SEA project:
Supply chain mapping and logistics report (3.1)

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Executive Summary

- Industrial system maps can capture a diversity of enterprises operating at different (and multiple) points within a value chain (in the case of the SEA project: covering onshore seaweed nurseries, offshore farming, harvest and first-stage processing, through to final seaweed-based products)
- Representing a sector in this manner can enable emerging actors/enterprises to demonstrate their 'value' to the rest of the ecosystem and provide insights for effective supply network design (i.e., in identifying stakeholder groups, gaps and opportunities)
- Early-stage firms are less resilient and require local/regional institutional support – there are lessons to be learnt on where geography has played a role in terms of industrial institutions (e.g. maritime cluster development) or governments playing early adopter roles
- Multi-stakeholder approaches are critical in engaging the major stakeholder groups – industrial actors, institutional and consumers – as well as capturing individual requirements of each stakeholder group, overlaps can highlight common (and often unseen) areas of interest

1. Introduction

Institutional actors (e.g., government, agencies, universities, innovation hubs, centres of excellence, strategy groups, consultancies) play a central role in the successful development of an industry through influencing the structure, enabling high connectivity between the various 'industrial system' actors, and by providing incentives, subsidies, and publicly-funded R&D projects (Aldrich and Fiol, 1994; Edquist and Johnson, 1997; Harrington et al., 2016).

The emergence of new industries and the increasing complexity of 'value networks' has set new challenges for both firm strategists and national/regional policymakers (Srai, Christodoulou and Harrington, 2014). Research suggests that these changes require new approaches that not only consider the dynamics of the total value network but also the **industrial ecosystem** in which it operates/or will operate.

This broader ecosystem idea, illustrated in Figure 1, includes not only the firms directly involved in creating valuable products and services but also a set of external stakeholders – institutional players and sector specialists – who have a strong interest and influence in growing a sector and its ongoing

'reconfiguration' to react to emerging trends. These stakeholders include investors, governmental institutions, research agencies and universities. Only by fully understanding this complete ecosystem is it possible to support the needs of local 'micro-innovators', firm strategists and policymakers in building and (re-)reconfiguring value networks. This will be the case in developing competitive supply chains in East Anglia - from onshore seaweed nurseries, offshore farming, harvest and first-stage processing, through to final seaweed-based products.

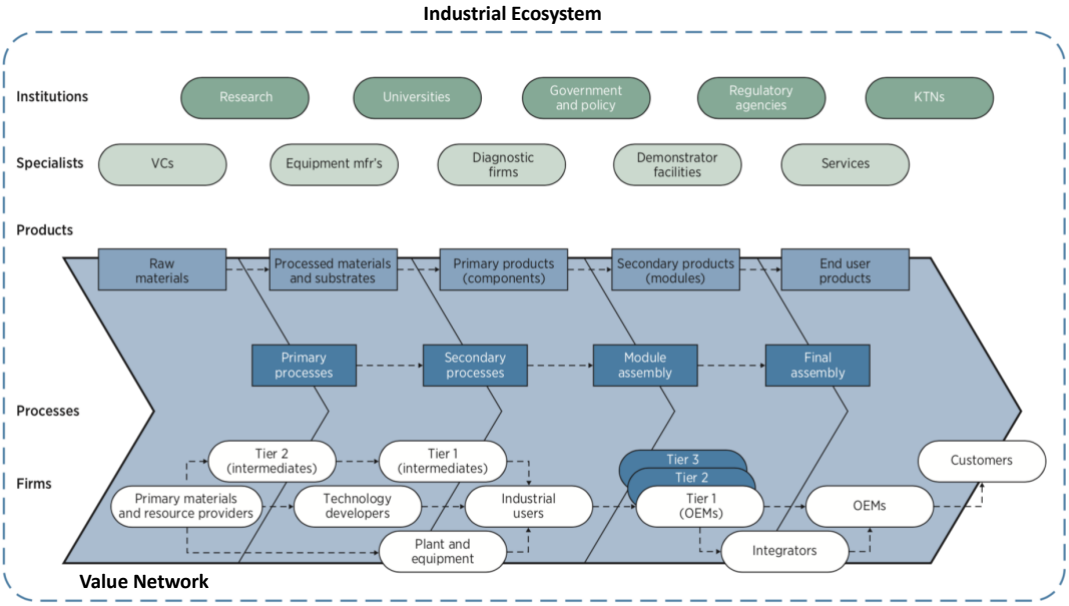


Figure 1. Generic industrial ecosystem map

A structured visualisation approach is used to capture the value network and its external stakeholders in order to aid understanding of the entire industrial ecosystem. This can typically focus on a specific industry i.e., UK seaweed sector map and a regional version for the East of England (in our case), and/or in the context of new technology emergence (at specific stages like cultivation, harvesting, processing, and distribution) or to represent disruptive changes to an existing network (for industries that are mature).

