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Assessment of the transformative potential of interventions in addressing coastal and marine plastic pollution in Norway: A literature review

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Abstract

Marine plastic pollution is a pressing and wicked problem. Hence, to tackle plastic pollution, the focus should be on systemic solutions and achieving societal transformation. Yet, how societies can effectively initiate such transformation is not well understood. This study examines implemented interventions to address coastal and marine plastic pollution in Norway, with a special focus on the interventions' transformative potential. Following PRISMA guidelines, a total of 52 eligible interventions from 39 publications were identified and categorized according to the leverage points (LP) perspective. The findings reveal that the majority of interventions (61.5%, n = 32)—such as recycling, cleanups, monitoring, and charges for plastic use—address system parameters and system feedbacks and indicate a predominant focus on interventions that are relatively easy to implement but possess limited transformative potential. Three interventions with transformative potential, addressing system intents, were identified. To further analyse interventions' transformative potential, this article integrated societal intrinsic and extrinsic values perspective from social psychology. Drawing on an analysis of LP and values perspectives, we presented a definition of a transformative intervention to integrate two disciplinary viewpoints; we also outlined several transformative interventions across different societal levels. The contribution of this study is to enhance understanding and encourage research on concrete interventions with transformative potential and transformative interventions.

Author summary

Marine plastic pollution is an urgent and complex problem. Hence, to tackle plastic pollution, the focus should be on systemic solutions and achieving societal transformation. Yet, how societies can effectively initiate such transformation

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is not well understood. In this study, we explore various implemented solutions to address plastic pollution along Norway's coasts and marine environments, focusing particularly on the efforts that can lead to a significant transformation of the current plastics system. We examined 52 concrete implemented solutions to plastic pollution. We found that the majority of them (61.5%, n = 32), such as recycling, clean-up efforts, charges on plastic usage, or monitoring, are relatively easy to implement, but fall short of tackling the root causes of the issue. However, we also identified three solutions with the potential to transform the existing plastics system. To deepen our understanding of these transformative solutions, we applied insights from societal intrinsic and extrinsic values from social psychology, specifically examining how prioritization of goals and values rooted in society might influence decisions within the plastics system and subsequently change the system. Finally, our study offers and contributes with additional perspective on how transformative solutions can look like in addressing marine and coastal plastic pollution in Norway. We hope to broaden the discussion and inspire future research focused on solutions that address the root causes and seek to fundamentally reduce and prevent marine and coastal plastic pollution.

1. Introduction

Plastic litter is a worldwide issue with anthropogenic causes. Due to the robustness and long-lasting property of plastic, plastic pollution puts ecosystems, food webs, and human health at risk [1]. One of the biggest challenges with plastic is that it leaks into and pollutes marine environments. It is estimated that from surface to deep-sea waters, 80% of collected marine litter is plastic [2].

Marine plastic pollution is also a pressing and wicked problem [3]. Wagner [3] argues that if plastic pollution is a system-based issue, we should acknowledge its interconnected causes, including decisions at multiple levels of the "plastic ecosystem". Research by the Pew Charitable Trusts and SYSTEMIQ [4] determined that only a system change scenario can decrease plastic leakage in the oceans to lower levels by 2040. To understand how to achieve system change, it is essential to define what transformation entails.

Social transformations toward sustainability involve the interplay of human and environmental system elements [5] and refer to "fundamental changes in structural, functional, relational, and cognitive aspects of socio-technical-ecological systems that lead to new patterns of interactions and outcomes" [6, p. 2] that can also be facilitated by changes in individual and collective values and behaviours [7]. Yet, how societies can effectively initiate such transformation is not well understood [8].

The field of social-ecological systems offers theoretical perspectives for a holistic understanding of natural and social systems and for tackling the social-ecological crisis. One of such approaches is the leverage points (LP) perspective that considers a systemic view and is argued to be promising to address wicked problems [9,10]. As posited by Meadows [10] and Fischer & Riechers [11] within the context of wicked

systems, for interventions to have a transformative potential to drive system change, it is necessary to address leverage points in the system intents, i.e., changing underpinning societal values, mindsets, and paradigms.

Norway was selected as a case study due to its high per capita waste generation in Europe [12]. The Norwegian Plastic Strategy outlines a vision for a more sustainable plastic value chain at national and global levels, emphasizing increased recycling and prolonged reuse (Klima- og miljødepartementet, 2021). The most prevalent solutions to tackle plastic pollution in Norway center around recycling, waste management, incineration, and clean-ups [13, p. 8, 14].

To understand the broader context of solutions to tackle coastal and marine plastic pollution in Norway this study aims to answer the following research questions: RQ1 addresses the existing implemented interventions to tackle coastal and marine plastic pollution in Norway across multiple disciplines, RQ2 - the impacts of these interventions, and RQ3 - the interventions with transformative potential. The article sets the stage for an overview and assessment of the interventions motivating transformative change that have been under-recognized [11]. Answering these questions will contribute to the current research and discussion of interventions with transformative potential and social transformation through the lens of social-ecological systems and social psychology, specifically the leverage points and societal values perspectives. Finally, informed by the mentioned perspectives, we discuss what transformative interventions might entail in an alternative plastics system in Norway.

1.1. Theoretical framework

1.1.1. Leverage points perspective. Leverage points are places in a system where a minor intervention may shift the system and lead to a significant change [see Fig 1, 10]. The leverage points (LP) perspective emphasizes the importance of interventions that can bring about transformative change in sustainability transformation, urban futures, food and energy, plastic packaging, and marine and coastal pollution [9,15–18]. Following the classification of Abson et al. [9], LP can be grouped into four system characteristics: system parameters, system feedbacks, system designs, and system intents (see Fig 1). System parameters are modifiable, mechanistic characteristics such as targets, incentives and standards, or physical elements of a system, such as sizes of stocks or rates of material flows [9, p. 32]. System feedbacks are the interactions between elements within a system of interest that drive internal dynamics or provide information regarding desired outcomes (e.g., the effectiveness of a given incentive scheme). System designs relate to

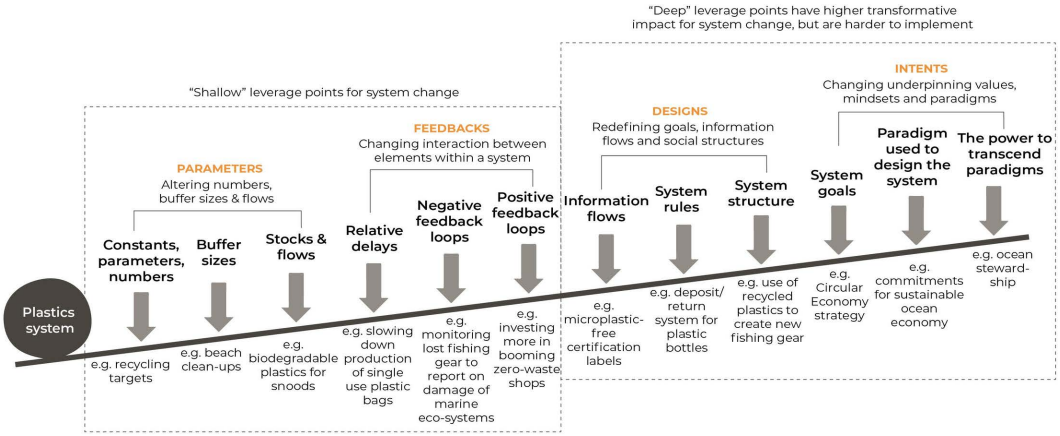

Fig 1. The 12 leverage points by Meadows [10] in their hierarchical scale from shallow (left) to deep (right), and the synthesized four system characteristics of Abson et al. [9] (parameters, feedbacks, designs, and intents). Some examples are based on the findings of the current literature review. The figure is adapted from Abson et al. [9], Meadows [10], and Fischer & Riechers [11].

