The Political Economy of Marine Plastic Pollution
Moerland, Stefanie

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Stefanie Moerland

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Dr. Rizal Shidiq
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1. Introduction

Marine ecosystems are an essential part of the global economy and provide us with food, oxygen, and jobs. Ecosystem services, provided by the marine ecosystem, are essential for the well-being of humans. Currently, there are large quantities of plastic pollution in the oceans which continues to increase every day. Plastic accounts for 85% of marine litter. It is estimated that the volume of plastic debris accumulating in the ocean will nearly triple by 2040 (UNEP, 2021). Marine plastic pollution is a transboundary problem, causing the origin and responsibility of plastic waste found in rivers and oceans difficult to retrieve. Marine species are harmed by plastic debris as it causes entanglement and is often ingested. In many countries there is a lack in the infrastructure and waste management to prevent plastic pollution. While there has been a large quantity of research conducted on the effects of plastic debris on the marine ecosystem, little research has focused specifically on the economic costs that stem from this problem. Plastic debris can induce large costs related to the ecosystem delivery and the tourism sector.

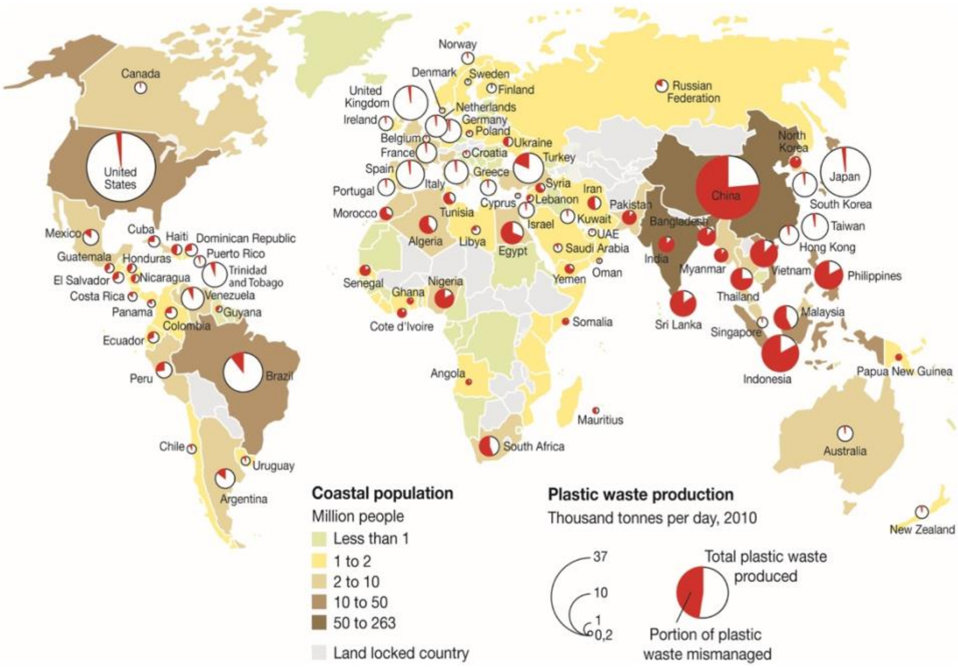
The increasing awareness of the effects on the environment caused by plastic pollution suggests that the issue has been put on the international agenda. However, little attention has been devoted to establishing the economic consequences that are a result of global marine plastic pollution, and there is an absence of a legal framework specifically addressing this issue. To fully understand the current and provisioned state of costs accumulating because of plastic debris, it is important to conduct a complete assessment of all sectors that are experiencing economic losses. This leads to this research posing the following question: What are the socio-economic costs that occur as a direct and indirect result of global marine plastic pollution?

This study will determine the socio-economic costs by first outlining the effects of marine plastic debris on marine ecosystems and coastal, touristic areas. Afterward, the research will consult data to determine the costs and loss of revenue in key industries such as ecosystem services and the tourism sector. In addition, costs related to human health, waste management, cleanup activities, and other efforts to rid the environment of plastic waste will be analyzed. Finally, three possible solutions that aim to address the issue of marine plastic pollution will be defined and assessed.

2. Background information – substantial marine pollution

One of the most pressing environmental issues is marine plastic pollution. Most plastic waste in the ocean gathers in large gyres. For now, five large oceanic gyres have been identified (United Nations, UN Ocean Conference Lisbon, Portugal, n.d.). The largest out of the five is The Great Pacific Garbage Patch (GPGP). To emphasize the scope of the problem, The Great Pacific Garbage Patch alone already covers an area as large as three times the size of France and contains over 100,000,000 kilograms of plastic (The Ocean Cleanup n.d.). The Ocean Conservancy's data shows that every year, an average of 11 million metric tons of plastic pollution enters the ocean. In total, marine plastic debris globally has accumulated to an average of 200 million metric tons (Ocean Conservancy 2022). In addition to the large scope of the issue, marine plastic pollution is a persistent problem. Research has shown that on average, it takes 450 years to decompose plastic waste (Whiting, n.d.). Fishing gear, the material of which marine plastic pollution is composed mostly of, takes on average 600 years to biodegrade (Ibid). Until this day, hardly any legislation has been developed to combat marine plastic pollution, and the legislation that is in place does not address plastic production industries. At the same time, the direct and indirect costs induced by marine plastic pollution keep increasing.

Fig. 1. Plastic waste from populations within 50 km of the coast.



Source: Jambeck et al. (2015), Neumann et al. (2015), reproduced with permission, available at www.grida.no/resources/6931. I. Tessnow-von Wysocki and P. Le Billon, Environmental Science and Policy 100 (2019) 94–104.

Research with regard to the composition of marine plastic pollution has shown that in the Great Pacific Garbage Patch fishing nets and other fishing industry-related products make up the largest percentage. More specifically, 75% to 86% of the total waste in the Garbage Patch is made up of fishing debris (The Ocean Cleanup, n.d.). A recent study by LeBreton et al. (2022), concludes that the debris identified as coming from the fishing industry is mostly linked to originating from China, Japan, South Korea, the United States and Taiwan. In many countries, waste management mechanisms are unable to cope with the extreme rise in plastic production. Especially in countries where waste is dumped in a landfill, instead of recycling the waste or using incineration, the possibility for waste to leak into the environment is very high. Many landfill locations are located nearby rivers or oceans, resulting in a high-risk possibility of floods dragging the plastic waste into the water. According to Wysocki and Le Billon (2019), rivers carry an estimated 1.15 to 2.41 million tonnes of plastic waste into the ocean yearly (96). The authors research shows an estimate of the amount of plastic waste coming from land-based sources. It shows that many countries in Southeast Asia tend to have the highest proportion of mismanaged plastic waste.

A study by Calcar and van Emmerik showed that a large issue contributing to the effects of marine plastic pollution is that plastic waste breaks down into microplastics when present in the ocean, which then will be consumed by animals such as fish, and other small species, and eventually will end up in our food cycle (Calcar, van Emmerik 2019, 1). The cause of microplastics is explained by the exposure to of the waste to ultraviolet UVB radiation of sunlight, oxidative factors found in the atmosphere of the marine environment and the exposure to seawater (Wysocki and Le Billon 2019, 97). To further define microplastics, Wysocki and Le Billon identify that microplastics are particles smaller than 5mm. In addition, particles smaller than 100mm are referred to as nano plastics (Ibid). Gall and Thompson (2015) argue that the animals most affected by microplastics include birds, turtles, fish, and other marine mammals (171).

Currently, over 260 marine species are affected by the detrimental effects of plastic pollution (Wysocki and Le Billon 2019, 97). Plastic pollution also may cause harm to coral reefs (Gall and Thompson 2015, 171). Furthermore, Ellenby states that on estimate, more than a million seabirds die each year as a direct cause of plastic pollution (Ellenby 2019, 1). One of the most threatened animals that is directly affected by marine plastic pollution is the toothed whale. Toothed whales are highly threatened by floating plastic debris as they mistake it for food. Ellenby highlights the issue through an example of a Cuvier’s beaked whale, which had been found with 40kg of plastic in its stomach (Ibid). Furthermore, research done by Macquarie University in Australia, according to Ellenby, identified that toxins released by plastic pollution affected the growth of the Prochlorococcus bacteria, a bacteria type that is responsible for the production of 10% of the oxygen intake by humans (Ibid). Furthermore, the research by Wysocki and Le Billion (2019) identifies that plastic waste can be dangerous for humans as during the manufacturing of plastic toxic chemicals can be used, which could be released into nature when the plastic is being discarded (Wysocki and Le Billon 2019, 97). Small plastic particles breaking down in rivers and oceans could also function as vectors for other pollutants, which can in turn affect non-toxic plastic particles (Ibid). According to IUCN, marine debris also has the ability to carry invasive marine species, which also affects biodiversity (IUCN 2021, 2) In terms of health, Wysocki and Le billon argue, a test done on mice showed that ingesting microplastic led to a possible disruption on energy and lipid metabolisms, cause oxidative stress and neurotoxic responses (Ibid).

