

Sea the Power of Sustainable Farming



**TACKLING AGRI-
AND HORTICULTURE
CHALLENGES WITH THE
POWER OF SEAWEED**

For all the problems we are facing on land...

The world is changing. Every year, countries all over the globe are confronted with extreme weather conditions due to climate change. Severe drought alternate with floods are damaging our crops. Otherwise a locust plague will do the rest.

A common reflex is to use more fertilisers and pesticides. The real question is if this is the solution for sustainable farming?

These chemical degrade the soil and its ecosystem, as well as lead to nutrient leaching which damages freshwater and marine ecosystems as well.

...Sea the solution

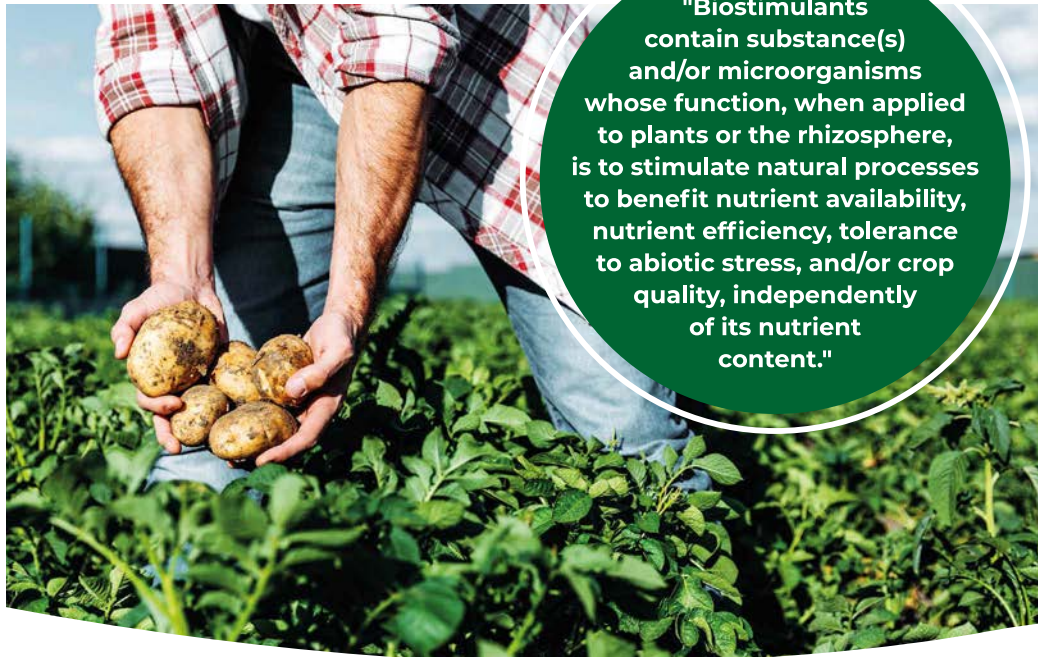
It is time to approach these issues from a different perspective: from the sea. After rapidly taking up oceanic CO₂ during its growth, seaweed can help the challenges of growing crops on land in two ways, as seaweed biostimulants can strengthen crops directly by influencing the plant, and indirectly by restoring the soil. In this way, seaweed biostimulants can significantly increase the robustness of agri- and horticulture



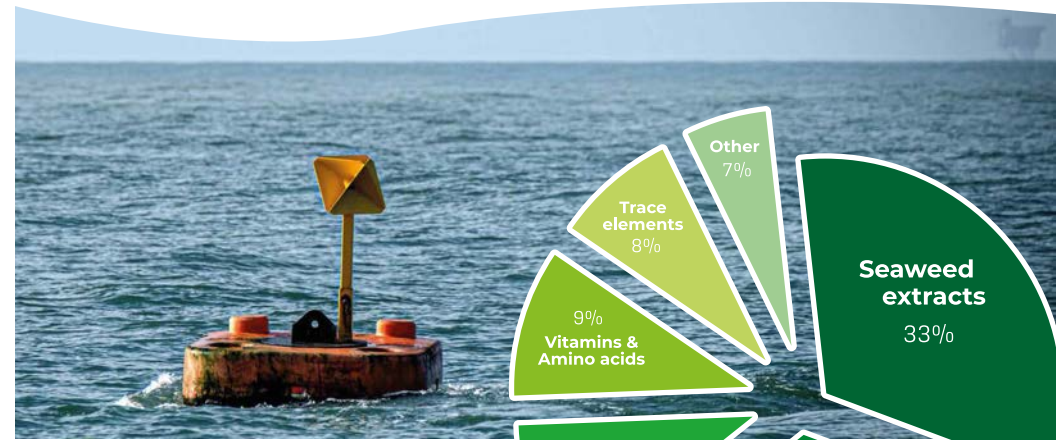
1 What are Biostimulants?

Biostimulants are designed to help farmers sustainably maintain crop yields for a growing agricultural demand while operating under increasingly harsh climate conditions.

