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CIRCULAR MATERIAL FLOWS, THE TWIN TRANSITION OF MANUFACTURING, AND THE FUTURE OF LABOUR

Insights from a Case Study of the Peniche Ocean Watch Initiative

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14.1 Introduction

In recent years, ocean plastics have emerged as a critical concern that transcends geographical boundaries and industrial and societal sectors. The Anthropocene era, marked by humanity's transformative impact on the planet, has witnessed the rapid rise of modern societies, technological advancements, and mass production practices. However, as the Anthropocene evolves, its defining characteristics are becoming increasingly entwined with the consequences of these very advancements. Notably, the relentless onslaught of the climate crisis, global warming, and the pervasive presence of ocean plastics are reshaping the narrative of this era (Ashton, 1997; Cressey, 2016; Sörlin, 2017). Here we define ocean plastics as both (1) ocean-bound plastic that has been defined as abandoned plastic waste located within 50 km from shores and is at risk of ending up in the ocean due to inefficient or nonexistent waste management practices and (2) plastic waste that is used in ocean-based industries, for example, fishing nets that may be disposed of through landfilling or incineration or that may be abandoned at sea or on land.

Ocean plastics, a manifestation of the challenges borne from our industrial world, have assumed a prominent place on the global agenda. In this chapter, we address the multifaceted dimensions of this issue, encompassing environmental, socio-economic, and technological aspects, with a focus on the urgent need for concerted action. While the problem of ocean plastics is already dire, projections indicate that its magnitude is poised to escalate exponentially in the near future. The oceans that connect the continents around the world, sometimes referred to

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as a modern-day “no man’s land”, raise pressing questions around responsibility and accountability. Who bears the responsibility for addressing the consequences of plastic pollution, and how can the costs be equitably shared? This dilemma is further complicated by the far-reaching repercussions that stretch beyond the scope of marine ecosystems alone.

The challenges posed by ocean plastics extend their influence across diverse sectors. Coastal communities, traditionally reliant on fishing and supporting industries, such as packaging and shipyards, confront the threat of diminishing livelihoods and smaller tax bases. Further, the hopes that the tourism sector would provide new livelihoods are now being dashed as coastal areas are often plagued by polluted beaches or rising tides washing beaches away, while harmful algae blooms and other bacteria-infested pollution proliferate in the water. Moreover, the nasty tentacles of this issue reach far inland, affecting the agricultural industry through rising sea levels and temperature shifts.

In juxtaposition to the complexities and uncertainties, one undeniable truth emerges – ocean plastics are indeed everyone’s problem. The global nature of the climate crisis underlines the inextricable interconnectedness of all nations and societies. Escaping the consequences of environmental degradation and plastic pollution is not an option; it is a challenge that demands collective action on a global scale.

Amidst the challenges, a glimmer of opportunity is emerging. This chapter recognises the potential of the labour market to harness innovation, entrepreneurship, and technological advancements to not only mitigate the impact of ocean plastics but also to transform the socio-economic landscape of coastal communities. The sheer scale of the problem opens doors to novel business models and technologies that can catalyse positive change. A pertinent avenue for exploration is the role of digital transformation and the “twin transition” – a symbiotic progression towards ecological sustainability and economic prosperity enabled through digital technologies.

To explore this idea, we present and discuss the case of the Peniche Ocean Watch Initiative. This initiative was founded by three of this chapter’s authors in 2018 in Portugal in order to develop a “blue circular economy” model, that is, a circular economy model grounded in ocean resources. Through efforts to develop its microfactory concept encompassing the digital transformation of manufacturing, the Peniche Ocean Watch Initiative has enabled the re-routing and re-imagining of ocean plastics into valuable materials while closing the loop through the creation of new opportunities for the labour market.

In essence, this chapter embarks on a comprehensive exploration of the multifaceted challenge posed by ocean plastics. It navigates the intricate interplay of environmental concerns, socio-economic impacts, and technological innovations, all the while advocating for a collective and global response to this defining issue of our time. As we stand at the precipice of a critical juncture, the solutions we devise and the actions we take will undoubtedly shape the course of the Anthropocene era for generations to come.