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the structure of information flows, rules, power, and self-organization. System intents relate to the norms, values, and goals embodied within the system of interest and the underpinning paradigms out of which they arise.

Meadows [10] as well as Fischer & Riechers [11] argue that system intents might represent the most transformative areas to intervene. System intents are the values, beliefs, and paradigms of a system and actors. When the system shifts its focus to new values, beliefs, and paradigms, these changes should be reflected in the following system designs, feedbacks, and parameters [19, p. 164]. We applied the LP perspective [10] to analyse implemented interventions to tackle marine and coastal plastic pollution in Norway. The four system characteristics [9] were used to structure and report the results. We included values perspective from social psychology to contribute to the discussion on the influence of societal values in driving transformation.

1.1.2. Societal values perspective. Values in psychology represent guiding principles [20] that are relatively stable over a lifetime and serve as a moral reference point for behavioural choices [21, p. 28]. Values can be studied at the individual, group, and society levels. Kasser [22,23] argues that on different societal levels, the activation of intrinsic values/goals and relevant behaviours and attitudes (i.e., the bleed-over effect) and suppression of extrinsic values/goals and relevant behaviours and attitudes (i.e., the seesaw effect) can lead to social change. Intrinsic values represent self-acceptance, affiliation, and community, i.e., supporting nature, social equality, good interpersonal relationships, personal growth, community volunteering, and creative expression [23]. Extrinsic or materialistic values are associated with rewards from things or people, i.e., for financial success, image, popularity, and status [23]. Maio et al. [24] and Kasser [23,25] argue that activating a particular value/goal at a specific time can produce bleed-over and seesaw effects. The bleed-over effect suggests that the activation of a value/goal should increase behaviours and attitudes that are coherent with the activated value/goal. The seesaw effect describes the activation of a value/goal suppressing behaviours and attitudes that oppose the activated value/goal. For instance, if people's community value is activated, they prioritize more attitudes and behaviours relevant to community value i.e., the bleed-over effect and less financial values/goals and relevant behaviours and attitudes that are on the opposite side to community value in the circumplex model of goals, i.e., the seesaw effect (See Fig 2, [23]). In contemporary capitalistic society, individuals are frequently exposed to extrinsic values through advertisements, social media, and pop culture such as movies, often prompting them to prioritize wealth over environmental conservation and social justice [22]. This causes society to suppress intrinsic values/goals and instead consume materialistic substitutes, such as products that claim to offer happiness and community acceptance. Thus, Kasser [22,23] argues that potential interventions with transformative potential involve activating intrinsic values/goals and minimizing exposure to extrinsic values/goals. Specifically, ensuring that decision-makers at various societal levels prioritize and act according to intrinsic values.

2. Results

2.1. Descriptives of interventions

Thirty nine publications were reviewed using qualitative content analysis [26], in which 52 interventions were identified. Over the last nine years (2014–2022), the number of implemented interventions increased, with a maximum of six interventions in 2018. Between 1983 and 2013, the number of interventions was characterised by one or two interventions implemented per year. Eight interventions out of 52 did not include information on the year of implementation. The distribution of interventions per implementation year is provided in S1 Fig. The allocation of interventions exhibited a comparatively balanced distribution across national (46.4%, n = 26) and local (35.7%, n = 20) spatial scope; and global spatial scope contained fewer interventions (17.9%, n = 10) (Fig 2) (See sub-section 5.1.2. Coding and data analysis for coding definitions). The interventions were relatively balanced, distributed across informational (23.8%, n = 15), political (20.6%, n = 13), technological (12.7%, n = 8), and/or economic (12.7%, n = 8) approaches (Fig 2). The collaborative (9.5%, n = 6), material (7.9%, n = 5), behavioural (6.3%, n = 4), and/or structural (6.3%, n = 4) approaches were implemented to a lesser extent (Fig 2). Note that several approaches within one intervention are possible.

Interventions were implemented mainly by scientists (30.8%, n = 16); by several actor groups including various collaborations among volunteers, fishers, NGOs, scientists, policy makers, businesses, and governmental institutions (28.8%, n = 15); only by policy makers (23.1%, n = 12); and by businesses and/or businesses with engineers (11.5%, n = 6) (Fig 2). Three interventions (5.8%) did not provide information on who implemented the interventions. The variable of evaluation of interventions revealed a relatively even distribution, 38.5% (n = 20) of interventions were not evaluated or did not provide information on evaluation and/or impacts, 30.8% (n = 16) of interventions addressed some discussion on evaluation and/or impacts, and 30.8% (n = 16) were evaluated and/or discussed impacts of an intervention (Fig 2).

2.2. Implemented solutions arranged across the leverage points

After classifying the implemented interventions across the system characteristics, our results showed that 28.8% (n = 15) of interventions addressed system parameters. System feedbacks were addressed by 32.7% (n = 17) of interventions, 32,7% (n = 17) of interventions addressed system designs, and 5,8% (n = 3) – system intents (Table 1, Fig 3). A detailed description of how the interventions were arranged along the LPs can be found in Section 5. Materials and Methods. Each intervention was assigned an identifier, with the label "P" indicating interventions in system parameters, e.g., [P1]; the

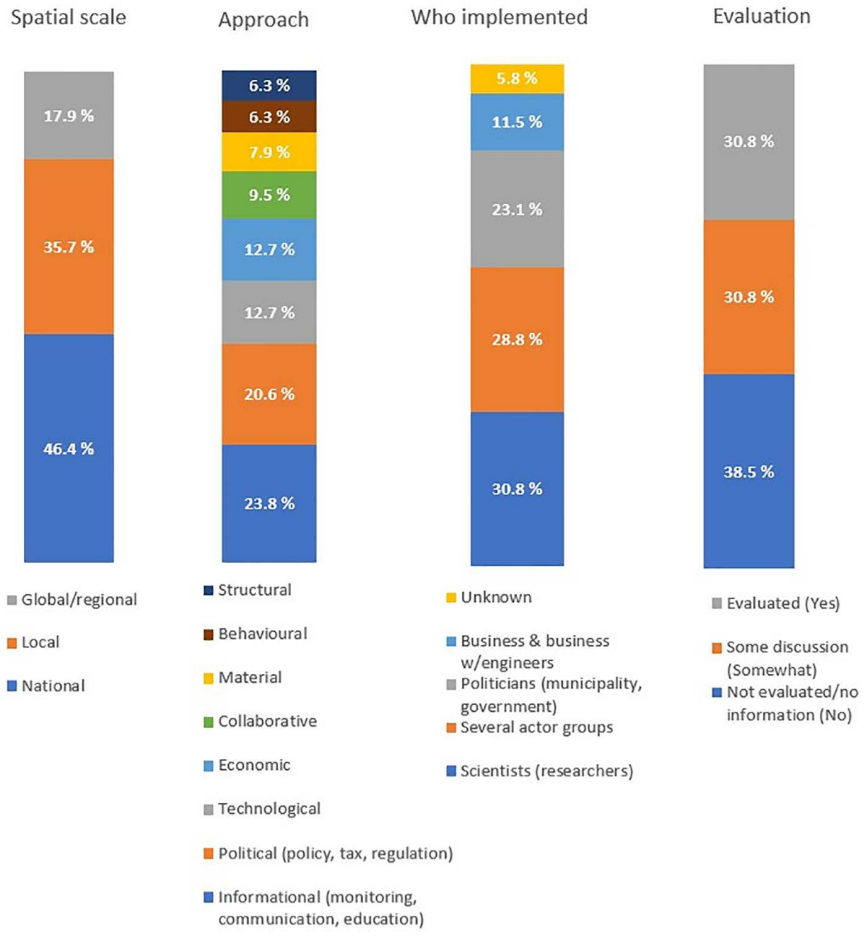

Fig 2. Categorization of 52 interventions (in percentages) according to the variables: the spatial scope of a study, the approach of an intervention, who implemented, and whether interventions were evaluated. One intervention can use several spatial scale and intervention approaches. The variables are explained in Table 2.

