frontiers | Frontiers in Marine Science

TYPE Opinion
PUBLISHED 07 January 2025
DOI 10.3389/fmars.2024.1496213

OPEN ACCESS

EDITED BY
Daniel Suman,
University of Miami, United States

REVIEWED BY
Henrik Lerner,
Marie Cederschiöld University, Sweden

*CORRESPONDENCE
Juan José Alava
j.alava@oceans.ubc.ca

RECEIVED 13 September 2024
ACCEPTED 11 December 2024
PUBLISHED 07 January 2025

CITATION
Alava JJ, Barragán-Paladines MJ, Vandenberg J, Alonso-Yanez G, Moreno-Báez M, Calle N, Denkinger J, Issifu I, Espinoza E, Gaibor N, Velásquez M and Cisneros-Montemayor AM (2025) Plastics' circular economy for the Galápagos Islands? Exploring plastics governance with implications for social and ocean equity in a UNESCO World Heritage Site. *Front. Mar. Sci.* 11:1496213. doi: 10.3389/fmars.2024.1496213

Plastics' circular economy for the Galápagos Islands? Exploring plastics governance with implications for social and ocean equity in a UNESCO World Heritage Site

Juan José Alava[1,2]*, María José Barragán-Paladines[3], Jessica Vandenberg[4], Gabriela Alonso-Yanez[5], Marcia Moreno-Báez[6], Nastenka Calle[7], Judith Denkinger[8,9], Ibrahim Issifu[10], Eduardo Espinoza[11], Nikita Gaibor[12], Mauricio Velásquez[13] and Andrés M. Cisneros-Montemayor[2]

[1]Ocean Pollution Research Unit, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada, [2]School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, Canada, [3]Charles Darwin Research Station, Charles Darwin Foundation, Galápagos, Ecuador, [4]School of Engineering and Applied Sciences, Harvard University, Allston, MA, United States, [5]Werklund School of Education, University of Calgary, Calgary, AB, Canada, [6]The Fletcher School, Tufts University, Medford, MA, United States, [7]Ocean EcoQuest, Burnaby, BC, Canada, [8]Galapagos Science Centre, Universidad San Francisco de Quito, Quito, Ecuador, [9]Geman Ocean Museum, Stralsund, Germany, [10]Fisheries Economy Research Unit, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada, [11]Dirección del Parque Nacional Galápagos (Galápagos National Park), Ministerio del Ambiente, Agua y Transición Ecológica, Galápagos, Ecuador, [12]Instituto Público de Investigación de Acuicultura y Pesca (IPIAP), Guayaquil, Ecuador, [13]Development Bank for Latin America and the Caribbean (CAF), Quito, Ecuador

KEYWORDS

plastic pollution impacts, plastics circular economy, ocean equity, plastics governance, colonialism, Galápagos Islands, blue economy, equitable solutions

Introduction

In an era dominated by plastics (i.e., The 'Plasticene' Haram et al., 2020), where synthetic plastic materials and chemicals are pervasive in our daily lives, industries, and natural environments, it is crucial to focus on addressing the underlying structural causes of marine plastic pollution, particularly those affecting remote islands and coastal communities of the global ocean. Conversely, within the context of the Blue Economy transition, which emphasizes the sustainable use of ocean resources, integrating equity and sustainability into development policies presents a key opportunity to address the systemic and root structural causes of marine plastic pollution (Bennett et al., 2023; Cisneros-Montemayor et al., 2019, 2021; Simon et al., 2021). Plastic production and pollution policies are deeply intertwined with the legacies of colonialism and the persistence of global inequities, which have shaped the production, consumption, and disposal of plastics

(Liboiron, 2021; Fuller et al., 2022). The unchecked proliferation of toxic and wasteful plastics, driven by monopoly capitalism and the influence of powerful multinational corporations (Jacques, 2023; Mah, 2022), drives these inequities, disproportionately affecting low-income and historically marginalized communities (Vandenberg and Ota, 2022; Vandenberg, 2024). Ineffective and inequitable waste management systems further entrench these disparities. Thus, developing a truly equitable and just circular economy for plastics necessitates critically examining these institutional and historical issues, ensuring that new policies do not perpetuate the same inequities they seek to resolve. An equitable circular economy requires bold solutions to eradicate the root causes of marine plastic pollution while championing sustainable management, environmental justice, and social equity.

