Geoforum 150 (2024) 103969

Contents lists available at ScienceDirect

Geoforum

journal homepage: www.elsevier.com/locate/geoforum

The role of proximity in environmental upgrading: plastics recycling in Norwegian aquaculture

Assiya Kenzhegaliyeva [a,b,*], Henrik Brynthe Lund [a,b]

[a] Department of Geography, Norwegian University of Science and Technology, Trondheim, Norway
[b] Department of Technology Management, SINTEF, Trondheim, Norway

ARTICLE INFO

Keywords:
Environmental upgrading
Cost-capability ratio
Plastics recycling
Norwegian aquaculture
Global value chains
Social, geographical and institutional proximity

ABSTRACT

End-of-life environmental upgrading can contribute to more sustainable use of natural resources. The authors look at recycling as end-of-life environmental upgrading and explore what influences recycling of discarded hard plastic equipment in the Norwegian aquaculture industry. They study the role of institutional, geographical, and social proximity in environmental upgrading of the plastics value chain in aquaculture and combine the concepts of environmental upgrading, proximity, and cost-capability ratio into a framework to understand better the conditions for end-of-life environmental upgrading. The findings reveal that material properties can be crucial for end-of-life environmental upgrading, as they can both influence costs of environmental upgrading and require development of new capabilities for environmental upgrading. To balance the costs and capabilities related to environmental upgrading, actors need to take geographical, institutional, and social dimensions of proximity into account. In conclusion, the development of recycling solutions in global value chains, such as end- of-life environmental upgrading, is affected by how proximity influences costs and drives development of capabilities.

1. Introduction

Research on global value chains (GVCs) and global production networks (GPNs) has recently started to focus on the environmental dimension of modern economy through the concept of environmental upgrading (EnvU). EnvU entails changes that lead to reducing the negative environmental effect of a production system (Krishnan, 2017). Most studies of EnvU have looked at changes made to production processes, products or organizations (De Marchi et al., 2019), and considerably fewer studies have addressed the product's end-of-life stage, for example in the form of developing recycling or waste treatment initiatives (Hansen et al., 2021). In this paper, we regard one circular economy (CE) strategy, namely recycling as a form of end-of-life EnvU. We emphasize that the aim of this paper is not to advocate for recycling per se but rather to consider recycling as end-of-life EnvU in GPNs to understand what can influence it and therefore to contribute to the literature on EnvU in GVCs through an improved understanding of conditions for EnvU/end-of-life EnvU.

Innovation is a key component of EnvU in GVCs (De Marchi & Di Maria, 2019; De Marchi, Di Maria, et al., 2013). The literature on innovation suggests that innovation results from interaction, knowledge exchange, and learning between different actors involved in innovation systems (Asheim & Isaksen, 2002; Bergek et al., 2008; Lundvall, 1992; Malerba, 2005). Furthermore, authors argue that proximity (social, organizational, geographical, cognitive, and institutional) between actors in innovation processes influences how the innovation and learning processes unfold (Balland et al., 2022; Boschma, 2005; Davids & Frenken, 2018). In this paper, we study the role of proximity in the development of end-of-life EnvU solutions in global value chains by looking at value chains as 'the full range of activities that firms and workers perform to bring a product from its conception to end use and beyond' (Gereffi & Fernandez-Stark, 2011, p. 4). Geographical proximity concerns the physical distance between actors participating in learning processes and the influence of this physical distance on innovation processes. Furthermore, geographical proximity can condition social proximity that relates to micro-level relations and closeness between actors involved in innovation and learning processes and can take the form of trust. Social proximity is differentiated from institutional proximity that relates to presence of common institutional framework at macro-level (Boschma, 2005), where institutions relate to 'cognitive, normative, and regulatory structures and activities that provide stability and meaning to social behaviour' (Scott, 1995, p.33). Organizational

* Corresponding author at: Department of Geography, NTNU, 7491 Trondheim, Norway.
E-mail address: assiya.kenzhe@sintef.no (A. Kenzhegaliyeva).

https://doi.org/10.1016/j.geoforum.2024.103969
Received 9 January 2023; Received in revised form 29 January 2024; Accepted 10 February 2024
Available online 20 February 2024

proximity is associated with the degree of autonomy that actors have, and such proximity can provide benefits for learning and innovation. It is also sometimes associated with cognitive proximity, which implies similarities in the knowledge bases of the actors, usually in the form of similar educational backgrounds or theoretical fields (Boschma, 2005).

Proximity between actors in the value chains can either contribute to or constrain learning (Boschma, 2005; Boschma & Frenken, 2010), and consequently also the development of capabilities that represent an important part of GPN dynamics. However, costs represent another important part of the competitive dynamics in GPNs, as they influence how GPNs are organized. Balancing costs and capabilities is necessary for firms to achieve greater value creation and can allow for higher value capture, which remains a core goal of firms' actors in GPNs (Yeung & Coe, 2015). Therefore, we propose that cost-capability ratio optimization (i.e. how firms can improve firm-specific capabilities and balance costs, (Yeung & Coe, 2015) is a fruitful way of connecting the GVC/GPN literature with literature on innovation, particularly regarding proximity in innovation and learning processes (Balland et al., 2022; Boschma, 2005), in order to explain what influences end-of-life EnvU in GVCs (De Marchi et al., 2019; Krishnan, 2017) and hence improve our understanding of this less-researched type of EnvU.

Our analysis is guided by the following research question: *How can proximity influence end-of-life EnvU in global value chains?* To answer this research question, we applied a qualitative research strategy with a case study as a research method and conducted interviews as our primary data collection method. We supported the interview data with data from documents and observations during workshops.

Empirically, we study the recycling of plastics from Norwegian aquaculture, where plastics constitute a great environmental challenge. Norwegian aquaculture is an important player in the global aquaculture industry and has recently started to address the challenge relating to plastics as one strategy to improve the environmental impact of the industry. Plastic pollution from the aquaculture industry is, however, a global problem that is expected to increase (Skirtun et al., 2022) and the value chains for plastics in aquaculture span geographical borders.

This paper aims to demonstrate how recycling contributes to EnvU of the studied GVC. In this paper we look at proximity between actors who possess resources that are recycled with the help of the innovative recycling solutions, actors who develop end-of-life solutions, and actors who use recycled resources afterwards.

The paper contains six sections. Section 2 provides the background to plastics recycling in the Norwegian aquaculture industry. Section 3 reviews the literature on EnvU in GPNs/GVCs, proximity, and cost-capability ratio, which are used to develop the analytical framework for this paper. Section 4 explains our methodology. In Section 5, we summarize and discuss the findings, and thereafter present our conclusions in Section 6.

2. An introduction to the Norwegian aquaculture industry and the issue of plastic waste

Fish farming is one of the most important industries in the Norwegian economy. The export volume worth 13 billion USD (120 billion NOK) in 2021 (n.g., 2021) made the industry the second largest export industry in Norway (Nærings- og Fiskeridepartementet, 2021). Norwegian aquaculture exports its products to markets in Poland, Denmark, France, the USA, the Netherlands, China, and other countries (Norges Sjømatråd, 2021). Norway is the largest salmon producer in the world, with a global production share of around 50 % (Norges Sjømatråd, 2023). The large market share is combined with a high degree of innovation related to technology development and production (Bergesen & Tveteras, 2019; Iversen et al., 2020). The industry aims to deliver 'the world's most effective and environmentally friendly industrial production of protein' (Norsk industri, 2017, p.7).

Recent strategies and roadmaps have identified sustainability as a precondition for further development of the Norwegian aquaculture industry (Tveteras et al., 2020). In this endeavour, addressing sustainability issues, particularly salmon lice and fish escapes, is important for the industry (Norsk industri, 2017). In addition, the handling of plastic waste has become another issue of growing concern for the industry, as plastic waste from aquaculture constitutes a major societal problem (Damman et al., 2022), not only in Norway but also globally (World Aquaculture Society, 2020).

Currently, plastic equipment constitutes a large part of Norwegian fish farms. Producers of aquaculture components use different types of plastic to produce, for example, flotation pipes, feeding pipes, ropes, and walkways. Complete solutions suppliers have contracts with component suppliers and create such solutions for fish farmers, both in Norway and abroad. Plastics for these components come from different raw materials suppliers, most of which are located abroad (e.g. Austria; Damman et al., 2022). In addition to contributing to plastic pollution in the ocean through their use phase, net pens (in which the salmon are kept) used in fish farming become a substantial waste problem when they are brought to shore and discarded. The Norwegian regulatory framework requires fish farmers to replace certain components (e.g. ropes) in fish farms every three to five years. Fish farmers in Norway annually discard large amounts of plastic equipment due also to wear and tear and to upgrading to larger net pens (Damman et al., 2022). The industry produces c.25, 000 tonnes of plastic waste per year (MEPEX, 2018), but the exact volumes are hard to estimate (Fiskeridirektoratet, n.d.). This is in addition to plastic waste that the industry has already generated and that now constitutes a waste problem either onshore or in landfills.