Climate change poses various challenges for crops in agri- and horticulture. Biostimulants are substances which strengthen and protect crops from these damaging conditions. Biostimulants have many sources, including microorganisms, humic substances and seaweed as well as many others. Their substance(s) stimulate natural processes in a plant and can lead to enhanced availability of confined nutrients in soil and rhizosphere, as well as nutrient efficiency, tolerance to abiotic stress and improved crop quality. Recently, European legislation acknowledged biostimulants as a specific category of agricultural input, that can play an important role in the circular economy.



2 The Market: Needs & Potential



Worldwide, biostimulants are growing in importance with a market share of over 1 billion euros. Among the various raw resources for biostimulants, the market share of seaweed is one of the largest and shows the fastest growth among biostimulants.

Intensive agri- and horticulture put pressure on the supply of fresh water and nutrients. This is further enhanced by the changing climate leading to an increase in the number and severity of droughts and crop diseases, which has induced societal and subsequent regulatory pressure for farmers to reduce their water and nutrient footprint. These pressures are pushing the growth of biostimulants.

The total global biostimulant market is growing at a rate of 11% per year. It is projected to cover an farmable area of approximately 27.6 million hectares in 2022, or about the amount of arable land in Argentina. In Europe, the economic value of biostimulants is estimated between 200 and 400 million euros with a similarly impressive growth rate (European Biostimulant Industry Council). Specifically the demand for biostimulants made from seaweed extracts have a fast and steady growth rate.

3 Biostimulants From the Sea



Seaweeds are the sea's supercrop for several reasons: they strengthen the ecosystem of the sea and grow without the need for fresh water or chemicals like fertilisers and pesticides.

The power of these supercrops comes in handy on land. As far as is currently known, there are 6 main categories of bioactive compounds in seaweeds which are known to improve crop health: polysaccharides, polyphenols, proteins, minerals, pigments and plant growth hormones. Currently, 90% of the European seaweed biostimulant market is based on the seaweed species *Ascophyllum nodosum*, which is sourced from 'government controlled' areas.

However, many other seaweed species containing similar bioactive compounds can be cultivated safely at sea on a large scale. This makes it possible to create a robust material source for widespread biostimulant use, whilst still providing the essential bioactive compounds which have established seaweeds as highly credible amongst other types of biostimulants.

4 Research & development for safe use



The potential of seaweed biostimulants to mitigate agricultural and horticultural challenges is great. A lot is yet to be discovered. That is why we need solid research projects that focus on effectiveness, efficiency and feasibility of this application: for sea farmers and land farmers.

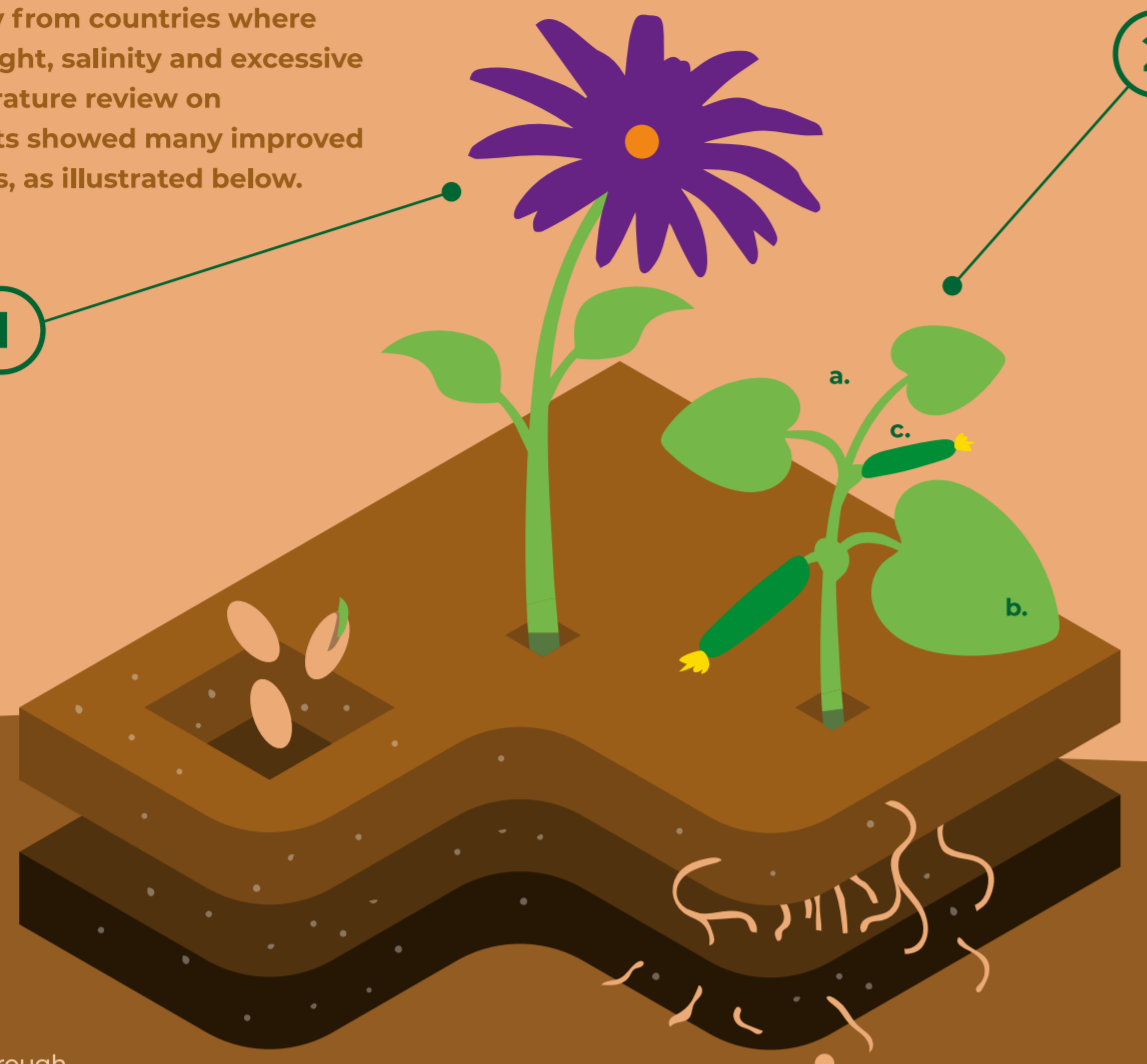
The Bio4safe project is such a research project. The aim is to reduce water and fertilizer input by 20% respectively 10% in agriculture and horticulture by using biostimulants and different sensors. The geographical focus lies on the area of the southern North Sea and The Canal as this area is known for intensive horticulture, demanding significant amounts of water and