The environmental management and ocean governance literature increasingly recognizes equity as a multidimensional concept that includes distributional, procedural, recognitional, and contextual dimensions, as defined elsewhere (Croft et al., 2024; Crosman et al., 2022; Friedman et al., 2018; Law et al., 2018; Pascual et al., 2014; McDermott et al., 2013; Ota et al., 2022). This call for advancing an equitable approach to environmental management emerges as a need to challenge how approaches to address global environmental change have often been developed in alignment with Eurocentric scientific and academic theories and methodologies. These approaches lack direct and meaningful engagement with diverse and plural forms of knowledge, values, actions, and practices that other cultural groups, especially in the Global South, apply to solve every day socio-ecological challenges. Hegemonic research-to-action strategies tend to be based on partial and limited design frameworks that marginalize the varied range of knowledges and practices of on-the-ground actors that are essential to advance partnerships and collaborations for more effective and innovative knowledge-action initiatives to address environmental change. In this context, the role of ocean equity frameworks - aimed to dismantle systemic inequity and inequality through the governance of oceans - is of paramount importance (Crosman et al., 2022; Ocean Nexus, 2022; Ota et al., 2022). In doing so, equitable interventions should recognize and address the systemic issues that cause inequities such as colonial oppressions, structural racism, and exploitative policies that benefit the already wealthy while worsening the poor, and building up plans and monitoring programs aimed to reverse these causes (Ocean Nexus, 2022). The diversity and heterogeneity of knowledge and value systems across different social actors and resource users particularly in the Global South, require a recognition of the existence of both ontological plurality (diversity in ways of existing in the world) and epistemic plurality (diversity of ways of knowing the world). Thus, collaborative forms of environmental governance must be able to accommodate equitable representation of diverse knowledges and value systems and provide spaces of inclusive dialogue and seats with equal voices at the table for social actors and rightsholders representing all facets of this plurality (Kovács and Pataki, 2016; Ludwig and Macnaghten, 2020). This is particularly important for addressing plastic pollution as it ensures that the perspectives of diverse stakeholders, rightsholders, and knowledge holders, including marginalized communities and those directly affected by it, are included and equitable solutions can be developed to tackle the root causes of the issue.

A specific showcase to study local ocean governance and equity to foster interventions that are socially equitable, environmentally sustainable, and economically viable in remote islands is the Galápagos Islands, which are at the crossroads facing environmental changes because of the emerging and cumulative multiple-anthropogenic stressors, affecting the complex socio-ecological systems of both the Galápagos Marine Reserve and Galápagos National Park (Alava et al., 2022). Among the human-made stressors impacting the islands, plastic pollution (i.e., contamination by macro- and microplastics) in tandem with other toxic chemicals (e.g., persistent organic pollutants and mercury) is affecting the unique marine-coastal ecosystems, endemic species, and coastal fishing communities heavily reliant on seafood (Alava et al., 2014; Alava and Ross, 2018; Alava et al., 2022; Jones et al., 2021; McMullen et al., 2024; Muñoz-Abril et al., 2022; Muñoz-Pérez et al., 2023; Schofield et al., 2020). A transition from a traditional linear 'cradle-to-grave' economy to a circular system that reduces waste and leakage, embracing reduction, reusing, recycling, and recovering via a circular economy for plastics in Galápagos has been suggested (Jones et al., 2023); however, the consequences and social-ecological impacts of implementing such a circular approach have yet to be critically evaluated, especially with the introduction of plastic— a material not locally sourced from their Galápagos coastal communities' land.

Aiming to address the plastic pollution problem impacting the socio-ecological systems of the Galápagos Islands, it is paramount to question and identify the potential inequities resulting from implementing a plastic circular economy model that resembles a complicated challenge. This not only includes objectives to better understand how plastics are affecting the structure and functions of natural and social systems (i.e., ecosystems, species, and coastal human communities), but also to explore the potential inequity and inequality gaps resulting from the implementation of a plastics' circular economy model (Figure 1). Understanding these dynamics is the foundation of solution-oriented research and is necessary for developing a community-grounded equitable intervention framework. Within this premise and considering that ocean plastics affect coastal and developing nations more than developed nations, we: (1) Argue that implementing a circularity economy of plastics may be challenging in remote oceanic islands such as small island developing states (SIDS) and the Galápagos Islands, where plastics are not locally produced, and are difficult to be repaired or recycled, and where ocean plastic pollution disproportionately affects local communities who already face social and equity challenges; by, (2) Demonstrating that the circular economy model may not effectively ensure natural or marine resources availability and address ocean inequity in coastal communities impacted by plastic pollution, as the current and future generations from these communities are unable to fully participate in the plastic circularity economy, thereby exacerbating ocean inequity in remote islands. This issue is especially relevant within the framework of the blue economy, where ensuring ocean sustainability and equitable solutions are essential.