Not only ingesting microplastics is potentially harmful to humans. According to research done by Prata (2017), airborne microplastics might even pose a larger threat. Airborne microplastics most likely stem from synthetic textiles, rubber tires and city dust. Other than that, landfills and waste incineration also causes airborne microplastics (Prata 2017, 116). The study by Prata illustrates that long-term exposure to airborne microplastics can cause respiratory issues and might cause an increased risk of cancer (Ibid, 117). The study also confirms that oxidative stress is caused in humans by inhaling airborne microplastics, which in turn can lead to cancer (Ibid, 120). Thus, these examples illustrate the scope of the issue of marine plastic pollution and how it is causing a loss in biodiversity and is potentially threatening human health.

This research will delve into the indirect consequences of plastic pollution and thereby the socio-economic consequences related to these factors. Globally, the governmental influence and control over marine plastic pollution is very little. Implemented environmental governance has been neglect as marine plastic pollution is a transboundary problem, which essentially results in the neglection of taking ownership over policies affecting the ocean by states. Much of the discarded fishing gear that is found in the ocean, stems often from illegal fisheries. While global policies or treaties with regard to marine plastic waste are neglected, Dauvergne (2018) argues that the average global consumption of plastic has accumulated to over 50kg of plastic a year per individual (Dauvergne 2018, 22). The start of mass plastic consumption dates back to the 1950s, as this time marked a moment of industrial development (Villarubia-Gómez, Cornell, Fabres 2017, 213). According to Villarubia-Gómez et al., global plastic production accumulated to an average of 322 million tonnes in 2015. Thus, plastic consumption seems to be ever-growing despite upcoming talks about Green Growth, sustainability, and circular economy initiatives.

This paper will bring forward the necessity of addressing the issue of marine plastic pollution and highlight arguments of why states ought to address plastic consumption, and 'closing the tap' to avoid plastic debris from flowing into the ocean. Until now, marine plastic pollution has been brought to attention through a few conferences and platforms. In September 2022, the 7th International Marine Debris Conference organized by the UN Environment Programme took place in Busan, South Korea. Earlier in 2022, the United Nations Environment Assembly adopted Resolution 5/14 to combat plastic pollution, to build an international legally binding treaty (Kantai 2022, 1). This resolution is a step forward for global leaders to work towards closing the tap.

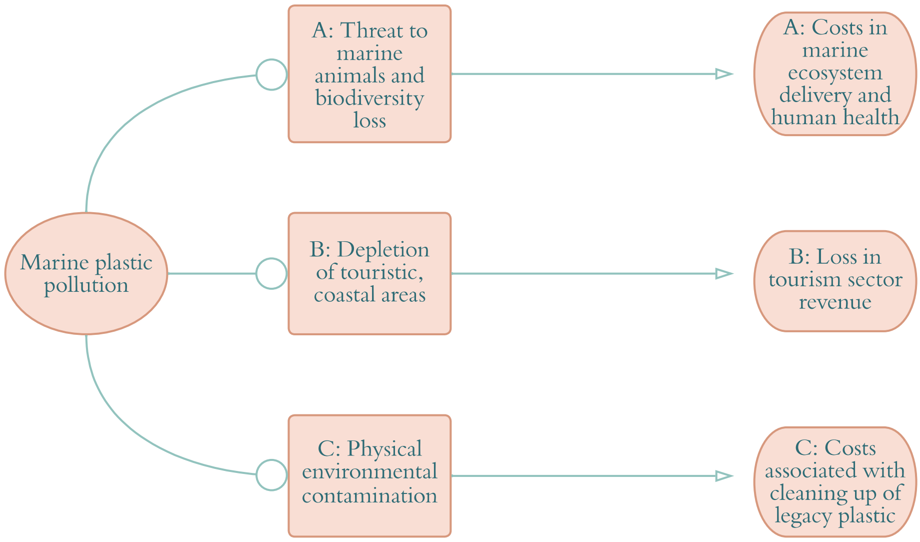
Furthermore, Villarubia-Gómez et al. highlight that other initiatives to combat marine plastic pollution include the Sustainable Development Goals (SDG), such as Goal 14 which is called 'Life below water'. Even other SDGs focused on the production and consumption of (virgin) plastics contribute to resolving the issue and keeping plastics out of the environment

(Villarubia-Gómez, Cornell, Fabres 2017, 217). There are two working groups, the G7 and the G20, that have affected policy toward marine plastic on a global scale. Villarubia-Gómez et al. state that the G7 and the G20 have had previous gatherings to create marine litter action plans. The G20 has published an action plan, which includes that G20 states will work on policy recommendations that address the protection and restoration of the ocean while simultaneously creating market opportunities in the ocean economy (World Economic Forum 2022). The policies will include pilot projects such as Coral Reef Restoration (Ibid). It is interesting to note that Indonesia is one of the key actors in the G20. For the Indonesian population, fish counts for 50% of the country's animal-based protein source. While at the same time, the marine area surrounding Indonesia is for 40% overfished (Tri Hita Karana Forum 2022). While the above-mentioned gatherings so far have been helpful, the legal Resolution 5/14 to combat plastic pollution is the current biggest legally binding effort toward ending marine pollution and is expected to be in place in 2024 (WWF, n.d.).

3. Methodology – analytical framework and data collection

This chapter will discuss the theories and outline the concepts that are used to analyze the collected data regarding the costs of marine plastic pollution. In this research, the socio-economic costs are defined as the costs in the ecosystem delivery and human health, the costs in tourism sector revenue, and the costs of cleaning up marine plastic pollution. The costs in ecosystem delivery and human health are classified as indirect costs, whereas the costs in tourism sector revenue and the cost of cleaning up are direct costs. The purpose of researching this topic is to highlight that the prevention and cleaning up of legacy plastic in the marine environment will eventually be less costly as compared to leaving the action neglected and eventually paying the indirect costs that accumulate after as defined above. The graph below outlines the theoretical framework of the research.

Fig. 2. The theoretical framework of the research



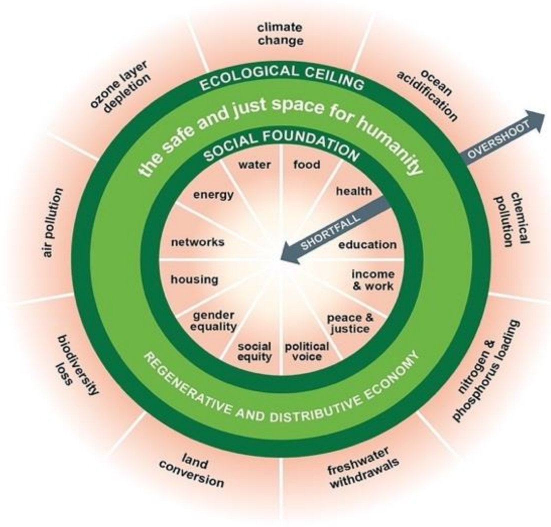
The first empirical analysis and findings chapter of this research outlines the threat that plastic pollution has on marine animals and organisms and emphasizes the loss in biodiversity that follows because of this. This chapter then assesses the financial losses in marine ecosystem delivery, whereby the focus will mostly be on the goods delivered by the marine ecosystem such as fish harvests and raw materials but also on service delivery such as transportation and flood control. The first chapter will in addition argue that costs in human health will occur because of MPP and will assess the effects of long-term ingestion of microplastics. The second chapter will research the depletion and pollution of nature in touristic areas that could be caused by marine plastic pollution. The research will be conducted by looking at two cases of coastal countries with a high number of visitors for touristic purposes: Indonesia and the Dominican Republic. In this chapter, the data collected will illustrate the costs and large losses of revenue in the tourism sector. The third chapter will dive into the physical contamination of the environment because of plastic pollution. The chapter will outline existing initiatives such as non-profit organizations working on the cleaning up of marine debris and will highlight the costs associated with cleaning up the existing legacy plastic in the environment. The costs of several clean-up initiatives and technologies will be discussed. Overall, the theoretical framework behind this research outlines that plastic pollution implies a threat to biodiversity, depletion of touristic areas, and the physical contamination of nature, and that three respective socio-economic costs will follow: the cost in ecosystem delivery and human health, the loss of tourism sector revenue and the costs of cleaning up plastic pollution.

The model mechanics of this theoretical framework are inspired by the paper “The price tag of plastic pollution” by Deloitte (Viool et al., 2019). The consultancy company developed, based on a model monitoring plastic waste in rivers by The Ocean Cleanup, an economic assessment to determine the costs of plastic pollution. The literature supporting the findings on the costs in marine ecosystem delivery and human health is mostly based on the paper “Global ecological, social and economic impacts of marine plastic” by Beaumont et al., who made an estimate on the decline in marine ecosystem delivery and the costs associated with it. The estimated costs related to human health are based on qualitative data. For estimating the costs and losses in the tourism sector, data derived from the research by Krelling, Turra and Williams is used to determine the perception of tourist groups to marine debris and how this determined a loss of tourism revue in these areas. The costs associated with the cleaning up of marine debris is established through data sources from The Ocean Cleanup and Deloitte.

