainability of seaweed produced are difficult to validate in the absence of uniformly accepted monitoring and data-sharing protocols. Insufficient information on safety issues and limited global discussions between supply chain actors contribute to the low level of regulations and represent a barrier for insurability.

The operationalisation of new seaweed standards within marine spatial plans will advance insurability of the seaweed producers and enable them to take up loans to invest in their own production.

> There is currently a lack of aligned and specific policies, standards and regulations to support a sustainable upscaling of the industry.

The development and integration of the seaweed market entails more consistent third-party certification requirements and clarity around safety limits for residues. The lack of environmental requirements might represent threats to a sustainable development of the industry.

TECHNOLOGY BARRIERS

Significant investments have been made into the advancement of technology and modelling of offshore seaweed production. While such investments should translate into piloting and subsequent scaling of production, there remains a need to increase by several magnitudes the available funding to address remaining technology barriers – for example, a lack of nutrients, strong waves, wind and currents.

Increases in funding should be linked to market mapping initiatives and to harvesting and post-harvesting processing (biorefining and extracting) initiatives, which in turn must address barriers specific to labour intensity and cost efficiency.

NEED FOR SOCIAL LICENCE AND SPATIAL PLANNING

Expansion of the seaweed industry will require a more complete understanding of the scale-dependent changes to balance environmental risks and benefits (Campbell et al., 2019; Hoegh-Guldberg et al., 2019).

A social licence to operate is needed to help shorten the time to get permits where the licensing process is slow. Both lack of spatial planning and operationalising existing marine spatial plans are barriers.

LIMITED UNDERSTANDING OF POTENTIAL AND NEED FOR ADVOCACY

There is currently limited understanding in several areas, such as climate mitigation potential and market opportunities. Advocacy work could help to bring seaweed to people's attention.

SUCCESS FACTORS

Further development of the global seaweed industry in a sustainable manner requires vision, leadership, research, innovation and partnerships. The set of success factors below suggests a framework for responsible development of the industry.

GLOBAL COLLABORATION AND KNOWLEDGE-SHARING

There is a need for collaboration and knowledge-sharing by experts and stakeholders across geographies, academia, different industries and society.

Advocacy work could contribute to an improved general public acceptance. Research needs to be highly collaborative and the outcome widely shared to accelerate the creation of the necessary knowledge and actionable insights. As evidence is made available, public and stakeholder engagement is needed to promote the environmental and social benefits of seaweed as a sustainable and safe alternative in people's diets. This could contribute to a shift to new production and regulatory systems.

There is a need for more data-sharing on the impacts of seaweed production and use, which could support public and stakeholder confidence and engagement.

SCIENCE-BASED DECISIONS

Research and development should be a part of any initiative, in order to make science-based decisions.

Compared to the thousands of years of experience in land-based agriculture, there is limited experience in seaweed production outside of Asia (Cottier-Cook et al, 2016).

More knowledge is needed about the environmental risks and benefits of aquaculture, local biodiversity and ecological safety.

> Research can also support deeper insights into the most optimal and environmentally friendly techniques for its cultivation.

Productivity drivers, how to design high-yielding seaweed cultivation systems adapted to new areas of production and understanding the cycle of harvesting based on seaweed maturity are also needed.

There is a need for expertise in seaweed biology, genetics and metabolomics to optimise the composition of seaweed, and to support informed choices about species selection, breeding, disease management, sustainability and diversity in order to fulfil large-scale production needs. The possibility to develop seaweed germplasm banks to secure genetic biodiversity needs to be explored.

POSITIVE ENVIRONMENTAL AND OCCUPATIONAL IMPACT

The potential impacts of seaweed farming must be better understood and monitored.

The seaweed industry should take action to avoid problems while scaling up the industry, rather than fixing problems in retrospect.

Human-made infrastructures used for farming activities (lines, cages, buoys) might contribute to an increased risk for mammal entanglement.

> There are multiple demands on coastal areas, such as tourism, aquaculture, fishing and energy production.

A growing industry must take other needs into account and consider spatial planning as part of its development. Ideally, seaweed will be grown within marine spatial planning frameworks and could also be developed through collocation with other ocean uses, such as renewable energy or animal aquaculture.

The production needs to be operationalized in a way that incentivizes the private sector to promote environmental safety and ocean restoration.

The possibilities of offshore production should be explored as a solution, with proper consideration of new and emerging technologies. New types of anchors, buoyancy systems, ropes, harvesting vessels and transportation might need to be designed and deployed specifically to each type of seaweed.

HARMONISED STANDARDS, POLICIES AND REGULATIONS

There is a need for harmonised and specific policies, standards and regulations to support safe large-scale production of seaweed.

Some examples of needs and suggestions for improved policies, standards and regulations are listed below:

- Food safety standards and regulations specific to seaweed need to be improved and harmonised
- Potential hazards must be identified and protocols developed for risk assessment, rapid alert systems and data collection in order to develop safe modes of production, focusing on food safety, occupational safety and environmental safety
- Biosecurity policies need to be developed and harmonised at national and international levels
- Food packaging standards and regulation could be developed for seaweed-based material. This would help in seaweed becoming a viable alternative to plastic
- Industry-wide certification tools might help to break down trade barriers and facilitate market-pull effects
- Thorough oceanic assessments could lead to easing of permitting mechanisms
- Insurance models are needed to enable a long-term financial mechanism
- National and international policy frameworks need to be adapted to encourage safe development of alternative value chains
- As part of countries' marine spatial plans, areas for seaweed farms could be designated, and an easily navigable legislative framework for seaweed farm leases could be established

COORDINATED INVESTMENTS

There is a need for increased investments (public and private) into the seaweed value chain.