14.2 Ocean Plastics: A Brief Background

Ocean plastics serve as a poignant symbol of how industrial development and globalisation have led to long-term unintended consequences for society and the environment. While the first plastics can be traced back to 1855 when celluloid was made from cellulose, a natural polymer in plants, it was not until the 1950s and 1960s that plastic production really started booming. This initial growth was characterised by consumer goods such as plastic bottles, containers, and other disposable products becoming ubiquitous in the Western world. A second boom for plastics then emerged on a global level in the late 1990s due to a combination of factors. New types of plastics were developed, such as polyethylene terephthalate (PET) for beverage bottles and expanded polystyrene (EPS) for packaging and insulation. On the supply side, plastic became the option of first choice for packaging and goods as supply chains became more globally integrated and transportation distances increased due to plastic's relative lightweight and durability compared to other materials such as glass, metal, or wood. Additionally, increased industrialisation combined with falling prices of energy, petroleum, and petrochemicals led to economies of scale and the mass production of plastic. As a result, annual plastics production has increased from two million tonnes in 1950 to over 413 million tonnes in 2023 and is expected to further increase to 1480 million tonnes by 2050 (Plastics Europe, 2022; Statista, 2024). Today the global plastics industry is highly concentrated with multinationals such as BASF SE, Celanese Corporation, Dow Inc., DuPont de Nemours, Inc., and Sumitomo Chemical Co. Ltd., as well as a few medium and small regional players (Grand View Research, 2023).

On the demand side, increasing urbanisation and fast-paced lifestyles together with mass marketing by fast-moving consumer goods multinationals has led to the demand for convenience products while globalisation has led to greater purchasing power of an expanding middle class in emerging economies and thus an increasing demand for consumer goods, predominantly made of plastic. As a result, plastic has become integral in our everyday lives and in just about every industry.

Our linear economy continues to prioritise the mass production, consumption, and disposal of goods, with neither accountability nor consideration of the long-term environmental impact, while a disposable culture emphasises convenience and disposability over durability and reusability. Despite recent advances within sustainability, around 90% of global plastic production is still from fossil-based raw material as manufacturers prefer virgin plastic due to its relatively low price and high quality and reliability (World Economic Forum, 2016). In 2021, bio-based/bioattributed plastics accounted for only 1.5% of world plastics production while around 8% were from post-consumer recycled plastics (Plastics Europe, 2022). Of note is that only around 9% of plastics produced since 1950 have been recycled

(Geyer, Jambeck, & Law, 2017), and one challenge to recycling is that plastics not only are produced with numerous potentially hazardous chemical compounds, but they also can absorb contaminants throughout their life cycle (Carmona et al., 2023; Plastics Europe, 2022).

As many plastics take hundreds of years to degrade, between 75 and 199 million tonnes are estimated to be now in our oceans with a further 8 to 14 million tonnes entering annually (Oceana, 2022; Sebille, 2016; Wakefield, 2022). The Great Pacific Garbage Patch, the largest of many accumulation zones, spans an area three times the size of France and weighs as much as 500 jumbo jets, and studies find that fishing gear, such as nets, lines, and traps, comprise 20–50% of the patch (Lebreton et al., 2018). Microplastics, defined as less than five millimetres in size, are now everywhere – from polystyrene fragments and polyethylene in the Mariana Trench, which holds the Earth's deepest known oceanic point – the Challenger Deep. Further, some studies are reporting 94,000 particles per litre in our drinking water and microplastics in our lungs and breast milk (World Health Organization, 2019).

In many countries, not only is the recycling infrastructure inadequate, but there is little monetary or other incentive for individuals or organisations to recycle, which is further compounded by the low level of awareness of the environmental, health, and societal effects of plastic pollution. Plastic pollution harms ecosystems and wildlife, and 90% of damage to marine wildlife is due to plastic waste while 700 marine species are threatened by plastic pollution (Chatziparaskeva, Papamichael, & Zorpas, 2022). Plastics leach harmful chemicals into the environment in addition to transferring additives, lethal metals, and other contaminants, for example, organic chemicals such as persistent organic pollutants (POP) that are toxic to animals and humans by consumption. Plastic pollution imposes significant economic costs, including clean-up expenses, damage to tourism, and impacts on fisheries and aquaculture, and the annual cost of marine litter is estimated to be around US$2.5 trillion (Chatziparaskeva et al., 2022).