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Table 1. Four system characteristics according to Abson et al. [9] and 12 Leverage points of Meadows [10]; the number of interventions identified in the literature and content analysis. "Evaluation" column: "Yes" refers to an intervention that was evaluated; "Somewhat" – some discussion was provided on interventions' evaluation and/or impacts; "No" – an intervention was not evaluated or no information on evaluation was provided.

Leverage points (Meadows, 1999)	Specific interventions identified from content analysis (Total n = 52 interventions)	Year of implementation	Evaluation	
System Parameters - Technical leverage 28. 8% (n = 15)				
12. Numbers	1. Recycling targets policies [27]	1991	Yes	–
11. Buffer sizes	1. Beach clean-ups by volunteers [28]	2011 - 2018	Yes	+
	2. Annual clean-up surveys in many regions of the Arctic [29]	From 1983	Somewhat	+
	3. Surface clean-up technologies: PGS bubble curtain tow [30]	2018	Somewhat	–
	4. Remotely operated underwater vehicles (ROVs) [31]	From 2017	Somewhat	–
	5. Wastewater treatment plant (WWTPs) with advanced treatment technologies for the removal of microplastics [32]	–	Yes	+
	6. Extraction of microplastics from soil, sludge [33]	–	Yes	+
	7. The laboratory scale sand-filter [34]	2022 - 2023	Yes	+
	8. Floating jetty with a system to collect and store macro marine plastic [35]	2018	No	n/a
	9. Port suction system collects floating garbage [35]	2016	No	n/a
10. Physical stock-and-flow structures	1. Biodegradable snoods [36]	2021	Yes	+
	2. Biodegradable gillnets [37]	2021	Yes	–
	3. Biobased and biodegradable food packaging materials [38]	–	Somewhat	–
	4. Thicker gillnet twine [39]	2022	Yes	+
	5. Port Reception Facilities (PRF) [40]	2016	Somewhat	–
System Feedbacks - Technical leverage 32. 7% (n = 17)				
9. Relative delays	–			
8. Balancing feedback loops	1. "Empower Plastic Credits" a service/system to incentivize businesses to fund plastic collection by blockchain-enabled tracking [35]	2018	No	n/a
	2. Landfill tax, 1999–2015 [27]	1999	Yes	+
	3. Packaging waste taxes in Norway (the Beverage Packaging Tax; the Amendment to the Packaging Tax; and Updates to Chapter 7 on Packaging Waste) [41]	From 1994	Somewhat	+
	4. Plastic pollution tax on households (Study) [42]	2018	Yes	+
	5. Recycling charges for households [27]	2015	No	n/a
	6. Beach litter monitoring on citizen science protocols and OSPAR [43]	From 2010	Somewhat	+
	7. Observation and monitoring initiatives: Norwegian Environmental Monitoring Programme; Norway Seafood Monitoring Programme at Institute of Marine Research [44]	–	No	n/a
	8. The PlastOPol marine litter monitoring system (based on citizen science) [45]	From 2013	Somewhat	+
	9. The Arctic Monitoring and Assessment Program – microplastic [46]	2019	No	n/a
	10. Monitoring in fulmar stomachs [47]	From 2002	Yes	+
	11. Monitoring: GIS-based predictive model to identify marine litter hotspots [48]	2018	Somewhat	+
	12. Ecosystem cruises: manta trawling for recording floating litter [29]	2014	Somewhat	n/a
	13. The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) (monitoring and assessment of marine and coastal litter) [49]	1992	No	n/a
	14. Regulation to report of lost fishing gear from commercial fisheries [50]	2020	N/a	n/a
	15. Voluntary app "fritidsfiske" for recreational fishers to report lost gear [31]	2017	Somewhat	+
	16. Reporting guidelines to increase the reproducibility and comparability of research on microplastics [51]	2019	No	n/a
	17. Food packaging optimization program (spec. meal preparation study) [52]	2014	Somewhat	n/a

(Continued)

Table 1. (Continued)

Leverage points (Meadows, 1999)	Specific interventions identified from content analysis (Total n = 52 interventions)	Year of implementation	Evaluation	
7. Reinforcing feedback loops	–			
System designs (structure) - Human leverage 32. 7% (n = 17)				
6. Information flows - who does/doesn't have access to information	1. Microplastic-free certification labels on products [53]	2019	Yes	–
	2. Campaign "Clean Oceans – Our Common Responsibility" [54]	2018	Somewhat	–
	3. Eco-design courses for student designers [55]	–	Somewhat	n/a
	4. Experimentation: Eco-visualization [56]	2020	Somewhat	n/a
	5. Films for fishers by Clean Nordic Oceans [31]	2019	No	n/a
	6. Real-time online maps showing locations of passive gear [31]	2015	No	n/a
	7. Website with information about green products [27]	–	No	n/a
	8. Co-production of policy actions plans scenarios in collaboration with scientists and industry (microfibre pollution) [57]	2021	No	n/a
5. Rules (incentives, punishments, constraints). Change of the norms	1. National Fishing for Litter (FFL) scheme [58]	From 2016	No	n/a
	2. Formal Regulation of Deposit Systems [27]	1999	Yes	+
	3. The pollution act and waste sorting system for households [27]	–	Yes	+
	4. Resirk/PET system - pant system (return - reward) [59]	From 2000	Yes	+
	5. Sorting stations at the Norwegian University of Science and Technology (NTNU) with various communication channels as a part of NTNU waste separation system [60]	2014	Yes	+
4. Self-organising system structure - the power to add, change, or evolve system structure.	1. Use of aquaculture waste to create new products/resource sharing [40]	2017	No	n/a
	2. Waste collection services for fishing nets and gear as a link in the value chain by connecting suppliers and recyclers to create new products [35]	2008	No	n/a
	3. Cross-sectoral dialogues: The multi-actor concept utilized by Norway – connecting governing bodies, researchers, and stakeholders in open dialogue [46]	–	No	n/a
	4. Extended Producer Responsibility (ERP) for plastics [27,40]	From early 1990s	Somewhat	n/a
System intents - Value based leverage 5,8% (n = 3)				
3. Goals of the system - purpose of the system	1. The Norwegian KIMO (Kommunenes Internasjonale Miljøorganisasjon/ Local Authorities International Environmental Organization) - relational environmentalism [61]	1990	No	n/a
	2. The National Circular Economy Strategy [62]	2021	No	n/a
2. Mindset/ paradigms	1. The High-Level Panel for Sustainable Ocean Economy – ocean stewardship [63]	2020	No	n/a
1. Transcending paradigms	–			

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label "F" – system feedbacks, e.g., [F1]; the label "D" – system designs, e.g., [D1]; and the label "V" – system intent, e.g., [V1] (See S1 Table for all identifiers of interventions).

We structured the further results of the arranged interventions in the following sub-sections: 2.2.1. System parameters, 2.2.2. System feedbacks, 2.2.3. System designs, and 2.2.4. System intents. The following subsections address RQ1 on the existing implemented interventions in addressing coastal and marine plastic pollution in Norway.

2.2.1. System parameters (15 interventions – 28.8%). Interventions addressing system parameters refer to adjusting numbers, sizes of buffers and stocks, and the structure of material stocks and flows [9,10]; system parameters were addressed by 15 interventions (Table 1, Fig 3). One intervention – recycling targets policies [27 [P1]] – involved adjusting *numbers*. Adjusting *sizes of buffers and stocks* included nine interventions, six of which engaged litter collection and removal through beach clean-ups [28 [P2],29 [P3]], technologies such as surface clean-up [30 [P4]], systems to collect and store floating plastic [35 [P9, P10]], and underwater vehicles to collect plastic at greater depths [31 [P5]].