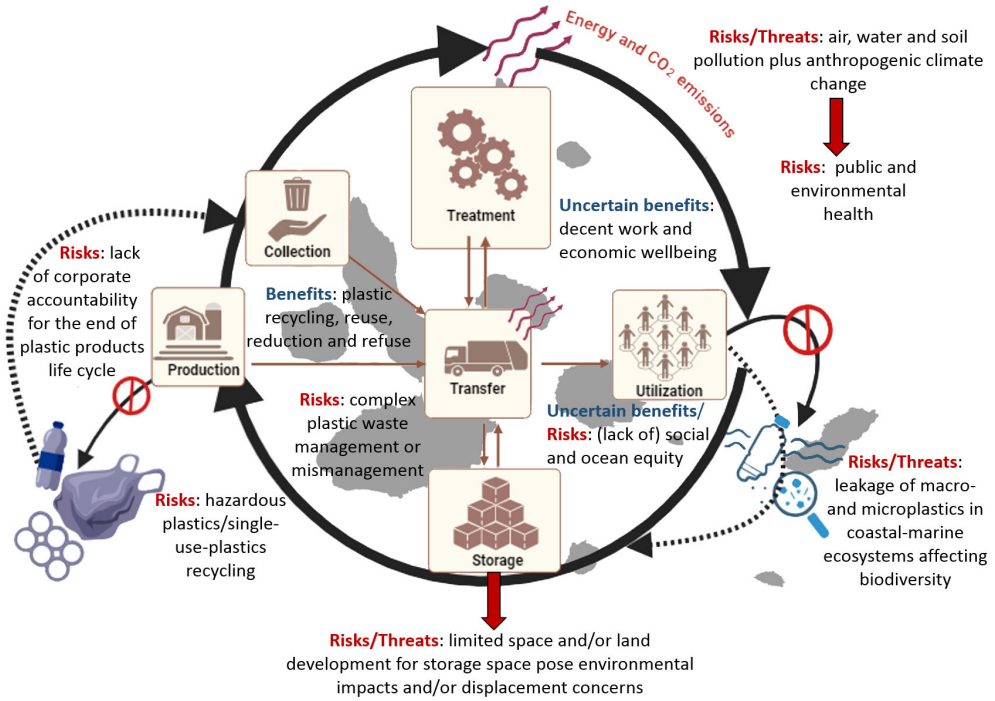

FIGURE 1
The challenges and shortcomings of a Circular Economy of Plastics for the Galápagos Islands as a function of the risks, potential threats and uncertain benefits. A complex infrastructure along with resources to keep plastics materials via recycling, reuse and reduction circulating in a closed loop with zero emissions is ideal. In reality, the circularity of plastics can be considered as a thermodynamic model with loss and leaking of energy and plastic waste escaping to the environment during the process while consuming water, fuel and energy plus further emissions (e.g., CO_2) and land use in the limited space available in the islands (e.g., human centers or urban areas). These emissions with associated pollution can affect human health, the marine-coastal environment and local (native and endemic) biodiversity. Within the island context, the "insularity" condition of the Galapagos Archipelago enlarges and exacerbates the already complex challenge of plastics pollution and a circular economy. To address uncertain benefits and eco-toxicological risks, a community-grounded plastics circular economy approach with equitable solutions and interventions to combat, reduce and eliminate marine anthropogenic plastic pollution is recommended for the Galapagos Islands' coastal communities to champion social and ocean equity and economic wellbeing. The dashed arrows indicates the reincorporation of plastic materials or discarded plastic items into the circular closed loop; the curve arrows with "no sign symbols" (Ø) means that no leaking or emissions of plastics should escape from the circular loop. Artwork for Figure 1 was partially created via BioRender.com and power point 2013.lnk.

Corporate accountability for the life cycle and circular economy of plastics

Although the plastic pollution problem is an inherently complicated issue, influenced by complex global supply chains, international trade policies and mechanisms, and powerful global market networks and actors, it can be largely attributed to the lack of industrial or corporate accountability for producing toxic and wasteful plastics and ineffective and inequitable solid or plastic waste management systems that are enabled through legacies of colonialism and racial capitalism. Ultimately, plastics governance has prioritized end-of-life approaches that are focused on symptom-targeted solutions, rather than solutions that address the root cause of the problem, which requires targeted efforts to limit plastics production (O'Neill, 2019; Vandenberg and Ota, 2022). As it stands, the industries or companies that should be accountable and responsible for addressing the plastic waste emissions avoid responsibilities by derailing regulatory actions and redirecting responsibility of the problem to actors outside of their supply chains, such as consumers and waste managers (Figure 1); while advocating for and supporting advances in technological solutions that keep governance focused on end-of-life solutions and away from potential production restrictions (Vandenberg, 2024; Tangpuori et al., 2020). Moreover, industry and state actors enable waste management systems to operate as a form of waste colonialism, by allowing high-income nations to dump plastic waste in low-income "pollution havens" (Owens and Conlon, 2021) or "shadow places" (Plumwood, 2008) with limited regulation, cost, or local political power.

It is therefore critical to recognize that systematic issues within social organizations, power dynamics, and governance structures are at the heart of and central to social inequity and inequality in ocean sectors. These factors must be considered when assessing sustainable development initiatives and policies aimed at mitigating and reducing plastic use and pollution. For example, the regional contribution to the plastic pollution footprint in the Galápagos Islands' coastlines and beaches can be assessed by analyzing the overall quantity of branded plastic litter, as demonstrated by Muñoz-Pérez et al. (2023). Their study identified 98 manufacturers contributing to plastic pollution in the islands, with four corporations as the top polluters accounting for 53.2% of the total plastic items. Specifically, the AjeGroup contributed to 20%, followed by the Coca-Cola Company (18.2%), Tingyi Holding Corporation (8.8%) and Pepsico (6.2%).

The remaining 46.8% of plastic pollution was attributed to other companies (Muñoz-Pérez et al., 2023).

Along with a life cycle assessment for plastic waste management, the plastic circular economy was prescribed as a panacea to address the negative externalities and impacts of plastic production emissions and marine pollution by The United Nations Global Plastics Treaty to combat global plastic pollution (UNEP, 2022), mainly pursued by developed countries from the Global North (i.e., European Union, North America), acknowledging the complexity of the Global North versus Global South binary meta-categorization debate (Haug et al., 2021). As shown in Figure 1, the circular economy of plastics per se is an ideal concept promoting a life cycle assessment strongly relying on the circularity of plastic materials for solid waste management by considering a new plastics economy constantly flowing back and forth from plastic production to consumption and back via a closed loop system through recycling, reduction, and reuse (Ellen MacArthur Foundation, 2016; O'Neill, 2019). Yet, the plastics circularity economy model may still perpetuate inequalities and neglect the potential environmental justice consequences due to the lack of equitable interventions and solutions available to the most exposed coastal communities and marginalized minority groups, i.e., Indigenous peoples (Bennett et al., 2023; Liboiron, 2021; McMullen et al., 2023; O'Neill, 2019; Vandenberg and Ota, 2022). Low-income, developing nations may well be concerned with the plastic circular economy approach because these nations have less legal and technical capacity to implement an infrastructure and a system to support the circular economy approach. The people living in oceanic, remote, and continental coast areas, mainly Indigenous and native communities, from developed and developing countries, have common and unique public health, food safety, and security issues in the face of pervasive ocean pollution by marine plastic and microplastics. Thus, a circular plastic economy may not work as intended for SIDS, communities inhabiting remote, oceanic islands such as the Galápagos Islands, and some developing or undeveloped countries.

