



## City Research Online

### City, University of London Institutional Repository

---

**Citation:** Fallon, N., Rivera, X. S., Anguilano, L. & Paterson, S. K. (2022). Seaweed in the UK food system: pitfalls and pathways to scaling up sustainably. In: Bruce, D. & Bruce, A. (Eds.), Transforming food systems: ethics, innovation and responsibility. (pp. 454-459). Wageningen Academic Publishers. ISBN 9789086863877 doi: 10.3920/978-90-8686-939-8\_71

This is the accepted version of the paper.

This version of the publication may differ from the final published version.

---

**Permanent repository link:** <https://openaccess.city.ac.uk/id/eprint/30379/>

**Link to published version:** [https://doi.org/10.3920/978-90-8686-939-8\\_71](https://doi.org/10.3920/978-90-8686-939-8_71)

**Copyright:** City Research Online aims to make research outputs of City, University of London available to a wider audience. Copyright and Moral Rights remain with the author(s) and/or copyright holders. URLs from City Research Online may be freely distributed and linked to.

**Reuse:** Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge. Provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.



# Seaweed in the UK food system: pitfalls and pathways to scaling up sustainably

N. Fallon<sup>1</sup>, X. Schmidt Rivera<sup>2</sup>, L. Anguilano<sup>2</sup>, S.K. Paterson<sup>3</sup>

<sup>1</sup>University of Greenwich, Natural Resources Institute, Medway Campus, Central Avenue, Chatham, ME4 4TB, United Kingdom, <sup>2</sup>Brunel University London, College of Engineering, Design & Physical Sciences, Kingston Lane, London, Uxbridge, UB8 3PH, United Kingdom, <sup>3</sup>Brunel University London, College of Business, Arts & Social Science, Kingston Lane, London, Uxbridge, UB8 3PH, United Kingdom; nf9964y@gre.ac.uk

## Abstract

Within an increased global focus on the Blue Economy, seaweed has the potential to play a much larger role in the future of the UK food systems contributing to multiple environmental, economic, social and health benefits. Seaweed is currently used along the UK food chain as fertiliser, animal feed, in food processing, and as a low-carbon, nutrient dense food source (Capuzzo 2021; Wilding *et al.* 2021).

Mapping conducted using publicly available online sources identified 60 seaweed producers operating in the UK in 2021. These are predominantly small-scale harvesters and producers operating under a range of business models. However, with new enterprises entering the market involving larger scale industrial production and mechanised harvesting methods, the UK seaweed industry appears to be at the precipice of major changes.

Scaling up the industry is seen as a priority for UK and devolved governments and an attractive sustainable investment option for venture capital. However, the potential impacts on the marine ecosystem and coastal livelihoods from an expected rapid expansion are currently unknown. In addition, regulation of the industry and the complex land and sea policy landscape is yet to be fully explored within the context of an expanded seaweed industry. Efforts have been expressed by government and industry bodies to ensure industry growth protects coastal communities and does not come at an environmental cost (Wilding *et al.* 2021), but questions remain with regards to rapidly shifting power dynamics and industry pressures to deliver returns on investment in a global market.

This paper will draw on examples from historical attempts to scale up seaweed production as well as other food-related industries to identify potential pitfalls for the industry to avoid if it is to find a path towards sustainable and responsible growth. More attention needs to be paid to the political economy of the seaweed industry, in particular the influence of powerful market actors and how this may impact the trajectory of the industry.

**Key words:** algae, aquaculture, sustainability, political economy

## Introduction

Seaweeds are rich in minerals and essential trace elements, high in fibre, low in fat and high in protein. The high nutrient content makes them appealing to health-conscious consumers as snack foods or food supplements, whilst hydrocolloids extracted from seaweed have properties that make them valuable as thickening agents and emulsifiers in the manufacturing of a range of processed foods such as ice-cream. In addition, seaweed is increasingly used as an alternative to petroleum-based inputs in agricultural value chains, as fertiliser and as animal feed, where it is attracting attention for its potential to reduce the Greenhouse Gas emissions (GHGe) caused by enteric fermentation in cows (Roque *et al.* 2021).