The approach can support a deeper awareness of the intrinsic nature of the ecosystem, including key relationships and inter-dependencies between players and influencers, and the value flows between them. It also provides an important template for defining the ecosystem, which can be used to map existing and desired states in different scenarios and for cross-sector comparison (for example, we can benchmark the seaweed sector in East Anglia versus the Norwegian maritime sector; where learnings can then contribute to advancing the seaweed sector in East Anglia and, in turn, the wider UK industrial biotechnology sector).

2. Seaweed supply chain and logistics mapping

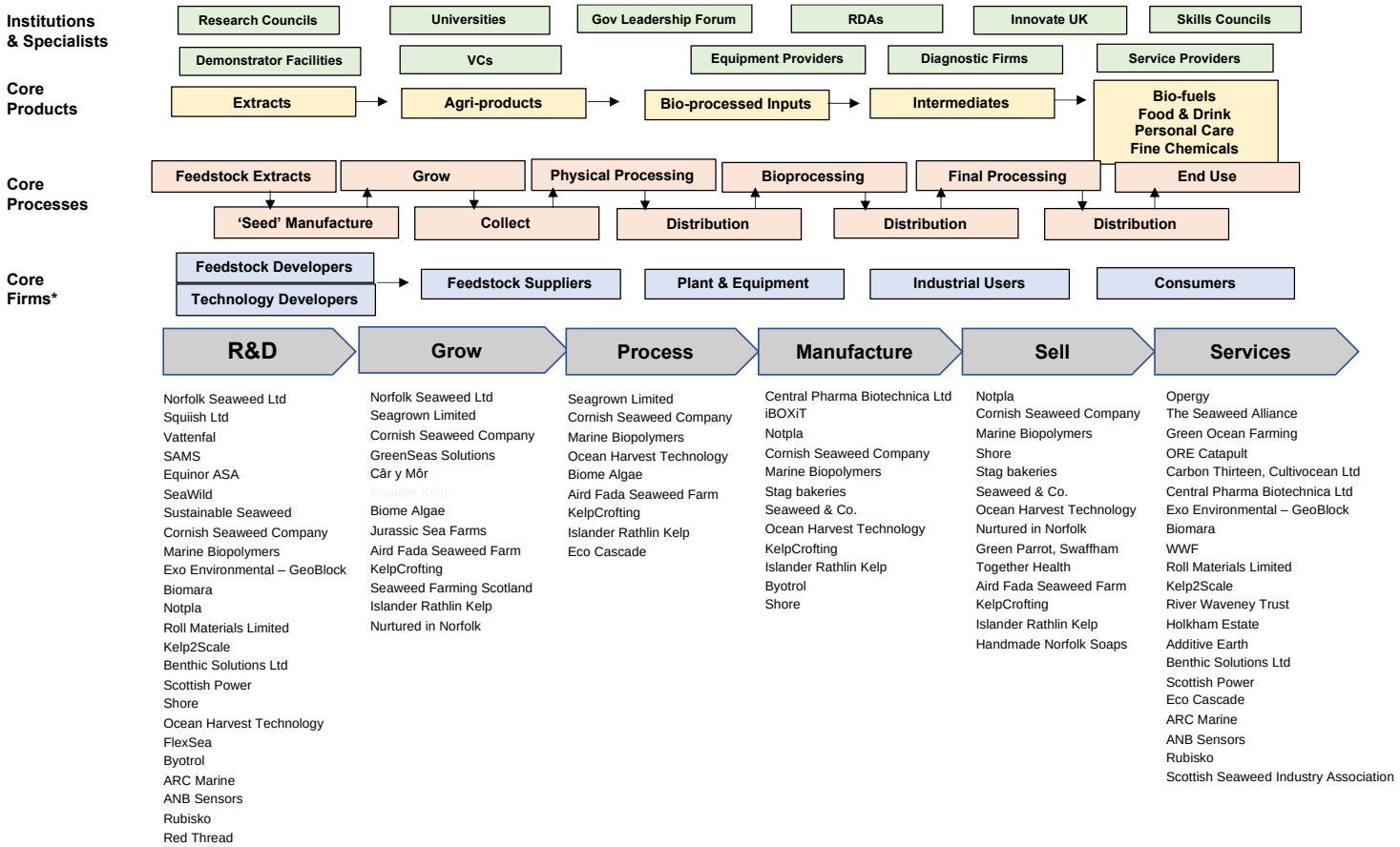
Any representation of an industrial system should include the context, resources, activities, processes, actors, and interdependencies that support the creation and delivery of products and services (Royal Academy of Engineering, 2012). Figures 2-4 present drafts of a UK sector map and a regional version (East of England) capturing value chain actors. A simple step-by-step guide for the development of maps is as follows:

- Determine the scope: You can examine the entire seaweed supply chain or specific stages like cultivation, harvesting, processing, and distribution and focus on specific outputs (food and bioplastics products). We recognise that: some firms do not grow seaweed and only harvest from the wild, hence, our focus is on cultivated seaweed; there are also no seedling/nursery/hatchery capabilities/facilities in the region;
- Break down the seaweed supply chain into its key components, such as cultivation, harvesting, transportation, processing, distribution, and end-use;
    - Identify key components;
    - Identify key players and stakeholders at each stage

To reduce complexity, some institutional players and secondary stakeholders, sector specialists and selected stakeholders are not represented (but are listed in the current state report by Hethel Innovation). This initial mapping exercise is based on the 23 organisations that engaged in semi-structured interviews conducted with people working in the seaweed sector, particularly for organisations that operate across the seaweed value chain in the UK. Members of the AIP (who were not interviewed) are also included. As maps are dynamic, it is an iterative process that requires collaboration with experts in the field. Going forward we will seek input and feedback from experts in seaweed cultivation and related fields as a validation exercise. Building on this study, maps can be used to represent alternative paths for emerging industry supply chains involving seaweed. Specifically, in capturing environmental features that are influenced by dynamic factors (market, product, production system, technology, policy, resources) – see section 3. Proposed next steps include:

- Gathering relevant data on existing seaweed supply chains and related industries (see also deliverable 3.2);
- Collecting information on potential alternative technologies, practices, or innovations in seaweed cultivation, processing, and distribution (including digital technologies, platforms, and Apps);
    - Consider here variations in seaweed cultivation methods (e.g., land-based vs. ocean-based), processing techniques, and distribution channels;
- Identify alternative paths for each stage of the supply chain. This could involve a variety of different technologies, business models, or collaborations;
- Understand the interconnections and dependencies between different stages and paths. How might changes in one part of the supply chain affect others?
- Conduct scenario analysis to understand the potential outcomes of each alternative path. Consider factors like economic viability, environmental sustainability, and scalability (linking to deliverable 3.2).

Figure 2. UK seaweed sector map (based on AIP membership and interview engagements as part of the SEA project)