Three interventions involved microplastic removal through wastewater treatment plants [36 [P6]], a protocol for extracting microplastics from soil and sludge [37 [P7]], and a sand filter for removing microplastics from wastewater [38 [P8]]. Five interventions focused on adjusting *the structure of material stocks and flows*: four aim to change the alternative materials of the product, specifically by replacing plastics with biobased and biodegradable materials for snoods, i.e., the rope or line attaching the hook to the mainline [40 [P11]], gillnets [41 [P12]], food packaging [42 [P13]], and altering the thickness of gillnet twine [43 [P14]]; and one intervention involves adjusting a physical structure to reduce marine plastic waste by creating Port Reception Facilities across Norwegian ports and collecting fisheries-related waste [44 [P15]].

2.2.2. System feedbacks (17 interventions – 32.7%). Interventions addressing the system feedbacks refer to managing delays, strengthening negative (balancing) feedback loops, and slowing down positive (reinforcing) feedback loops - the interactions between elements within a system that drive internal dynamics [more on balancing and reinforcing feedback loops read [9], p. 32, [10], pp. 9–11, [18], p. 2]. The current review did not identify interventions addressing *delays* and *reinforcing feedback loops*. Seventeen interventions addressing *balancing feedback loops* were identified. These interventions included five economic/financial interventions, such as a credit service incentivizing businesses to fund plastic collection by blockchain [35 [F1]] and various taxes and charges, such as the landfill tax [27 [F2]], packaging tax [41 [F3]], plastic pollution household tax [42 [F4]], and household recycling charges [27 [F5]]. Eleven interventions addressing monitoring and reporting included the PlastOPol marine litter monitoring system [45 [F8]], the Arctic Monitoring and Assessment Program focusing on microplastic monitoring [46 [F9]], the GIS-based predictive model identifying marine litter hotspots [48 [F11]], the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) involving monitoring and assessing marine and coastal litter [49 [F13]], regulation on reporting lost fishing gear from commercial fisheries [50 [F14]], and the “fritidsfiske” mobile app on reporting lost fishing gear for recreational fishers [31 [F15]]. The rest of the monitoring and reporting interventions can be found in Table 1. One intervention was an optimization program for food packaging that addressed decreasing packaging waste within the food chain for meal preparation [52 [F17]].

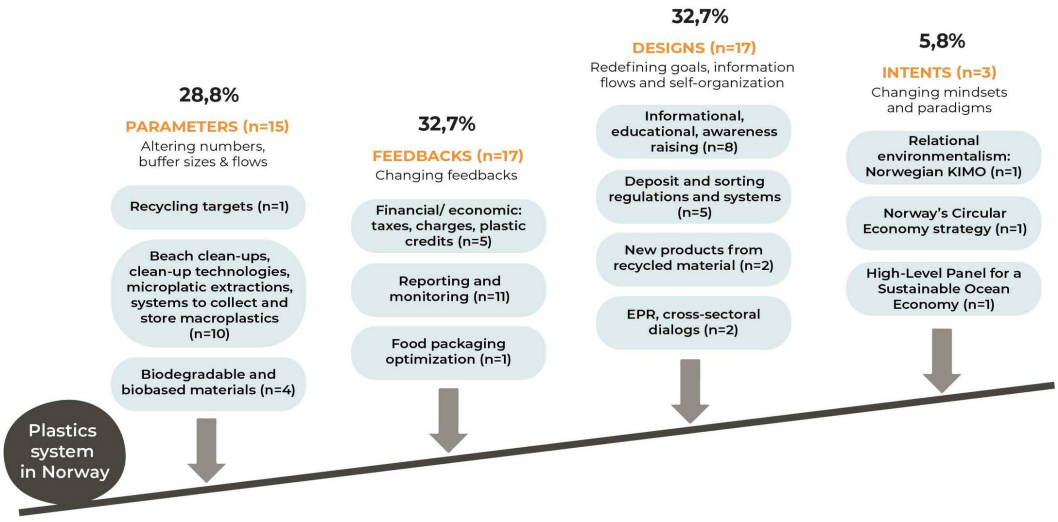

Fig 3. Categorisation and the number of implemented interventions across system characteristics. “n” represents the number of interventions; “EPR” – Extended Producer Responsibility; “KIMO” - Kommunenes Internasjonale Miljøorganisasjon (English translation: Local Authorities International Environmental Organization). The figure is adapted from Abson et al. [9], Korhonen-Kurki et al. [18], and Meadows [10].

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2.2.3. System designs (17 interventions – 32.7%). Interventions addressing system designs extend information to previously underrepresented or unserved areas or actors, altering or creating new social rules, social norms, and system structures [9,10]. In this review, system designs included eight *informational*, awareness-raising, and educational interventions, such as a campaign [54 [D2]], short films [31 [D5]] for fisherfolk, eco-design courses for student designers [55 [D3]], a website with information on green products [27 [D7]], an eco-visualization [56 [D4]], microplastic-free product labels [53 [D1]], real-time online maps showing locations of passive gear [31 [D6]], and co-production of scenarios for policy action plans [57 [D8]]. Changing and creating *social rules and norms* with the help of strategies and policies involved two interventions, such as the National Fishing for Litter Scheme [58 [D9]] and formal regulation of deposit systems [27 [D10]]. Changing and creating *social rules and norms* with the help of creating physical structures included three interventions, such as a waste sorting system for households [27 [D11]], resirk/PET system [59 [D12]], and a waste sorting system at the Norwegian University of Science and Technology [60 [D13]]. Changing *system structures* concerned with using recycled material as raw material, which included two interventions, such as the use of local aquaculture waste [40 [D14]] and waste collection services for fishing nets and gear [35 [D15]] to create new products and two interventions, such as Extended Producer Responsibility for plastics [27 [D17],40] and cross-sectoral collaboration as a precautionary approach in supporting the national strategy to address plastic pollution [46 [D16]].

2.2.4. System intents (3 intervention – 5.8%). Interventions addressing system intents refer to the goals embodied within the system, i.e., the underpinning society's paradigms or beliefs from which the system arises, as well as the power to transcend paradigms [more on paradigms read [9], pp. 32, 36, [10], pp. 17–19]. We identified three interventions in this characteristic. Two interventions related to changing *goals or the purpose of a system* included the Norwegian KIMO (Kommunenes Internasjonale Miljøorganisasjon, English translation: Local Authorities International Environmental Organization) [61 [V1]] and the Norway's National Circular Economy Strategy [62 [V2]]. The Norwegian KIMO aimed to change the goals of a system by giving local authorities a political voice at the regional, national, and international levels through a newly established concept: *relational environmentalism*. The authors defined *relational environmentalism* as "a movement of humans who purposefully interact with each other as well as external organizations in a variety of dynamically developing ways to affect the perceptions, motivations and practical actions for the caretaking of endangered natural environments", in the context of plastic pollution, local authorities with a political voice at different levels could engage with other actors to address pollution prevention and mitigation efforts in marine and coastal environments [61, p. 4 [V1]]. For example, KIMO International works and lobbies for changes at national, EU, and international levels, including campaigning for improvements in legislation to address issues caused by marine litter [64]. The Norway's National Circular Economy Strategy aimed to change the goals of a system by transitioning from a linear economy (system) to a circular one. The Strategy was based on "sustainable production and product design, sustainable ways to consume and use materials, products, and services, and non-toxic circular loops" [62, p. 11 [V2]]. One intervention addressed changing the *system's paradigm*: the High-Level Panel for a Sustainable Ocean Economy [63 [V3]]. Among members, the High-Level Panel for a Sustainable Ocean Economy included the head of the Norwegian government. The Panel aimed to change the system's paradigm by formalizing and securing commitments to ensure stewardship of oceans under national jurisdictions at a high national level. The *stewardship* was defined through four dimensions: "moving beyond compliance, taking a systems perspective, living with uncertainty, and understanding humans as embedded elements of the biosphere" [63, p. 2 [V3]]. The current review did not identify interventions concerning *transcending paradigms*.