nutrients. The research project Bio4safe is set up to measure and improve water and fertilizer use efficiency of plants. The project therefore plays an important role in several EU directives that aim to protect water quality in this region by preventing nitrogen and phosphorus leaching and anticipate water shortages.

Facts & figures: effects of biostimulants

Scientific literature provides a large number of examples of biostimulant effectiveness, mostly from countries where abiotic stress factors such as drought, salinity and excessive UV are more commonplace. A literature review on commercial seaweed biostimulants showed many improved parameters in various crop species, as illustrated below.

1
Decorative plants produce more flowers
Due to the production of more chlorophyll, the 'fresh look' of florals is increased. Additionally, the number of flowers per plant is often doubled, as is their vase life.



2
Food crops increase their yield & quality
a) An increased dry weight of plants by 10 - 30%.
b) Leaf sizes improving by an average of 30% as well as a remarkable average increase in the fresh yield of crops of 43% in conditions of abiotic stress such as high salinity or drought.
c) Produce quality can also improve through the production of more antioxidants, flavonoids, sugars, phenols and proteins.

3
Improved plant resilience and efficiency
By increasing the fertility of soil through stimulating a healthier soil microbiome; biostimulants lead to improved resilience and nutrient use-efficiency in crops.

4
Improved and enlarged root system
Foliar biostimulant application doesn't only influence the crops above ground. By increasing the depth and surface area of the root system by on average about 50%, seaweed biostimulants allow crops to take up more of the available nutrients and water.

Field trials in Europe: from theory to practice



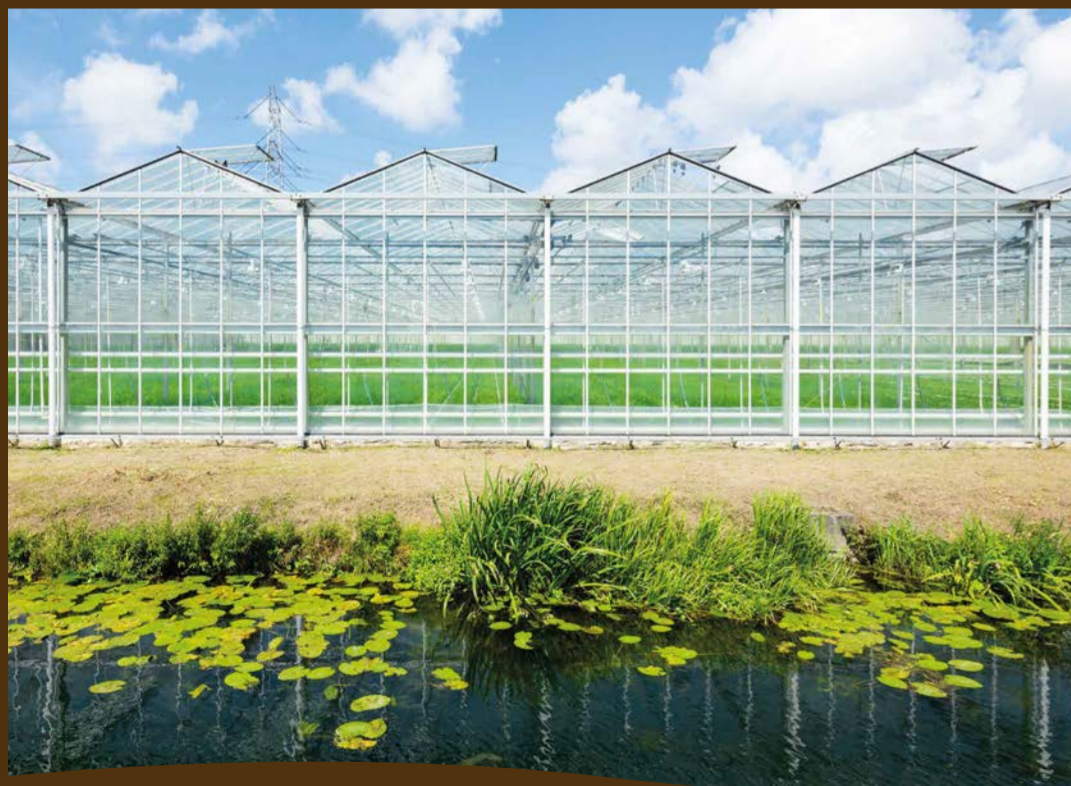
To put the theory of biostimulants to the test in Europe, several trials were carried out in the Bio4safe project to see how the biostimulants impact European agriculture and horticulture.