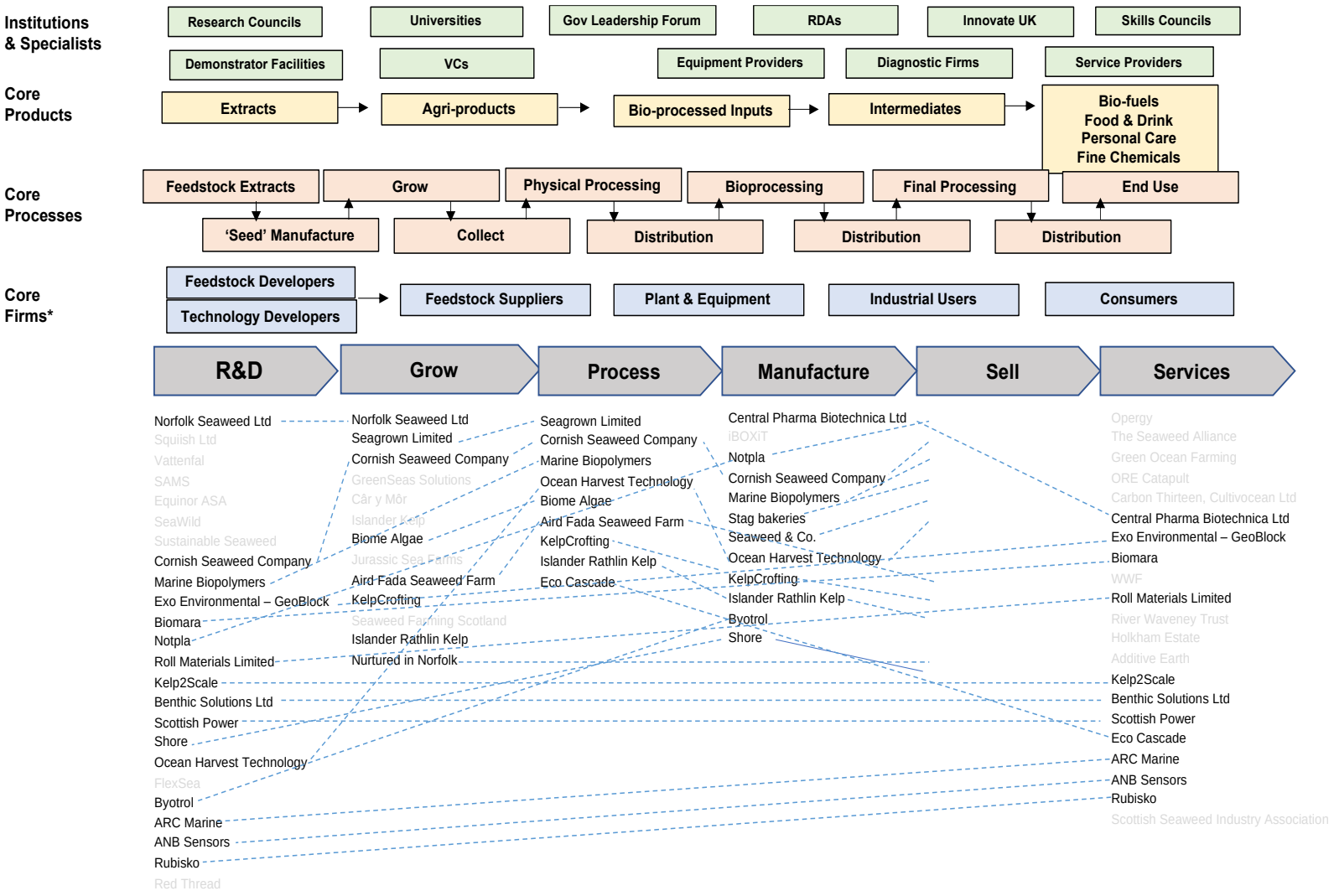
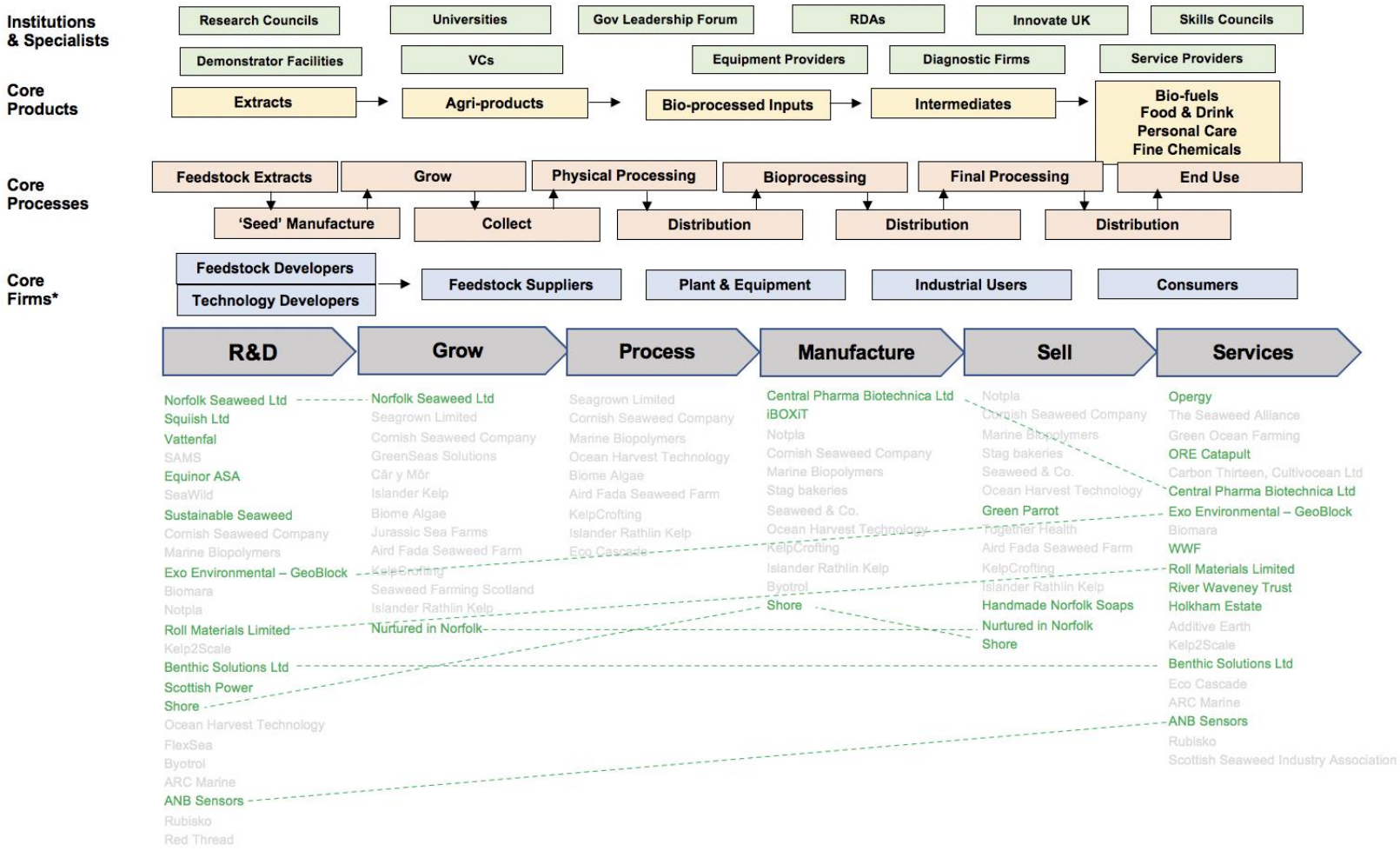