2.3. Evaluation and impacts of interventions

The results showed that out of 52 interventions, 16 interventions (30.8%) were evaluated, 16 interventions (30.8%) discussed some impacts, and 20 interventions (38.5%) were not evaluated or did not provide information on impacts (Fig 2). Since this literature review was based on interventions from various disciplines, the evaluation methods varied. They included technical performance analyses, cost-benefit analysis, laboratory tests, contingent valuation method, user study,

life cycle assessment with material flow analyses, experimental panel survey, and quasi-experimental analysis. The evaluation methods were not cross-validated by the authors of this study. The aim was to review the existing interventions on marine and coastal plastic pollution in Norway and their impacts, drawing upon the authors' evaluation, analysis, discussions, and conclusions. Further subsections expand on interventions that were evaluated or contained discussions on the evaluation or impacts, i.e., addressing the RQ2 on the impacts of implemented interventions.

2.3.1. System parameters. Among the 15 interventions in system parameters, eight were evaluated, and five discussed impacts. The intervention addressing adjusting *numbers,* recycling targets policies as of 1991, for 2020 in Norway were insignificant, i.e., were not met [27 [P1]]. However, the authors stated that even though waste generation and recycling rates showed a move in the right direction, the increase in rates was relatively low [27, p. 166 [P1]].

Interventions concerning reducing the sizes of *buffers and stocks of plastics* demonstrated an increase in annual clean-up actions along the Norwegian coast [28 [P2]] [29 [P3]], negative results in litter removal by clean-up technologies, and high efficiency results in microplastics removal. According to the authors, clean-up efforts resulted in more accountability through marking fishing gear and a required reporting of lost fishing gear. In the context of litter removal using technologies, authors stated that clean-up technologies generally lack environmental cost-benefit analyses, for example, surface clean-up technologies can destroy habitats and affect nutrient flows [30 [P4]]. Also, clean-up technologies focused on larger fractions of plastics and miss more abundant floating microplastics [30 [P4]]. Certain technologies, like remotely operated underwater vehicles, evaluated as part of the Norwegian clean-up campaign, exhibited lower efficiency in retrieving plastic debris, like lost fishing gear, and were more expensive and time-consuming compared to dredging [31 [P5]]. Lastly, microplastics removal interventions showed high efficiency in removing microplastics: the adsorption and membrane filtration [32 [P6]]; Fenton's reagent in combination with density separation [33 [P7]]; and the laboratory-scale sand filter [34 [P8]]. The authors stated that as recycling rates increase, microplastic removal interventions demonstrate the importance of formulating effective microplastic removal strategies and ensuring compliance with possible future discharge regulations [34 [P8]].

Interventions relevant to adjusting *the structure of plastic material stocks and flows,* specifically concerning alternative materials to substitute fossil fuel plastic materials and to reduce plastic pollution resulting from discarded fishing gear and food packaging, demonstrated mixed results. The results of the catch efficiency compared between biodegradable and nylon materials showed no substantial differences for snoods [36 [P11]] and reduced catch efficiency for biodegradable gillnets [37 [P12]]. Barriers to acceptance by the fishing sector included the catch efficiency of gillnets [37 [P12]], and the cost of biodegradable snoods: biodegradable materials were stated to be more expensive compared to nylon [36 [P11]]. The increase in twine thickness of gillnets did not impact catch performance; thicker gillnet twine has the potential to reduce marine plastic litter from damaged gears without affecting catch performance [39 [P14]]. Further, authors [38 [P13]] argued that biobased and biodegradable food packaging materials might not be an immediate substitute to reduce the use of fossil-based plastics, as they require specific waste stream management and must match conventional plastics in food protection, which increases durability, complexity, cost, and consequently reduces biodegradability [38 [P13]].

Lastly, port reception and collection facilities across the Norwegian ports for fisheries-related waste—the intervention relevant to adjusting *a physical structure to reduce stocks* of marine plastic debris—demonstrated negative results [40 [P15]]. Norway has not met the requirements of EU Directive 2000/59/EC, with one-third of Norway's registered ports containing a dedicated port reception facility or waste management plan [40 [P15]]. The authors were concerned that this insufficient infrastructure may result in reduced waste collection, increased illegal dumping, incineration, or waste accumulation in ports, thereby limiting valuable material recovery within the waste collection system.

2.3.2. System feedbacks. Three of the 17 interventions in balancing feedback loops were evaluated, and seven discussed impacts. They primarily included economic and policy interventions and interventions involving monitoring, reporting, and optimization.

Economic and policy interventions demonstrated majorly positive results. The landfill tax and closure of non-compliant sites significantly improved Norway's waste management by reducing the number of landfills by 81.82% between 1992 and 2012 and decreasing household waste sent to landfills by 79.17% from 1998 to 2010 [27 [F2]]. Since 1999, there has been a notable increase in plastic and packaging policies in Norway [41 [F3]], addressing waste management, such as collection, landfilling, sorting, and recycling [41 [F3]]. However, they did not cover the circular economy principles like reduce, repair, reuse, refurbish, remanufacture, and repurpose [41 [F3]].

Interventions regarding monitoring and reporting have also demonstrated positive results. The collected citizen science data in Norway proved valuable in identifying the primary sources of marine debris, where some limitations could be improved with geo-tagging of beaches [43 [F6]]. The PlastOPol system showed to be effective in monitoring and communicating marine litter, and connecting citizens, researchers, and decision-makers [45 [F8]]. Monitoring of birds has shown a significant decrease in plastic mass in fulmars over the recent 10-year and 17-year periods, which suggests that ongoing efforts were effective [47 [F10]]. The GIS-based predictive tool with refinement might optimize marine litter clean-up efforts by detecting the most heavily polluted shores along heterogeneous and remote coastlines [48 [F11]]. Voluntary reporting of lost fishing gear via the "fritidsfiske" app, developed by the Norwegian fishing authorities, enabled effective clean-up and recovery, with a high 70%-80% percentage of fishing gear being returned to owners [31 [F15]].

Lastly, the results of the food packaging optimization intervention showed that ready-to-eat meals generate more packaging weight along the value chain than home-cooked meals from fresh or semi-prepared ingredients [52 [F17]]. As ready-to-eat meal consumption might rise in Norway, the authors emphasized the need for improved packaging design for ready-to-eat meals to reduce the usage of packaging materials [52 [F17]].

2.3.3. System designs. Five of the 17 interventions on system designs were evaluated, and four discussed impacts. Impacts of interventions concerning *information flows*, awareness raising, and educational interventions were not substantially effective. Using certification labels to mitigate marine plastics showed to be ineffective: Norwegian consumers show little interest in paying extra for conscientious certified products over non-certified options [53 [D1]]. Next, "Clean Oceans – Our Common Responsibility" awareness campaign and increased media coverage have stimulated local regulations on the reduction of plastic pollution in Norway and shifted fishers' attitudes [54 [D2]]. However, increased sensitivity has not entirely led to effective practices [54 [D2]]. In contrast, eco-visualization as disruptive communication was effective in triggering active engagement and strong emotions in children that were crucial to direct towards actions such as solution development [56 [D4]].

Interventions concerning *social rules and norms* showed positive results. In Norway, coverage for waste sorting system for households was high, with 87% of municipalities providing separate collection for plastic packaging. However, Norway's recycling rate has stagnated and somewhat decreased between 2016 and 2017 [27 [D11]]. The Norwegian deposit and recycling system for PET bottles has demonstrated significant results, with the total return rate of PET bottles at 88.2% in 2016 [27 [D10]]. The system has been in operation since 2000 [59 [D12]] and supported by the Formal Regulation of Deposit Systems (1999) [27 [D10]]. Further, another more localized intervention, implemented at the Norwegian University of Science and Technology, found that combining structural strategies (waste separation system) with informational approaches (flyers, cards, and website) proved effective in motivating people to sort, especially for individuals with high motivation and self-efficacy [60 [D13]].