Trials in the Bio4safe project were performed with commercial seaweed biostimulants on various crops, including hydrangea, surfinia, chrysanthemum, tulip, lettuce, tomato, raspberry and strawberry.

These trials were implemented at the research testing facilities Proefcentrum voor Sierteelt (BE), Proeftuin Zwaagdijk (NL), NIAB EMR (UK), ISA Lille and Pôle Légumes Région Nord (FR) in all four countries of the 2-Seas Region and investigated the effects of reduced water and/or fertilizer inputs. Observed effects included improved soil water retention, plant water uptake, chlorophyll content and increased plant fresh weight.

Additionally, plants produced more flowers and showed significant improvements in leaf length and stem weight. These experiments will be continued in 2020 using the most promising commercial seaweed biostimulants, as well as a newly formulated biostimulant product made from a North Sea cultivable seaweed species.

Towards sustainable farming of the future...



The most obvious driver for an agri- and horticultural system change is the increasingly extreme and unpredictable weather due to climate change.

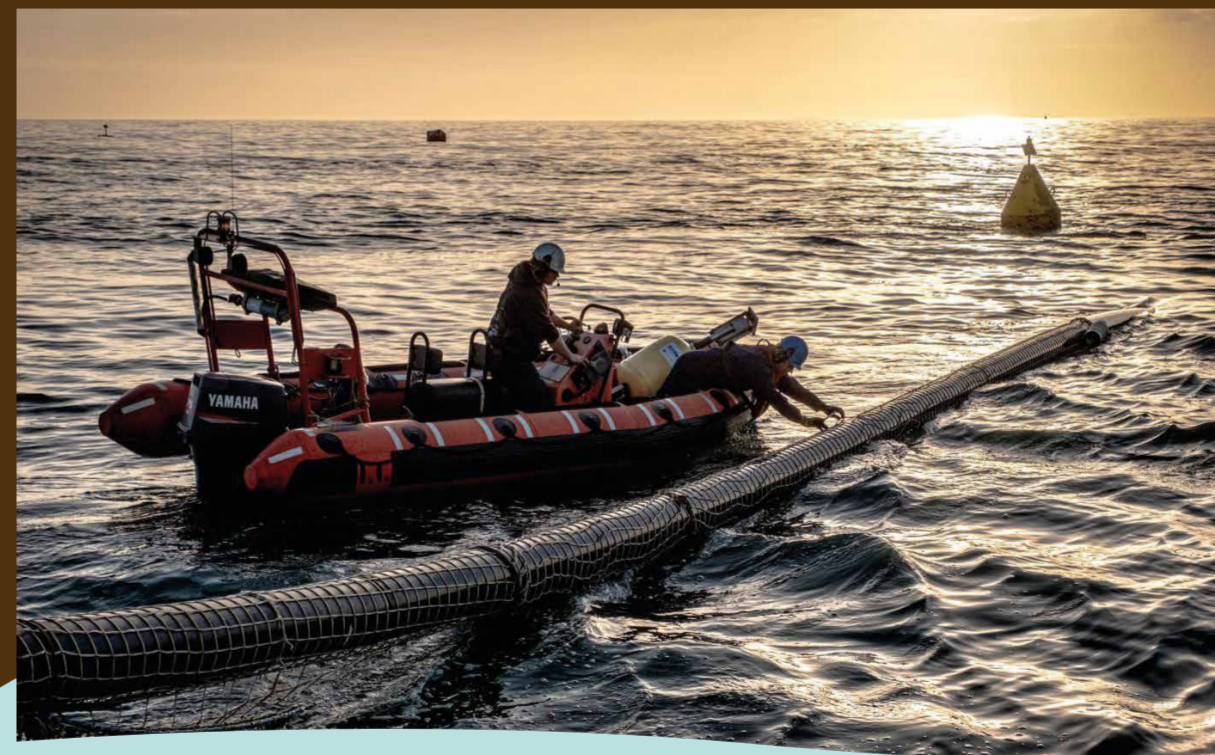
As severe droughts and unexpected cold fronts are becoming more and more common, alongside pressure to reduce inputs of pesticides and fertilizers, farmers require adequate tools to keep providing the glowing global demand for food. These developments have led to a decrease in the use of agrichemicals and hence an increase in the demand for more sustainable products such as biostimulants. Seaweed biostimulants fit particularly well within the circular agronomy, as they recover runoff nitrogen and phosphorus during their growth.