Figure 3. UK seaweed sector map (based on actors who have a presence in multiple points of the value chain)

Figure 4. Regional seaweed sector map (based on actors who are based in Norfolk/East Anglia or have a presence here)



3. Lessons to be learned from other sectors

Analysis of the structure of various industrial systems (Dicken 2003), and the performance of 'clusters' (Porter, 2000) has largely focused on mature industries. Mapping the potential to develop competitive supply chains in a region from a supply perspective involves assessing various factors that influence the efficiency, cost-effectiveness, and reliability of various supply chain configurations (Srai et al. 2016) - see also deliverable 3.2.

As emerging industries develop with varying levels of dynamism and complexity (Nair and Boulton 2008) the Industrial System mapping methodology we use can form the basis of representing alternative and novel evolution paths and provide the platform for cross-industry analyses involving complementary industrial systems previously studied (UK Biotechnology, Norwegian Maritime, and UK Last-Mile Logistics – see Appendices A, B, and C respectively)

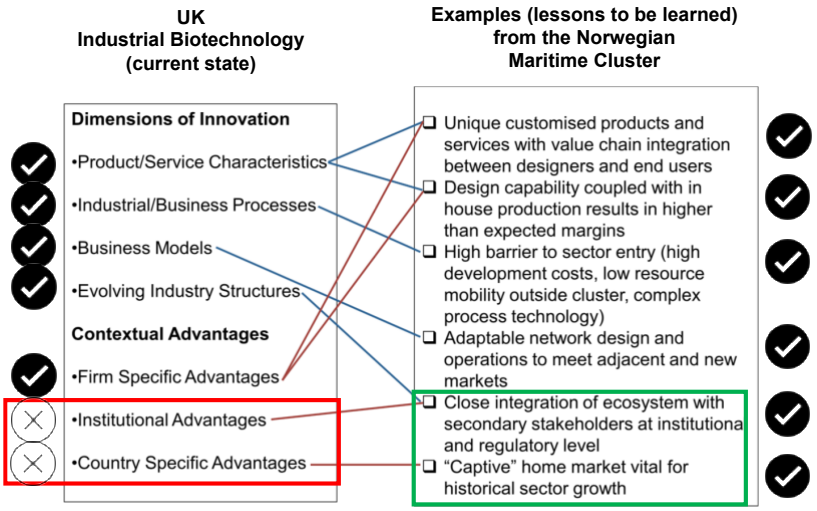


Figure 5. Observations on the importance of the type of innovation and 'context' (adapted from Srai, Harrington and Tiwari, 2016)

Previous emerging industry studies have captured the nature of innovations and to what extent 'context' specific advantages are being exploited to support industrial emergence. We can already highlight some cross-case characteristics and briefly highlight here linkages between the types of innovation and contextual factors (Srai, Harrington and Tiwari, 2016). Figure 5 compares these 'connections' using the case of the exemplar Norwegian maritime cluster and UK Biotechnology.

While the Norwegian maritime cluster avails of country-specific advantages (i.e,. close integration of the ecosystem with secondary stakeholders at the institutional and regulatory level; a 'captive' home market essential for sector growth), UK Biotechnology has traditionally failed to exploit such context-specific advantages. As a result, early-stage firms are often less resilient and require local/regional institutional support. Geography has also played a role in terms of industrial institutions (e.g. the

maritime cluster) or governments have played early adopter roles (SME national clusters in the EU, and personalised medicines in Ireland).