Previous studies have shown that discarded plastic components either end up in landfills or used in energy recovery, or simply are not handled and remain where they have been brought ashore, as the market for recycled plastics from Norwegian aquaculture is rather non-existent, with a lack of willingness to pay more for recycled materials (Damman et al., 2022). While higher prices for recycled plastics can be disadvantageous, some producers expect that their customers should be willing to pay higher prices for recycled materials, as such materials contribute to environmental improvement of the production systems. In addition, actors expect that recycled plastics will be price-competitive with the virgin plastics at some point, and that virgin plastics will even become more expensive in the future (Damman et al., 2022).

Despite the lack of willingness to pay more for recycled plastics, as well as the lack of regulatory pressure to use recycled plastics in Norway, the willingness to use recycled materials has been increasing (Damman et al., 2022). At the same time, several regulations regarding the treatment of waste in the products' end-of-life stage are under development, such as extended producer responsibility (EPR) for plastic equipment used in the fisheries and aquaculture sector (Miljødirektoratet, 2023). While regulatory requirements regarding the sorting of discarded equipment are lacking, the internal culture of the Norwegian aquaculture industry shows an emerging awareness of the resources' value and an emerging willingness to be sustainable, including when it comes to the issues concerning plastics (Damman et al., 2022).

Despite the challenges, several initiatives aim to address the problem of plastic waste from the Norwegian aquaculture industry through the establishment of new recycling facilities (FHF, 2019; Nygård & Kristoffersen, 2021). While the problem of plastic waste from aquaculture has received some attention outside Norway (World Aquaculture Society, 2020), the Norwegian aquaculture industry is, to our knowledge, a front-runner regarding plastics recycling, although the phenomenon is still emerging. As Norwegian companies serve the global market and constitute key suppliers in global value chains for plastic equipment for aquaculture, recycling of this equipment represents an example of end-of-life EnvU (Hansen et al., 2021). In the following section, we elaborate on the theoretical perspectives that we employ to gain a better understanding of the conditions for end-of-life EnvU in the GVC studied in this paper.

3. Environmental upgrading, proximity, and cost-capability ratio

3.1. Environmental upgrading in global production networks and global value chains

The GPN and GVC literature aims to explain how economic activities are organized in the modern globalized world (Dicken, 2011; Gereffi, 1994) within production networks and value chains, and how economic and non-economic actors (e.g. states, NGOs) have strived to couple firms with these global networks to ensure value creation and value capture. This literature accounts for non-economic actors (Coe et al., 2008) and the role of institutions (Gereffi & Fernandez-Stark, 2011) in influencing production systems, and allows us to understand firms' strategies regarding the activities they take part in, as well as how those strategies influence configurations of GPNs. In addition, the literature focuses on how the production networks and value chains are governed (Gereffi et al., 2005), and how firms move up the value chain to take on roles that ensure greater value capture (or conduct economic upgrading; Humphrey & Schmitz, 2002).

In the GPN/GVC literature, the concept of upgrading originally related to the economic aspects of production systems and value chains, where 'economic actors move from low-value to relatively high-value activities in global production networks' (Gereffi et al., 2005, p.171). Previous research has investigated different types of upgrading: product, process, functional, and interchain (Humphrey & Schmitz, 2002), conditions for upgrading, the role of innovation in upgrading, and other topics (Gereffi, 2019). Also, social upgrading, defined as 'process of improvement in the rights and entitlements of workers as social actors, which enhances the quality of their employment' (Barrientos et al., 2011, p.324), has received some attention in the GVC/GPN literature.

An emerging stream of literature on GVCs responds to the calls for more research on environmental and sustainability issues (Coe & Yeung, 2019) and puts emphasis on how the environmental performance of production systems can be improved. This literature stream has introduced the concept of environmental upgrading (EnvU), defined as 'any change that results in the reduction of a firm's ecological footprint, such as their impact on greenhouse gas emissions, on biodiversity losses and on natural resources overexploitation, that is, when the net gains in environmental improvements are more than the losses' (De Marchi et al., 2019, p.312).

Thus far, the EnvU literature has identified four forms of EnvU. EnvU can happen through 1) process improvements where reorganization of production systems or the use of more advanced technology (e.g. reduction of energy or materials used per unit of output) leads to better eco-efficiency; 2) product improvements through the development of environmentally friendly product lines. Usage of recyclable, recycled or natural inputs, dematerialization of products, avoidance of toxic or impacting materials can also relate to this category; 3) organizational improvements in a firm's overall way of doing business and managing the organization. This category of EnvU is represented by the achievement of standards and certifications (De Marchi et al., 2019, p.313); 4) product end-of-life improvements through reducing products' end-of-life waste flows, for example in form of waste collection and recycling schemes, initiatives to repair and refurbish used products, and the establishment of waste collection centres (Hansen et al., 2021, p.67).

The GVC literature has identified both internal and external drivers of EnvU to firms. External drivers of EnvU by the firm actors come from the firms' customers, state and civil society organizations, and other non-firm actors outside the firm's reach. External drivers can be in the form of, for example, regulations and standards, and market pressure and demand (De Marchi et al., 2019). Drivers internal to the firm originate from the firm's internal motivation to become more competitive through a reduced environmental impact. These internal drivers can, for example, be in the form of cost savings through either energy optimization or reduced material input. Some firms see the ability to offer more environmentally friendly products as a competitive advantage in itself (De Marchi et al., 2019; Khan et al., 2020).

Moreover, the GVC literature emphasizes the role of EnvU drivers that lead firms use in their relationships with their suppliers. Lead firms can request compliance with standards and certifications, demand new and more environmentally friendly product design, or transfer their knowledge regarding different aspects of production that could help to improve the suppliers' environmental impact (De Marchi et al., 2019).

Having devoted much attention to drivers of EnvU, researchers studying EnvU in GVCs have focused much less on conditions for EnvU. We suggest that drawing upon the literature on innovation could help to illuminate the conditions for EnvU, as innovation is key for EnvU (De Marchi et al., 2019). Based on most definitions of innovation, we understand it as novel ideas or technology implementations that require changes in existing routines. Such implementation requires interaction between the actors involved in the existing routines and systems relating to the developed innovations (Lundvall, 1992).

Collaboration and interaction between actors in innovation and learning processes can be influenced by the proximity between these actors, and therefore proximity plays an important role in how the processes will evolve (Boschma, 2005; Kirat & Lung, 1999). The existing literature on EnvU in GPN/GVCs does not, however, explicitly address to a great extent the role of proximity and its influence on innovation in EnvU (De Marchi et al., 2019; De Marchi, Di Maria, et al., 2013). An exception is a doctoral thesis by Aarti Krishnan, who addresses the role of relational proximity for actors' abilities to disembed from the production networks and re-embed in them to improve their environmental performance (Krishnan, 2017). Krishnan refers to earlier works (De Marchi, Di Maria, et al., 2013; De Marchi, Maria, et al., 2013) that emphasize the meaning of trust for EnvU. Following the argument that innovation is necessary for EnvU (De Marchi et al., 2019; De Marchi, Di Maria, et al., 2013) and that proximity influences innovation and learning (Boschma, 2005), we argue that we would benefit from a better understanding of how proximity between actors who develop end-of-life solutions influences the EnvU of global value chains. Thus, we recognize the need to introduce also other types of proximity than relational types into the literature on EnvU.

3.2. Proximity dimensions and innovation

Boschma (2005) differentiates between five proximity dimensions: cognitive, organizational, social, institutional, and geographical. He suggests that some dimensions are more important than others; however, each dimension can still have an impact on innovation. Whereas Boschma (2005) discusses the importance of proximity between actors who are involved in the innovation processes, we look at proximity between actors who conduct end-of-life EnvU through innovative solutions, as well as their proximity to fish farmers or waste collectors who are in possession of discarded plastic equipment.