A shift of European farmers towards the use of seaweed biostimulants would not only reduce our ecological footprint and safeguard future food provision but also broaden the farmer's arsenal to battle climate change and ensure their livelihood.

With only 0.4% of Europe's 180 million hectares of agricultural lands being treated with biostimulants, there is much to be gained from using seaweed biostimulants.



Valuation with the help of sea farming.



Currently, the majority of seaweed used for seaweed biostimulants is sourced from wild populations. To maintain a stable supply chain for the growing market demand, we'll have to switch to cultivation for safe, qualitative and naturefriendly seaweed.

As previously mentioned, wild harvesting seaweed can never fulfill the enormous demand for sustainable crop strengthening agents in European agri- and horticulture. This is becoming increasingly apparent as wild stocks are becoming more regulated while demand for seaweed for food,

feed, biostimulants and energy production is steadily growing. This drives investigations for new sourcing of seaweeds and strengthens the case for seaweed cultivation in farms. Farming seaweed amongst offshore wind turbines could fill this growing market gap by combining seaweed

cultivation, energy production and other aquaculture practices to allow sustainable upscaling, reduce our environmental footprint and provide economic opportunities.

A single square kilometer of this type of offshore farm has the same productivity as 4 km² of land area, whilst saving up to 2400 tons of CO₂. Furthermore, the use of these vast spaces within the wind farms also creates many opportunities for 'blue' jobs, as every square kilometer of multi-use seaweed farm expansion creates 8 new jobs.



COLOPHON

Developed by:

Edition (03/2020) by Stichting Noordzeeboerderij for the European Bio4safe project, as part of the Roadmap (D1.2.3).

together with:

Brandfriend & OD designstudio.

Project partners:

Proeftuin Zwaagdijk, PCS, Ugent, NIAB EMR, Pôle Légumes Région Nord, Yncréa Hauts de France. Stichting Noordzeeboerderij.

Photo's:

Matthijs Blind, Lisette Kreicher, Jill Pegnataro of GreenWave, Oscar Seijkens, Stichting Noordzeeboerderij, Darcy Hennessey Turenne for GreenWave en Maarten van der Voorde.

Contact for info:

Marlies Draisma, marlies@noordzeeboerderij.nl



Sea the Power of Sustainable Farming

TACKLING AGRI- AND HORTICULTURE CHALLENGES WITH THE POWER OF SEAWEED

What we know

With what we now know from the Bio4safe project, it seems that commercial biostimulants as well as extracts made from cultivated seaweeds improve the performance of crops. Observed effects in literature and trials in Europe, include: increase in leaf length, flower production, fresh weight as well as in retention and uptake of the available water. Further research is needed to confirm these outcomes, but the potential of biostimulants seems eminent: for sea farmers and land farmers.

How to get there

The European agri- and horticulture can benefit from using biostimulants, leading to better crop health and help tackling the climate challenges the sector faces. To have sufficient product for the entire European agri- and horticulture, these biostimulants must be sustainably produced on an industrial scale.



Nature-inclusive sea farming

North Sea cultivated seaweeds seem to have an equivalent performance to imported or wild-harvested species. With the rising demand for biostimulants, cultivation provides an ideal sourcing material for large-scale use of seaweed biostimulants. Additional benefits of cultivation are quality control, alleviating environmental pressure and providing economic opportunities.

Go to our database at www.bio4safe.eu to find out which biostimulant products are suitable for you!

NORTH SEA SEAWEED CULTIVATION CAN YIELD **10 to 20 tons** OF DRY SEAWEED PER HECTARE

Biostimulants from seaweeds

Seaweed biostimulants are non-synthetic and biodegradable products that support farmers in adverse times. They make up one third of all biostimulants and have proven to be highly effective due to their numerous bioactive compounds.



To learn more about the Bio4safe project and the potential of seaweed, follow the QR code to the North Sea Farm website



CURRENT MARKET VALUE €350 MILLION GROWS **11% each year** APPLIED ON 27.6 MILLION HECTARES BY 2022

Great market potential for biostimulants

As you can imagine, this creates an enormous demand for sustainable solutions in European agri- and horticulture! This is where biostimulants propose to play a significant part in providing this solution, as they have already proven their worth in regions of the world where these issues have already persisted for many years. With an annual market growth rate of over 10 percent and a projected surface area of 27.6 million hectares in 2022, it's clear that biostimulants are here to stay!