Seaweed production has a consistently low impact across key environmental indicators (eg., GHGe), can improve water quality by absorbing excess nutrients, and act as a carbon store (Gephart *et al.* 2021). Furthermore, it offers an opportunity to support and strengthen coastal

communities, through the provision of jobs and broader economic through-flow (United Nations Global Compact 2021). Given these elements, there is understandable interest in scaling up the seaweed industry in the UK, and this is changing the nature of the UK seaweed industry.

### **UK Seaweed industry**

Mapping conducted for this project identified 60 primary producers operating in the UK, with half of those involved in producing seaweed for human consumption in the form of high-value food products for both business and consumer markets. For businesses, seaweed is sold dried and/or milled in large quantities for the wholesale market and for use in the hospitality industry. Meanwhile, consumers can find their products such as seasonings, and snack products marketed under brands which emphasises the quality and provenance, artisanal, natural, and sustainable nature of their harvest and sold directly online or through retailers.

It is common for companies to adopt a ‘sea-to-shelf’ approach, with fewer specialised processors. Indeed, large-scale processing is recognised as a bottleneck for the industry (Phyconomy 2021), and in the past year several companies have received large investments to scale up processing capacities (eg., Scottish Government 2021). This investment has come from both government grants and private investors and is being mirrored across the industry as production moves from wild harvesting towards large-scale seaweed farming to satisfy the demand for large volumes of biomass for industrial applications. Indeed, whilst currently most producers are small-scale wild harvesters, the number of farming enterprises is growing, with 9 commercial seaweed farms currently operating, and more in the process of applying for a marine licence (Capuzzo 2021). Ambitions are high, with farm applications covering over 2 million m<sup>2</sup> submitted in the past 3 years in Scotland alone (Sustainable Inshore Fisheries Trust (SIFT) 2021), and feasibility studies in England identifying 58% of English waters covering 29,000 km<sup>2</sup>, as suitable for kelp aquaculture (Marine Management Organisation 2019). The nature of the businesses is also changing, with more ‘blue-tech’ start-ups entering on a wave of venture capital investment.

### **An uncertain regulatory landscape**

The effects from this rapid expansion on the marine ecosystem and coastal livelihoods in the UK are unclear, and this is driving uncertainty in how the seaweed industry should be regulated within the complex land and sea policy landscape. Currently, prospective seaweed farmers and commercial harvesters must obtain a lease from the Crown Estate and a licence. The regulators responsible for the licensing of marine activities depends on whether the proposed activity is inshore (0-12NM) or off-shore, with responsibility for in-shore licensing devolved across the four nations of the UK and off-shore regulated by the Marine Management Organisation, except in Scotland, where Marine Scotland has the authority across both (Woods *et al.* 2017).

Applicants for a marine licence must demonstrate that their activities will protect the marine environment and will not detrimentally impact other coastal users. Depending on the scale and location of the proposed activity, applicants may have to undertake several different assessments, including a Habitats Regulations Assessment and Marine Protected Area Assessment that add time and cost to the process. The assessments for approval of seaweed farming are particularly difficult because, as a relatively recent venture, the nature and magnitude of the effects of seaweed farming in the UK on the ecosystem are unknown beyond modelling studies (Wilding *et al.* 2021; Gephart *et al.* 2021).

Evidence from China, the leading global producer of seaweed, shows how large-scale seaweed farming can have deleterious environmental effects through the escape of farmed

species. The farmed species have been cultivated for desirable industrial traits such as faster growth rates and higher yields, and cross-breeding with wild species has left the latter vulnerable to disease and the impacts of climate change (Hu *et al.* 2021).

A series of technical reports and feasibility studies (eg., Capuzzo, Mengo and Kennerley 2019) have been developed which provide recommendations to ensure that industry expansion doesn't compromise social and environmental goals in pursuit of economic growth. However, there are calls from across industry and academic groups to review the current regulations, which are seen as being over-cautious (Wilding *et al.* 2019) and can add significant time and economic burdens to the application process which may deter potential investors (Capuzzo, Mengo and Kennerley 2019). This hints at the tension between encouraging economic growth and protecting the environment.