Plastic pollution management in the Galápagos: a wicked problem

According to Schofield et al. (2020), the pervasive nature of plastic pollution is becoming a wicked problem in the Galápagos Islands. At a glance, however, the coastlines of the Galápagos have remained virtually unchanged since Charles Darwin visited the islands, except for localized urbanization on three to four of the larger islands and the ubiquitous marine anthropogenic litter and plastic contamination that is now found in some beaches, waters and endemic species of the archipelago (Alava et al., 2014; Alava and Ross, 2018; Jones et al., 2021; Schofield et al., 2020, 2021; Alava et al., 2022; McMullen et al., 2024; Muñoz-Pérez et al., 2023). In the human-populated islands of the Galápagos, on the other hand, the level of municipal waste collection and local shore cleanup initiatives are becoming high and fairly organized in urban areas of the islands despite challenges to improve the local solid waste management infrastructure (Alava et al., 2014, 2022). Galápagos is also the first province of Ecuador to implement clear policies and regulations to ban and reduce the use and commercialization of single-use plastics (Alava et al., 2022), including plastic bags (e.g., high-density and low-density polyethylene bags) and disposable Styrofoam (expanded polystyrene) food containers (Galapagos Government Council, 2021; UNESCO World Heritage Centre, 2019). Contrasting to these regulatory efforts, uncontrolled and illegal dumping of solid waste in the islands still constitutes a critical challenging issue compromising the future of the Galápagos systems' health in the short and long terms (Alava et al., 2014; Muñoz-Pérez et al., 2023; UNESCO World Heritage Centre, 2019).

Moreover, the recurrent incidence of massive international fishing fleets (e.g., Asian-flagged vessels) operating as illegal, unreported, and unregulated (IUU) fishing activities around the exclusive economic zone (EEZ) and within the waters of the Galápagos Islands and the Galápagos Marine Reserve (Alava and Paladines, 2017; Alava et al., 2022) are also plausible mobile and major sources of plastic debris and waste (Alava et al., 2022; Jones et al., 2021; Schofield et al., 2020). Schofield et al. (2020), for example, identified plastic bottles with Asian labels found on the islands' shorelines, recently. Similarly, ocean circulation modelling predicted the global and regional oceanographic pathways and sources of floating plastic debris in the southeastern tropical Pacific, identifying continental coasts as emission sources of plastic pollution (Jones et al., 2021; Schofield et al., 2020; Van Sebille et al., 2019). These coastal regions include the Pacific coast of South America and Central America, including nations such as Costa Rica, Panamá, Colombia, southern Ecuador, and mainly Perú, as plausible main inputs to the archipelago and plastic pollution resulting from maritime traffic (Van Sebille et al., 2019; Muñoz-Pérez et al., 2023). In the Galápagos, for example, traceable plastic products and branding information identified 14 nations as sources of transboundary plastic pollution. Among these, Perú accounted for 46.14% of the total, followed by Ecuador and China contributing to 24.4% and 18.32%, respectively (Muñoz-Pérez et al., 2023). Meijer et al. (2021) also revealed that Ecuador has a 12% share of plastic waste emitted to the eastern tropical Pacific Ocean via rivers or 1,136 tons per year. Conversely, Ecuador releases 0.09 tons of plastic waste exported by air.

The permanent emission and oceanic transport of anthropogenic marine plastic debris from urbanized and industrial nations, including Asian and South American continents, suggest that current management practices to address plastic pollution are likely to have limited impact. Additionally, the plastics' circular economy may not effectively benefit the human centers and coastal fishing communities of the main populated islands of the Galápagos. These challenges highlight the transboundary nature of the problem, compounded by regional emissions from foreign IUU fishing fleets, and long-range oceanic transport of marine plastic pollution. This situation emphasizes the need for a concerted international effort and the political will of regional and international governments to foster coordinated solutions to combat the plastic footprint - a wicked problem in the Galápagos. Within the framework of the blue economy, sustainable and equitable approaches must integrate the economic

needs of local communities with the preservation of marine ecosystems. Ensuring long-term resilience and a healthy economy depends on fostering collaborative efforts that actively involve these communities in ocean resource management.

Is plastics' circular economy an equitable solution for the Galapagos?

Historically, since the early human settlements arrived to the archipelago, the continuous and unlimited human population growth in Galapagos has been a matter of debate and preoccupation. How many people could the Galapagos Islands accommodate? How much of that growth is compromising the sustainability and viability of the socio-ecological systems that the islands foster? And what to do remains to be challenging questions that have yet not been fully answered. Within that uncertainty, the likeliness for the systems to remain healthy diminishes. During the last years, a more active and explicit debate has arisen among local bodies who have managed to put in place certain policies (e.g., the Resolutions Nro. 038-CGREG-19-XI-2014, and Nro. 05-CGREG-2015 to limit and prohibit the import and usage of single-use plastics) and practices (e.g., the popular habit among local Galapagos residents to have a refillable water bottle) to reduce the production/import/usage of plastics in the islands.