Lastly, interventions related to *system structures* demonstrated mixed results. Norway's multi-actor dialogues, involving governing bodies, researchers, and other stakeholders, exemplified an effective approach for knowledge-sharing, prioritizing critical topics for research and policy, contributing to policy development, and establishing and updating action plans [46 [D16]]. However, regarding another intervention—Extended Producer Responsibility—the feasibility assessment in 2018 emphasized the need for a detailed understanding of the system's life cycle flows and stocks to select more effective implementation mechanisms [40 [D17]].

2.3.4. System intents. In system intents among the three interventions, no interventions were evaluated. However, the following aspects recognized by the authors of this study are valuable to consider. The potential impact of the Norwegian KIMO (giving local authorities a political voice at various political levels) lay in sharing knowledge with broader audiences, building new alliances, ensuring commitment, diversifying communication and mobilizing measures, thus safeguarding social justice and political equality [61 [V1]]. Next, the Norway's National Circular Economy Strategy [62 [V2]] holds significant potential to encourage manufacturers and producers to reduce material use and pollution; however, the strategy did not outline actionable targets and mechanisms to evaluate and assess its performance and impact. Lastly, the High-Level Panel for a Sustainable Ocean Economy established commitments, such as in 2018, commitments included to protect 30% of marine habitats by 2030, and to reduce ocean plastics, and in 2020 – to sustainably manage 100% of national ocean areas by 2025 [63 [V3]]. The progress of commitments was documented but not evaluated [65]. Thus, authors argued that ensuring governments' accountability for their commitments and integrating them into supportive policies were important [63 [V3]].

3. Discussion

This literature review and analysis of interventions on marine and coastal plastic pollution in Norway suggested that scientific publications emphasize reducing plastic pollution rather than preventing it. The majority of interventions (61.5%, n = 32), addressing system parameters and feedbacks, focused on interventions that are relatively easy to implement but with no or low transformative potential. In system parameters, these interventions revolve around recycling targets, beach clean-ups, microplastic removal, and suggestions of alternative materials without addressing the cause of the pollution, i.e., overall plastic litter continues to increase. This also mirrors the funding of Handelens Miljøfond, Norway's largest private environmental fund supporting national and international projects to reduce plastic pollution, which funded 141 projects in Norway in 2023, 94 of which appear to emphasize clean-up interventions [14]. Likewise, previous research supports that interventions, such as waste collection and recycling, are the most prevalent solutions to tackle plastic pollution [66]. Further interventions, such as adjustment of charges and fees, recycling, monitoring and reporting, and optimization of processes, tackle the system feedbacks, yet are also unlikely to lead to a transformative change on their own. Reporting and monitoring interventions appear to focus more on diagnosing the problem than solving it. Even if these interventions are not inherently transformative, while considering existing information gaps and the necessity for long-term monitoring, they can serve as a crucial precondition toward transformative change [67].

Further subsections expand on the RQ3, addressing interventions with transformative potential in tackling coastal and marine plastic pollution in Norway from the LP and value theory perspectives.

3.1. Interventions with transformative potential in addressing coastal and marine plastic pollution in Norway

The past and current predominant discourses about interventions such as litter clean-ups, recycling, individual consumer changes, and increasing awareness about the plastic pollution issue alone are unlikely to solve the issue of plastic pollution [53 [D1],54 [D2]]. Many researchers advocate for interventions with transformative potential, which focus on preventing and reducing the production and consumption of plastics [68–71], including top-down interventions such as regulatory frameworks and the institutionalization of pro-environmental practices [53 [D1],54 [D2]]. In this study, we found noticeably less focus on efforts to intervene in deep leverage points, such as the worldviews, beliefs, and paradigms. According to the LP perspective, we identified three interventions that attempt to lead to transformative changes, i.e., establish new societal goals, beliefs, and paradigms of the system: 1) the Norwegian KIMO (relational environmentalism) [61 [V1]], 2) the Norway's National Circular Economy Strategy (circular economy) [62 [V2]], and 3) the High-Level Panel for a Sustainable Ocean Economy (stewardship of oceans) [63 [V3]]. The LP perspective suggests that if a plastics system shifts its focus towards new paradigms such as relational environmentalism, circular economy, and stewardship of oceans, these pro-environmental goals and paradigms should also be reflected in the system's designs, feedbacks, and parameters, ultimately leading to transformative change in a system [19, p. 164].

The three identified interventions of relational environmentalism, circular economy, and stewardship of the oceans, that exhibit a transformative potential in line with LP [10], also attempt to establish intrinsic values in the plastics system in accordance with the values perspective [22,23]. The Norwegian KIMO [61 [V1]] promotes an intrinsic value – political equality and environmental caretaking; the Norway's National Circular Economy Strategy [62 [V2]] is motivated not only by economic feasibility (materialistic values), but also by ecological sustainability and sufficiency (intrinsic value); and the High-Level Panel for a Sustainable Ocean Economy [63 [V3]] is also intrinsically motivated by attempting to achieve ocean stewardship on a high national level. In comparison to the LP perspective, values perspective posits that it is not about *changing* individuals' or societal values [9,10,72], instead the focus should be on *strengthening* intrinsic societal values and goals and ensuring all levels of a system operate around them [22,23]. This also includes effectively communicating on various levels, e.g., social media channels, TV, video sharing platforms, and political campaigns, through the lens of intrinsic rather than materialistic values [23,73].

The identified three solutions demonstrate transformative potential from the perspectives of LP and societal values, yet they also present several challenges. The challenges include the limited implementation and prioritization of materialistic values (economic goals). Limited implementation, indicated by the absence or insufficiency of implementation plans with defined targets, actionable steps, and deadlines, hinders evaluating their impact in addressing the plastic pollution issue. The following two solutions are framed through the lens of materialistic values, prioritizing economic prosperity over healthy oceans. This is evident in the use of the term "economy" in the titles of interventions such as the Norway's National Circular Economy Strategy [62 [V2]] and the High-Level Panel for a Sustainable Ocean Economy [63 [V3]], where healthy oceans and sustainable production are regarded as secondary considerations. While comprehensive in vision, the Norway's National Circular Economy Strategy lacks defined targets, action plans, and timelines for transitioning to sustainable production and consumption. Similarly, the Progress Reports of 2022 and 2024 suggest that while the High-Level Panel for a Sustainable Ocean Economy established commitments and some targets, they have yet to develop comprehensive action plans with specified deadlines, including implementing and evaluating these actions [65,74]. Finally, concerning KIMO International, the definition of relational environmentalism and implementation actions possess a transformative potential: the organization can influence policymaking, including at the European Parliament level [64]. However, the Norwegian KIMO's [61 [V1]] implementation efforts in Norway appear to focus primarily on cleanup actions rather than lobbying and driving systemic change [75,76].