14.3 Sustainability on the Agenda, but What about Circularity?

Currently, governments and practitioners alike are looking for more sustainable approaches to tackle the negative spiral brought on by the linear economy, such as that presented earlier. Initiatives such as sustainable development, ecosystems, environmental stewardship, corporate social responsibility, Environmental, Social, and Governance (ESG), green and blue transitions, and twin transitions are being developed and implemented to help fulfil the United Nations Sustainable Development Goals (United Nations, 2024). A central, recurring element in many initiatives is the concept of "circularity" – spanning from circular economy models, for example, Zeiss, Ixmeier, Recker, and Kranz (2021), circular material flows (MF theory) (Bucknall, 2020) and recirculation of natural resources (Chen, 2009) to circularity and waste management, for example, Cobo, Dominguez-Ramos, and Irabien (2018).

Unfortunately, while sustainability is seemingly on almost everyone's agenda, most efforts pertain to merely sustaining the status quo. For instance, we recognise the significant issues related to CO_2 emissions from fossil fuelled cars, but rather than critically questioning the use of cars and whether individuals should own a car, we seek instead to find alternative fuel sources. Ethanol was an up-and-coming candidate just a decade ago, and now batteries for electric cars are on the agenda. Thus, a life cycle or a holistic perspective is rarely taken. Indeed, few are aware or wish to acknowledge that for every tonne of mined lithium, 1.9 tonnes of water are required, with the added emission of 15 tonnes of CO_2 in the process (Crawford, 2022; Katwala, 2018). Mining lithium, cobalt, and nickel requires hazardous chemicals and extensive manual labour (sometimes even child labour) in areas where water is scarce, and runoff contaminates underground water sources (McKie, 2021). Conversely, China, where around 77% of all batteries are produced, uses coal as its primary energy source (Crawford, 2022).

Moreover, electric cars are generally heavier than their counterparts due to their battery packs. The average electric car weighs 1.9 tonnes with the largest SUVs strikingly heavy, for example, Mercedes EQV at 2.96 tonnes, Audi e-tron 55 at 2.72 tonnes (Kane, 2021). It is no wonder that some have labelled this development "the green paradox" (Larsson & Hatzigeorgiou, 2022). Meanwhile, cars on the road continue to grow, requiring ever more resources. In 2020, of the 56 million new cars sold globally, 56% or 30.1 million were SUVs (of which 29.6 million were fossil fuel and 1.1 million electric), a sixfold increase in just nine years (Bekker, 2023; Carlier, 2023). To build these cars, extensive global supply chains providing the 30,000 parts for an average car have been created with little transparency (DataInterchange, 2021). Indeed, Renault was the only company as of 2022 requesting that members of its supply chain set targets aligned with the Paris Agreement (Wood, 2022). When it comes to end of life, while around 80% of automobile content by weight is recycled (LeBlanc, 2019), only 25–30% of a new automobile is made from recycled materials, meaning that 70–75% is still virgin materials extracted from the earth (Renault Group, 2022). The sustainability goals set by some of the globe's largest auto manufacturers could be claimed to not even be that inspiring, for example, Volvo – 35% recycled materials by 2030, Mercedes – 40% recycled materials by 2030, and BMW – an aim to use 50% recycled materials but with no year designated (BMW Group, 2024; Mercedes-Benz Group, 2024; Volvo, 2024).

Thus, it appears that our common approach is merely "to treat the symptom and not the disease" as we continue our journey towards resource depletion. Perhaps this is why, as noted by the 2023 Circularity Gap Report, only 7.2% of the world is circular as of 2023, a number that has declined from 9.1% in 2018 due to increasing raw material extraction, build-up of material stocks, and low levels of end-of-use processing and cycling (Circle Economy Foundation, 2023; Larsson, 2021). Thus, researchers are increasingly realising that to truly reach a circular economy, a systems-level transformation must be achieved (Despeisse et al., 2017), in which our dominant linear models of production and consumption and belief systems are challenged.

14.4 Re-routing the Tide for Community Resilience: Re-imagining Waste as a Valuable Resource through the Twin Transformation of Manufacturing

Moving forward, we need to take a more holistic perspective and find alternatives to challenge and break the "take→make→use→waste" linear material flow. It is not only about the plastic materials, the waste, and the pollution, but it is also about the larger system in which plastics are embedded – that is the material practice surrounding these materials – ranging from the sourcing of material to the production facility to the distribution channels, to the customer, and to their final destination. We think about this not only as a "call to action" but also as a "call to re-imagine and re-route". It is meaningless to just act if we do not also change the underlying system – so that new material practices can be established, including means for repurposing, and reusing, and maybe even repairing the things we make.