The circular economy for plastics has been proposed as a transitioning innovative approach for the sustainability of the Galápagos Islands (Jones et al., 2023). While this idea is conceived to reduce, reutilize, treat, and export used or recycled plastics to continental Ecuador to control and hamper the plastic pollution problem originating from local human centres, including residents and visitors, or partially urbanized environments of the insular region to conserve the surrounding ocean, coastal zones, shores, and the unique marine biodiversity of this UNESCO World Heritage site, a circular economy of plastic may not work as envisioned. To combat plastic pollution in oceanic remote islands such as the Galápagos Islands, local ocean governance policy and sustainable interventions should contribute to dismantling and eradicating systemic social inequity and inequality in ocean sectors. Thus, questions linger as to whether a transition to the circular economy of plastics, formulated as a Westernized or colonial innovation approach can address, mitigate, and minimize social-ecological negative impacts in the face of exposure to plastic and energy emissions, with associated chemicals or additives and potential microbial pathogens from plastics via recycling, reusing and repairing that otherwise would affect local wellbeing, public health and the fragile ecosystems of the Galapagos.

We claim that there should not be plastics and energy-related emissions leaking into the marine ecosystems and coastal communities of the Galápagos Islands under a circular economy model as it does not address the inequity and inequality gap framework (Figure 1). This circular approach may internalize access to a new form of colonialism as a transition towards a circular economy for plastics, portrayed as a Westernized environmental solution recipe to plastic pollution that may actually reproduce an intended colonial legacy (Liboiron, 2021). According to Skene (2018), the circular economy is an imaginary garden fantasy unable to deliver sustainability. Few authors have referenced the impacts of the flow of materials through the economy (e.g. Allwood and Cullen, 2012; Allwood, 2014), while Cooper (2005) emphasized the sufficiency of resources, at a fundamental level: "*a circle is a circle, zero-waste means zero waste and a closed loop is a closed loop*". Thus, the terminology associated with the circular economy is misrepresentative, re-enforcing the deceiving idea that the nature of the economy can somehow inform a revolution in sustainable economics because it is a closed, zero-waste, circular system (Skene, 2018), bringing an ideological agenda with hypothetical-normative utopia generating uncertainty into contributions to sustainability and depoliticizing sustainable growth (Corvellec et al., 2022). Lamberton (2005) already highlighted the problem that exists between a growth-based economic model and the need to reduce material use by expressing that "*the sustainable sufficiency concept reinforces the view that neoclassical economic principles provide a barrier to achieving the social and ecological objectives contained within contemporary interpretations of sustainable development*" (Lamberton, 2005, p. 53). Thus, necessary steps are needed to inform what an equitable policy may look like to foster the reduction of plastic use and combat the associated pollution footprint before internalizing a plastics circulatory economy in SIDS and the Galápagos Islands.

First, the social implications and inequitable consequences of integrating just a circular economy approach to plastics, in UNESCO sites, remote islands, and developing and underdeveloped nations are critical. In this context, inequality exists in who causes plastic pollution, who experiences its impacts and consequences, and who can fix it and provide solutions along with those who have the political will to make the decisions to divorce from a plastic dependence and foster a proactive end of the life cycle assessments (Simon et al., 2021). The people exhibiting high consumption rates of plastics stemming from a pervasive plastic demand and those who supply it disproportionately affect the success or failure of plastic pollution mitigation. To explore the feasibility of a circular economy of plastic, concerted socioeconomic surveys on the impacts of plastics and associated aspects on consumption and behavioral changes within the local coastal communities heavily reliant on ecotourism, recreation, local fisheries, and seafood markets for subsistence and work should be pursued. Doing so, the perceptions and sentiments generated by the local community will help to integrate information on basic needs, traditional and local practices for livelihood, culture, well-being, and human connections with nature.

Second, community-grounded solutions, participatory consultation, and equitable interventions for equal access and treatment to clean waters and healthy seafood and fish for subsistence via ocean governance fostering ocean equity framed within the local context and realities, local and traditional knowledge, and environmental justice are paramount for coastal communities affected by plastic pollution and other environmental changes and anthropogenic stressors. In this context, new transdisciplinary collaborative research and community-based

conservation frameworks are vital to ensure that the health and environmental protection needs of people living in coastal, rural, and remote communities can be assisted with appropriate care, mitigation strategies, and environmental and health education programs to ensure equal treatment and access to hygiene, public health and pollution prevention measures for a healthy ocean environment, clean seafoods and oceans free of plastics (Alava et al., 2022; Bennett et al., 2023; McMullen et al., 2023; Onyena et al., 2022). Ultimately, this approach in close conjunction with the development and implementation of community-grounded policies should dismantle systemic inequity —all key components of the Blue Economy (i.e., the Blue Economy refers to the development of sectors based on marine resources that simultaneously improve the conditions of sustainability and social equity and help align industrial development with the quantification of ecosystem services; see Spalding, 2016; and Cisneros-Montemayor et al., 2021) - via the governance of the oceans by championing interventions that are socially equitable, environmentally sustainable, and economically viable to ensure that the inequality gaps are addressed and the local residents are empowered to benefit equitably from the ocean sectors and the implementation of solutions via community decision-making processes in the face of plastic pollution.