Some common features that have emerged from previous cross-case analyses involving emerging sectors (that may resonate with the seaweed sector) include:

- the blurring of industry boundaries in almost all cases with 'connections' beyond the traditional 'sector' boundary commonplace;
- platform technologies that support multiple product categories are often 'disconnected' from end-user markets so require institutional support (to avoid excessive technology firm market failures);
- new supply chain actors can provide 'network integration' and supply/demand balancing capabilities to actively manage supply and demand-side uncertainties. For example, supply chain assets such as "Seaweed Source" - a free app for active seaweed farmers, hatcheries, and buyers to discover new partners, initiate forward contracts, and get real-time updates on supply or purchasing offers (Greenwave, 2023).
- The emergence of new supply chain actors or 'archetypes', which have included system integrators, technology developers, resource capturers, asset diversifiers and material/information consolidators that can support particular emerging industry evolution paths;
- Regulatory environments that initially require local institutional and regulator support, but rapid subsequent development to serve international markets requires international standards and partnerships;
- One critical challenge in developing 'competitive' supply chains, as part of a commercialisation process, is that there is no defined pathway to follow. Lack of certainty, in terms of product definition and end-user requirements, forces emerging actors and enterprises to experiment with supply chain strategies. This process is very time-consuming; increasing time-to-market, making it difficult to exploit any 'first-mover' competitive advantage and reduces opportunities to grow market share. High levels of uncertainty require new 'clusters' where risk pooling can mitigate against unattractive risk profiles (other process industries have emerging mechanisms in place here, such as the idea of 'design rules' – see deliverable 3.2)
- Recently, '*distributed manufacturing*' models have emerged, defined as: '*the ability to personalise product manufacturing at multiple scales and locations, be it at the point of consumption, sale, or within production sites that exploit local resources, exemplified by enhanced user participation across product design…and supply, and typically enabled by digitalisation and new production technologies'* (Srai et al., 2016; Srai et al,. 2017). This model (or 'variants' such as Re-Distributed Manufacturing) seems appropriate for the seaweed sector, in utilising digitally-enabled and scalable manufacturing facilities (agile biorefineries) for specific volume-variety products, particularly when considering seasonality factors and associated needs for biofertilisers (Tsolakis, Harrington and Srai, 2023).

4. The need for multiple stakeholder approaches

Collaboration with the fishing industry and co-location with energy companies could create additional local employment and access to prospects in Norfolk. Here, multi-stakeholder approaches will be critical in engaging major stakeholder groups – industrial actors, institutional, end-consumers, and inhabitants.

In short, areas of overlap can highlight common (yet often unseen) areas of interest between different stakeholders captured in a sector map. For example, industrial/consumer interests could include factors such as improved service and lower costs; industrial/institutional interests could include factors such as co-location decision-making; the institutional/consumer interests could include factors such as green choices. Norfolk residents may have different needs, which should also be captured (a focus of deliverable 4.3). In combination, common interests of all three stakeholder groups, might include factors such as skilld development and job creation, customer satisfaction (greener products), and overall service performance.

A categorisation framework of stakeholders, previously developed for supply chain design and 'last-mile' logistics (Harrington et al., 2016), could be adapted using the sector maps (figures 2-4) with the aims of capturing:

- Individual perspectives, requirements, objectives and interests of the different stakeholder groups: Consumer (customers and inhabitants), Industrial, and Institutional;
- Common interests and trade-offs between the stakeholder groups: Industrial–Institutional, Consumer–Institutional and Industrial–Consumer;
- Industrial–Consumer–Institutional common interests and trade-offs (a three-way perspective on the emerging seaweed sector)

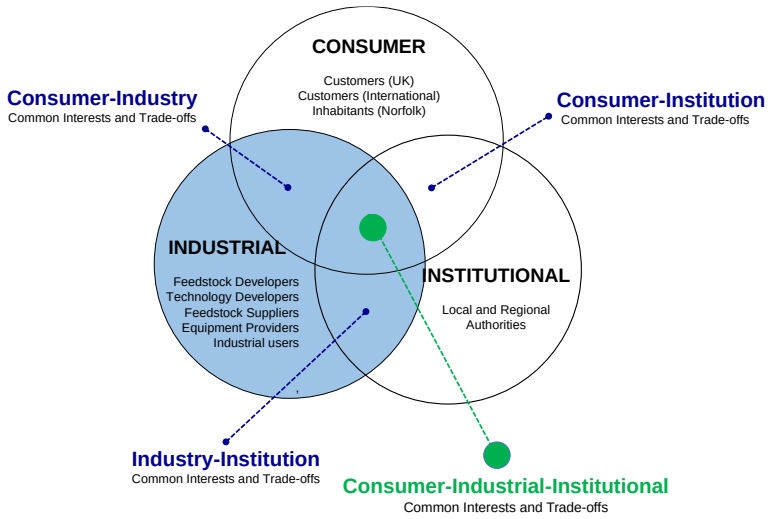


Figure 6. Framework to capture common interests/trade-offs involving stakeholders as well as individual requirements of each stakeholder group - adapted from Harrington et al., (2016)

5. Conclusion

Industrial system maps can capture a diversity of enterprises operating at different (and multiple) points within a value chain. In the case of the SEA project, we offer a series of draft maps that can capture onshore seaweed nurseries and companies that offer seedlings, R&D capability and support (see deliverable 5.1), offshore farming, harvest and first-stage processing, through to final seaweed-based products.