However, material practices are not easily changed. According to Giddens' (1984) structuration theory, structures are established over time, through patterns of practices, which in return are maintained and adapted through the exercise of agency. What we repeatedly do forms our practices, and over time these practices form structures that are exceptionally difficult to change. Accordingly, to change or "re-imagine" current practices, including "re-routing" established material flows, is not something that can occur quickly nor only because new rules, laws, regulations, or policies are implemented. Instead, it changes through the exercise of agency that is through actions taken by individuals, repeatedly and over time. We can lead by example, but for large-scale change to occur, we need to repeatedly act and approach materials in alternative ways – to exercise agency, to form new practices over time, and to form new structures that govern material flows. Thus, to help us on this transformation, we are following these principles in the establishment of new material practices, and, in particular, using the case of ocean plastics to create a sense of urgency. The trajectory of ocean plastics and its direct and indirect effects on the environment and coastal communities presents an unparalleled opportunity for change.

Currently about 40% of the global population lives within 100 kilometres from the coast (Burke et al., 2001). The ocean and its living resources are the primary source of food, livelihood, community, and even identity for hundreds of millions of people across the globe. For centuries, traditions and cultural norms around fishing practices have been followed, ensuring not only that the collective resource was conserved and replenished but also creating a collective spirit and sense of community. However, similar to many other industries, industrialisation and globalisation have, since the 1950s, brought about a disassociation between the development of a modern industry and the development of those traditionally involved in the industry. Within the fishing industry, industrialisation has led to significant efficiency through new technologies such as radar, sonar, and electronic navigation systems while global policies opened waters for large-scale fishing fleets. As a result, demersal (bottom) trawl nets have destroyed coral reefs, and large-scale fishing fleets and illegal fishing have overfished waters across the globe. It is estimated that nearly 90% of global fish stocks are overexploited, depleted, fully exploited, or in recovery from exploitation (Kituyi, 2018). In recent years, fishing bans and regulations in areas across the globe have cut off the livelihoods of not only the fishermen but also those working in supporting jobs such as boat building, gear manufacturing, and packaging. Furthermore, the ocean is also threatened by climate change and industrialisation in other sectors that have led to effects such as increased algae growth due to fertiliser runoff and migrating fish due to warmer waters.

For coastal communities, the effects of industrialisation and globalisation have been devastating. For example, the Atlantic Northwest cod industry collapsed in the early 1990s, and 35,000 fishermen and plant workers lost their jobs (Gien, 2000). Today West-African fisheries have declined by around 50% in the past 30 odd years (Vince, 2022). A 2011 study found that 99% of all fishermen in the world were small-scale fishers (Shester & Micheli, 2011); however, only a small percentage of the world's fishers and fishing communities actually have benefited from industrialisation and globalisation. As a result, coastal communities have become increasingly poor (Campbell, Whittingham, & Townsley, 2006). For example, in the UK, these communities have higher rates of unemployment, poorer health, and lower wages and lag in digitalisation while experiencing a brain drain and other demographic challenges as younger residents leave for cities while the number of pensioners grows (Ward, Cromarty, Garratt, & Barton, 2022). At the individual level, there is a sense of lost identity and hopelessness in addition to addiction, such as gambling and alcoholism. Coastal communities have become trapped in a cycle of disadvantage as they are unattractive for investment and do not have access to the resources or power needed to tap into new opportunities. One study in the UK revealed that individuals in coastal communities were around 44% less likely to start a business, and those individuals who did start a business were 24% more likely to go into insolvency than their counterparts in non-coastal communities (Carpenter & Balata, 2018).

Recent years have led to an increase in tourism due to economic development and changing consumer values, deregulation, and low-fare airlines combined with digitalisation (OECD, 2016). While tourism may create jobs and bring income, highly seasonal tourism leads not only to a low-level of local services during the off-season but also to difficulties in providing the necessary health and social care for locals year-round. Even anti-social behaviours of visitors and pollution can further worsen the situation for the locals. Finally, tourism brings jobs that tend to be relatively low skilled, low paid, and highly seasonal, leading to a highly transient and seasonal workforce that does little to build the skill base and resilience of the local community nor enable a coastal community to maintain strides with urban areas when it comes digitalisation.

14.5 Peniche Ocean Watch Initiative: Driving Change through Engaged Scholarship

By devising effective strategies to mitigate these environmental and socio-economic repercussions, we can pave the way for a more equitable and sustainable future. Together the first co-author and an international team of practitioners and researchers under the umbrella of the Peniche Ocean Watch Initiative are currently developing the concept of a blue circular economy model in Peniche, Portugal.