Recent contributions to the proximity debate suggest that combining network and proximity dynamics is necessary for a better understanding of the evolution of innovation networks (Boschma & Frenken, 2010). In addition, the proximity debate became extended in the form of a more dynamic view of the proximity framework (Balland et al., 2015). Despite these developments, the dimensions of proximity have remained unchanged (Balland et al., 2015; Broekel & Boschma, 2012; Davids & Frenken, 2018). This paper does not aim to develop the proximity literature per se yet further, but rather to inform the emerging EnvU literature (De Marchi et al., 2019; De Marchi, Di Maria, et al., 2013) by introducing proximity dimensions and investigating how innovation and learning necessary for EnvU is conditioned by proximity. Therefore, in this paper we rely on the seminal contribution by Boschma (2005) and the dimensions of proximity suggested in his contribution.

Boschma (2005, p.66) defines social proximity as 'socially embedded relations between agents at the micro-level' such as 'friendship, kinship and experience'. Social proximity is important for learning and innovation, as relationships built on trust '…facilitate the exchange of tacit knowledge' (ibid.). Social proximity with a high level of trust and collaboration results in the development of relational value chains where suppliers have high competencies and capabilities and become costly to replace (Gereffi et al., 2005). Furthermore, the presence of social proximity promotes long-lasting relationships between actors (Boschma, 2005).

Institutional proximity relates to relations, albeit at macro-level where they are structured through laws, rules, cultural norms and habits, beliefs, and expectations (i.e. formal and informal institutions). As the institutions provide structures (Scott, 1995) and 'stable conditions for interactive learning' (Boschma & Frenken, 2010, p.4), they also influence how actors coordinate their actions when it comes to learning and innovation. At the same time, institutional lock-in (e.g. very rigid rules or regulations that are hard to change) can hinder innovation. Both institutional and social proximity can sometimes be conditioned by geographical proximity, as institutions and relations can result from belonging to specific communities (Boschma, 2005).

Geographical proximity in the form of 'spatial distance between economic actors in absolute or relative meaning' (Boschma, 2005, p.63) can influence processes of learning and innovation. However, the effect of geographical proximity on knowledge exchange and innovation is less direct compared to other types of proximity, with co-location not being a mandatory condition for learning, but an additional possibility that can be realized ad hoc (Boschma, 2005). As knowledge exchange is an important prerequisite for innovation (Jensen et al., 2007), scholars have investigated how geographical proximity (or distance) influences the exchange (Torre, 2008; Torre & Rallet, 2005). At the same time, in looking at the role of geographical proximity in innovation, scholars have limited their work to addressing its role in interaction between actors. As our paper aims at understanding the conditions for end-of-life EnvU in the form of recycling, we suggest that proximity between actors who conduct end-of-life EnvU is important, as too is their proximity to fish farmers who have the discarded plastic equipment necessary for this form of EnvU.

Other streams of research have long emphasized the influence of physical distance on the development of economic activities without necessarily utilizing the concept of geographical proximity. For example, location theory (also known as 'least cost theory') suggests that distance and related transportation costs can be decisive for the localization of new industries (Weber, 1909). Researchers studying industrial symbiosis have investigated the role of distance and related transportation costs in recycling (Velenturf & Jensen, 2016). Havas et al. (2022) argue for a need for local recycling facilities and suggest a 'small circles approach' where waste is treated within smaller geographical areas to solve the challenges of plastic waste.

Furthermore, organizational proximity in the form of interfirm or intrafirm relations and the way they are organized can influence learning and innovation. Too much organizational proximity can be harmful, while strong ties between organizations remain beneficial. Cognitive proximity often occurs together with organizational proximity and relates to similarities in actors' knowledge bases. While some cognitive proximity is beneficial (similar to organizational proximity), too much cognitive proximity can hinder learning and innovation (Boschma, 2005).

Proximity dimensions can overlap and condition each other. Geographical proximity can stimulate social proximity, as social proximity relates to embeddedness in specific communities or networks. Social and institutional proximity can overlap, as both dimensions are anchored in values and beliefs, but relate to different levels. At the same time, social proximity (trust) can compensate for lack of institutions. Geographical proximity is also associated with institutional proximity, with informal institutions being anchored at the community level and formal institutions in the form of laws and rules being related to national and state level (Boschma, 2005; Boschma & Frenken, 2010).

As discussed earlier in this section, whereas proximity influences learning and innovation processes, and conditions knowledge exchange and development of capabilities (e.g. in terms of knowledge or technology upgrading), proximity can have implications for the costs side, which in turn can influence the way production is organized (Yeung & Coe, 2015). We suggest, therefore, that the concept of cost-capability ratio can be useful to explain how proximity influences actors' efforts to optimize their costs and capabilities related to and necessary for the development of innovative end-of-life solutions that enable EnvU.

3.3. *Cost-capability ratio*

The concept of cost-capability ratio has been developed to understand how firms in GPNs balance their costs and capabilities to achieve greater value creation and firm-specific capabilities (Coe & Yeung, 2015). These processes and firm strategies vary from firm to firm and give unique outcomes in terms of the ratio (Yeung & Coe, 2015). The concept of the cost-capability ratio enables us to understand how efforts to decrease costs and build capabilities (e.g. technology, knowledge and skills, productivity, organizational routines) can either improve firms' positions in the value chain or force firms to change the activities they are involved in, leading to upgrading or downgrading (Coe & Yeung, 2015). Long-established collaboration and trust (i.e. social proximity) lead to mutual development of capabilities, as well as higher switching costs in the case of the end of collaboration (Gereffi et al., 2005). However, as suggested by Weber (1909), also physical distance (i.e. geographical proximity) can influence costs, implying that firms might need to take it into account to achieve greater value creation.

Previous research has focused mainly on the cost-capability ratio and economic upgrading. Yeung and Coe (2015), for example, suggest that firm actors can achieve higher competitiveness and greater capture of value if they manage to have a low cost-capability ratio. They also argue that continuous improvement in the ratio is crucial for sustaining achieved competitiveness. Therefore, firms need to work continuously to achieve further costs decreases and capabilities development. At the same time, costs also play an important role in EnvU (Ponte, 2020). EnvU is governed through standards and certifications, product design, and knowledge transfer (De Marchi et al., 2019), where standards and certifications, as well as formal requirements regarding design can be seen as institutions (Scott, 1995). Compliance with the standards, changes in product design, and knowledge transfer require either the development of new knowledge and skills or the adoption of new technologies (i.e. development of capabilities) (Yeung & Coe, 2015) as crucial for EnvU. As EnvU can require development of capabilities and influence costs, we suggest that the concept of cost-capability ratio is useful in the analysis of EnvU and we have integrated the concept into the analytical framework of our paper.

4. Methodology

To understand how proximity influences end-of-life EnvU, we applied a qualitative research strategy with a case study as an appropriate research method. We analysed in depth a real-world phenomenon, namely recycling (Yin, 2014). The cases are represented by two separate recycling initiatives in the value chain for plastics in aquaculture. The current value chain for plastic components in Norwegian aquaculture is illustrated in Fig. 1. Component suppliers use plastics as raw materials and provide necessary products to suppliers of complete solutions, who deliver turnkey solutions that include all equipment necessary to farm fish. The complete solution suppliers usually have direct contact with fish farmers who need to buy equipment for setting up fish farms. When fish farmer companies discard used equipment, the equipment goes to waste companies that either process the waste themselves (usually in the form of landfill or by selling it to energy recovery) or, in rare cases, send it to recycling actors.

This paper represents a follow-up study of a thematically broader original study within a research project that focused on issues related to

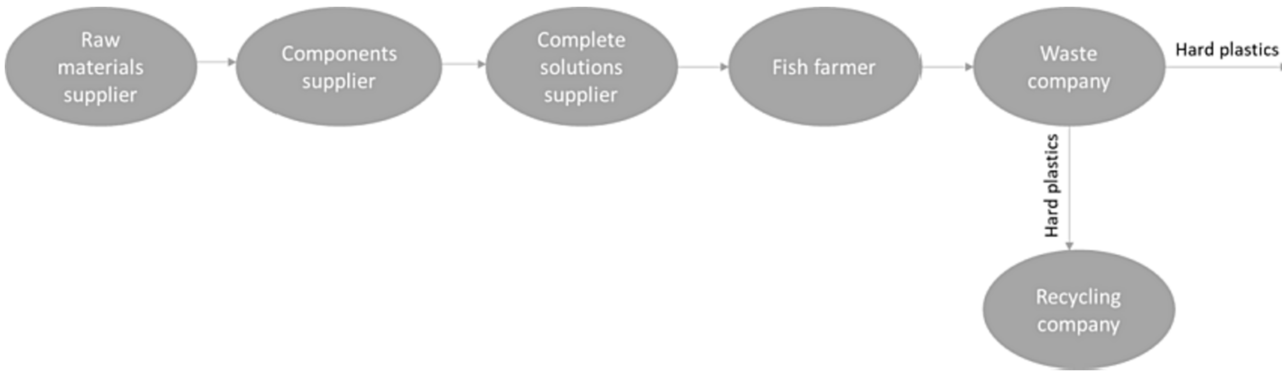

Fig. 1. Actors in the traditional value chain for plastics from Norwegian aquaculture. Source: authors' visualisation.

more sustainable use of discarded plastic equipment from the Norwegian aquaculture sector (Damman et al., 2022). 27 semi-structured interviews with actors within and associated with the Norwegian aquaculture sector on topics related to the handling and recycling of discarded plastic equipment, and the utilization of recycled plastic granulates were conducted in the original study. These data together with secondary data (documents, reports, companies' web pages) created a basis for a deeper investigation of the research question addressed in this paper. The informants were representatives from the aquaculture industry (suppliers and fish farmers), actors in plastics recycling, cluster organizations, actors using recycled granulate from plastics discarded from Norwegian aquaculture, and interest organizations. The sampling strategy for the interviews aimed at covering the whole value chain for plastics in aquaculture, including waste companies and recycling actors. We identified relevant actors through desktop studies and interviews and conversations with the project partners, as well as by using the snowballing method (Bryman, 2016). The interviews in the original study covered all segments within the value chain (see Fig. 1).