Initial observations – based on industrial system maps – suggest the potential of '(re-)distributed manufacturing models' in the region to support emerging industries based on seaweed - with smaller-scale dispersed options (agile biorefineries) that might impose less stress on local resources and have a democratising effect on participation in Norfolk and East Anglia (informing deliverable 4.3). However, early-stage firms are less resilient and require local/regional institutional support – there are lessons to be learnt on where geography has played a role in terms of industrial institutions (e.g. maritime cluster development) or governments playing early adopter roles.

Representing a sector using mapping methodologies can enable emerging actors/enterprises to demonstrate their 'value' to the rest of the ecosystem and provide insights for effective supply network design (i.e., in identifying stakeholder groups, gaps and opportunities). Multi-stakeholder approaches will be vital in engaging the major stakeholder groups – industrial actors, institutions and consumers (including Norfolk residents) – to highlight conflicts but also common areas of interest.

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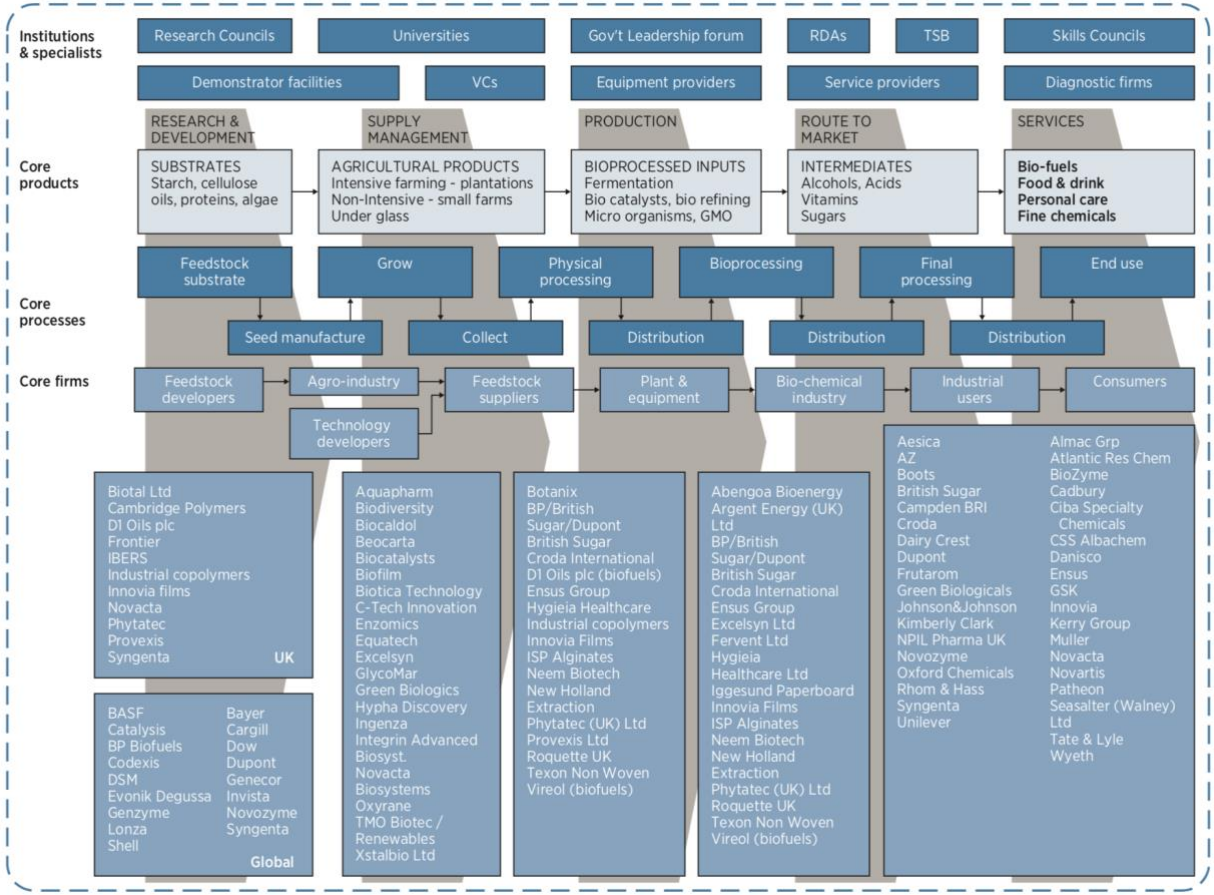
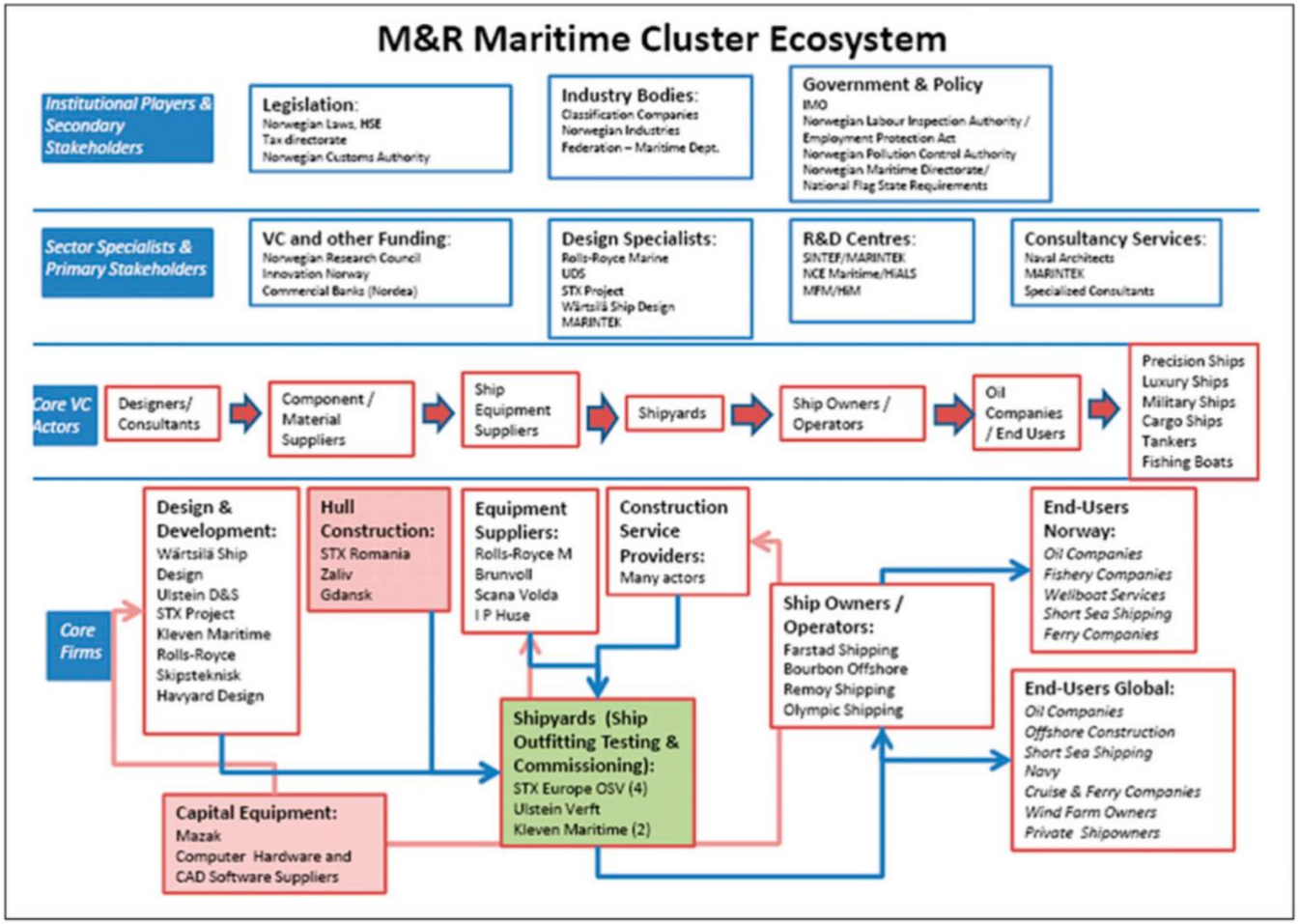
Appendix A: Examples of other sector maps (UK industrial Biotechnology)



Appendix B: Examples of other sector maps (Norwegian Maritime)



Appendix C: Examples of other sector maps (UK Last-Mile Logistics)