Peniche lies 95 kilometres northwest of Lisbon and is one of the largest traditional fishing ports in Portugal. Gillnet fishing is the second most common fishing practice in Peniche, with 40 boats operating from the Peniche port. The environmental challenge is that gillnets are used only once or twice, and while some nets are lost or dumped at sea, every year more than 40,000 kilos of discarded gillnets are dumped in the Peniche harbour, before ultimately ending up in landfills or burned at incineration sites. The environmental impact is alarming as burning just one tonne of fishing nets releases 2.9 tonnes of CO_2 emissions (QMRE, 2023).

To solve this unsustainable practice and close the loop of plastic production while enabling a more resilient community through jobs and digitalisation, a systems-level transformation must be achieved. Peniche Ocean Watch's vision since its start in 2018 is to digitally transform manufacturing through developing a circular model based on its "microfactory" concept. The primary idea behind the microfactory concept is that a local industrial waste stream, for example, plastic, is collected and recycled into a secondary raw material that is then fed into a large-scale additive manufacturing machine that produces large products on demand for the local market – *all within the walls of the same production facility*. The microfactory concept can then be "scaled" out through creating a global network of microfactories connected through a digital platform on the Internet. This solution would enable firms to manufacture their products from local waste streams on demand and close to a local market, without lengthy transportation times or the risk of being exposed to supply chain shocks.

Since 2018, the Peniche Ocean Watch team has been developing the microfactory concept together with local fishermen and other community members. To move towards the circular model, the company Circular Ocean Lda was founded under the Peniche Ocean Watch Initiative to collect, sort, clean, and shred discarded gillnets in Peniche. Sorting and cleaning are a manually labour-intensive process as it requires handiwork of individuals to ensure a clean, monomaterial, that is, comprising only one plastic type. The gillnets are made from polyamide 6 (PA6 – nylon), while the ropes are made from other plastic types and therefore need to be removed. Further, other objects such as fishhooks, fish, seaweed, and other biomaterial must also be removed before the nets are washed. Once the nets are dry, they are shredded and then compounded into pellets and filaments for manufacturing under the name of PENYLON™. To date, Peniche Ocean Watch has recycled around 90 tonnes of fishing nets, preventing the emission of 232 tonnes of CO_2.

While the goal of the microfactory concept is to produce products in Peniche from the PENYLON material for the local market, initial attempts by Peniche Ocean Watch to complete the circle were unsuccessful. Portugal did not have the design or additive manufacturing skills nor was there an interest from the local market for such sustainable, innovative products. Thus, to complete the circle, some team members founded Ekbacken Studios AB in Sweden to produce high design furniture from the PENYLON material using large-scale additive manufacturing. However, as Ekbacken Studios was a start-up, it was difficult to arrange financing for the purchase of large-scale additive manufacturing machines to produce in-house. As a result, Circular Ocean and Ekbacken Studios partnered with Research Institutes of Sweden (RISE), Artex AB, and The Industry AB to gain access to their production equipment and facilities. Ekbacken Studios also designed its products such that at the end of their life, they could be returned, shredded, pelletized, and then printed once again, thereby closing the loop. Of significance is that IVL – the Swedish Environmental Research Institute calculated that even with the transportation of the PENYLON material to Sweden from Portugal, there is a remarkable approximate 90% reduction in CO_2 compared to manufacturing with virgin plastic.

In addition to the above, the team's efforts have resulted in two interdisciplinary innovation research projects: OCEAN-LSAM in 2022 and SuRF-LSAM in 2023, under Sweden's Produktion2030 Strategic Innovation Program financed by Vinnova – Sweden's Innovation Agency, the Swedish Energy Agency, and the Swedish Research Council for Sustainable Development. The overarching objective of these projects is to turn the network of microfactories concept into reality in Portugal and Sweden by the year 2027, with the further aim to replicate and implement the microfactory concept in coastal communities worldwide, while empowering local communities with entrepreneurial mindsets and stimulating their local economies.

Thus, this "blue circular economy" model re-imagines the traditional linear model of centralised production that overproduces a standardised product to reduce unit costs through economies of scale for global transportation. Peniche Ocean Watch's novel solution enables the production of customised or smaller quantities of products on demand using local recycled materials for delivery to local buyers. Products will then be both easily traceable and returnable to the microfactory for further recycling and remanufacturing into new products for the local market. Further, through the digital platform, a company, for example, in Sweden can sustainably meet the demands of customers in Portugal as it can design a customised product for local production in Portugal, thereby not only reducing transportation costs but also delivery times.