Conclusion

Concerted, community-grounded policy decisions along with precautionary actions and local regulatory enforcement to cap and reduce plastic production, along with a reform for plastics' end-of-life solutions, are urgently needed to combat the roots of global plastic pollution and implement just-transitions at the corporative level in nations manufacturing and exporting plastics to SIDS and remote UNESCO Global Heritage sites such as the Galapagos Islands. These policy efforts should also champion global plastic governance by including equitable interventions and equal access to pollution prevention and innovations with environmentally friendly materials that eliminate plastic materials before it reaches consumers in the first place. This is of paramount importance in addressing the inequality gap framework, intending to champion ocean equity and environmental justice in plastic pollution management for the most exposed people and marine biodiversity in impacted remote, oceanic-coastal communities such as those existing in the Galápagos Islands.

Author contributions

JJA: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. MB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – review & editing. JV: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. GA: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. MM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – review & editing. NC: Data curation, Investigation, Methodology, Resources, Validation, Writing – review & editing. JD: Investigation, Writing – review & editing. II: Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – review & editing. EE: Investigation, Writing – review & editing. NG: Investigation, Writing – review & editing. MV: Investigation, Writing – review & editing. AC: Methodology, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The first author (JJA) thanks the former funding provided for the Nippon Foundation-Ocean Litter Project at the Institute for the Ocean and Fisheries, University of British Columbia, and the Nippon Foundation-Ocean Nexus Centre at the University of Washington. JV and AC-M acknowledge funds from the Nippon Foundation-Ocean Nexus Centre.

Acknowledgments

We acknowlegde the partial use of generative AI software BioRender.com and power point 2013. Ink to create the Artwork for Figure 1 in this paper.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

References

Alava, J. J., McMullen, K., Jones, J., Barragán-Paladines, M. J., Hobbs, C., Tirapé, A., et al. (2022). Multiple anthropogenic stressors in the Galápagos Islands' complex social–ecological system: Interactions of marine pollution, fishing pressure, and climate change with management recommendations. *Integr. Environ. Assess Manage.* 19, 870–895. doi: 10.1002/ieam.4661

Alava, J. J., and Paladines, F. (2017). Illegal fishing on the Galápagos high seas. *Science* 357, 1362–1363. doi: 10.1126/science.aap7832

Alava, J. J., Palomera, C., Bendell, L., and Ross, P. S. (2014). "Pollution as an emerging threat for the conservation of the Galápagos Marine Reserve: Environmental impacts and management perspectives," in The Galápagos Marine Reserve: A dynamic social ecological system. Social and Ecological Interactions in the Galapagos Islands. Eds. J. Denkinger and L. Vinueza (Springer, Cham), 247–283. doi: 10.1007/978-3-319-02769-2_12

Alava, J. J., and Ross, P. S. (2018). "Pollutants in tropical marine mammals of the Galápagos Islands, Ecuador: An ecotoxicological quest to the Last Eden," in *Marine mammal ecotoxicology: Impacts of Multiple Stressors on Population Health*. Eds. M. C. Fossi and C. Panti (Academic Press, Elsevier, London, UK), 213–234. doi: 10.1016/B978-0-12-812144-3.00008-5

Allwood, J. M. (2014). "Squaring the circular economy: the role of recycling within a hierarchy of material management strategies," in *Handbook of recycling: state-of-the-art for practitioners, analysts, and scientists*. Eds. E. Worrell and M. A. Reuter (Elsevier, Amsterdam), 445–477.

Allwood, J. M., and Cullen, J. M. (2012). *Sustainable materials—with both eyes open: future buildings, vehicles, products and equipment—made efficiently and made with less new material* (Cambridge: UIT Cambridge Ltd).

Bennett, N. J., Alava, J. J., Ferguson, C. E., Blythe, J., Morgera, E., Boyd, D., et al. (2023). Environmental (in) justice in the Anthropocene ocean. *Mar. Policy* 147, 105383. doi: 10.1016/j.marpol.2022.105383

Cisneros-Montemayor, A. M., Moreno-Báez, M., Reygondeau, G., Cheung, W. W., Crosman, K. M., González-Espinosa, P. C., et al. (2021). Enabling conditions for an equitable and sustainable blue economy. *Nature* 591, 396–401. doi: 10.1038/s41586-021-03327-3

Cisneros-Montemayor, A. M., Moreno-Báez, M., Voyer, M., Allison, E. H., Cheung, W. W., Hessing-Lewis, M., et al. (2019). Social equity and benefits as the nexus of a transformative Blue Economy: a sectoral review of implications. *Mar. Policy* 109, 103702. doi: 10.1016/j.marpol.2019.103702

Cooper, T. (2005). Slower consumption reflections on product life spans and the "throwaway society. *J. Ind. Ecol.* 9, 51–67. doi: 10.1162/1088198054084671

Corvellec, H., Stowell, A. F., and Johansson, N. (2022). Critiques of the circular economy. *J. Ind. Ecol.* 26, 421–432. doi: 10.1111/jiec.13187

Croft, F., Breakey, H., Voyer, M., Cisneros-Montemayor, A., Issifu, I., Solitei, M., et al. (2024). Rethinking blue economy governance – A blue economy equity model as an approach to operationalise equity. *Environ. Sci. Policy* 155, 103710. doi: 10.1016/j.envsci.2024.103710

Crosman, K. M., Allison, E. H., Ota, Y., Cisneros-Montemayor, A. M., Singh, G. G., Swartz, W., et al. (2022). Social equity is key to sustainable ocean governance. *NPJ Ocean Sustain.* 1, 4. doi: 10.1038/s44183-022-00001-7

Ellen MacArthur Foundation (2016). *The New Plastics Economy — Rethinking the future of plastics* (Geneva, Switzerland: World Economic Forum, and McKinsey & Company). Available online at: http://www.ellenmacarthurfoundation.org/publications (Accessed November 26, 2024).