Building on the LP and values perspectives, as well as values highlighted by the three interventions with transformative potential—relational environmentalism, circular economy, and ocean stewardship—we have developed a definition of a transformative intervention and present such interventions to contribute to an alternative vision for the plastics system in Norway (Fig 4). To foster intrinsic ocean values among the broader population and accelerate widespread change, these values should be embedded within structural and systemic conditions involving all stakeholders, such as producers, manufacturers, policymakers, citizens, and other relevant actors [78,79], that can prioritize these intrinsic values and goals across their decision-making processes and actions. Thus, we define *transformative interventions* as interventions that shape new systems with intents [10] focusing on intrinsic values and goals, e.g., clean and healthy oceans, reducing materialistic values and goals [22,23], e.g., economic growth in the plastics system, and prioritizing the implementation of these intrinsic values and goals across all levels of decision-making. Further, we outline several transformative interventions across different societal levels, while assuming no resistance to changing the current system:

1. **Substitute indicators of progress with ocean health metrics over economic.** The provision and implementation of ocean health metrics over the standard economic indicators in governmental decision-making is crucial because it redirects the goals of policy and progress measurement from economic growth to ecological health. By adopting this intervention, governments can assess policies based on their impact on ocean water quality, ocean biodiversity, and other indicators of healthy oceans rather than prioritizing economic indicators and addressing the health of oceans

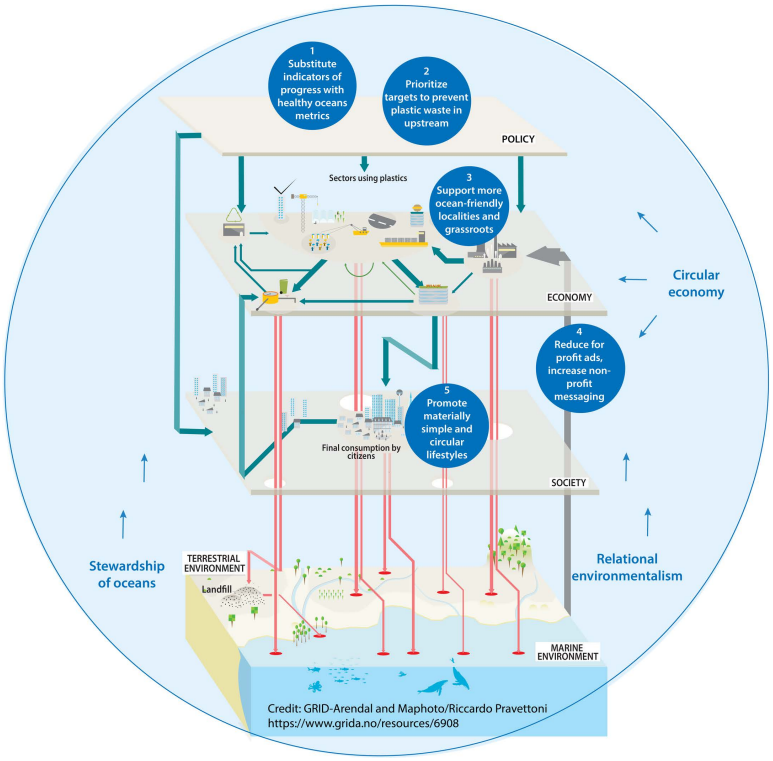

Fig 4. Transformative interventions across different societal levels portrayed with the aim of envisioning an alternative plastics system in Norway. Based on the LP perspective, value theory, and the values such as ocean stewardship, relational environmentalism, and a circular economy, highlighted through the three identified interventions with transformative potential. Original graphic is adapted from GRID-Arendal and Maphoto/Riccardo Pravettoni, https://www.grida.no/resources/6908 [77]. "Policy" layer is added and connected to the original graphic; blue bubbles and "Circular Economy", "Relational Environmentalism", and "Stewardships of oceans" are also added to the original graphic.

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and ecosystems as a secondary consideration. Such measures can be used at the national, regional, and local levels. This intervention is informed by the recommendations of Kasser [23] and Kasser et al. [80] on alternative metrics of progress.

2. **Prioritize targets to prevent and reduce plastic waste in upstream**. Establishing clear targets and timelines to prevent and reduce plastic waste in the upstream can enhance the Norway's Circular Economy Strategy [62 [V2]] and the Norwegian Plastics Strategy [81] and accelerate the implementation of these targets. This intervention can encourage the intrinsic value of the circular economy, i.e., ecological sustainability and sufficiency.
3. **Support more ocean-friendly and local grassroots, farmers, and small-scale businesses.** Promoting and strengthening local grassroots and small-scale businesses, such as local zero waste shops, artisan producers, regenerative farmers, and other businesses focused on plastic prevention and reuse, can enable their prevalence in Norway comparable or higher to the widespread presence of major chains, including Coca-Cola, Kiwi, Coop, Rema 1000, IKEA, H&M, Orkla and others. This intervention can contribute to the reduction of plastic packaging while fostering the intrinsic value of relational environmentalism, community cohesion, local autonomy, and community engagement [82]. The intervention is informed by the Norway's Circular Economy Strategy [62, p. 13 [V2]]
4. **Reduce for-profit advertising and increase nonprofit messaging.** Supporting policies and initiatives that reduce the prevalence of profit-oriented and consumption-driven advertising, both online and offline, while increasing nonprofit

and community-centred messages, can assist in cultivating widely intrinsic values that emphasize environmental stewardship and collective well-being over materialistic values/goals such as overconsumption [23]. This intervention is informed by the recommendations of Kasser [23].

5. **Promote communities for materially simple and circular living.** Promoting and strengthening communities that advocate for simpler, less materialistic, and circular lifestyles can not only prevent and reduce plastic consumption while supporting the intrinsic value of the circular economy, but also can foster sustainable behaviour among people, who may lack motivation for environmental protection through communal initiatives [83]. This intervention is informed by the recommendations of Kasser [82].

The described interventions also necessitate additional interconnected targeted interventions across various societal levels within the plastics system (Fig 4). Such a comprehensive approach is essential to foster an alternative system prioritizing the health of oceans and natural ecosystems. For instance, in Fig 4, intervention to "Promote communities for materially simple and circular living" may entail policy-level interventions, such as regulations and tax deductions for local businesses to support simpler lifestyles, allocated funding for NGO and citizen related initiatives; and economy-and-society level interventions – changes in physical systems to make reuse and reduce behaviours more prevalent and accessible, such as widespread allocation of repair shops, café and restaurants with reusable takeaway food packaging, grocery stores with no plastic packaging, and others.

This societal value orientation provides a foundation for interventions aiming to reduce and prevent plastic consumption and production and has been shown to foster more healthy communities and nature, as well as alternative economic models [22]. However, barriers to this orientation include difficulty to shift values at this scale, resistance from current economic and political systems, and measurement and implementation challenges. Because current economic system relies on profit and competition; promoting intrinsic values can be seen as threatening to these systems and leading to institutional resistance. While values can be measured, applying them, for example, in policy can be abstract or challenging to implement.

Lastly, this literature review and analysis highlight limited evaluated interventions, specifically interventions with transformative potential. Interventions that lead to transformative change are essential, even though their impacts are more challenging to measure than the impact of interventions with less transformative potential. The difficulty in quantifying these impacts does not imply that such interventions should be disregarded. At a minimum, it is essential to recognize the existence or absence of these interventions with transformative potential within a transitioning system.

4. Limitations and future research implications

This literature review relied on academic databases, which might have introduced a bias emphasizing the knowledge gaps. In research articles, often much attention is given to the production of new knowledge [15,17], which may result in less emphasis on implementation. Therefore, future research should also utilize data from diverse sources, such as policy and NGO reports. Our findings indicate that implemented interventions in system intents, i.e., system values and paradigms, are fewer and require more research attention. While interventions like beach clean-ups and recycling are important, research should expand its focus on under-researched interventions with transformative potential. Also, there is a notable gap in data on the evaluation and impacts of implemented interventions. More evaluations and reported impacts of interventions are necessary to enhance evidence synthesis. While evaluation is essential, it remains challenging to measure the impact of interventions with transformative potential. Future research could develop methodologies for assessing these interventions.