Regarding labour, throughout this circular flow enabled by the microfactory concept, we have found that new forms of labour have been created – from more manual routine to more highly skilled, non-routine work. The beginning of the circular material process requires (1) extensive manual labour due to the physical collection and transportation of the heavy fishing nets, (2) fine motor skills required in the sorting and cleaning process, and (3) machine operation skills to run the shredding machine. To facilitate this, Circular Ocean has created several jobs in its microfactory in Peniche: three full-time jobs for the overseeing and running of the microfactory as well as two part-time jobs and hourly work for around ten additional individuals through a partnership with CERCIPeniche – a social rehabilitation centre that provides inclusive work opportunities for individuals who have difficulty entering or remaining in the workforce. Results from Circular Ocean's efforts have proven promising, as all those involved in the process report that both their work in the microfactory creates a real sense of meaning and purpose. Furthermore, this local collaboration with the community has enabled Circular Ocean to expand its activities to nearby fishing ports, despite inter-port rivalry, as members of other communities understand that these circular model activities are indeed beneficial for the community at the collective level.

Moving through the circular model from material preparation to material compounding and production, a higher level of cognitive and non-routine skills in several areas are required, especially as several technological challenges exist (Rouhi, Landberg, Wiest, Teigland, & Teigland, 2023). Firstly, material science skills are needed to create the right "recipe" for compounding the shredded nets into a material suitable for additive manufacturing. For example, decisions need to be made related to which fillers/stabilisers should be compounded with the pure nylon material and in what percentages, depending on the final product use case. Furthermore, digital design skills are required to design a product suitable for large-scale additive manufacturing using the compounded material, while digital twin/simulation skills using artificial intelligence are required to improve the design's feasibility for additive manufacturing. By simulating the printing process in advance, mistakes due to parameters such as printing speed and printing nozzle temperature can be avoided, thereby minimising the amount of wasted material, energy, and time during manufacturing. Compounding and large-scale additive manufacturing machine operators are also needed to run the machines as well as individuals involved in logistics within the microfactory. Further, higher level cognitive skills will also be required in order to create a global network of microfactories, as a digital platform needs to be created and maintained that enables the sharing of knowledge, data, and files among the microfactories as well as material sourcing and product traceability.

With the aim to create a microfactory in Portugal by 2026, the Peniche Ocean Watch Initiative will create both manual and cognitive jobs comprising more routine to less routine tasks. As a result, this localised approach of microfactories can be instrumental in not only combatting ocean plastics but also contributing to local economies by offering a blueprint for fostering community-level resilience and sustainable employment opportunities.

14.6 Implications and New Directions

Reflecting on the discussion in this chapter, we find that when we move in the direction of a blue circular economy model of manufacturing, there are also implications for how work is conducted – where, by whom, through which division of labour, and along which process. As noted in this chapter, if we start with the concept of microfactories, we envision not just one microfactory in one location but the establishment of global networks of microfactories, which clearly signifies a transformation in the way we approach manufacturing. We can move from centralised mass production using virgin materials for inventory to the decentralised, local production of on-demand goods using locally collected and recycled materials, that is, "close to the market, but also close to the material". This decentralisation has the potential to revitalise local economies by creating all types of jobs and reducing the dependence on centralised and automated manufacturing hubs. As such, the microfactory concept is not only about reshaping and repurposing materials, but it is also about completely reshaping assembly lines, distribution chains, and even local economies. We can also see how the establishment of networks of microfactories enables new sustainable practices since these networks can drastically reduce the carbon footprint associated with traditional supply chains as the proximity of microfactories to consumers minimises transportation emissions and fosters sustainability. This decentralised model can serve as a blueprint for reducing global reliance on long-distance shipping and, consequently, mitigating the environmental impact of transportation.

Another aspect has bearing for the development of a global circular economy. The use of collected waste materials as inputs for microfactories promotes one of the fundamental principles of a circular economy – to re-imagine materials for new purposes. To recycle and repurpose is key to the circular economy. This approach not only reduces waste but also reduces the demand for virgin resources. This shift towards circularity aligns with global efforts to combat resource depletion and environmental degradation. By relying on recycled materials, businesses can reduce their dependence on fluctuating commodity and raw material prices. This not only enhances stability but also contributes to resource security and resilience.