Friedman, R. S., Law, E. A., Bennett, N. J., Ives, C. D., Thorn, J. P., and Wilson, K. A. (2018). How just and just how? A systematic review of social equity in conservation research. *Environ. Res. Lett.* 13, 53001. doi: 10.1088/1748-9326/aabcde

Fuller, S., Ngata, T. B., and Borrelle, S. B. (2022). Plastics pollution as waste colonialism in Te Moananui. *J. Political Ecol.* 29, 535. doi: 10.2458/jpe.2401

Galapagos Government Council (2021). *Galápagos 2030 Plan: Galápagos Islands strategic plan 2030* (Puerto Baquerizo Moreno, Galápagos, Ecuador). Available online at: https://unidosporgalapagos.com/2021/04/21/galapagos-island-strategic-plan-2030/ (Accessed June 6, 2022).

Haram, L. E., Carlton, J. T., Ruiz, G. M., and Maximenko, N. A. (2020). A plasticene lexicon. *Mar. pollut. Bull.* 150, 110714. doi: 10.1016/j.marpolbul.2019.110714

Haug, S., Braveboy-Wagner, J., and Maihold, G. (2021). The 'Global South' in the study of world politics: examining a meta category. *Third World Q.* 42, 1923–1944. doi: 10.1080/01436597.2021.1948831

Jacques, P. J. (2023). Stages of capitalist development and maximum marine plastic pollution. *Cambridge Prisms: Plastics* 1, 1–7. doi: 10.1017/plc.2023.1

Jones, J. S., Howard, J., Galloway, T. S., Norris Crespo, L., and Aspinosa, S. (2023). "Island innovation: transitioning towards a circular economy for plastics in galápagos, Ecuador," in *Island Ecosystems. Social and Ecological Interactions in the Galapagos Islands*. Eds. S. J. Walsh, C. F. Mena, J. R. Stewart and J. P. Muñoz-Pérez (Springer, Cham), 469–478. doi: 10.1007/978-3-031-28089-4_30

Jones, J. S., Porter, A., Muñoz-Pérez, J. P., Alarcón-Ruales, D., Galloway, T. S., Godley, B. J., et al. (2021). Plastic contamination of a Galapagos Island (Ecuador) and the relative risks to native marine species. *Sci. Total Environ.* 789, 1–13. doi: 10.1016/j.scitotenv.2021.147704

Kovács, E. K., and Pataki, G. (2016). The participation of experts and knowledges in the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). *Environ. Sci. Policy* 57, 131–139. doi: 10.1016/j.envsci.2015.12.007

Lamberton, G. (2005). Sustainable sufficiency—an internally consistent version of sustainability. *Sustain. Dev.* 13, 53–68. doi: 10.1002/sd.245

Law, E. A., Bennett, N. J., Ives, C. D., Friedman, R., Davis, K. J., Archibald, C., et al. (2018). Equity trade-offs in conservation decision making. *Conserv. Biol.* 32, 294–303. doi: 10.1111/cobi.13008

Liboiron, M. (2021). *Pollution Is Colonialism* (Durham and London: Duke University Press). doi: 10.1515/9781478021445

Ludwig, D., and Macnaghten, P. (2020). Traditional ecological knowledge in innovation governance: a framework for responsible and just innovation. *J. Responsible Innov.* 7, 26–44. doi: 10.1080/23299460.2019.1676686

Mah, A. (2022). *Plastic Unlimited: How corporations are fuelling the ecological crisis and what we can do about it* (Cambridge, UK: Polity).

McDermott, M., Mahanty, S., and Schreckenberg, K. (2013). Examining equity: a multidimensional framework for assessing equity in payments for ecosystem services. *Environ. Sci. Policy* 33, 416–427. doi: 10.1016/j.envsci.2012.10.006

McMullen, K., Calle, P., Alvarado-Cadena, A., Kowal, M. D., Espinoza, E., Domínguez, G. A., et al. (2024). Ecotoxicological assessment of microplastics and cellulose particles in the galápagos islands and galápagos penguin food web. *Environ. Toxicol. Chem.* 43, 1442–1457. doi: 10.1002/etc.5874

McMullen, K., Tirapé, A., Calle, P., Vandenberg, J., Alvarado-Cadena, O., Dominguez, G. A., et al. (2023). Marine litter and social inequities entangle Ecuadorian mangrove communities: Perceptions of plastic pollution and well-being concerns in Puerto Hondo and Isla Santay, Ecuador. *Mar. Policy* 157, 1–18. doi: 10.1016/j.marpol.2023.105857

Meijer, L. J., Van Emmerik, T., van der Ent, R., Schmidt, C., and Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. *Sci. Adv.* 7, p.eaaz5803. doi: 10.1126/sciadv.aaz5803