In order to improve the value creation from the industry in geographies where the industry is less developed, the scale of the production needs to be increased, and seaweed biomass needs to be successfully refined into multiple useful products.

> Financial viability requires scale, and scale requires investments.

Catalytic funding for seaweed farmers and processors is encouraged, as well as effectively coordinated public funding aiming to support future commercialisation and value creation.

There is a need to create mechanisms that pair new intellectual property rights with private sector funding in order to bring new technologies to market as part of targeted industry collaborations.

Investment in production technology is needed to optimise the farming of seaweed, while investment in processing is needed to increase the value of the harvested seaweed.

MILESTONES

The following milestones are suggested for a fully and responsibly developed seaweed industry. Some of these initiatives are already materializing.

MAPPING OF THE MARKET

The global seaweed industry needs mapping and assessments to ensure that public and private funding will underpin sustainable development. This is a suggested exercise that could enable more collaboration and efficiencies among the value chain actors.

Better information and insights can increase the market attractiveness and help channel investments into more successful business opportunities.

> Market mapping is also needed to guide policy decisions.

In addition to mapping of existing production, useful market assessments would include identification of optimal pricing mechanisms for new products, quality requirements, appropriate bi-product destinations, suitable locations for production of the different seaweed species, and potential applications attractive to the private sector.

The diversification of applications might make the industry more resilient to shifting demands. The market mapping could be an important step towards commercial development.

ESTABLISHMENT OF A SAFE SEAWEED COALITION

Lloyd's Register Foundation recognizes safety as a non-competitive issue that can catalyze collaboration. The Foundation has already invested in a FAO program to develop a curriculum for food safety in developing economies and is carrying provision to establish a Safe Seaweed Coalition.

The coalition's work would address the need for regulations and certification, and encompass standards for food safety, production safety (including marine spatial planning and workers' safety) and environmental safety (including monitoring and reporting recommendations).

RESTORATION OF SEAWEED HABITATS

Increasing levels of atmospheric carbon dioxide are causing ocean acidification, with serious consequences for marine life, and global warming of the ocean, with dramatic loss of seaweed habitats and biodiversity.

Restoration of habitats is an anticipated benefit of testing and piloting new safety protocols through the anticipated Safe Seaweed Coalition.

Seaweed makes use of excessive nutrients in the sea, such as phosphorous and nitrogen, so it can help cleaning the water where eutrophication is a problem.

It can also restore abundance through providing hatchery locations and feeding of other marine species such as fish and shellfish.

> The seaweed industry has the potential to be a restorative industry.

SEAWEED AS CARBON SINKS

A restored ocean and seaweed farming forests should be considered carbon sinks to mitigate climate change. A compensation mechanism based on marine plants should be developed and seaweed investment officially recognized as a means to offset carbon production.

It will consequently provide investments and early revenues for new seaweed farmers to support the development of the supply chain.

Development of an international standard to measure the carbon sequestration of seaweed to reduce the transaction costs of setting up seaweed carbon credits is encouraged.

Recognizing the role of seaweed as a carbon sink at UNFCCC (United Nations Framework Convention on Climate Change) level and making it part of its future COP discussions will be key.

SUPPORT OFFSHORE PRODUCTION DEVELOPMENT

To develop innovation and experience in offshore production, pilots need to be established. Pilot standards and protocols developed by a safe seaweed coalition could be part of the operationalization of offshore marine spatial plans.

INTEGRATED MULTI-TROPHIC AQUACULTURE

The progress of integrated multi-trophic aquaculture from research into commercial practice is slow in implementation. This could be particularly useful in areas with finfish farming. Programmes could be developed to ensure that facilities practising this kind of aquaculture adhere to the same food safety standards currently required for shellfish-only culture operations.

SUPPORT INNOVATION FOR SEAWEED BIOREFINERIES

Biorefinery systems need to be developed and piloted (ideally in the ocean to avoid the cost of transporting wet seaweed) in order to extract the various seaweed compounds into different sub-products for multiple and higher value applications to maximise resilience and profits for production.

FOUNDATION OF A GLOBAL BLUE FARMING PLATFORM

There is a need for clear leadership in setting up an overarching global blue farming platform and with the overall purpose of encouraging the effective use of public funds, pair finance with technology to advance sustainable climate resilient marine value chains, and advance cross fertilization across regions.

The global platform would complement the envisioned Safe Seaweed Coalition via the below set of actions:

1. Facilitate science, private sector and government coordination and collaboration to effectively share knowledge and drive measurable action;

2. to provide a business-to-business finance platform;

3. advance the use of "blue farming" to a) create a way by which universities and technical colleagues can market new degrees/diplomas and b) create an identity and a sense of pride for people engaged in the blue farming industry (across e.g. primary production, genetics and breeding, economics, crop systems etc.) and;

4. develop regional centres of excellence to provide subject experts to do outreach and training, and engage in cross fertilization across regions.

A blue farming coalition platform might also become an anchor for "market mapping initiatives", which are necessary tools when providing direction for sustainable private/public investments.

ANNEX

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