As discussed before, few efforts to restrict and minimize plastic pollution and the costs associated have been made on an international level. In the sixth chapter, this research will investigate several solutions to the problem. First, the concept of a ‘plastic tax’ and bans on single-use plastics will be discussed. Several initiatives taken by states will be assessed. Second, the paper will dive into the possibility of solving this problem through market-based solutions and will take plastic credits as an example, assessing several plastic credits programs and evaluating the effectiveness of this solution to the waste issue. Third, the paper will assess the treaty design needed for an adequate response to marine plastic pollution on a global level.

In this paper, several theories will be used to analyze the data. The theories that will be used are the theory of green growth, and the theory of the Doughnut Economy by Kate Raworth. Both theories will be used through the critical political economy perspective. The theory of green growth will be used for analyzing the above-mentioned solutions, specifically to determine whether the introduction of a plastic tax or market-based solutions such as plastic credits will be credible solutions. Green growth theory can be explained as a long-term initiative of investing in sustainability and environmental protection, while fostering economic growth. Thus, making economic growth and sustainability compatible (Smulders, Toman, Withagen 2014, 423). According to the book 'Towards Green Growth' by the OECD (2011), green growth has the potential to generate new markets, and thereby new job opportunities. It also will lead to greater productivity and innovation (OECD 2011, 9). The OECD specifically highlights that innovation can be a way to decouple economic growth from natural capital depletion, and thereby avoiding crossing the ecological boundaries of the planet (Ibid, 10). The OECD states that the economy needs to embody well-implemented macroeconomic policy, international trade and investment opportunities and free competition to allow green growth policies to thrive (Ibid, 51). Overall, using the theory of green growth in this research as a framework can be useful to investigate whether economic growth and innovative solutions to plastic pollution can be compatible.

Fig. 3. Illustration of the Doughnut Economy model



Source: Kate Raworth, Why It's Time for Doughnut Economics (IPPR Progressive Review, 2017), 218.

The second theory that will be relevant for this research is the theory of Doughnut economics. The theory of Doughnut economics is described by Kate Raworth as a compass to tackle this century's social and ecological challenges (Raworth 2017, 216). The model illustrates the basic human needs, while at the same time showing the ecological boundaries of the earth. Raworth explains that the current economy should shift towards an embedded economy; thereby increasing state involvement, embedding the market and the global commons (Raworth 2017, 220). Furthermore, Raworth emphasized the need for a regenerative economy. Instead of following traditional economic theory which believes that growth will eventually clean up environmental pollution, Raworth explains that 21st-century economics should work towards circular product design, making the economy more regenerative instead of degenerative (Ibid, 221). Therefore, Raworth's model is important for this study as it lays a good foundation for assessing the economic cost of current marine plastic pollution, and it explains the significant need for innovative, regenerative solutions to this issue. In addition, it provides a contradicting theoretical perspective from green growth, making the two theories interesting to assess for this research. The model of Doughnut Economics will be used as a basis to evaluate the current ‘overshoot’ of the ecological ceiling that is happening because of marine plastic pollution. Marine plastic pollution possibly affects the ecological boundaries of chemical pollution and biodiversity loss.

Furthermore, in this research several concepts related to plastic waste and recycling will be used. One of the concepts that will be used is the term of legacy plastic. The definition of legacy plastic is the plastic waste neglected in the environment which is the result of decades of inadequate disposal of plastics. The definition includes plastic waste in the environment, rivers, and oceans. The term relates to the longevity of plastic waste; and that plastic waste in the environment is now a phenomenon that is nearly impossible to reverse (Neill, n.d.). The concept of virgin plastic will be used in this research to describe ‘newly produced’ plastic, which is defined by the WWF as “the direct output produced from refining a petrochemical feedstock, such as natural gas or crude oil, which has never been used or processed before” (WWF 2021, 15).

In addition, the term net plastic circularity will be used in chapter 6 of this research. The definition of this term is the complete offset of a company’s plastic footprint through the recovery or recycling of plastic waste collected from the environment. The amount of plastic waste that is offset, should be at the same rate as the consumption level. The plastic waste that is offset should also consist of similar types of plastic polymers. It is also possible to achieve net plastic circularity if a company would adopt 100% recycled plastics (Ka Ka Lee 2021, 3). In terms of addressing plastic waste which stems from the fishing industry, the term ‘abandoned, lost or otherwise discarded fishing gear’ (ALDFG) will be used in this research. In addition, the term ‘marine plastic pollution’ will be abbreviated by MPP in this research.

Moreover, the following paragraph will discuss the methods that are used in order to analyze the collected data regarding the costs of marine plastic pollution. This research will for a large part be based on qualitative data, and quantitative data has been used to illustrate the correlation between marine plastic pollution and the differentiative costs it leads to. Qualitative methods are mainly used to analyze literature and academic articles with regards to marine litter, environmental degradation and pollution, waste management and sustainability initiatives. The data gathered from these secondary sources has been used to assess the indirect impacts of marine plastic pollution, meaning the impacts on the marine ecosystem delivery, biodiversity loss and human health. Both the qualitative and quantitative data used in this study was derived from online sources, journal articles retrieved from the Leiden University Library, and books.

Quantitative data used in this research has been obtained from secondary sources. The quantitative data has been analyzed and assessed to establish the arguments for the costs that stem from marine plastic pollution on the tourism sector, and the costs associated with the cleanup of marine plastic pollution. Secondary sources used in this study to collect data from are the consultancy report "the price tag of plastic pollution" by Deloitte, the report "plastics: the costs to society, the environment and the economy" by the WWF, and the data set of the journal article "Global ecological, social and economic impacts of marine plastic" by Beaumont et al. Close analysis of these secondary sources will allow a clear overview of the costs associated with environmental pollution. The goal was to collect 1-3 data sets on the costs of marine plastic pollution to ensure that the costs determined have been verified by multiple research projects to ensure reliability.

It is important to note that certain limitations are bound to the use of secondary material in this study. Most research on the costs that occur because of marine plastic pollution has been conducted over the last 10-5 years and therefore is a recent topic of research. In addition, most research done has been reliable but indicative. Therefore, as the issue of marine plastic pollution is an ever-growing problem, the data used in this study might have changed or costs estimated may have increased over the last few years.

4.1 Empirical analysis and findings – the threat to marine animals, biodiversity and the costs in the marine ecosystem delivery and human health

Marine plastic pollution affects 267 species worldwide (Derraik 2002, 844), through either entanglement by large plastic debris or the ingestion of micro and nano-plastics. This could lead to illness and even death. As a result, biodiversity is at risk, and when marine animals ingest plastics, it can lead to polluting the entire food chain. Plastic pollution currently already causes billions of financial losses in marine ecosystem delivery annually and leads to risks and costs in human health.

Marine plastic, as discussed previously, is often mistaken by animals for food. Especially sea turtle species are largely affected, as 86% of sea turtle species are identified to have ingested marine debris. According to Andrady (2011), 44% of bird species in or near the marine environment have been found with plastic debris in their stomach (1596). In addition, Derraik states, 43% of all marine mammal species seem to be harmed by marine debris (Ibid). These numbers are a result from research done on fishing by-catch. One of the issues in research about this topic is that most marine animals affected are found ill in fishing by-catch or close to the shore, which does not provide an adequate overview of how large the number of animals affected really is. Derraik highlights that the deaths of many marine animals through plastic pollution go unnoticed, as most affected marine animals would either sink to lower sea levels or could be eaten by predators (Ibid). According to Wong (2022), predictions have found that the percentages of species affected by marine plastic pollution could increase to 99% by 2050 if the inflow of plastic does not fundamentally change (1).

The plastic waste found in the marine environment is often mixed, however, the plastic type most encountered in the marine environment is low-density polyethylene (LDPE) and high-density polyethylene (HDPE) (Andrady 2011, 1597). This plastic maintains buoyancy when discarded into the ocean, and thus is situated right at the sea-level surface meaning that animals living on or near the surface are affected by this debris. Most fishing gear consists of the types of plastic mentioned above. Abandoned, lost or discarded fishing gear (ALDFG) makes up most of the concentration of marine plastic pollution in the Great Pacific Garbage Patch. Bryce (2022) states that an average of 2% of all fishing gear used globally ends up in the ocean (1). As the scale of the global fishing industry is very large, 2% accumulates quickly to a very high amount of waste, leading up to thousands of square kilometers of gill nets (Ibid). Fishing gear tends to be the most dangerous form of plastic pollution for marine animals.

Marine plastic has been found to have several negative health effects on animals related to the functioning of their organs. Ingested plastic tends to block the digestive system of an animal or could reduce the stomach volume. As a result, animals will eventually be unable to process any other food (Wong 2022, 1). In addition, research shows the reproductive system of marine animals is damaged upon the consumption of microplastics (Ibid). The negative results on marine animals, after ingestion or entanglement in plastic waste, eventually could lead to the extinction of species. The death or extinction of species could lead to a large loss in biodiversity. It is, however, important to note that the decrease in marine biodiversity could be caused by multiple factors, such as overfishing and the effects of climate change, not solely because of plastic debris (Derraik 2002, 847).

Fig 4. Goods, services, and cultural benefits obtained from the marine ecosystem.