5. Materials and methods

5.1. Methods

The study used the PRISMA guidelines. The following PRISMA steps were followed: 1. Defining the research objective, 2. Database selection, 3. Keyword identification, 4. Selection of compatible articles, 5. Data extraction [84]. To identify

interventions, a review was conducted that included articles, conference papers, and reports. Two strategies were used to identify relevant interventions. The first strategy was to enter search terms into databases: Scopus and Web of Science (WoS), as these are the two multidisciplinary databases [85]. To expand the number of interventions, we included backward searching, i.e., examining the reference list of publications identified through database searches.

5.1.1. Search strategy and eligibility. The literature review workflow of compatible publications selection is illustrated in Fig 5. The search was limited to the literature published between 2000 and February 2024 and to the geographical region of interest – Norway. No limitations were placed on language; however, the specified keywords may have restricted the search to English-language results only. The following search terms were used: plastic crisis* plastic problem* OR plastic pollution* OR plastic waste* OR plastic litter* OR plastic debris* AND resolv* OR strateg* OR lever* OR intervention* OR systemic* OR transform* OR transition* OR innovation* OR solution* OR recommendation* (See S1 File for more details). The search string was mainly informed by Riechers et al. [17]; the authors conducted a literature review on marine and coastal pollutants on a global scale. This first search strategy resulted in 403 relevant publications.

The screening process involved three stages. Firstly, duplicates were removed. Next, the resulting publications' titles, abstracts, and conclusions were screened to meet the criteria: a) plastic pollution, b) in Norway, c) implemented interventions. For this study, an "implemented intervention" is defined as an intervention that has been fully or partially executed, trialled on a small scale within a laboratory setting, piloted, or formalized as an established regulation, organization, or initiative. The titles and cited information of publications from backward searching were screened using the same criteria. Then, 62 remaining publications from electronic database searching and 21 publications from backward searching were thoroughly reviewed to determine if they clearly discussed 1) an implemented intervention, 2) to tackle plastic pollution, 3) in Norway. Publications lacking information on any of these three aspects were eliminated from consideration. The reviewed parts included extracts from results, evaluations, and conclusions that were only relevant to implemented interventions rather than a comprehensive assessment of the full publications. The screening process returned 44 publications for qualitative content analysis [26]. The interventions were analysed descriptively following the explanations of the LP perspective by Meadows

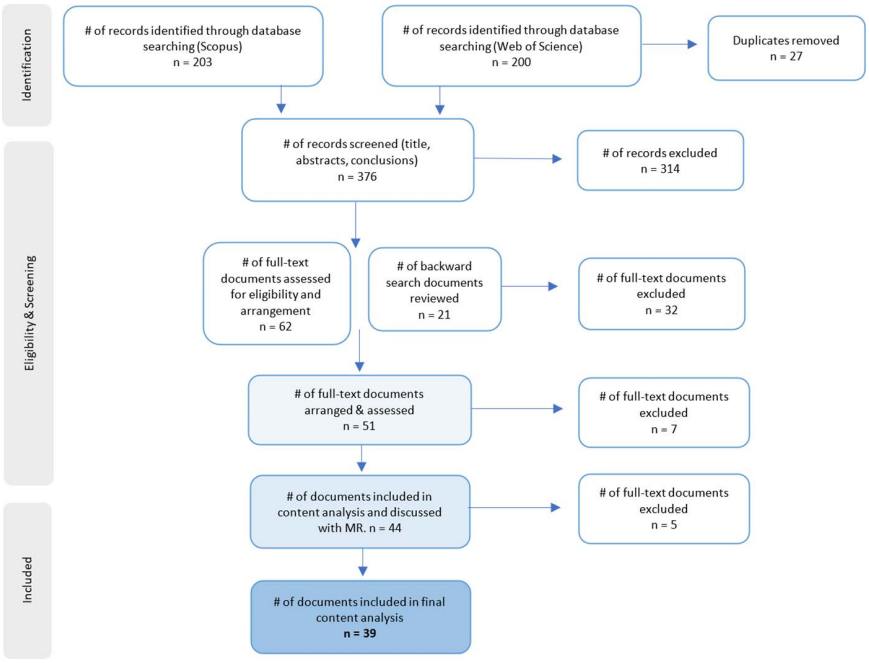

Fig 5. Systematic literature review workflow, PRISMA flowchart [84].

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Table 2. The five variables of the coding scheme of Fig 2.

1.Year of implementation	The year an intervention is implemented
2. Spatial scale	"Global/regional" – a global or regional intervention in which Norway participates and/or has implications for the Norwegian context; "National" – an intervention that is implemented on the countrywide scale in Norway; "Local" – an intervention that is implemented in an area, city, or organization in Norway
3. Approaches	"Technological" – an approach of an intervention that emphasizes the use of technology; "Material" – an approach that is characterized by the use of alternative materials; "Behavioural" – an approach that focuses on influencing behaviours; "Economic" – an approach that involves monetary value or cost; "Political" – an approach that includes policy, tax, and/or regulation; "Informational" – an approach that includes monitoring, reporting, educational, and/or communication strategies; "Structural" – an approach that entails changes to a physical system such as sorting station; "Collaborative" – an approach that emphasizes collaboration among various stakeholders.
4. Who implemented	Scientists (researchers); Politicians – municipality, ministries, government; Business and business w/engineers; Several actor groups – various collaborations among volunteers, fishers, NGOs, scientists, policy makers, businesses, and governmental institutions; Unknown
5. Evaluation	"Evaluated (Yes)" – an intervention was evaluated; "Some discussion (Somewhat)" – some discussion was provided on interventions' evaluation and/or impacts; "Not evaluated/no information (No)" – an intervention was not evaluated or no information on evaluation was provided.

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[10] and then arranged accordingly. To ensure consistency the review, eligibility, and screening procedures were conducted. For more reliability and to reduce subjectivity in categorization, after arranging interventions along the leverage points [10] by the first author, the arranged interventions were inspected by the second author. Then different perspectives on the arrangement of interventions were discussed with the second author. Five interventions were excluded because interventions were recommended and not implemented or were implemented by the Norwegian actors, but not in Norway.

5.1.2. Coding and data analysis. Consequently, 39 publications, resulting in 52 interventions were included in the final content analysis; note that several interventions within one publication are possible. These interventions were coded in accordance with the variables summarized in Table 2. Data from individual interventions were extracted using an Excel sheet that was created for the current review. The extracted data included publication details such as publication title, authors, and publication year, as well as methodological details such as year of intervention implementation, spatial scale, approaches, who implemented, and evaluation (Table 2).

In this study, the term "evaluated" refers to interventions that included an assessment of an intervention, the relevant evaluation method, and/or a discussion, or analysis of impacts of the intervention (Table 1 "Evaluation" column and Fig 2 "Evaluation" variable). Since this literature review was based on interventions from various disciplines, the evaluation methods varied. Among others, they included technical performance analyses, cost-benefit analysis, laboratory tests, contingent valuation method, user study, life cycle assessment with material flow analyses, experimental panel survey, and quasi-experimental analysis. The evaluation methods were not cross-validated by the authors of this study. The aim was to review the existing interventions on marine and coastal plastic pollution in Norway and their impacts, drawing upon the evaluation, analysis, discussions, and/or conclusions presented by the authors of those interventions.

Due to the focus of this study on identifying transformative interventions, additional research was carried out only on three interventions with transformative potential in accordance with the LP perspective, i.e., 1) The Norwegian KIMO [61 [V1]], 2) the Norway's National Circular Economy Strategy [62 [V2]], and 3) the High-Level Panel for a Sustainable Ocean Economy [63 [V3]], beyond the data from publications identified in the screening and analysis processes. This included an examination of relevant web pages and progress reports.

Supporting information

S1 Fig. Number of interventions per implementation year.
(DOCX)

S1 Table. Implemented interventions and their identifications.
(DOCX)

S1 File. Search string.
(DOCX)

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Visualization: Natalya Amirova.

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Writing – review & editing: Natalya Amirova, Maraja Riechers, Isabel Richter.

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