For an in-depth biostimulant market forecast, use the following QR code



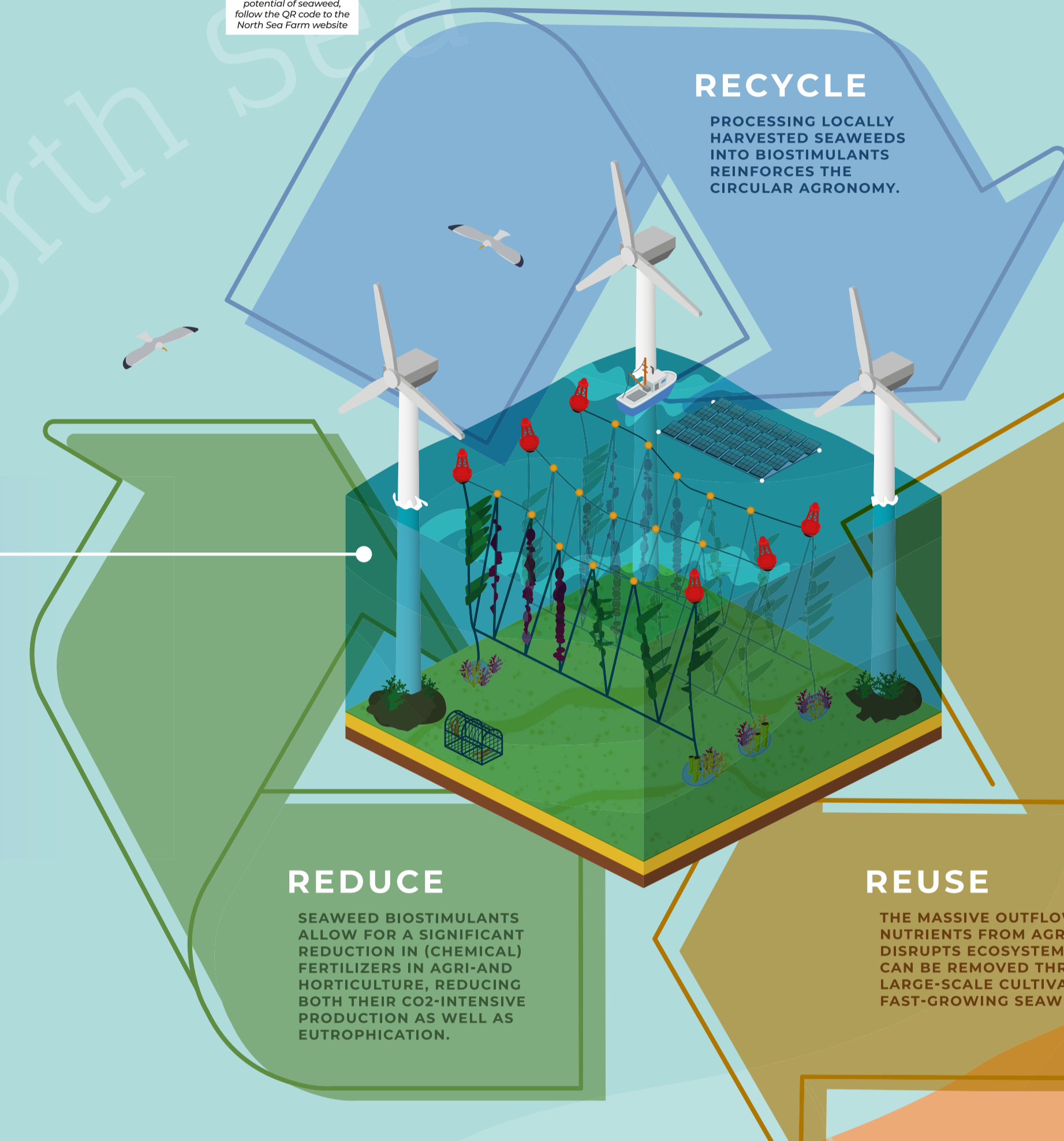
CHEMICAL FERTILIZER PRODUCTION IN THE NETHERLANDS USES **25%** OF THE COUNTRY'S NATURAL GAS, DRIVING A SHIFT TOWARDS BIOSTIMULANTS

Drivers for change

As many of us have experienced in the past few years, extended summer droughts are becoming commonplace and the use of fertilisers is under substantial strain. Add this to a degraded soil microbiome and outflow of nutrients into the sea in what is known as eutrophication, and you get significantly weakened crops which are less able to defend themselves from pests and diseases. In addition, the use of conventional pesticides to fight these pests is highly controversial and subject to progressively stricter regulations.



Use the QR code to read more on drought effects in Europe



North Sea Farm Foundation (NSF)

"To support and catalyse the seaweed sector in and from the Netherlands", that is the aim of this non-profit organisation. To achieve this goal, they promote knowledge-sharing, collaboration and public awareness whilst also guiding the production of sustainable, local seaweed.



ZWAAGDIJK

THE HAGUE

The Netherlands

Proeftuin Zwaagdijk (PTZ)

This is one of the Bio4safe trial sites. As one of the primary agricultural research centres of The Netherlands, PTZ performs practical research in its numerous facilities. Their main operating sectors include crop protection, fertilizers, crop varieties, cultivation techniques and residue testing.



THREE UNIQUE BUYING REASONS

1. INSURANCE FOR A MORE RELIABLE YIELD
2. INCREASING PLANT SURVIVAL
3. OPTIMAL GROWTH AND ITS PRODUCED CROP QUALITY



Strengthening plants and soil

Since seaweed biostimulants are applied before significant stress occurs, they act as an insurance against the weakening of plants due to abiotic stress. By pre-emptively activating the defense genes of plants and strengthening the soil microbiome when conditions are still favourable, crops will have built up their defences once these conditions deteriorate in the form of extended drought, excess UV radiation or a shortage of nutrients.