We conducted follow-up interviews with one recycling company, one supplier of aquaculture equipment that recycles plastics and uses them in its own production, and two cluster organizations that planned to establish new recycling terminals. In the follow-up interviews, we elaborated on the dimensions of proximity and asked questions related to the influence of proximity on the development of recycling solutions. We conducted follow-up interviews to capture the latest developments that had taken place after the interviews had been held in the original study. Actors interviewed in follow-up round did not provide insights contradictory to their views or the views of other actors in the original interviews.

In addition to interviews, we observed and participated in digital and physical project workshops (2020, 2021, and 2022) in which industry actors discussed challenges and opportunities concerning plastics recycling, availability of resources, and utilization of recycled plastics from aquaculture. Notes from those observations constituted an important part of our empirical data, as they provided in-depth insights into the collaboration on development of recycling schemes for plastics from aquaculture, reflecting especially the social dimension of proximity.

The 27 interviews conducted within the original study were recorded, transcribed, and coded. A thematic analysis for proximity dimensions was later performed for the purpose of this paper. Detailed notes were taken on four follow-up interviews and the notes were subsequently subject to thematic analysis. An overview of interviewed informants and the interviews is provided in Table 1.

Table 1
Overview of all interviews.

No.	Organizations with representative(s) interviewed within the research project	Informant(s) role (s)	No.	Follow-up interview
1	Waste company	Marketing manager		
2	Waste industry organization and waste company	Administrative director and head of aquaculture		
3	Directorate 1	Senior advisor 1 and senior advisor 2		
4	Directorate 2	Project manager and chief engineer		
5	University	Researcher		
6	Research funding body	Chief advisor		
7	Recycling actor 1	Business developer		A follow-up interview request was declined because the informant was ill.
8	Recycling actor 2	R&D advisor	28	yes
9	Interest organization	Head of environment and health		
10	Cluster organization 1	Cluster leader	29	yes
11	Cluster organization 2	Senior advisor 1 and senior advisor 2		
12	Environmental organization	Senior advisor for aquaculture		
13	Aquaculture actor 1	Manager		
14	Aquaculture actor 2	Regional production manager		
15	Aquaculture actor 3	Environment and authorities coordinator		
16	Producer 1	CEO		
17	Producer 2	CEO		
18	Producer 3	Business developer and sustainability manager		
19	Technology supplier	CEO		
20	Total supplier 1	Project manager		
21	Total supplier 2	Sustainability director		
22	Subcontractor 1	CEO	30	yes
23	Subcontractor 2	CEO		
24	Subcontractor 3	Service manager and R&D manager		
25	Subcontractor 4	Development manager and quality assurance manager		
26	Subcontractor 5	Market and development manager		
27	Business incubator	Project manager	31	yes

5. Findings and discussion

5.1. Recycling of plastics from the Norwegian aquaculture industry

While most of the discarded plastic equipment from Norwegian aquaculture goes to energy recovery or landfills, a few recycling initiatives have been developed in recent years. Actors who recycle discarded plastic equipment collect it directly from fish farmers or through waste companies. After recycling and the production of granulate, recycled plastic granulate is sold to component or product suppliers in the aquaculture industry and to other value chains for application in other industries. Therefore, the life of some plastic products and components does not end linearly but continues after the 'end-of-life'. When the data were collected, the sending of plastic equipment to recycling was, however, more an exception than a rule, with only two actors in Norway recycling the equipment made of hard post-consumer plastics (high-density polyethylene, HDPE).

One of the existing recycling initiatives (hereafter referred to as Recycling Initiative 1) was by a recycling company established in 2017, with its roots in a waste company established in 2008 (Recycler 1 in Fig. 2). The recycling company plays a key role in enabling plastics recycling from the Norwegian aquaculture sector. Established as a subsidiary in 2017, the recycling company installed a granulation line and started its recycling activities. The granulation line turns discarded plastic equipment from aquaculture components such as walkways, fish cages, and feeding hoses into high-quality plastic granulate that can be used as input into new products. The recycling company sells its granulate to actors in different industries (furniture, construction and aquaculture). Both the company and the waste treatment company have long been subsidiaries of the same parent company and were co-located. They also shared administration services and collaborated closely on research and development. In 2023 they merged and became one company.

A components supplier (Recycler 2 in Fig. 2) located in northern Norway is behind the second recycling initiative (hereafter referred to as Recycling Initiative 2). This component supplier established a recycling solution for its own components, which it collects (directly or through the local waste companies) from its local customers, local fish farmers, and then mechanically recycles and uses the recycled material in other products that enter value chains outside aquaculture. The company has recently (after 2020) started working on prototypes of aquaculture products made of recycled granulate.

Fig. 2 shows where in the value chain the recycling initiatives take place.

As plastics recycling is a relatively new phenomenon in Norwegian aquaculture, recycling actors are few and, when the interviews were conducted, their organizational routines regarding recycling were still under development. The interviewed actors represented different segments of the value chain, with different organizational structures. The ties between such actors are anchored in their belonging to the value chain at stake, although they preserve high degree of autonomy, which indicates low organizational proximity (Boschma, 2005). Cognitive