### **Industry pressures in the context of a global seaweed industry**

Although seaweed has been part of the culinary tradition of coastal communities around the UK for generations, it is not currently consumed in great quantities. There are ambitions to change that, in the UK and across Europe (van den Berg, Dagevos and Helmes 2021), but until that transition occurs, production increases will be searching for global buyers. This means the UK seaweed industry must be viewed in the context of the global seaweed market. Global seaweed production has risen rapidly over the past two decades, from 10.6 million tonnes in 2000 to 32.4 million tonnes in 2018, with East and South-East Asian countries dominating in seaweed cultivation (Food and Agriculture Organisation 2020). There is growing investment from countries across Africa, North and South America and Europe as the unique potential for seaweed as a positive force to contribute towards Blue Economy ambitions and the Sustainable Development Goals is recognised (van den Berg, Dagevos and Helmes 2021).

Examples from history demonstrate how market forces can make or break an industry. In the 18<sup>th</sup> Century, soaring demand for soda ash – produced by the burning of brown seaweeds and used in a range of industries – saw seaweed become an important and profitable endeavour for coastal communities in Scotland. This lasted until early 19<sup>th</sup> Century when a cheaper alternative source of soda ash was developed, and the market dried up (Capuzzo 2021). Meanwhile, international competition and oversupply depressing market value have also been cited as hampering attempts to industrialise seaweed production in Canada and Japan respectively (McHugh 2003).

The competitive nature of the global seaweed industry exerts external pressures on the UK industry to find ways to gain a competitive advantage, such as by driving down production and harvesting costs through mechanisation and economies of scale (ibid). However, scaling up production through large-scale seaweed farming, thereby following down the 'old path' of consolidation and intensification seen in agriculture and aquaculture, may have unintended social and environmental consequences. The next section will consider examples from two sectors: dairy and salmon farming.

### **Lessons from the UK food system**

Dairy farming in the UK has changed considerably over the past two decades and this has had social and economic impacts on rural communities. The number of dairy producers in the UK fell by 67% between 1995 and 2020 (Uberoi 2021) as the industry consolidated into fewer, larger farms, and increased the intensification and mechanisation of production (Gonzalez-Mejia *et al.* 2018). The mechanisation of production reduced the need for farm labour, with the result that smaller farms now tend to employ more workers per unit area than larger

farms, and they are also usually more embedded within the community (Winter and Lobley 2016).

In comparison, the expansion of the salmon industry in Scotland did initially provide employment to local workers, an income stream to local suppliers and service providers within the industry and related industries, as well as an economic lift to the local area's shops, schools, housing, transport and services (Ellis *et al.* 2016). However, consolidation in recent years has resulted in an industry dominated by a small number of internationally owned businesses leading to a perceived reduction in local employment opportunities, and environmental concerns (Billing *et al.* 2021). Indeed, whilst consolidation improved production metrics (eg., yield), damaging environmental impacts such as eutrophication and increased susceptibility to disease outbreaks became much more prevalent (Ellis *et al.* 2016).

### **What could sustainable and responsible growth look like?**

Recognising the issues outlined above, the UN Global Compact (2021) and the FAO (2020) reference the industrialisation of agriculture and fisheries respectively as models the seaweed industry must avoid emulating. There is a growing literature offering alternative pathways to encourage the growth of a sustainable and responsible seaweed industry. Possible areas worth further exploration include adopting innovative business models such as co-operatives and partner-farmer models (UN Global Compact 2021), and adopting a circular economy approach to development (Van den Burg, Dagevos and Helmes 2019). Other options include integrating or co-locating seaweed with other forms of aquaculture (SIFT 2021), or compensating seaweed producers for organising their activities in ways that provide ecological benefits (Hu *et al.* 2021), in a similar manner to the Environmental Land Management scheme in the UK (Department for Farming, Environment and Rural Affairs 2021).

Finally, including a requirement for applicants to gain a social licence could offer a way to ensure community interests are included throughout the design and application process. Billing *et al.* (2021) spoke to community members in Scotland and France who described the provision of local jobs, community embeddedness, and accountability as critical factors for acceptable operations. In Scotland, the community members were distrustful of large corporations and expressed a preference for small scale producers operating as co-operatives or community focused enterprises. However, crucially, stakeholders within the seaweed industry surveyed as part of the same study argued that to grow in a way that aligned with the desires of local community members would not be economically viable (*ibid*).