Goods	Services	Cultural benefits
• Fish harvests	• Recreation and tourism	• Carbon sequestration
• Wild plant and animal resources	• Transportation	• Bequest for future generations
• Raw materials	• Scientific and educational opportunities	• Religious significance
• Genetic material	• Flood control	
• Water	• Storm protection	
	• Pollution control	
	• Breeding and nursery habitats	
	• Shoreline stabilization and erosion control	
	• Carbon sequestration	

Source: Barbier, Edward B. "Marine ecosystem services", (Current Biology Magazine, 2017), 507.

Global plastic pollution is negatively impacting the marine environment, and therefore the goods and services provided by the marine ecosystem. To establish the costs, it is important to look at the overall revenue from marine ecosystem delivery, the total population depending on these goods and services as their primary resource and the ways in which plastic pollution is affecting marine ecosystem delivery. According to Barbier (2017), coastal areas make up 4% of the earth's total land area, however, they inhabit over a third of the world's total population (507). The marine ecosystem provides us with many significant economic benefits, which are currently at stake if plastic pollution continues in the same pace. The table outlines all ecosystem goods and services obtained from the marine ecosystem. Overall, according to Collins, the goods and services derived from the ocean globally accumulate up to being worth at least $2.2 trillion every year (Collins 2019, 1). This provides a perspective for the estimation of economic losses in the marine ecosystem delivery.

Especially fish harvests, water, transportation, and carbon sequestration in terms of goods, services and benefits are significantly essential in both formal and informal economies. Especially countries that depend on the informal economy would notice the effects of a withdrawal in marine ecosystem services, as these economies tend to rely on fish harvests and raw materials directly (Ibid, 508). In terms of formal economies, the costs for recreation and tourism could also be significantly affected. Tourism activities such as the visiting of a marine park to scuba dive or bird watch may be less attractive for visitors to pay for when plastic pollution increases in these areas, which will be discussed in the next chapter. Furthermore, Barbier argues that marine ecosystems are very valuable for the protection of citizens, from floods or wind damage (Ibid, 509). These two aspects, if lost due to pollution, may lead to large economic losses for coastal communities in terms of loss of infrastructure.

Beaumont et al. (2019) argue that upon measuring the impact of marine plastic on the ecosystem, there is an expected 1-5% reduction in marine ecosystem service delivery (Beaumont et al. 2019, 193). This number has most likely increased since then as plastic production and consumption has increased in combination with the slow pace of degradation of most plastic types. Beaumont et al. included three separate spheres of ecosystem service in their study. The first sphere is the ‘provisioning service’ which includes genetic materials, plant or animal materials, fibers and other, aquaculture and wild food. The second service, ‘regulatory service’ includes climate regulation, water conditions, pest/disease control, life cycle maintenance, mediation of flows, and mediation of wastes. The third service, ‘cultural service’, includes heritage, sacred, entertainment, educational, science, experiential and physical use (Beaumont et al. 2019, 192). After assessing the impact of marine plastic on all the above-mentioned services, the authors conclude that the expected decline accumulates to an annual loss of $500-2500 billion in the value of benefits obtained from the marine ecosystem (Ibid, 193). The annual loss of an estimated $500-2500 billion might even increase as research has shown that plastic production and use continues to grow.

According to the WWF (2021), plastic production has almost doubled over the last two decades (7). To emphasize the severity of the lifecycle of plastics, the research by the WWF confirms that the cost of the plastic produced in 2019 that becomes marine plastic pollution will incur a cost of at least USD$3.7 trillion over its lifetime, more than the total GDP of India (Ibid). The lifecycle of plastics includes a large amount of GHG emissions, and the management to collect, sort, dispose and recycle plastics. The GHG emissions induced by plastic waste in the marine environment, according to the WWF, contribute to climate-change related issues such as flooding, melting glaciers, and crop deaths caused by droughts (Ibid, 15). It is problematic that plastic is widely accessible and relatively cheap and easy to produce. The current market price of plastic does not account for more than 90% of the actual lifetime cost of plastic (Ibid, 23).

Research shows that human health might be at risk as marine plastic pollution may lead to a shortage in food supply caused by a loss in biodiversity, consuming seafood might lead to ingestion of microplastics, and because of the use of hazardous additives in plastic production. As seen from the above research, the loss in fish harvests has an obvious effect on human health. For many coastal communities, the more severe the marine plastic pollution problem will be, the less fish and thereby protein intake these communities will have. The research by Beaumont et al. assessed whether consuming fish which has been caught in a polluted area could be harmful for human health. Beaumont et al. state that until now findings have illustrated that marine plastic is only ingested by humans when a contaminated fish or marine animal is consumed as a whole (Beaumont et al. 2019, 191). Marine organisms which are often eaten in its entirety include mussels, oysters, and anchovies (Ibid). Thus, further research is needed to determine whether the ingestion of marine plastic by humans takes place through other sources besides when the marine organism is eaten in its entirety. Biodiversity loss on the other hand will inevitably be harmful to human health. According to UNESCO, without any action, more than half of all marine species could be on the edge of extinction by 2100 (Collins 2019, 1). The extinction of marine species could also lead to a reduction in other parts of the marine ecosystem, such as plant materials and fibers. Overall, a decrease in biodiversity could cause food supplies to be vulnerable to disease and scarcity.

In addition, the use of hazardous additives in plastics can pose a serious threat to human health and may lead to developmental issues, reproductive issues and metabolic disorders. De-la-Torre (2019) argues that one of the most common additives in plastic is bisphenol A (BPA) which can be used as a stabilizing or antioxidant material (1605). For human health the ingestion of BPA can be harmful as it can cause agitating effects on the endocrine system (De-la-Torre 2019, 1605). For now, research has identified the presence of BPA in tune fish and tap water, but a number on the average amount daily ingested by humans is yet to be determined (Ibid). According to The Minderoo Foundation, phthalates and flame retardants are two other chemical additives used in plastics, which have shown to lead to infertility, developmental issues such as ADHD and autism, and diabetes and obesity (Merkl and Charles 2022, 12). Phthalates are found to be used in bottles, food packaging, flooring, wires and cables, car tires and cooking utensils. Bisphenols are mostly to be found in pesticides, reusable liquid containers and PVC (Ibid, 37).

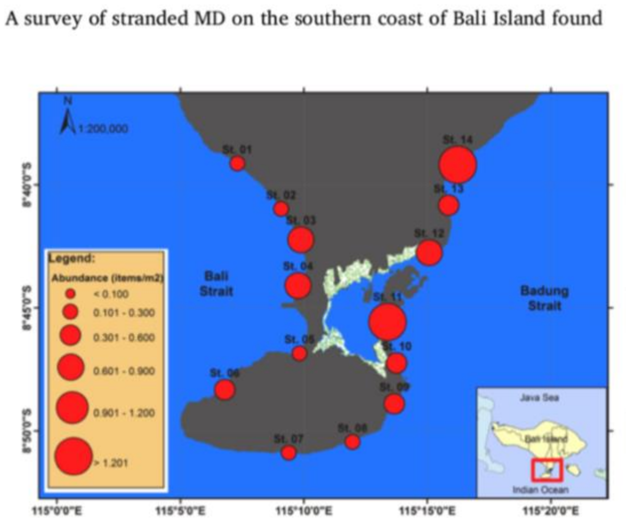
The Minderoo Foundation has estimated the costs in bodily injury to be US$100 billion per year, based upon the estimate of the current presence of chemical additives affecting human health. Thus, the cost of US$100bn per year is estimated upon plastic waste in the environment which includes the effect of bisphenols, flame retardants, PFAS, phthalates, micro & nano-plastics, and unidentified chemicals (Ibid, 25). However, to put the severity of the costs into perspective, this cost does not yet include several health costs identified by the WWF. These costs include: health costs from production processes, waste management processes, and plastic use (WWF 2021, 15). To conclude, at this stage, the quantity of the costs associated with the above-mentioned health risks is indicative. As currently more than 5,000 published papers cover plastic-related harms to human health (Merkl and Charles 2022, 22), further research is urgently needed to formulate a more precise quantity of the costs to establish the connection between (marine) plastic pollution and human health.

4.2 The depletion and pollution of nature in touristic areas as a result of marine plastic pollution, and the costs and loss of revenue in the tourism sector

In coastal, touristic environments marine plastic pollution has severe ecological, economic, and social consequences and can create large economic costs in the form of GDP reductions. The consequences of plastic pollution are millions of losses for the tourism industry annually, as touristic spots become more and more polluted and less attractive or even dangerous for tourist groups to visit. The amount of lost fishing gear and single-use plastics have covered touristic spots, and plastic pollution has grown exponentially over the last few years. The current level of pollution is projected to increase even if current government commitments are met. To avoid severe economic consequences in areas where tourism is the main form of income, a global, systemic response is needed to urgently.

Viool et al. highlight that marine litter will affect tourism, commercial shipping, and local coastal governments in many ways and will cause direct and indirect costs (Viool et al., 2019). The authors state that the waste crisis could lead to safety and health concerns by visitors of touristic areas, which causes a decline in tourism in certain areas and thus a loss of revenue for businesses operating in the tourism sector (Viool et al., 2019). Waste management in these areas should be improved to avoid rising costs in preserving the nature in touristic areas, and to support local tourism businesses. To assess the current impacts of marine plastic pollution on coastal countries two cases where tourism is a key industry will be researched: the case of Indonesia, and the case of the Dominican Republic. Afterwards, the direct costs that result from this pollution will be analyzed and the risks of this cost will be discussed.