Muñoz-Abril, L., Valle, C. A., Alava, J. J., Janssen, S. E., Sunderland, E. M., Rubianes-Landázuri, F., et al. (2022). Elevated mercury concentrations and isotope signatures (N, C, Hg) in yellowfin tuna (*Thunnus albacares*) from the Galápagos Marine Reserve and waters off Ecuador. *Environ. Toxicol. Chem.* 41, 2732–2744. doi: 10.1002/etc.5458

Muñoz-Pérez, J. P., Lewbart, G. A., Alarcón-Ruales, D., Skehel, A., Cobos, E., Rivera, R., et al. (2023). Galápagos and the plastic problem. *Front. Sustain.* 4. doi: 10.3389/frsus.2023.1091516

Ocean Nexus (2022). Procedural Key Performance Indicators (PKPI) for Assessing Global Ocean Equity. *United Nations Ocean Conference 2022*. Available online at: https://oceannexus.uw.edu/2022/07/06/2022-un-ocean-conference-presentation-on-assessing-global-ocean-equity/ (Accessed June 27, 2022).

O'Neill, K. (2019). *Waste* (Cambridge, UK: John Wiley & Sons).

Onyena, A. P., Aniche, D. C., Ogbolu, B. O., Rakib, M. R. J., Uddin, J., and Walker, T. R. (2022). Governance strategies for mitigating microplastic pollution in the marine environment: A Review. *Microplastics* 1, 15–46. doi: 10.3390/microplastics1010003

Ota, Y., Singh, G. G., Clark, T., Schutter, M. S., Swartz, W., and Cisneros-Montemayor, A. M. (2022). Finding logic models for sustainable marine development that deliver on social equity. *PloS Biol.* 20, e3001841. doi: 10.1371/journal.pbio.3001841

Owens, K. A., and Conlon, K. (2021). Mopping up or turning off the tap? Environmental injustice and the ethics of plastic pollution. *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.713385

Pascual, U., Phelps, J., Garmendia, E., Brown, K., Corbera, E., Martin, A., et al. (2014). Social equity matters in payments for ecosystem services. *Bioscience* 64, 1027–1036. doi: 10.1093/biosci/biu146

Plumwood, V. (2008). Shadow places and the politics of dwelling. *Aust. Humanit Rev.* 44, 139–150. Available at: https://Australianhumanitiesreview.org/2008/03/01/shadow-places-and-the-politics-of-dwelling/ (Accessed August 23, 2024).

Schofield, J., Aylmer, J., Donnelly, A., Jones, J., Muñoz-Pérez, J. P., Perez, E., et al. (2021). Contemporary archaeology as a framework for investigating the Impact of single-use plastic bags on environmental pollution in Galápagos. Journal of Contemporary. *Archaeology* 7, 276–306. doi: 10.1558/jca.41134

Schofield, J., Wyles, K. J., Doherty, S., Donnelly, A., Jones, J., and Porter, A. (2020). Object narratives as a methodology for mitigating marine plastic pollution: Multidisciplinary investigations in Galápagos. *Antiquity* 94, 228–244. doi: 10.15184/aqy.2019.232

Simon, N., Raubenheimer, K., Urho, N., Unger, S., Azoulay, D., Farrelly, T., et al. (2021). A binding global agreement to address the life cycle of plastics. *Science* 373, 43–47. doi: 10.1126/science.abi9010

Skene, K. R. (2018). Circles, spirals, pyramids and cubes: why the circular economy cannot work. *Sustain. Sci.* 13, 479–492. doi: 10.1007/s11625-017-0443-3

Spalding, M. J. (2016). The New Blue Economy: the future of sustainability. *J. Ocean Coast. Econ.* 2, 1–21. doi: 10.15351/2373-8456.1052

Tangpuori, A. D., Harding-Rolls, G., Urbancic, N., and Zallio, X. P. B. (2020). *Talking trash: The corporate playbook of false solutions to the plastic crisis* (Netherlands, Utrecht: Changing Markets Foundation). Available online at: https://changingmarkets.org/report/talking-trash-the-corporate-playbook-of-false-solutions-to-the-plastic-crisis/ (Accessed September 3, 2024).

UNEP (2022). *End Plastic Pollution: Towards an International Legally Binding Instrument* (Dakar, Senegal: United Nations Environment Assembly of the United Nations Environment Programme). Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/39812/OEWG_PP_1_INF_1_UNEA%20resolution.pdf (Accessed October 17, 2023). UNEA Resolution 5/14.

UNESCO World Heritage Centre (2019). *State of conservation report-44 COM* (World Heritage Convention: United Nations Educational, Scientific and Cultural Organization (UNESCO). Available at: https://whc.unesco.org/document/180121.

Vandenberg, J. (2024). Plastic Politics of Delay: How political corporate social responsibility discourses produce and reinforce inequality in plastic waste governance. *Global Environ. Polit* 24, 122–145. doi: 10.1162/glep_a_00745

J. Vandenberg and Y. Ota(2022).Towards an equitable approach to marine plastic pollution. In: *Ocean Nexus Equity & Marine Plastic Report 2022* (Seattle, WA: Nippon Foundation Ocean Nexus Center, & Earth Lab, University of Washington). Available online at: https://oceannexus.org/equityandmarineplastic/ (Accessed September 3, 2024).

Van Sebille, E., Delandmeter, P., Schofield, J., Hardesty, B. D., Jones, J., and Donnelly, A. (2019). Basin-scale sources and pathways of microplastic that ends up in the Galápagos Archipelago. *Ocean Sci.* 15, 1341–1349. doi: 10.5194/os-15-1341-2019