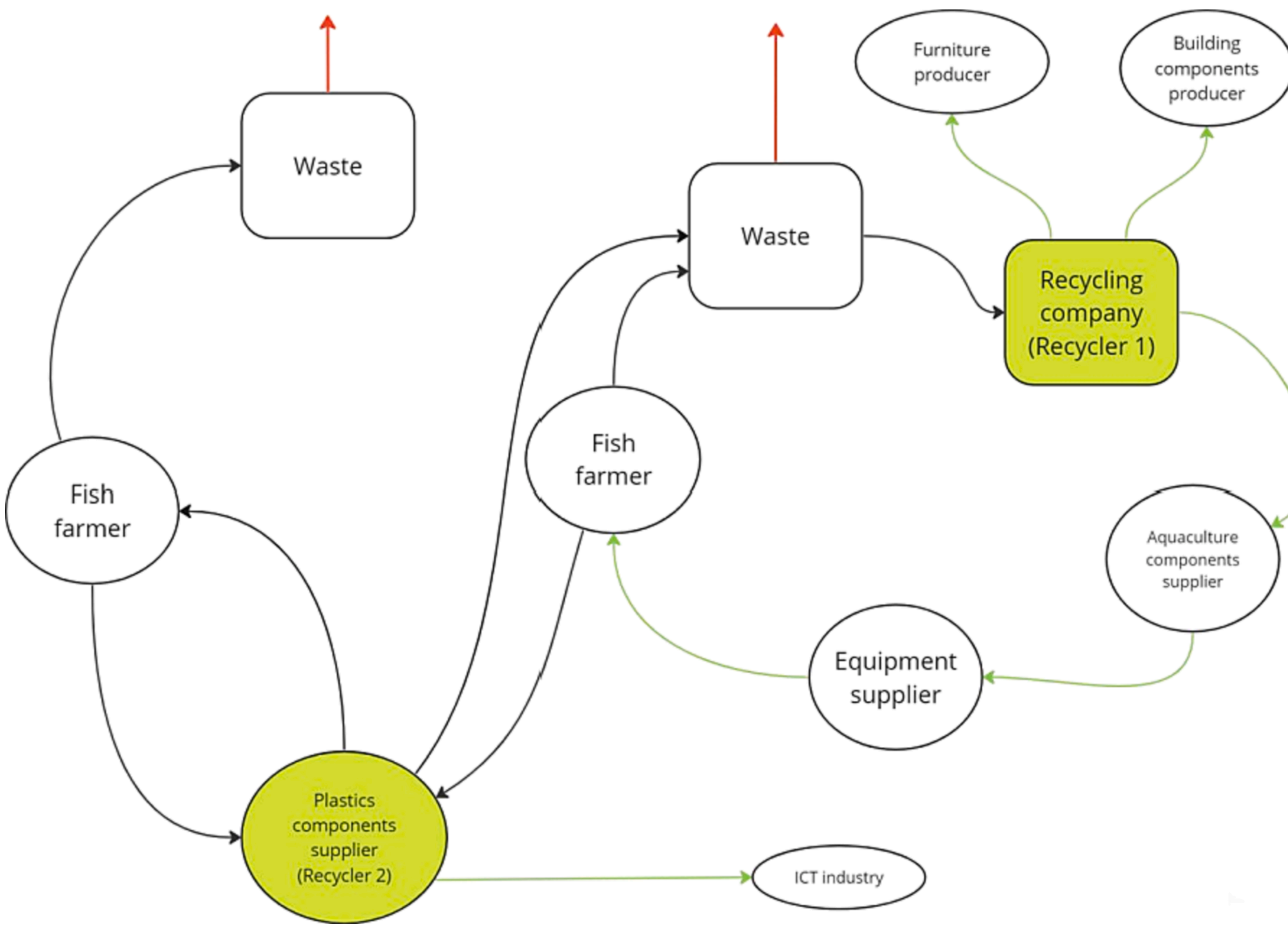

Fig. 2. Recycling initiatives in the plastic components value chain in Norway. Green arrows show the flow of recycled granulate or products made of recycled granulate. The red arrows show the existing linear end-of-life phase for discarded plastic equipment. Black arrows show the flow of hard plastics or components made of hard plastic. Actors, shown in green, recycle plastic equipment. Waste collection and recycling actors are shown in rectangles, and traditional actor firms in the value chain in circles. Source: authors' visualisation.

proximity implies similarities in the actors' knowledge bases, usually as similar educational background or theoretical fields (Boschma, 2005), and the novelty of plastics recycling in the Norwegian aquaculture has resulted in big knowledge gaps among actors in this regard. While actors are working on developing their capabilities in plastics recycling, the knowledge level in different segments of the value chain varies. Actors have identified lack of knowledge and competence as one of the main barriers to plastics recycling, where lack of common knowledge implies low cognitive proximity (Boschma, 2005).

In the following sections (5.2–5.4) we present and discuss our findings on the role of geographical, institutional and social proximity in the development of existing recycling solutions for plastics from the Norwegian aquaculture industry in detail. Our findings indicate that these dimensions have played a more prominent role in the development of the recycling solutions at stake.

5.2. Geographical proximity

Boschma (2005) suggests that geographical proximity between actors involved in innovation processes can be important but emphasizes that other dimensions of proximity can compensate for the lack of geographical proximity. In contrast to Boschma (2005), we have studied actors who possess physical resources, in addition to actors who develop plastics recycling solutions (i.e. actors who innovate). Our findings indicate that the material properties of recycled materials and related logistics condition the importance of geographical proximity in the development of recycling solutions and hence end-of-life EnvU. Hard post-consumer plastic waste from aquaculture is high quality because the equipment from which it is derived does not suffer much degradation during the use phase. In the recycling of plastic components from the aquaculture industry, the material properties of plastics are crucial, as they have good recyclability potential due both to their high quality and large volumes of homogenous materials, and they influence the costs of transportation of the materials due to the low weight of big

Fig. 3. Operating areas of the existing recycling initiatives for plastic components from Norwegian aquaculture. Map source: Esri (2022), authors' modification.

volumes.

As suggested by localization theory (Weber, 1909), geographical proximity strongly influences the transportation aspect and related costs, and our findings show a similar influence of geographical proximity on transportation costs of plastics. The transportation of plastics can become too costly for the owner of discarded equipment due to the material properties of plastics (Int. 22, 28). Plastics have very low weight, and 'transporting plastics is like transporting 90 % air' (Int. 8). However, while Weber (1909) suggests that geographical proximity influences the choice of location of new industries, in our case it influences how existing industry actors develop new activities and where they operate: 'Some things go to Rørvik. They are […] a bit in Finnmark and collect some [plastics], and we are in Nordland County and collect some [there], but in general geography matters, as transporting over long distances is expensive' (Int. 22).

Applying the concept of geographical proximity to the distance between the possessor of the discarded resources and the actors who use these resources as an input factor, we see that the costs of transportation become a direct consequence of geographical proximity. This aspect is especially important in the development of end-of-life EnvU (Hansen et al., 2021) solutions where specific physical materials such as plastics are involved. The learning takes place at the organizational level, since the recycling actors adjust their logistics routes when they collect the plastic (where they go), as well as the recycling schedule itself (how often they go there). High transportation costs are among the reasons why fish farmers choose other ways of treating the discarded equipment, for example by sending it to landfills instead of recycling: 'If we will get a batch of feeding pipes from Finnmark (region) it will be much cheaper for them to send it to a landfill than sending it to us, as the transportation costs are so high' (Int. 8).

To overcome the challenge of transportation, a recycling company (Recycler 1 in Fig. 3) started to operate locally and later built a mobile grinding mill to keep the costs of the recycling activities at an appropriate level and therefore load larger amounts onto the same form of transport than if the plastics had not been pre-processed. Building a mobile grinding mill represents an example of building capabilities in the form of technology (Yeung & Coe, 2015). To preserve its competitive advantage, Recycler 1 continued to develop its capabilities and currently plans to build additional granulation lines to increase the recycling capacity from 3000 to 7000 tonnes per year.

Geographical proximity can ease learning, especially if combined with other forms of proximity. Lack of it can, however, be compensated for by other forms of proximity to ensure learning and interaction between economic actors (Boschma, 2005; Davids & Frenken, 2018). In the first recycling initiative, the geographical proximity between the recycling company and the aquaculture industry was the main reason behind the establishment of the recycling facilities (Int. 8) and did not relate directly to learning. The geographical proximity allowed Recycler 1 to account for transportation costs (as suggested by Weber, 1909) and to reduce them. At the same time, the learning component related to geographical proximity between the recycling actor and the aquaculture industry of the region (Boschma, 2005; Boschma & Frenken, 2010) was present, as the recycling company had its roots in the waste company, which, over a long period of time, received large amounts of waste from the aquaculture industry in the region. This knowledge about the problem's scale was among the reasons for establishing recycling facilities.

A components supplier (Recycler 2 in Fig. 3), which has established a recycling solution for its own components, confirmed that distance and transportation are crucial for the components that are recycled, in line with the view of Weber (1909) on the importance of transportation of goods and materials. Recycler 2 supplies its products to customers in Norway, Russia, Canada, Iceland, and the Faroe Islands, but only recycles products from its local Norwegian customers in the northern part of the country (Int. 22). Therefore, for the end-of-life EnvU of plastics from aquaculture, geographical proximity between the actor who innovates and the actors who possess the resources (waste) is crucial.

5.3. Institutional proximity

Institutional proximity relates to a common institutional framework (Boschma, 2005) comprised of formal and informal institutions. Our findings on institutional proximity indicate the presence of common formal institutions at a rather general level, such as policy documents on circular economy and sustainability. These institutions have influenced attitudes towards the sustainability of actors in the Norwegian aquaculture industry who suggest that dealing with local waste should be a priority. Moreover, the emerging interest concerning the issues of plastics and possibilities for recycling in the aquaculture industry indicates changes in informal institutions in the industry as well. Increasing interest in sustainability and a circular economy leads to actors' expectations of higher prices for virgin plastics in the future, which in turn is expected to result in higher demand for recycled plastics at some point in the future.

When the interviews were conducted, some formal institutions that could drive establishment of recycling solutions in the Norwegian aquaculture industry, such as EPR for fisheries and aquaculture (Miljødirektoratet, 2023), were still under development. While the interviewed actors reported that work on EPR had been ongoing for several years, they had low expectations regarding the formulations of future requirements in that EPR. As of January 2024, no EPR for aquaculture and fishery equipment containing plastics was in place. It has been suggested that future EPR should include requirements regarding collection of plastic waste from fishery and aquaculture and investigation of possibilities for setting requirements that could stimulate recycling and reuse (Miljødirektoratet, 2023). Nevertheless, at the time when the interviews were conducted none of these requirements were expected or foreseen by the actors, and there were no requirements that could drive recycling of plastic waste in Norway.