Fig. 5. A survey of stranded marine debris on the southern coast of Bali Island found



Source: Suteja, Yulianto, Agus Saleh Atmadipoera, Etty Riani, I Wayan Nurjaya, Dwiyoga Nugroho, and Anna Ida Sunaryo Purwiyanto. "Stranded Marine Debris on the Touristic Beaches in the South of Bali Island, Indonesia: The Spatiotemporal Abundance and Characteristic." (Marine Pollutin Bulletin 173, no. Pt A, 2021: 113026–113026). https://doi.org/10.1016/j.marpolbul.2021.113026.

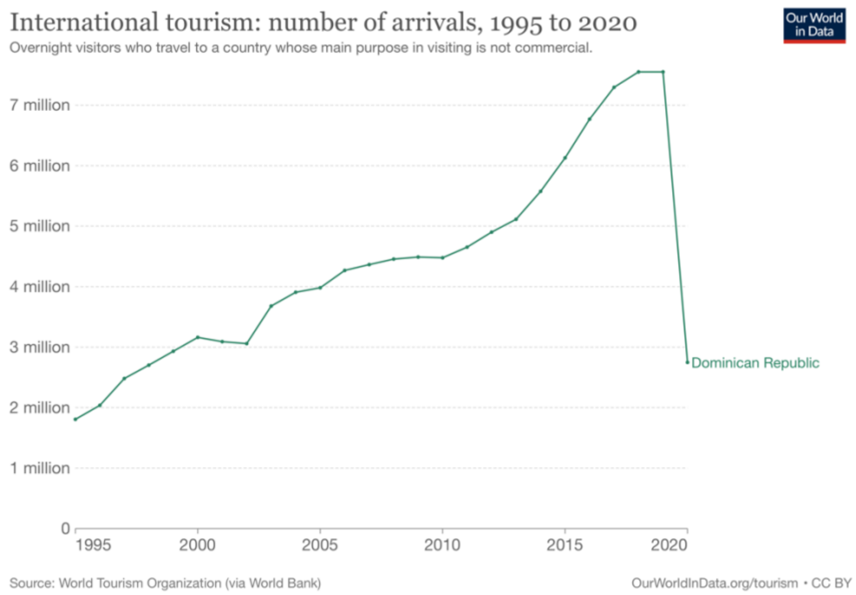
Tourism is a key industry for many coastal communities in Indonesia, and accounts for 5% of the country's GDP (Smith and Wiryawan 2022). However, the country has been struggling to keep up with managing the plastic waste washing up the shores of popular beaches on their islands. One of the most popular islands to visit in Indonesia, Bali, will be taken as an example to assess the impact of MPP on their tourism sector. Readfearn (2021) illustrates that during monsoon season, large amounts of plastic cover the beaches in Bali. In 2021, only two days of cleaning in three different beach areas resulted in the collection of 90 tonnes of waste (Readfearn 2021, 1). As the production of plastic globally is not halted or reduced, plastic pollution in Bali continues to increase every year. According to Menon (2018), Bali's economy is dependent on tourism for 80% of its economy. The island attracts 5 million tourists every year (1). However, marine life surrounding the Indonesian islands has been extremely threatened by marine plastic pollution, both caused by the fishing industry and by plastic waste related to tourism. Menon highlights the example of a sperm whale found in Wakatobi National Park, which had ingested six kilos of plastic waste (Menon 2018, 1). While the park is not situated in Bali, the example shows the way in which marine life is being harmed by plastic pollution in the region.

To illustrate the severity of the plastic pollution issue on Bali, Suteja et al. (2021) have researched and mapped the density of marine debris during the rainy season (5). The graph shows that some coastal areas combat marine debris of up to more than 1.201 items per m2 during rainy season. Marine debris assessed varies and is composed of mixed plastic waste, and the volume of waste washing up the shore is much lower during the dry season. Thus, the data assessed shows marine debris pollution in Indonesia and specifically Bali is severe, with detrimental consequences observed on marine animals. The costs induced on tourism by this high volume of pollution are assessed by Deloitte and published on the website of The Ocean Cleanup. The data covers costs emerging from marine plastic pollution in land-based water sources.

The costs that arise from plastic waste related to tourism are on average $9.445.000 per year in Indonesia (The Ocean Cleanup 2022). As these costs are estimated on a yearly basis, the overall costs of the complete plastic lifecycle of current MPP in Indonesia are much higher. Especially in areas where Indonesian communities depend on their income from tourism, these costs are severe. The cost estimated are losses in tourism that directly would benefit Indonesian residents, not the government. The risk is acknowledged by Minister Luhut Binsar Panjaitan, and state officials have planned rid the amount of plastic waste in the (marine) environment in Indonesia up to 70% by 2025 (Anjar Sawitri, n.d.).

Second, the case of the Dominican Republic will be assessed. In the Dominican Republic, plastic pollution is a large issue as the country lacks a well-functioning waste management infrastructure. This results in significant losses for the country’s tourism industry, which leads up to more than US$10 million in economic losses annually. The Rio Ozama River situated across the Dominican Republic is a highly polluted river, which transports a large amount of waste towards the shores of the Caribbean nation and the ocean. The large amount of mismanaged waste eventually could result in a decline in tourism and income related to tourism. Döhne (2021) states that there are no recycling facilities on the island, and there are more than 350 illegal dumpsites (1). Since waste management is not well regulated, the government does not control illegal dumping sites. The Dominican Republic consists of both poor and very touristic areas. The poorer areas and settlements do not have another option other than dumping the waste in the river, while at the same time, touristic areas and beaches are kept relatively clean from plastic waste. The combination of mismanaged waste, communities living close or alongside the river, and rainfall cause the transport of land-based plastic pollution to rivers and oceans.

Fig 7. International tourism: number of arrivals in the Dominican Republic



Source: International tourism: number of arrivals, 1995 to 2020. (Our World in Data, 2022), retrieved from: https://ourworldindata.org/tourism.

The data by Our World in Data illustrates that international tourism in the Dominican Republic still goes up to nearly three million visitors annually (Our World in Data, 2022). Further research should be done to assess whether tourism will decline over the next few years because of plastic pollution, as the number of international visitors in 2020 most likely has declined because of the Covid-19 pandemic. Currently, the tourism sector is still one of the key industries of the Dominican Republic. Data published by López highlights that in 2019, tourism counted as 16.28% of the country's GDP (López 2021). As it is one of the key industries, plastic pollution could pose a serious threat to their economy.

According to the dataset by The Ocean Cleanup and Deloitte used previously for the case of Indonesia, the economic losses for the tourism sector in the Dominican Republic caused by plastic pollution accumulate up to $11.390.000 per year (The Ocean Cleanup 2022). Other sectors, in this case fisheries and aquaculture and governmental costs have also been assessed in the same data set making the total costs related to plastic pollution in the Dominican Republic on average $20 million per year (Ibid). These are large costs that are taken away from more important causes such as education and health care. Deloitte states that costs induced by plastic pollution on human health are not included in the costs mentioned above. The real cost of plastic pollution is most likely higher than the cost mentioned above; the U.S. Embassy of the Dominican Republic (2020) has mentioned that communities in the Dominican Republic living near disposal sites are facing issues from contaminated water as a result from plastic pollution. Therefore, aside from the overall costs to human health established in this research, further research should examine the exact costs in human health specifically for the population of the Dominican Republic.

The research by Krelling, Williams and Turra (2017) assessed that an increase in plastic pollution in a coastal and touristic area leads to a decline in visitors. The authors conducted studies where various polluted beaches were assessed, all varying in the level of plastic pollution. The evidence shows that most beach users of the beach assessed (83.6%) would not continue visiting the same beach if pollution accumulated to above 3 debris items per linear metre, which would be 15 items per m2 (Krelling, Willams and Turra 2017, 97). Furthermore, the authors argue that the research showed a loss of US$64 per decreased visitor that would otherwise be contributed to the municipality, and local businesses near the touristic area involved (Ibid). Based upon this research, Krelling, Williams and Turra concluded that annually the economic loss related to tourism would range from 15% to 39.1% (Ibid). Thus, a significant proportion of income for small businesses focused on tourism would benefit from avoiding marine debris accumulating near touristic areas.

Furthermore, the waste management costs for municipalities that rely on the coastlines as a form of economic income can rise significantly if marine pollution increases even further.

Leggett et al. (2014) describe the example of a research done of six popular beaches in Orange County, California. The research shows that as the municipality improved its waste management structure and managed to clean up 75% of the marine litter that had washed up the shore, the additional economic revenue of these beach areas accumulated to $46.5 million (39). The data collected in the study by Leggett et al. was conducted over two months. The research highlights that a clean and non-polluted environment and recreation area is of high value for touristic purposes. Thus, the research shows a connection between economic growth and a clean environment. In the next chapter, the costs for cleaning up marine plastic debris are evaluated which will allow for a comparison between the costs induced by plastic waste and the what the necessary costs are to avoid marine plastic pollution.