Thus, it is important to recognise that the interests of coastal communities and seaweed producers may not be compatible (Billing *et al.* 2021). In those circumstances, how should the industry proceed? And how is it likely to develop? For regulators, there needs to be an awareness of the potential conflict between protecting the marine environment and supporting the growth of the Blue Economy (Scottish Association for Marine Science 2020), and clarity over the priorities and decision-making processes. However, one area that has received less attention is the political economy of the seaweed industry, and in particular, the different stakeholders seeking to influence the trajectory of development.

### **The political economy of the UK seaweed industry: A contested landscape**

Viewing the seaweed industry through a political economy lens allows the consideration of the relationships between different actors involved as well as a framework to identify potential obstacles to change by questioning who currently controls and benefits from the present manifestation (De Schutter 2019). Corporations dominate the global food system, and they are turning their attentions to seaweed. The conglomerates Cargill and DuPont have both

launched their own ‘Sustainable Seaweed’ initiatives focusing on increasing production in the Global South, whilst Nestlé is using the crop in their plant-based seafood and egg products (Financial Times 2022). In a market economy, these actors wield significant influence in the creation of standards and regulations that have ramifications globally, not just in their country of operations.

In the UK, the entrance of companies with global ambitions and venture capital investment brings with it pressure to deliver that may drive producers to seek efficiencies through scaling up production and reducing operating costs, and persuade regulators to facilitate economic growth through a more permissive regulatory landscape. In addition, as seaweed has gained political and economic importance, numerous indirect actors have emerged that seek to influence the developing seaweed industry in the UK. Mapping for this project identified a host of industry groups, philanthropic foundations and public-private partnerships who have entered the discourse arena in recent years. These different groups are conducting research, publishing reports, or otherwise seeking to influence policy and regulations in ways that further their own, potentially conflicting, interests. Regulators need to be aware of and account for the power imbalances and conflicting interests as the industry grows to ensure it is not steered down the ‘old path’.

## **Conclusion**

This article has identified tensions between economic, social and environmental goals of the development of the seaweed industry. How the inevitable trade-offs are managed will go a long way to determining the long-term sustainability of the industry. If the economic interests of powerful private actors are allowed to dominate, there are concerns that seaweed farming could follow suit of other commodities in the food system. However, if social and environmental objectives are given greater weighting, scaling up of seaweed industry in the UK has the potential to model a path for others to follow.

## **Acknowledgements**

Supported by UKRI Transforming UK Food Systems Strategic Priorities Fund as part of the UK Food Systems CDT.

## **References**

- Billing, S.L., Rostan, J., Tett, P. and Macleod, A. (2021). Is social license to operate relevant for seaweed cultivation in Europe? *Aquaculture*, 534, p.736203.
- Capuzzo, E., Mengo, E., Kennerley, A. (2019). Seaweed farming feasibility within the Dorset and East Devon FLAG area. Report 1 - Potential species, farming methods, end uses and benefits. Cefas Contract C7747, European Maritime and Fisheries Fund (EMFF) grant number ENG2805
- Capuzzo E. (2021) Seaweed Industries and Products in the UK: A Brief Review (Chapter-14); In: A. Ranga Rao and G. A. Ravishankar (Eds.) Sustainable Global Resources of Seaweeds: Industrial Perspectives; Volume-I : Bioresources , cultivation , trade and multifarious applications; Springer Nature (in press) doi 10.1007/978-3-030-91955-9\_14
- De Schutter, O. (2019) The political economy approach to food systems reform. IDS Bulletin. 50(2) pp.13-26. doi:10.19088/1968-2019.115
- Department for Farming, Environment and Rural Affairs (2021) Environmental Land Management Scheme Overview. Available at: <https://www.gov.uk/government/publications/environmental-land-management-schemes-overview/environmental-land-management-scheme-overview> (Accessed 17/02/2022)
- Ellis, T., Turnbull, J.F., Knowles, T.G., Lines, J.A. and Auchterlonie, N.A. (2016). Trends during development of Scottish salmon farming: An example of sustainable intensification?. *Aquaculture*, 458, pp.82-99.