The microfactory concept also presents an opportunity to redefine work and job opportunities. It fosters the creation of new roles associated with materials collection, recycling, microfactory operation, and digital platform management. This diversification of job profiles also enhances inclusion and social sustainability by addressing unemployment and offering meaningful work. Our proposed transition to microfactories and sustainable practices imbues work with a sense of purpose. Employees in these settings often find their roles deeply connected to a feeling of "doing good" for nature – an ethical way of being and living as well as adding to community well-being. People find it meaningful to engage, on a personal level, as well as in relation to doing small but important work for a more sustainable future. This sense of purpose contributes to social justice by offering people opportunities to engage in meaningful, socially responsible work, while also giving them an opportunity to engage in a concrete action for a more sustainable planet.

While the microfactory concept may be small by definition, it can deliver fundamental impact in terms of the three areas of sustainability:

- **Economic impact:** The growth of microfactories and the networks enabling them can stimulate local economies, increase resilience by reducing dependence on imported goods, and potentially lower costs of goods through efficient resource utilisation and elimination of extensive transportation costs.
- **Environmental impact:** The use of recycled materials, on-demand production, and reduced transportation distances can result in a significantly decreased environmental footprint, extending beyond immediate production to resource conservation and waste reduction.
- **Social impact:** The emergence of new job opportunities, coupled with a sense of purpose, contributes to social well-being, while empowering communities and supporting a more equitable distribution of wealth and resources.

Thus, the microfactory concept, the utilisation of recycled materials, and the reconfiguration of labour might come with far-reaching implications. They extend into the realms of environmental sustainability, economic resilience, and social justice. This innovative approach to manufacturing holds the potential to transform industries, reshape labour markets, and create a more sustainable and equitable future. As we progress towards these goals, we need to remain mindful of the potential challenges and continue to refine and adapt our strategies to ensure the long-term success of this transformative vision. In the next section we take this as our point of departure for thinking about what this means in terms of a gateway to an alternative future.

14.7 Towards an Alternative Future

In this chapter, we have addressed ocean plastics from a standpoint of constructive progress. Rather than just acknowledging and underscoring the existing problems regarding this material in our ecosystem, we have examined an alternative path for moving forward. We have personally engaged in how these materials are approached and re-imagined. Our team works with the local community and local stakeholders and engages them in these new material practices, and we do it repeatedly – over time. Instead of seeking to sell the idea of microfactories to the local communities, we work from within, together with, and through the materials – as change agents – to "exercise agency", to form new socio-material practices, and accordingly new ways of doing, working, and living – over time. Accordingly, our approach neither seeks "quick fixes" nor aims to achieve radical change. Instead, we take a long view – to slowly but steadily re-imagine existing practices into something more sustainable.

In this chapter, we have also presented an empirical and action-oriented case where we work as engaged scholars to realise the concept of "microfactories" as a new form of manufacturing enabled through a twin transition. Here, the focus is on the small scale, on the "close to the material" practice of cleaning fishing nets with our own bare hands, working with local communities, and building a network of actors, rather than huge, automated factory plants operating based on the economies of scale principle. Location is key, and so is the closeness to the local community.

There are also interesting side effects and implications for research methods and approaches here. Staying close to the *place*, the *community*, and *the material at hand* leads to an engaged and responsible way of working. It is sustainable, not only from a temporal viewpoint, but, more importantly, from an ethical and social viewpoint. When people are engaged in this alternative system, they can feel that their actions matter, they can feel a sense of belonging, and they can find their jobs meaningful. The small actions taken in cleaning a fishing net correspond directly to helping our oceans.

Leaving the micro-level for a second, we can also say that this shift towards engaged and sustainable ways of working – doing something meaningful while contributing to sustainable development – provides benefits for the future labour market around the world. Instead of travelling into huge megacities to spend the day in a factory or an office, work can be locally situated – for the locals. As such, this project also has real-life practical implications.

Now, as we re-imagine and re-route our approach towards a new theory of circular economy, we must at the same time confront and challenge the dominant linear model of "take→make→use→waste" that has led to the proliferation of ocean plastics and other material waste. This transition demands a fundamental shift towards the establishment of local circular material ecosystems, which are not only ecologically sound but also socially just as we have pinpointed in this chapter. But how should this transition happen? What are the key concerns for making this shift?