Take a look at our Bio4safe video here!

Proefcentrum voor Sierteelt (PCS) & Ghent University

This is one of the Bio4safe trial sites. In collaboration with Ghent University, who has important expertise in research on biostimulants, PCS is a Belgian research station focusing on the link between applied scientific research as well as research in practice to improve cultivation techniques, crop value and protection.

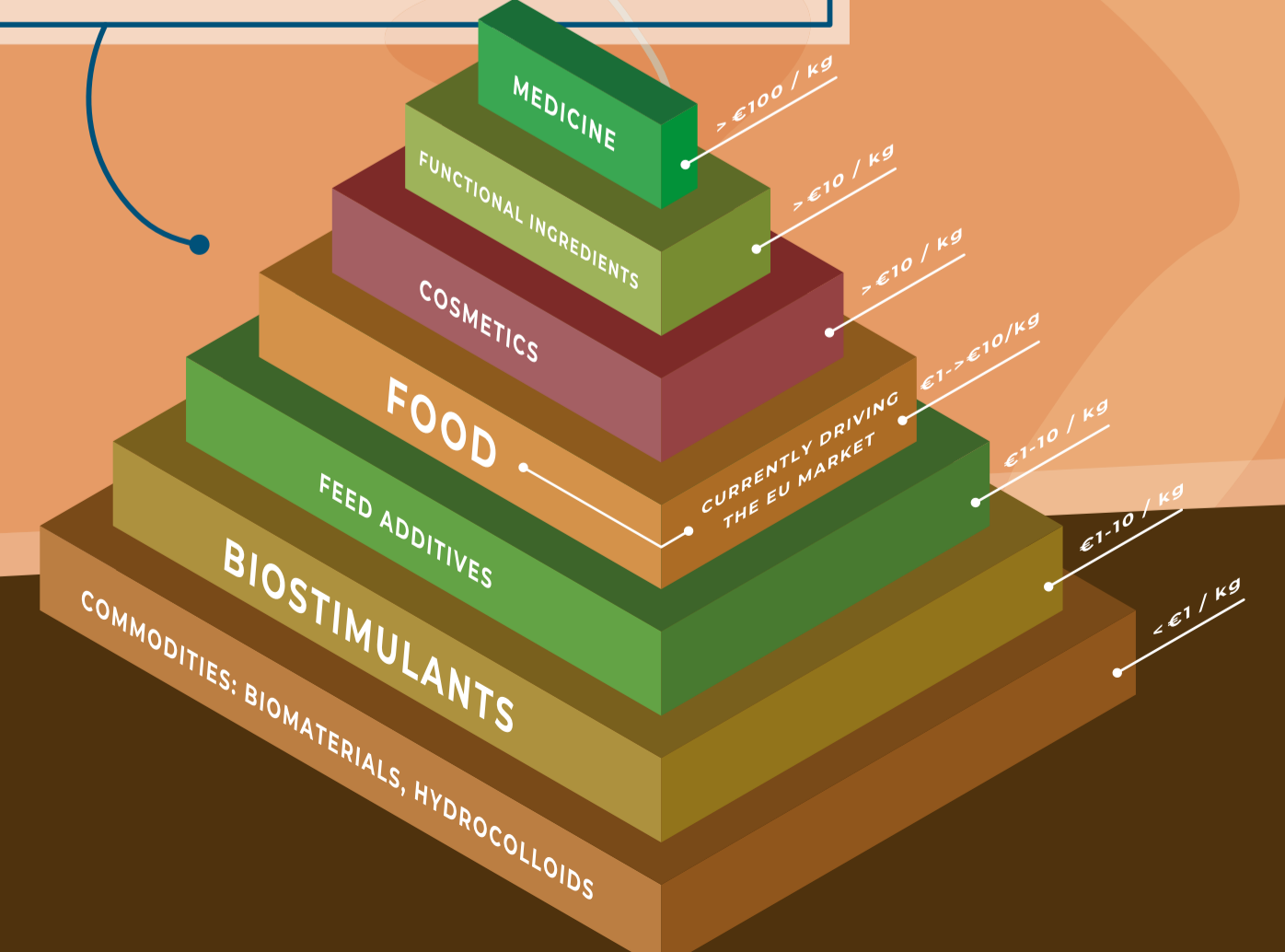


GHENT

Belgium

Seaweed valorization

The valorisation pyramid demonstrates the many applications of seaweed. The main drivers of seaweed cultivation in Europe are high-value applications, mainly in food products. These often don't require the entire seaweed, leaving behind surplus source material that can be sold as animal feed or in this case, the extraction of biostimulants. Through this method, the large-scale and affordable production of seaweed biostimulants can be accomplished! Source: North Sea Farm foundation



Developing a business case for seaweed farmers

In collaboration with the financial advisors at Green Giraffe, this information is being accumulated into a business case for seaweed farmers, outlining the many possibilities and necessary actions for each member of the value chain to make this ambition into a reality!