Similarly, other potential institutional drivers for recycling, such as requirements for certain percentages of recycled content in plastic products or sorting requirements were lacking. However, Norwegian industry provides better sorted materials despite the lack of formal requirements (Int. 31): 'Norway, they were much better to do it [sorting]. This is what one does. It's much easier to get rid of the materials if they are sorted and they will have higher value'.

The interviewed recycling actors and actors who plan to start recycling do not collaborate much with actors from abroad. Some of them assume that customs rules would be a hinderance with regard to what is considered waste or what waste can contain, and would use it as a supporting argument for their current collaboration with local Norwegian actors (Int. 30). Dealing with plastics from Norway can give recycling actors more information about what it contains and therefore enable them to comply with the local requirements on materials quality and safety (Int. 28, 31). While no formal requirement to share information about the plastics content existed when we conducted the interviews, the informants pointed out that Norwegian actors could easily obtain the necessary information on request. This demonstrates how lack of institutional proximity (common institutions) is compensated for by social proximity (Boschma, 2005) in the form of trust, as well as by knowledge about the industry's internal culture.

While the interviewed actors reported the presence of formal institutions for a circular economy at more general level (strategies on circular economy and sustainability) and rather a lack of formal institutions that could drive recycling, there were expectations of possible common governmental requirements that could drive further collaboration on recycling within the industry. The expectations were still unclear, and only a few recycling initiatives were established at that time. The initiatives arose due to identified local needs based on trust and non-formalized agreements, and this points to the importance of social proximity, as we elaborate on further in the next section.

5.4. Social proximity

While geographical proximity between the recycling company and the aquaculture industry helped the company to avoid challenges related to transportation costs (Int. 8), the proximity to the industry led Recycler 1 (recycling company) to believe that access to the discarded materials would not be a problem. Originally, Recycler 1 did not have any formal agreements regarding access to the amounts of discarded plastic resources needed to develop a viable business model for plastics recycling. The company based its decision to start a recycling line on trust and informal contacts with the industry, as well as the belief that the industry would continue to use local actors for discarding their plastic equipment (Int. 8), thereby proving the importance of 'socially embedded relations between agents at the micro-level' (Boschma, 2005, p.66). The trust was crucial for the establishment of a granulation line. The recycling company now sells granulate to actors from different industries, one of which is the aquaculture industry.

Trust and established collaboration have also driven further Recycler 1′s work on improvement to the cost-capability ratio. Over the years, Recycler 1 has improved its knowledge base concerning the material qualities of plastics. To guarantee the quality of its recycled material, Recycler 1 invested in knowledge upgrading by hiring a dedicated resource (a chemist) to run material quality tests in a laboratory; previously such work been outsourced. It also collaborated with external knowledge sources through research projects.

Long established collaboration over many years has enabled further end-of-life EnvU (Hansen et al., 2021) through a new product (a walkway used on fish farms) made of 100 % recycled hard plastics recently introduced to the market. Involved partners (recycling actor, aquaculture components supplier, and fish farmer) collaborated closely to produce and make use of an innovative and more sustainable solution. The trust and relations at the micro-level (i.e. social proximity; Boschma, 2005) between the actors, which had developed through the years of collaboration and interaction, had enabled them to overcome the challenge of lack of demand for a recycled product and to create a completely new product as a result of more interactive learning and better innovative performance.

The aquaculture components supplier and the supplier of complete solutions have, over several years, collaborated on the development of solutions for aquaculture. In addition to this collaboration, the aquaculture components supplier has closely collaborated with the recycling company, Recycler 1. These actors have worked together on the improvement of material properties necessary for the products under development to ensure that recycled materials can deliver the required quality. The components supplier, which buys recycled granulate from Recycler 1, has influenced the decisions of both the fish farmer and the supplier of complete solutions to start the development of a 100 % recycled walkway. This is in line with Boschma's emphasis on the importance of a common collaborator for trust (Boschma, 2005). The fish farmer agreed to purchase a non-existent product under the condition that the components supplier and recycling actor would provide a solution of the equivalent quality. That agreement allowed the components supplier and the equipment supplier to work on the development of the product together with Recycler 1, which ran several tests to find materials of the necessary quality.

The partners in the initiative are neither co-located nor geographically close to each other, so geographical proximity was not influential in the success of the walkway project. This suggests that social proximity developed over time through different forms of collaboration can compensate for lack of other proximity dimensions (Boschma, 2005), especially in later stages of development when trust is established.

Thus, social proximity (Boschma, 2005) has both enabled and pushed the recycling company (Recycler 1) to develop its capabilities (Yeung & Coe, 2015) for conducting end-of-life EnvU (Hansen et al., 2021). These capabilities allowed Recycler 1 to add new activities to its portfolio, indicating that it too has upgraded economically (Humphrey & Schmitz, 2002). The actors involved in the initiative in the long term wish to see whether this new 100 % recycled product can be recycled again and what the quality will be (workshop observations), and therefore they aim to test whether further end-of-life EnvU is possible.

Through another recycling initiative, Recycler 2 (components supplier) receives back its own products used by the aquaculture industry, recycles them, and then makes new products from the recycled granulate. The 'new' products are then used in a different industry. Social proximity was crucial in this recycling initiative. The mere idea to establish a recycling solution came after a meeting with local actors, public and private, who recognized a need to solve the problem of plastic pollution and waste related to fish farming activities in the region. Recycler 2 started collaborating with local entrepreneurs to customize a machine to cut pipes. The cut pipes are put into sacks and transported before they are grinded, melted down, and made into new plastic granulates. Recycler 2 also collaborated with local waste collecting actors, who gathered the used plastic equipment for them (Int. 22). Here, we see an overlap between geographical and social proximity, where colocation has conditioned the creation of regional arenas for social interaction (Boschma, 2005; Davids & Frenken, 2018). Similarly to Recycler 1, Recycler 2 has added some functions in the value chain to its portfolio and therefore also been responsible for economic upgrading (Humphrey & Schmitz, 2002).

Recycler 2 represents an example of the supplier's improvement in the cost-capability ratio (Yeung & Coe, 2015), as it uses its contacts with local entrepreneurs and waste treatment companies to reduce the costs of transportation. The installation of a recycling line required Recycler 2 to develop its capabilities in the form of knowledge of plastics. While the recycled granulate was originally used in the manufacture of products for industries other than aquaculture, Recycler 2 aims in the long-term to reintroduce the resources to aquaculture and to develop its capabilities by experimenting with prototypes of aquaculture products from recycled plastics.

Overall, our findings on the importance of geographical proximity and social proximity may imply that end-of-life EnvU requires collaboration of local actors in the early stages of development when materials properties have to be taken into account. In line with localization theory (Weber, 1909), we argue that as material properties can lead to high transportation costs, end-of-life EnvU preferably needs to take place as close as possible to the potential user of the material or product that results from this form of EnvU. At the same time, our findings show that social proximity compensates for lack of geographical proximity in later stages of development when collaboration occurs between actors not located closely to each other. While lack of institutional proximity for recycling in our cases was compensated for by social proximity, geographical proximity can condition social proximity where the latter takes forms of common culture, norms, and trust (Boschma, 2005; Davids & Frenken, 2018), as our two cases demonstrate.

6. Conclusions

In this paper, we have analysed the role of proximity in development of end-of-life environmental upgrading (EnvU) solutions. We argue that the EnvU literature needs a better understanding of the connection between innovation/the conditions for innovation and EnvU. To provide such an improved understanding, we have combined Boschma's proximity dimensions for innovation (Boschma, 2005) with the GPN concept of cost-capability ratio. We find that the application of these concepts provides a more nuanced understanding of how end-of-life EnvU is developed, as it provides an analytical lens through which to examine how innovation is conditioned by different forms of proximity, and how the innovation processes necessary to achieve EnvU are contingent on the ability of firms to improve their own capabilities and balance costs. In contrast to Boschma (2005), we argue that proximity between actors who possess material resources (in our case plastic waste) and those who are able to utilize these resources is important for the development of end-of-life recycling solutions, in addition to learning and innovation processes. In combining these concepts, our paper contributes to the literature on EnvU of global value chains by unpacking the connection between factors influencing innovation and end-of-life EnvU (Hansen et al., 2021). This paper, therefore, sheds light on conditions for EnvU and how actors conducting EnvU make use of these conditions.