Firstly, we advocate for the need to break existing material flows, and accordingly we challenge established manufacturing principles and practices. The linear approach has been built around a one-way journey for materials, leading to their eventual disposal as waste or other forms of footprints. By truly embracing circularity, we disrupt this one-directional flow, and we recognise how materials can be valuable resources that can be re-routed to circulate within a circular material system. Secondly, we emphasise the importance of breaking existing material practices. This means re-imagining how we interact with materials, who the stakeholders are, and how they are engaged in these material practices. We propose an approach that joins and challenges these networks of materials and stakeholders, aligns interests, and facilitates change from within. This approach recognises the interconnectedness of materials and the stakeholders involved in these systems.

Furthermore, our commitment to social justice as part of our striving for a better future – for everyone – is indeed integral to this transition. We acknowledge that the burden of plastic pollution disproportionately affects developing countries. Therefore, any shift towards a circular material ecosystem must be inclusive and "scalable" across these regions. This implies not only mitigating the adverse effects of existing waste but also providing opportunities for economic development and improved living conditions. This is also the case at the local level. Our approach is about engaging rather than pushing for additional separations between those who are privileged and those who suffer. In this context, our microfactory concept serves as a promising example. By working closely with local communities, engaging in hands-on material practices, and building networks of actors, such as local stakeholders, we not only address the ecological challenges but also foster social and economic well-being. This approach can be adapted and scaled to regions facing similar environmental and social dilemmas.

Ultimately, our vision of a circular material ecosystem is a slow process with a clear goal cantered on a long-term commitment to re-imagine existing practices into something more sustainable. By staying close to the geographical place, the community, and the materials at hand, we promote engaged and responsible ways of working that are not only temporally sustainable but, more crucially, also ethically and socially responsible. This shift towards engaged and sustainable ways of working is not limited to our specific empirical case but holds promise for the future labour market worldwide. Instead of feeding the urban megacities, this new paradigm of local circular material ecosystems allows people to find meaningful employment within their local communities. It enables individuals to see the direct impact of their actions on the environment, fostering a sense of purpose and belonging while simultaneously contributing to a more sustainable planet and way of living.

14.8 Conclusion

As we now move to the conclusion, we suggest that our chapter advocate a shift from the linear "take→make→use→waste" model to local circular material ecosystems. By breaking existing material flows and practices and prioritising social justice, we chart a heading towards a more sustainable and equitable future. This journey not only puts us "hands-on" in direct contact with the materials and as such revitalises our relationship with the environment, but it also offers a transformative vision for the global labour market and for thinking about a more inclusive and engaged future – for everyone.

The notion that ocean plastics could morph into the source of digital transformation of manufacturing and more meaningful work is not a mere speculation but a tangible prospect rooted in the urgency of the issue. The scale of plastic pollution necessitates an expansive and diversified workforce to tackle its myriad facets – from clean-up and collection efforts across coastlines to the development of advanced mechanical and chemical recycling technologies and waste management strategies to AI-enabled design and manufacturing. In this regard, our example can serve as an inspiration for the potential for large-scale job creation in response to environmental challenges.

Thus, the compelling narrative of ocean plastics resonates far beyond its explicit presence in the text. The urgency of this issue and its manifold ramifications warrant a comprehensive exploration that navigates the interplay of environmental, socio-economic, and technological factors. Through a concerted effort to reshape the labour market, leverage innovative solutions, and acknowledge the urgency of addressing this challenge, we can steer the course of the Anthropocene towards a more sustainable and resilient trajectory. To break existing linear material flows is by no means a "one man's job". On the contrary, the existing material flows are upheld, protected, and fuelled by strong stakeholders and their established business models, tempting incentive structures, and expensive developed and installed technologies. Accordingly, to break or redirect these flows is a matter of finding alternative models, new opportunities for more sustainable collaborations, and alternative ways of using technologies. The future is accordingly not only about *reducing* omissions but fundamentally reimagining what we do and how we do it – together. The future of labour is accordingly about togetherness, to collaborate and co-create across different expertise areas, across different domains, and across different business models, but towards a shared goal – to make the world a better place. The future of labour is rich from the viewpoint of how we need to re-imagine what we do, who should do it, and who should pay for the work that needs to be done. And there is plenty of work to be done in order to re-route and re-imagine current (material) practices. As we uncover the intricate layers of the ocean plastics phenomenon, we invite the reader of this chapter to embark on their own journey of discovery, realisation, and transformation – a journey that holds the promise of a better, cleaner, and more interconnected future.

Conflict of Interest

The first, third, and seventh authors are the co-founders of the Peniche Ocean Watch Initiative, Circular Ocean Lda, and Ekbacken Studios AB.

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