4.3 Physical environmental contamination caused by marine plastic pollution, the costs associated with cleaning up legacy plastic, and an analysis of the overall costs induced by marine plastic pollution

While plastic pollution is found everywhere in the global ocean, certain key ecosystems are at risk. Coral reefs are an example of this, as they are found to be facing multiple negative effects caused by plastic. Coral reefs are essential to marine life, and therefore to humans as well. Therefore, cleaning up legacy plastic in the environment is important, and several NGO’s and non-profit organizations have taken the initiative. However, the cleaning-up of marine litter is not an easy task and the costs associated with it can accumulate up more than US$10 billion.

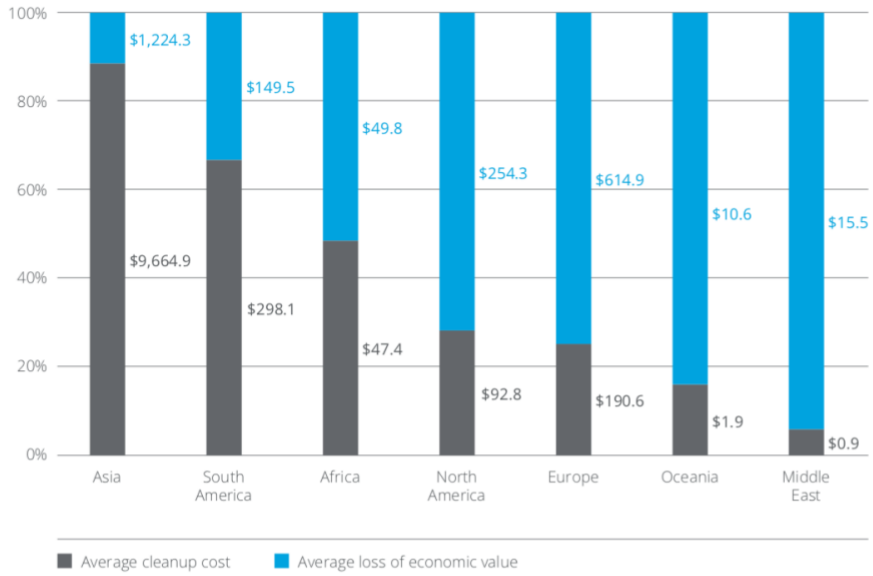
Environmental contamination, as briefly mentioned in the first chapter of the empirical findings, can be caused by plastic debris as floating plastic acts as a vector for other pollutants. Rochman has found that chemical contaminants can possibly, when stuck onto marine plastic debris, transport vast distances and might even reach adjacent oceans (Rochman 2015, 128). This is the case for positively buoyant plastics. Negatively buoyant plastics, on the other hand, seem to transport the attached chemical contaminants to the seafloor (Ibid, 128). Research done on marine debris found on remote locations confirms this statement, as the debris found contained large concentrations of chemicals which would not have been able to accumulate on the locations where the research was conducted (Ibid, 129). Rochman, in addition, states that some plastic types, such as PVC, include monomers that have been added during the production. The monomer m-phenylenediamine, for example, is classified as environmentally hazardous (Ibid, 130).

While chemical contaminants can possibly contaminate the seafloor, microplastic particles seem to reach the seafloor as well and are harmful for the growth of coral reef. Coral reefs are seen to be highly distressed by the effects of ocean acidification and global temperature rise, and microplastics would be able to be an additional factor for the contamination of coral reefs. According to Huang et al. (2021), 11.1 billion large plastic items were found during a field investigation existing of 159 coral reefs in the waters in the Asia-Pacific region. The researchers predicted that this could potentially increase with 40% more plastic items by 2025 (2). Coral reefs are exposed to and ingest microplastics. Huang et al. identified that ingestion and passive surface adhesion of microplastics to coral affects coral growth and health and leads to tissue bleaching and necrosis, a disease in corals which causes issue degradation and death of the colony (Huang et al. 2021, 3).

The above research shows the need for a systematic and consistent cleanup of plastic pollution in rivers and coastal areas. Currently, there are several existing cleanup initiatives by NGO’s and non-profit organizations. The initiatives range from manual cleanups of coastal areas to technological developments related to the removal of legacy plastic in marine environments. However, cleanup activities and systems are yet to be implemented in areas where waste management is not very well regulated in general. To assess what needs to be done to avoid the pollution of the ocean floor and coral reefs, several cleanup activities will be discussed, and the costs associated will be highlighted in this part of the research. A few examples of NGO's and non-profit organizations that have organized manual cleanup efforts, and therefore collect Ocean Bound Plastic, are: 4Ocean, The Ocean Conservancy, and Project AWARE Foundation. Organizations that have developed technology based cleanup solutions are: The Ocean Cleanup, SpillTech and The SeaCleaners. The organization 4Ocean has for example has recovered 26,326,650 pounds (11.941,568 kg) to date from coastal areas (4Ocean 2022). The Ocean Conservancy has reported to have collected more than 348 million pounds of debris from rivers and coastal areas (The Ocean Conservancy 2022). As these cleanups were conducted manually by volunteers or workers, and the debris was collected on the beach or near the water, the plastic is classified as Ocean Bound Plastic.

Furthermore, when looking at technological solutions, The Ocean Cleanup has recovered 1.905,806 kg so far from the Great Pacific Garbage Patch and 6 rivers (The Ocean Cleanup 2022). Thus, the debris collected by The Ocean Cleanup consists of plastic waste directly emitted into the ocean such as fishing gear. The Ocean Cleanup uses a cleanup system, system 003, in the Great Pacific Garbage Patch which is a U-shaped barrier which creates an artificial coastline to catch plastic debris items (The Ocean Cleanup 2022). Upon extraction, the plastic waste is brought back to the shore and is recycled in The Netherlands. In addition to system 003, the company employs several 'interceptors' in highly polluted rivers; a technological solution which scoops up plastic debris from the water with a conveyor belt, while running on solar energy (Ibid).

Fig. 8. The cost components of the average cleanup cost and the average loss of economic value because of marine plastic pollution in 2018 by region, values in USD million



Source: Viool, Vincent. Gupta, Abishek. Petten, Laurens. Schalekamp, Jorg. "An overview of the cost components in 2018 by region, values in USD million", (Deloitte, 2019), 11.

To conclude, various organizations have been working on ridding nature, rivers, and oceans of plastic pollution. While most of these organizations are non-profit organizations, the cleaning up of plastic in the environment can become expensive, especially when new technologies are being developed and used. Viool et al. (2019) established the price of cleaning up marine litter, divided per continent. The price estimated is based upon government sanctioned cleaning activities, and not on activities by NGO's or non-profit organizations. Viool et al. (2019) highlight that the average cleanup cost of marine litter present on land-based sources and rivers will be the highest in Asia, followed by South America. The report solely covers costs in marine tourism, fisheries, and aquaculture. In Asia, the average land-based cleanup cost is valued at $9,664.9 million (Viool et al. 2019) It is interesting to note that the average cleanup cost for Europe and North America is much lower, however, the average loss to economic value from the marine ecosystem, including tourism, fisheries and the aquaculture sector is high in comparison to Asia. When calculated all together, the cleanup costs for all continents based on waste density found in rivers in total would lead up to an average of more than $10 billion (Ibid).

To assess the current state of economics, the theory of the Doughnut Economy by Kate Raworth will be taken into account. Raworth (2017) takes the example of early 1990s economics, where the theory of the Environmental Kuznets Curve had been brought into existence (207). The inverted-U shape suggested that growth will eventually fix the environmental problems that it creates. However, the current state of the environment and the way marine plastic pollution currently affects the environment, marine species and humans debunks the use of this theory. Instead, Raworth argues, environmental quality tends to be much higher in countries where income is more equitably distributed, where literacy rates are higher and where political and civil rights are better enhanced (Raworth 2017, 209). So far, our economic system has been built up in a degenerative industrial design, which should be enhanced by more regenerative properties. Therefore, Raworth suggests companies to move towards a circular economy model, which could be an alternative for plastic production companies as well. By restoring and regenerating the materials used, the industry could operate within planetary boundaries.

After analyzing several cleanup initiatives and the economic theory necessary for achieving a cleaner environment, an overall analysis of the costs induced by plastic pollution will be made. Beaumont et al. (2019) estimated an economic loss of $500-$2500 billion annually in marine ecosystem delivery. The estimate by Beaumont et al. assessed the impact on a global scale. The data by Deloitte used for this research estimated the total cost of plastic pollution in terms of the loss in tourism revenue, the cleanup cost, and fisheries (aquaculture) up to $6-19 billion annually (Viool et al. 2019). Important to note is that the dataset by Deloitte included 87 coastal countries. The research previously highlighted the issue of the long lifecycle of plastics. According to the WWF, plastic produced in 2019 will be the cause of a cost more than US$3.1 trillion over its lifetime in marine ecosystem delivery, as plastic waste is persistent and stays in the environment for hundreds of years if not cleaned up (WWF 2021, 18). The costs in human health are established by The Minderoo Foundation. The costs in bodily injury accumulate to be US$100 billion per year, based upon the estimate of the current presence of chemical additives affecting human health (Merkl and Charles 2022, 25).