Financial Times (2022) Can kelp help? Investors eye sustainable harvest from seaweed. By Patrick Temple-West, 03/02/2022. Available at: <https://www.ft.com/content/52e6ed83-f2ef-4391-9918-9734649bd4e4> (Accessed 08/02/2022)

Food and Agriculture Organisation (2020) The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome, Italy.

Gephart, J.A., Henriksson, P.J., Parker, R.W., Shepon, A., Gorospe, K.D., Bergman, K., Eshel, G., Golden, C.D., Halpern, B.S., Hornborg, S. and Jonell, M. (2021) Environmental performance of blue foods. *Nature*, 597(7876), pp.360-365.

Gonzalez-Mejia, A., Styles, D., Wilson, P. and Gibbons, J. (2018) Metrics and methods for characterizing dairy farm intensification using farm survey data. *PloS one*, 13(5), p.e0195286.

Hu, Z.M., Shan, T.F., Zhang, J., Zhang, Q.S., Critchley, A.T., Choi, H.G., Yotsukura, N., Liu, F.L. and Duan, D.L. (2021) Kelp aquaculture in China: a retrospective and future prospects. *Reviews in Aquaculture*, 13(3), pp.1324-1351.

Marine Management Organisation (MMO) (2019) Identification of Areas of Aquaculture Potential in English Waters.

McHugh, D.J. (2003) A guide to the seaweed industry. *FAO Fisheries Technical Paper*. No. 441. Rome.

Phyconomy (2021) Seaweed startups in 2021: an ecosystem emerges. Available at: <https://phyconomy.net/state-of-the-industry-2022/startups/> (Accessed 17/02/2022)

Roque, B.M., Venegas, M., Kinley, R.D., de Nys, R., Duarte, T.L., Yang, X. and Kebreab, E. (2021) Red seaweed (*Asparagopsis taxiformis*) supplementation reduces enteric methane by over 80 percent in beef steers. *PLoS One*, 16(3), p.e0247820.

Scottish Association for Marine Science (2020) Strategy to secure healthy and sustainable oceans. Available at: <https://www.sams.ac.uk/t4-media/sams/pdf/Digital-Sams-Strategy-Report-2020---2025.pdf>

Scottish Government (2021) Marine Fund Scotland 2021-2022: beneficiaries. Available at: <https://www.gov.scot/publications/marine-fund-scotland-2021-2022-beneficiaries/> (Accessed 03/02/2022)

Sustainable Inshore Fisheries Trust (SIFT) (2021) Seaweed cultivation in Scotland: A guide for community participation in seaweed farm applications, Available at: <https://sift.scot/wp-content/uploads/2021/03/SIFT-Seaweed-Guide.pdf>

Uberoi, E. (2021) UK dairy industry statistics. Commons Library Research Briefing, 9 September 2021, No. 2721, House of Commons Library

United Nations Global Compact (2021) Seaweed as a Nature-Based Climate Solution: Vision Statement. New York: United Nations

Van den Burg, S.W.K., Dagevos, H. and Helmes, R.J.K. (2021). Towards sustainable European seaweed value chains: a triple P perspective. *ICES Journal of Marine Science*, 78(1), pp.443-450.

Wilding, C. Tillin, H. Corrigan, S. E. Stuart, E. Ashton I. A. Felstead, P. Lubelski, A. Burrows, M. Smale D. (2021). Seaweed aquaculture and mechanical harvesting: an evidence review to support sustainable management. Natural England Commissioned Reports. Natural England Report NECR378.

Winter, M. and Lobley, M. (2016) Is there a future for the small family farm in the UK? Report to The Prince's Countryside Fund, London: Prince's Countryside Fund.

Wood, D., Capuzzo, E., Kirby, D., Mooney-McAuley, K. and Kerrison, P. (2017). UK macroalgae aquaculture: What are the key environmental and licensing considerations? *Marine policy*, 83, pp.29-39.