We have applied this analytical framework to recycling of plastics in Norwegian aquaculture considering recycling as end-of-life EnvU. By doing that, we contribute to the literature on EnvU through (1) widening its empirical scope, and (2) our research on a less-studied type of EnvU. In our study, we have demonstrated that geographical, institutional, and social dimensions of proximity as factors influencing innovation and learning processes for EnvU can all be important, although to different extents. Innovation for EnvU requires development of capabilities and balancing costs to develop these capabilities and implement innovation. Our study has demonstrated that social proximity in the form of trust and informal contacts can be decisive for the establishment of recycling solutions in value chains. Trust (i.e. social proximity) can also strengthen collaboration, which in turn can help the involved actors to further optimize their cost-capability ratios. Development of new solutions that require testing by actors make trust between actors conducive to the development of innovative recycling solutions. Geographical proximity can lead to social proximity, but also has an influence on the costs related to recycling activities and transportation costs; therefore, actors need to account for geographical proximity when developing solutions that contribute to end-of-life EnvU where material properties are decisive for the costs part. Lack of formal institutions can to certain extent be compensated for by informal institutions that, in turn, are often conditioned by social and geographical proximity.

We have demonstrated that material properties are of key importance when EnvU is done through the development of recycling schemes, and that proximity can help actors to balance capabilities and costs necessary to achieve the required material properties or to overcome challenges related to these properties. For example, social proximity and collaboration allows actors to test the recycled materials together, while geographical proximity between actors possessing resources and recycling actors allows transportation costs to be kept low. Therefore, geographical proximity can be particularly important in value chains where material properties can increase costs of EnvU. In addition, we have demonstrated that social proximity is important in further development of the innovative solutions, where collaboration includes geographically dispersed actors. This might also apply to end-of-life EnvU in the form of refurbishing, repair, or remanufacturing where physical properties of the products can cause high transportation costs (geographical proximity) or where the demand has not been established (social proximity).

Additionally, our findings in this paper shed light on interconnections between EnvU and economic upgrading. Pursuing EnvU can lead to economic upgrading when companies add new activities to their existing portfolios. These interconnections between EnvU and economic upgrading allow actors to capture more value and could thus be an incentive for existing companies to develop additional capabilities and integrate VC functions. This paper, therefore, supports the calls of the recent research agenda to investigate further the interconnections between different types of upgrading and the possibilities that lie in these interconnections (De Marchi et al., 2019). In addition, we suggest that further research is needed to understand possible consequences of the integration of the functions in the value chains as a result of EnvU for the configuration of the GVC.

Given the current leading role of Norwegian aquaculture and the global reach of Norwegian fish farmers with production in several countries worldwide, it is likely that actions towards ensuring more sustainable use of plastic waste in Norway can pave the way for similar initiatives in other countries. At the same time, our study has demonstrated that geographical, social, and institutional proximity can be important, implying that similar initiatives need to be developed locally together with local actors and adapted to local and regional contexts, at least in the value chains where end-of-life solutions are developed for products with similar material properties as plastics have.

Furthermore, the importance of geographical, institutional, and social proximity for end-of-life EnvU can imply that the global nature of the modern value chains might hinder end-of-life EnvU in the form of recycling, at least for some materials, when the respective actors in these value chains are globally dispersed. High transportation costs of products (waste) to recycling facilities, lack of necessary capabilities, and embeddedness in different institutional contexts might hinder the ability of producers to take responsibility for end-of-life phase of their products, despite the presence of regulatory requirements. Therefore, further research should focus on end-of-life EnvU in value chains for similar materials in other countries or industries, and it should investigate how different dimensions of proximity might influence the development of such end-of-life solutions. In addition, future research could investigate global value chains for other materials to explore further the role of material properties for end-of-life EnvU.

Funding

The Norwegian Research Council (SFI Manufacturing – 237900, Pocoplast - Pathways to sustainable post-consumer plastics in aquaculture, 302455).

CRediT authorship contribution statement

Assiya Kenzhegaliyeva: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing, Visualization. **Henrik Brynthe Lund:** Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Data curation, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Acknowledgements

The work reported in this paper was based on activities within the Centre for Research-Based Innovation SFI Manufacturing in Norway (funded by the Research Council of Norway under grant 237900) and the Collaborative and Knowledge-Building Project on Pathways to sustainable post-consumer plastics in aquaculture (Pocoplast, funded by the Research Council of Norway under grant 302455). The authors thank Asbjørn Karlsen and Markus Steen for valuable feedback on earlier drafts. The authors also thank the research projects' partners and informants.

References

Asheim, B.T., Isaksen, A., 2002. Regional innovation systems: The integrations of local 'sticky' and global 'ubiquitous' knowledge. J. Technol. Transfer 27, 77–86. https://doi.org/10.1023/A:1013100704794.

Balland, P.-A., Boschma, R., Frenken, K., 2015. Proximity and innovation: From statics to dynamics. Reg. Stud. 49 (6), 907–920. https://doi.org/10.1080/00343404.2014.883598.

Balland, P.-A., Boschma, R., Frenken, K., 2022. Proximity, innovation and networks: A concise review and some next steps. In: Torre, A., Gallaud, D. (Eds.), Handbook of Proximity Relations. Edward Elgar Publishing Limited, pp. 70–80.