When put in perspective, the data illustrates that the average cost for cleaning up water-based plastic pollution in 87 countries is $10 billion on a yearly basis. While this is a significantly large sum of money to be invested in waste management infrastructure, it seems that it is more profitable in comparison to leaving plastic waste neglected in the environment, especially over the long term. Overall, the data combined provides an estimate of the economic impact that the current level of marine plastic pollution has and will have and aims to demonstrate that actions towards reducing marine plastic pollution would benefit the marine ecosystems, the global economy and human health.

5.1 The introduction of a plastic ban or taxes as a solution to marine plastic pollution

The next three chapters will elaborate on possible solutions to the problem of marine plastic pollution. More specifically, these solutions focus on both the prevention of the large stream of plastic into the environment, and the cleaning up of legacy plastic. The taxation of the production or import of single use plastics would be a possible solution to the large production of virgin plastics. The incentive to produce plastic packaging from recycled material would become larger, if prices of producing new material were to increase. Recently, the plastic tax has been introduced by the United Kingdom and has been in effect as of April 2022. The tax system charges the producing company for all products made from and packaged in plastic, that are produced or imported in the UK (KPMG, n.d.). The UK is charging £200 per ton of chargeable plastic packaging components. The aim is to deteriorate the extremely high production of single use plastic packaging. Further research has to be conducted over the next few years to evaluate whether the tax has been successful at diminising production rates of virgin plastic material.

Furthermore, the EU has introduced the program "Plastics own resource" as of the 1st of January 2021. According to the information published by the EU, the program includes a national contribution made by member states based on the amount of non-recycled plastic packaging produced. The rate of contribution is currently set at €0.80 per kg of non-recycled plastic waste produced, with the rate varying on the level of wealth of each member state. The plastic tax can either be paid by the member state from their general budget, or the state can choose to finance it by taxing the production companies or consumers (European Commission, n.d.). The plastic tax can be seen example of moving towards green growth. By introducing the incentive to encourage large firms to produce packaging made from recycled plastic, the production process will be more environmentally sustainable. In addition, the establishment of such a solution embodies a statist economic policy, legitimizing the action of the state to implement the tax in the aim to achieve the goal of creating a more sustainable economy.

Another initiative by the EU, according to Morath (2022), was the Directive 2015/720 which commanded states to minimize the use of plastic bags (116). In this case it was up to the states themselves to decide how to minimize the use – by setting a tax for consumers of plastic bags or banning them. Morath mentions the example of Portugal, where the government decided to implement a tax. After four months of having the tax in place, research found that the use of plastic bags had declined with 74 percent (Morath 2022, 116). One of the reasons for this large decline is that previously no other alternatives were offered – such as paper bags. Thus, it highlights that when more alternatives to plastic use are introduced, most consumers are willing to change their usual behavior towards plastic use.

According to Morath (2022) several countries in the Southern Hemisphere, such as Rwanda and Bangladesh, have also introduced a ban on single-use plastics instead of adding a tax to the use of plastics (109). As highlighted in the chapter discussing the effects of plastic pollution on touristic areas in Indonesia and the Dominican Republic, Morath confirms that countries in the Southern Hemisphere are more likely to encounter the harmful effects of plastic pollution and climate change. Thus, it gives countries in the Southern Hemisphere a larger incentive to act against the consumption of single-use plastics. Countries in the Northern Hemisphere are more likely to be able to distance themselves from the impacts of plastic pollution, this is especially seen in the United States. In the US, according to Morath, the domestic single-use plastic economy is very strong, and this is especially noticeable as the petrochemical and plastic industry is known to be highly engaged with lobbying (Morath 2022, 110). The US has announced to reduce single-use plastics in the environment in June 2022, as the Biden administration decided to start a project on banning the sales of single-use plastic in national parks by 2032 (Newburger 2022, 1). Newburger states that the recycling rate in the US has been declining over the last few years, and the administration has introduced the plan on single-use plastic in national parks to balance out the large plastic production rates (Ibid). To globally resolve the plastic waste crisis a plastic tax and bans on single-use plastics have been a helpful first step, however, as global governance regarding this topic is fragmented more standardized laws and treaties should be introduced. Further in this research treaty design for adequate marine plastic waste management will be discussed.

5.2 Market-based solutions to marine plastic pollution: plastic credit programs

Over recent years the private sector has become more involved with opportunities to promote sustainable actions. There are various market-based solutions currently available, such as carbon offsetting programs and tax credits for wind and solar energy. Plastic credit programs are another example of this, as these programs are opportunities for companies to offset their plastic production or use through financially supporting plastic clean-up projects. For now, plastic crediting programs have not been standardized and thus there are many different platforms available to gain 'credits' in exchange for the plastic waste. Most are local projects in cooperation with waste pickers, who get financial rewards for picking up the plastic waste that has been found in the environment. The companies, in exchange, receive recognition to show that they have participated in the cleaning up of the plastic. The plastic credit programs are solutions that could be specifically suitable for touristic, coastal areas experiencing economic losses in the tourism sector. It should be seen as a temporary solution; long-term solutions could include obvious improvements such as developing mechanical recycling capacities, however, funding for this specific sector is not widely available in many countries.

Verra is a company that has set up one of the largest plastic credit platforms, called the "Plastic Waste Reduction Program". Verra has created a standard with all requirements that need to be fulfilled before the collection of the plastic can be verified in exchange for credits. The requirements include that there should be independent auditing of the plastic collected, there should be an adequate accounting methodology, and a well-functioning registry system (Verra 2021, 1). According to the information by Verra, the requirement of independent auditing includes both third-party auditors and staff from Verra to verify the amount of plastic collected, and to ensure that the collectors meet the standards set by Verra. In addition, the registry system is a way to track the 'chain of custody', it also keeps track of all generation and cancellation of plastic credits (Ibid). Within these projects, there is an option to either gain credits for solely waste collection or waste collection and recycling credits. The standard set by Verra is that for each ton of plastic collected, the company funding the project will receive one credit.

One example of the projects Verra has endorsed is "Second Life Thailand", which is organized in remote coastal and island communities in Thailand. The project uses the 3R methodology, meaning that the plastic is first recovered, then recycled and afterwards reinforced. The goal of the project is to recover and recycle ocean plastic in all island and coastal areas of Thailand (Second Life 2022). For all projects, industries involved fund Verra, after which the aim is to sort and recycle debris retrieved from the ocean, to invest in regional initiatives that promote the recycling of waste that would otherwise end up in landfill (Verra 2021, 1).

A second platform of the plastic credits industry includes the organization called Plastic Credit Exchange (PCX), who have partnered with EY for auditing purposes and with brands such as Lays, Doritos and Quaker who in turn received plastic credits. Their mission is to follow the various Sustainable Development Goals such as 14: Life Below Water, and 11: Sustainable Cities and Communities (Plastic Credit Exchange 2022). PCX works together with various partners, such as individually organized or manual clean-ups, local waste management infrastructures and recycling companies such as Suez Circular Polymers. Upon verification, brands are allowed to use the eco-labeling of PCX on the packaging of their products. Another large brand that has worked with PCX is PepsiCo, which has made a start to work towards net plastic circularity with their location in the Philippines. In total, they have offset 919,090 kg of plastic waste that would have otherwise ended up in the environment (Ibid).

There are some risks involved with plastic crediting programs. For instance, the issue of green washing by large MNC's is a potential risk. Large corporations, such as Nestle or Lays, are involved with several sustainability initiatives, including plastic crediting. One of the risks is that while MNC's are making an effort to become more sustainable, the scale on which production of virgin plastics is continued is often in comparison much higher. Only a small percentage of the neglected waste is often reused or recycled. In addition, according to the WWF (2021), a possible risk of using plastic credits is the issue that companies might receive illegitimate credits because of the lack of a credible standard. Currently, it is not clear whether the credits given out refer to a specific amount of plastic waste collected, or whether it refers to only collected material or collected and recycled material (4). The WWF states that it is also a risk that there is not yet a standard for the price of the credits. The issue might be that companies neglect their Extended Producer Responsibility (EPR) as credits might be a cheap substitute to cover for the other large percentage of waste that is still not being collected or recycled (Ibid). The concept of EPR will be further discussed in the next chapter. Plastic credits could potentially form an effective business model for retrieving and recycling plastic waste from the environment, however, an international standard for plastic credits should be further developed to avoid the risks involved.

The idea of setting up plastic credit programs stimulates companies to increase the recycling of their products. Plastic credit programs are an example of market-based sustainability solutions, fitting in with the theory of Doughnut Economics. The theory of Doughnut Economics, according to Raworth (2017), states that the current economy should be redesigned into a regenerative economy (221). As traditional economic theories have claimed that pollution should increase before it can decline, and that growth will clean it up again, the current state of marine plastic pollution has proved the opposite. Therefore, Raworth states that the current economy should move towards a circular, not linear one (Ibid). While plastic credit programs are operated at a very small scale for the moment, it is a first step towards funding a waste management infrastructure and recycling plastic in countries where this is not yet established.