ISA Lille & Pôle Légumes Région Nord

This is one of the Bio4safe trial sites. This regional research station is working together with the French (Bio)engineering School and employs particular knowledge of agroecology, improving both the economic and environmental performance of crops.



LILLE

France

What is researched

These research stations are using state-of-the-art and novel sensors to test both commercial seaweed biostimulants as well as newly developed biostimulants derived from local North Sea cultivated seaweeds. These are subsequently tested in conditions simulating drought or nutrient deficiencies which might be expected in farming practices.

THE BIO4SAFE PROJECT PROVIDES

1. AN EXTENSIVE DATABASE WITH RELIABLY TESTED PRODUCTS
2. PROTOCOLS & SENSORS TO TEST THEIR EFFECTIVENESS YOURSELF

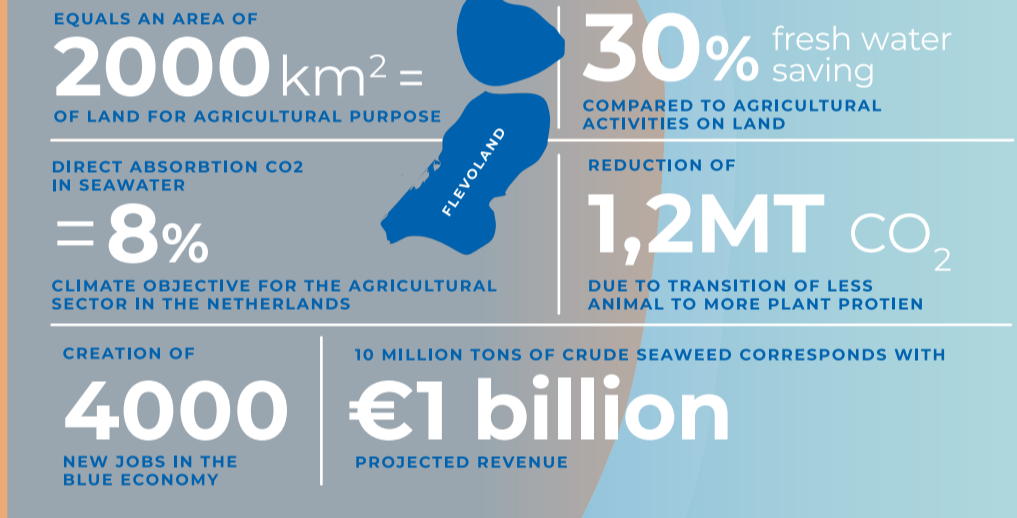
The National Institute of Agricultural Botany (NIAB EMR)

This is one of the Bio4safe trial sites. The UK's fastest growing crop science organisation, applying genetics, physiology, soil science, precision agronomy and data science to improve yield, efficiency and resilience of crop production in horti- and agriculture.



KENT

500 km² multi-use seafarms



United Kingdom

BIBLIOGRAPHY

- MarketsandMarkets (2017). Biostimulants Market - Global forecast to 2022.
- Yakhin, O. I., Lubyantseva, A. A., Yakhin, I. A., & Brown, P. H. (2017). Biostimulants in plant science: a global perspective. *Frontiers in plant science*, 7.
- Overview of the seaweed industry by country: Iceland, France, Norway, Portugal, Spain, United Kingdom. A summary of the initial findings of the netalgae project regarding the current status of the seaweed industries in the participant countries, 2012.
- Chojnacka, K., Saied, A., Witkowska, Z., & Tuhy, L. (2012). Biologically active compounds in seaweed extracts: the prospects for the application. In *The open conference proceedings journal* (Vol. 3, No. 1, pp. 20-28).
- Battacharyya, D., Babgohari, M. Z., Rathor, P., & Prithivira, B. (2019). Seaweed extracts as biostimulants in horticulture. *Scientia Horticulturae*, 196, 39-48.
- Bulgari, R., Cocetta, G., Trivellini, A., Vernieri, P., & Ferrante, A. (2015). Biostimulants and crop responses: a review. *Biological Agriculture & Horticulture*, 33(1), 1-7.
- Global Aquaculture Production statistics database updated to 2013 Summary information, (2015). Aquaculture and Fisheries department FAO

Seaweed species for biostimulants



Laminaria digitata
The locally cultivable brown macroalgae *Laminaria digitata* contains bioactive compounds such as laminarin, which are known to effectively activate plant resistance genes. Subsequently, the species is already being used in commercial biostimulants in Europe.



Saccharina latissima
The leaves of this 'Royal Kombu' are most well known for their culinary application. In the Bio4safe trials however, extracts of this seaweed have shown similar effectiveness to commercial biostimulant products. This promising species will therefore also be used in further trials.



Palmaria palmata
Although *Palmaria palmata* or 'Dulse' is typically consumed as a snack, its high antioxidant activity and unique polyphenol content also make it a promising cultivable source of seaweed biostimulants.



Ulva lactuca
The green macroalgae *Ulva* sp. has been known for various functional bioactive compounds which not only make it a healthy food but also demonstrated highly effective biostimulating activity. Additionally, *Ulva* is already being cultivated in European waters!