Barrientos, S., Gereffi, G., Rossi, A., 2011. Economic and social upgrading in global production networks: A new paradigm for a changing world. Int. Labour Rev. 150 (3–4), 319–340. https://doi.org/10.1111/j.1564-913X.2011.00119.x.
Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Res. Policy 37 (3), 407–429. https://doi.org/10.1016/j.respol.2007.12.003.
Bergesen, O., Tveteras, R., 2019. Innovation in seafood value chains: the case of Norway. Aquac. Econ. Manag. 23 (3), 292–320. https://doi.org/10.1080/13657305.2019.1632391.
Boschma, R., 2005. Proximity and Innovation: A Critical Assessment. Reg. Stud. 39 (1), 61–74. https://doi.org/10.1080/0034340052000320887.
Boschma, R., Frenken, K., 2010. The spatial evolution of innovation networks. A proximity perspective. In: Boschma, R., Martin, R. (Eds.), The Handbook of Evolutionary Economic Geography. Edward Elgar Publishing, pp. 120–135.
Broekel, T., Boschma, R., 2012. Knowledge networks in the Dutch aviation industry: the proximity paradox. J. Econ. Geogr. 12 (2), 409–433. https://doi.org/10.1093/jeg/lbr010.
Bryman, A., 2016. Social research methods, (5 ed.). Oxford Univeristy Press.
Coe, N.M., Yeung, H.W., 2019. Global production networks: mapping recent conceptual developments. J. Econ. Geogr. 19 (4), 775–801. https://doi.org/10.1093/jeg/lbz018.
Coe, N.M., Dicken, P., Hess, M., 2008. Global production networks: realizing the potential. J. Econ. Geogr. 8 (3), 271–295. https://doi.org/10.1093/jeg/lbn002.
Coe, N.M., Yeung, H.W., 2015. Global production networks. Theorizing economic development in an interconnected world. Oxford University Press.
Damman, S., Lund, H.B., Kenzhegaliyeva, A., Lindberg, H.Ø. & Ullern, E.F., 2022. Fra oppdrettplast til verdi. Drivere og barrierer for sirkulær økonomi basert på hardplast fra norsk havbruk. (In Norwegian, From aquaculture plastics to value. Drivers and barriers for circular economy based on hard plastics from Norwegian aquaculture). FINAL-WP2+rapport_POCOplast+%28part+1%29+-+signed%5B2%5D.pdf (ntnu.no).
Davids, M., Frenken, K., 2018. Proximity, knowledge base and the innovation process: towards an integrated framework. Reg. Stud. 52 (1), 23–34. https://doi.org/10.1080/00343404.2017.1287349.
De Marchi, V., Di Maria, E., Micelli, S., 2013a. Environmental strategies, upgrading and competitive advantage in global value chains. Bus. Strateg. Environ. 22 (1), 62–72. https://doi.org/10.1002/bse.1738.
De Marchi, V., Di Maria, E., Ponte, S., 2013b. The greening of global value chains: Insights from the furniture industry. Compet. Chang. 17 (4), 299–318. https://doi.org/10.1179/1024529413Z.00000000040.
De Marchi, V., Di Maria, E., 2019. Environmental upgrading and suppliers' agency in the leather global value chain. Sustainability 11 (23), 6530. https://doi.org/10.3390/su11236530.
De Marchi, V., Di Maria, E., Krishnan, A., Ponte, S., 2019. Environmental upgrading in global value chains. In: Ponte, S., Gereffi, G., Raj-Reichert, G. (Eds.), Handbook on Global Value Chains, (2021 ed.). Edward Elgar Publishing Limited.
Dicken, P., 2011. Global shift. Mapping the changing contours of the world economy, (6 ed.). The Guilford Press.
FHF. (2019). Rent hav – plast: Marin plast fra norsk sjømatnæring – Kartlegging, kvantifisering og handling - HAVPLAST (In Norwegian: Clean ocean - plastics: Marine plastics from the Norwegian seafood industry - Mapping quantifying and acting). Retrieved 22.01.2024 from https://www.fhf.no/prosjekter/prosjektbasen/901518/.
Fiskeridirektoratet. (n.d.). *Plast i havet (In Norwegian: Plastics in the ocean)*. Retrieved 08.12.2021 from https://www.fiskeridir.no/Areal-og-miljo/Marin-forsoepling/plast-i-havet.
Gereffi, G., 1994. The organization of buyer-driven global commodity chains. In: Gereffi, G., Korzeniewicz, M. (Eds.), Commodity Chains and Global Capitalism. Greenwood, pp. 95–122.
Gereffi, G., 2019. Economic upgrading in global value chains. In: Ponte, S., Gereffi, G., Raj-Reichert, G. (Eds.), Handbook on Global Value Chains. Edward Elgar Publishing.
Gereffi, G., & Fernandez-Stark, K. (2011). *Global value chain analysis: A primer*. Durham NC: Duke Center on Globalization, Governance and Competitiveness.
Gereffi, G., Humphrey, J., Sturgeon, T., 2005. The governance of global value chains. Rev. Int. Polit. Econ. 12 (1), 78–104. https://doi.org/10.1080/09692290500049805.
Hansen, U.E., Nygaard, I., Dal Maso, M., 2021. The dark side of the sun: solar e-waste and environmental upgrading in the off-grid solar PV value chain. Ind. Innov. 28 (1), 58–78. https://doi.org/10.1080/13662716.2020.1753019.
Havas, V., Falk-Andersson, J., Deshpande, P., 2022. Small circles: The role of physical distance in plastics recycling. Sci. Total Environ. 831 https://doi.org/10.1016/j.scitotenv.2022.154913.
Humphrey, J., Schmitz, H., 2002. How does insertion in global value chains affect upgrading in industrial clusters? Reg. Stud. 36 (9), 1017–1027. https://doi.org/10.1080/0034340022000022198.
Iversen, A., Asche, F., Hermansen, O., Nystoyl, R., 2020. Production cost and competitiveness in major salmon farming countries 2003–2018. Aquaculture 522, 725089. https://doi.org/10.1016/j.aquaculture.2020.735089.
Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B.Å., 2007. Forms of knowledge and modes of innovation. Res. Policy 36 (5), 680–693. https://doi.org/10.1016/j.respol.2007.01.006.
Khan, M.J., Ponte, S., Lund-Thomsen, P., 2020. The 'factory manager dilemma': Purchasing practices and environmental upgrading in apparel global value chains. Environment and Planning a-Economy and Space. 52 (4), 766–789. https://doi.org/10.1177/0308518x19876945.
Kirat, T., Lung, Y., 1999. Innovation and proximity - Territories as loci of collective learning processes. Eur. Urban Reg. Stud. 6 (1), 27–38. https://doi.org/10.1177/096977649900600103.
Krishnan, A., 2017. Re-thinking the environmental dimensions of upgrading and embeddedness in production networks: The case of Kenyan horticulture farmers. [University of Manchester].
Lundvall, B.-Å., 1992. National systems of innovation: towards a theory of innovation and interactive learning. Pinter.
Malerba, F., 2005. Sectoral systems of innovation: a framework for linking innovation to the knowledge base, structure and dynamics of sectors. Econ. Innov. New Technol. 14 (1–2), 63–82. https://doi.org/10.1080/1043859042000228688.
MEPEX, 2018. Underlag for å utrede produsentansvarsordning for fiskeri og akvakulturnæringen. Basis to investigate producer responsibility scheme for fisheries and aquaculture industry, In Norwegian https://www.miljodirektoratet.no/globalassets/publikasjoner/m1052/m1052.pdf.
Miljødirektoratet, 2023. Videreutvikling av produsentansvaret i Norge. Svar på oppdrag fra KLD - gjennomgang av produsentansvaret - del 2. Further development of producer responsibility in Norway, In Norwegian https://www.miljodirektoratet.no/sharepoint/downloaditem/?id=01FM3LD2SZGGWDWVNUHVDKGVGJV7LHTYV4.
N.g. (2021). Rekordår for eksport av norsk sjømat (In Norwegian: A record year for the export of the Norwegian seafood). *Nettavisen*. Retrieved 02.02.2022, from https://www.nettavisen.no/nyheter/innenriks/rekordar-for-eksport-av-norsk-sjomat/s/12-95-3424227396.
Nærings- og Fiskeridepartementet. (2021). Et hav av muligheter - regjeringens havbruksstrategi (In Norwegian: An ocean of possibilities - the Government's aquaculture strategy). https://www.regjeringen.no/contentassets/e430ad7a314e4039a90829fcd84c012a/no/pdfs/et-hav-av-muligheter.pdf.
Norsk industri. (2017). *Veikart for havbruksnæringen. Sunn vekst (In Norwegian: Roadmap for the aquaculture industry. Healthy growth)*. https://www.norskindustri.no/siteassets/dokumenter/rapporter-og-brosjyrer/veikart-havbruksnaringen_f41_web.pdf.
Nygård, F., & Kristoffersen, K. J. (2021). Vil resirkulere 3000 tonn plastavfall i året: – Plast er et fantastisk materiale (In Norwegian: Want to recycle 3000 tonnes plastic waste a year: - Plastics is a fantasic material). *NRK*. https://www.nrk.no/nordland/vil-resirkulere-3000-tonn-plastavfall-fra-oppdrettsindustrien-og-nova-sea-1.15505982.
Ponte, S., 2020. The hidden costs of environmental upgrading in global value chains. Rev. Int. Polit. Econ. https://doi.org/10.1080/09692290.2020.1816199.
Scott, W.R., 1995. Institutions and organizations. Sage. Publications.
Norges Sjømatråd. (2021). 10 største eksportmarkeder hittil i år, 2021. (In Norwegian: 10 largest export markets until now this year, 2021). Retrieved 22.01.2024, from https://seafood.no/markedsinnsikt/nokkeltall/.
Norges Sjømatråd. (2023). Ny undersøkelse: Hvilken vei svømmer laksen? (In Norwegian: New analysis: where is the salmon swimming?). Retrieved 22.01.2024, from https://seafood.no/aktuelt/nyheter/ny-undersokelse-hvilken-vei-svommer-laksen/.
Skirtun, M., Sandra, M., Strietman, W.J., van den Burg, S.W.K., De Raedemaecker, F., Devriese, L.I., 2022. Plastic pollution pathways from marine aquaculture practices and potential solutions for the North-East Atlantic region. Mar. Pollut. Bull. 174, 113178 https://doi.org/10.1016/j.marpolbul.2021.113178.
Torre, A., 2008. On the role played by temporary geographical proximity in knowledge transmission. Reg. Stud. 42 (6), 869–889. https://doi.org/10.1080/00343400801922814.
Torre, A., Rallet, A., 2005. Proximity and Localization. Reg. Stud. 39 (1), 47–59. https://doi.org/10.1080/0034340052000320842.
Velenturf, A.P.M., Jensen, P.D., 2016. Promoting Industrial Symbiosis: Using the Concept of Proximity to Explore Social Network Development. J. Ind. Ecol. 20 (4), 700–709. https://doi.org/10.1111/jiec.12315.
Weber, A., 1909. Über den Standord der Industrien (In German: About the location of the industries). Mohr.
Tveteras, R., Hovland, M., Reve, T., Misund, B., Nystoyl, R., Bjelland, V., Misund, A., & Fjelldal, Ø. (2020). *Value creation potential and roadmap for offshore aquaculture*. https://www.uis.no/sites/default/files/inline-images/iwoCs5gOwRqdnyMH9CIHv8ORymSafzsLMkLIb4w6hqj9nzV0GC.pdf.
World Aquaculture Society. (2020). Plastics in Aquaculture – The WAS-IMarEST Roundtables. https://www.was.org/articles/Plastics-in-Aquaculture-The-WAS-IMarEST-Roundtables.aspx#.
Yeung, H.W., Coe, N.M., 2015. Toward a Dynamic Theory of Global Production Networks. Econ. Geogr 91 (1), 29–58. https://doi.org/10.1111/ecge.12063.
Yin, R.K., 2014. Case Study Research. Design and Methods, (5th ed.). Sage.