5.3 Treaty design for resolving marine plastic pollution

Currently, several international treaties are in place to regulate climate pollutants. However, a binding treaty on marine plastic pollution has not been realized yet. Efforts to clean up legacy plastic in the environment are important and significantly reduce the amount of waste flowing into rivers and oceans, however, a well-designed treaty is necessary to "close the tap" and stop the plastic waste crisis. According to von Wysocki and Le Billon (2019), an international treaty with the aim of solving transboundary pollution problems, that serves as a successful example, is The Montreal Protocol. The authors state that three elements included in The Montreal Protocol caused it to be successful. The elements include: a) "common but differentiated responsibilities, b) trade restrictions, c) a financial mechanism, and d) adjustments and amendments" (von Wysocki and Le Billon 2019, 95). The common but differentiated responsibilities made the treaty acceptable by all countries involved as the responsibilities were perceived as fair. In addition, the trade restrictions included in the treaty aimed to avoid relocation of production in which the involved states saw much value. The financial mechanism, Wysocki and Le Billon argue, is necessary to ensure that developing countries can cover the implementation costs (Ibid, 95-101). Overall, the authors state, these elements seem to have contributed to the success of The Montreal Protocol, and therefore seem to be necessary elements for the development of a treaty on marine plastic pollution.

The issue of MPP was put on the international agenda in the 1960s because of seabirds that had been found to have ingested plastic items, for the first time (Ibid). Since then, various agreements have been established related to sea-based plastic pollution control. Agreements include the ‘Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (The London Convention of 1972)’ and the ‘International Convention for the prevention of Pollution from Ships 1973 (MARPOL)’ (Ibid, 98). In terms of land-based plastic pollution control, one of the previously discussed examples is the EU Directive the ‘Packaging and Packaging Waste Directive’ related to single-use plastics. Another example is the ‘Basel Convention on the Control of Transboundary Movements of Hazardous Wastes’, which prohibits the transboundary movement of hazardous and other wastes. These treaties combined to help to mitigate environmental pollution, although an element addressing marine plastic pollution is missing.

In November 2022, the Intergovernmental Negotiating Committee of UNEP came together in Punta del Este, Uruguay, with the aim to develop an international legally binding instrument on plastic pollution, including in the marine environment (UNEP 2022). This is the first effort towards a legal obligation to mitigate marine plastic pollution that will be developed. Therefore, this research outlines several necessary elements to be included in a treaty addressing MPP for it to be successful. First, Von Wysocki and Le Billon (2019) argue that the treaty would need to include a legal agreement on lost fishing gear, rigid and fibrous plastics and microplastics (100). In this agreement, stronger regulations for the fishing industry on a global level are needed. Abandoned, lost, or otherwise discarded fishing gear (ALDFG) should be retrieved and recycled by the industry. According to Raubenheimer (2016), the MARPOL agreement Annex V states that the accidental disposal of fishing gear is not legally prohibited in the case that reasonable precautions had been taken to prevent the loss of the gear. The loss of the material does have to be logged in a report and send to any (coastal) state nearby (160). The treaty is not accurately addressing a quantification of the lost or disposed fishing gear allowed, creating a gap in the legal area covering this issue. Especially since, according to Richardson et al. (2022), the quantity of ALDFG in the oceans currently is estimated at “2963 km2 of gillnets, 75,049 km2 of purse seine nets, 218 km2 of trawl nets, 739,583 km of longline mainlines and more than 25 million pots and traps are lost to the ocean manually" (1). Thus, a significant number of fishing gear has ended up in the ocean, meaning the MARPOL Agreement should be further adjusted.

Second, the international legally binding instrument on marine plastic pollution should address the issue of illegal, unregulated, and unreported (IUU) fishing. Abandoned and lost fishing gear can be the result of illegal fishers who abandon fishing gear to avoid being caught. According to the FAO (2009), the discarded material used by IUU fishing is often not marked, identified, or reported as the IUU fisheries try to avoid being associated with a particular vessel. IUU fishing activities may also include gear conflicts because of a lack of communication with other fishers, resulting in lost fishing gear. Lastly, the FAO identifies that IUU fishing done at night poses a larger risk to lose fishing gear (56). Thus, the legal agreement on marine plastic pollution should address the issue of IUU which likely has resulted in a large amount of ALDFG.

Third, the legal agreement on MPP should address the plastic production industry, as there is a gap in global environmental standards in responsibility for all parts of the plastic product lifecycle. According to Raubenheimer, a closed-loop lifecycle for resins and additives should be included in a binding agreement on marine plastic pollution. To achieve this, the 'Polluter Pays Principle' (PPP) should be implemented (52). The principle, introduced by the OECD, holds the manufacturer responsible to pay for the burden of environmental pollution, as funding required to address these global-scale issues is often difficult to obtain by governments. In 1991, Gaines wrote that the PPP had not yet been evenly implemented in neither Europe nor the United States (466). In 2021 a report published by the European Court of Auditors stated that the PPP should be more strongly integrated into environmental legislation and that EU funds were used to finance projects that should have been funded by the polluter, meaning that the principle still has not been fully applied to climate change related issues (European Court of Auditors 2021, 5). The European Court of Auditors states that the application of the Environmental Liability Directive should be reinforced for the PPP to be more well integrated. In addition, EU funds should be protected in collaboration with Member States, to ensure that the polluter is charged for the pollution one is responsible for (Ibid, 36).

Related to the Polluter Pays Principle is the Extended Producer Responsibility (EPR). EPR schemes should be legally binding to adequately address the plastic waste crisis. According to Kosior and Crescenzi (2020) the Extended Producer Responsibility is an agreement which aims to reduce neglected (plastic) waste, through enforcing recycling and decreasing the dependency on raw materials. EPR lays the responsibility for end-of-life products by the producing industry and encourages industries to focus on the recyclability of their products and packaging. In addition, the authors highlight that EPR schemes for packaging, batteries, end-of-life vehicles and electrical equipment are regulated by EU Directives (Kosior and Crescenzi 2020). For most of the material that is found to be marine pollution, such as gillnets or single-use plastic packaging, EPR schemes are not well established yet. The responsibility for waste by the fishing industry or by food packaging industries remains low as it is difficult to control the end-of-life of these material and to determine the recyclability of these plastics, especially when found in the environment as the material might be polluted and classified as hazardous waste. Treaty design on MPP should include various solutions to address the recyclability and responsibility for waste by producing industries and should set targets and sanctions for companies producing single-use plastics that are often found to be in rivers. In the case that a country's waste management systems are not capable of large-scale recycling, a solution may be that the producer takes initiatives to produce biodegradable packaging for the products sold. To conclude, the treaty elements discussed above could potentially manage the large stream of plastic waste into the marine environment. At this stage, marine plastic pollution has been brought forward to the international agenda now more than previous years and introducing a suitable policy response could potentially turn off the 'plastic tap'.

6. Conclusion

The research aimed to identify the direct and indirect costs associated with marine plastic pollution, and address three potential solutions to the issue. The research showed that more than 200 marine species are affected by plastic pollution currently, and that this has led to a 1-5% decline in marine ecosystem delivery. In addition, the research highlights a causal relation between the increase in marine debris in touristic areas, leading to a decline of visitors and thereby a loss in economic revenue in the tourism sector. The case studies conducted outlined the current impacts of marine plastic pollution on the tourism sector in Indonesia and the Dominican Republic. The data proved that the economic losses in the tourism sector in Indonesia lead up to on average $9.445.000 per year. In the Dominican Republic the estimated yearly loss in the tourism sector as a result of marine plastic pollution is $11.390.000. Based on both a quantitative and qualitative analysis of the costs induced by MPP on the fishing industry, the tourism sector, and waste management costs, it can be concluded that the costs lead up to $6-19bn USD annually in these sectors. Based on the analysis of the costs induced by MPP on the marine ecosystem delivery, the researched showed a loss of $500-2500 billion in the value of benefits obtained annually. As plastic waste is persistent and could take hundreds or even thousands of years to degrade, the severity of the problem is outstanding. The research established that the cost of the complete lifecycle of plastic produced in 2019 will be at least US$3.7 trillion, meaning that this cost will generate from the lifecycle of all plastic produced every year.

To avoid environmental contamination and the damage of marine ecosystems, waste management should be improved and the current quantity of land- and ocean-based plastic should be cleaned up. It can be concluded that there is a strong need for the plastic production industry and global governance to address the continuously growing plastic waste crisis. Large companies responsible for the production of plastics should be held accountable for the plastic waste crisis and invest in initiatives that work towards cleaning up MPP. Taking steps to prevent plastic waste in the environment is necessary to avoid governments burying themselves in increasing plastic debt. The research outlined several possible solutions, including plastic bans -and taxes and plastic credit programs, and identified the gaps that need to be focused on in the development of a treaty addressing marine plastic pollution.

While the limitations in the accuracy of the determined economic costs are acknowledged, the costs provide an estimate useful for potential solutions. Further research is needed to quantify the financial costs related to human health. The research illustrated qualitative costs to human health that result after the ingestion of microplastics, however, further research would be necessary to determine the exact impact and costs this issue might result in future years. Besides the economic losses in the sectors assessed in this research, there are many other economic consequences related to plastic pollution that were not addressed yet, related to the complete lifecycle of plastic waste. The costs yet to be researched might be related to sorting and recycling costs by both formal and informal sectors, and the costs of valorization of the plastic waste when created into a new product. Therefore, these costs should be assessed in future research for policies to address every step of the management of marine plastic pollution.

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