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A framework for assessing the blue equity of social-ocean systems in marine governance transformation

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The equitable utilization of marine resources and the maintenance of healthy and sustainable marine ecosystems are essential to advancing the United Nations Sustainable Development Goals (SDGs) and promoting the well-being of all humanity. In this paper, we propose a Blue Equity Assessment Framework, which is based on a systematic literature review approach and takes into account the characteristics of Social-Ocean Systems (SOSs). The framework consists of Distributional Equity, Procedural Equity, Recognitional Equity, and Contextual Equity. The aim of this framework is to conduct equity analyses of policies or behaviors within SOSs in order to assess whether blue equity is explicitly implemented and practiced in these societal norms and policy mechanisms. The assessment framework reveals that blue equity has a positive synergy for the majority of the SDGs. This synergy is analyzed in terms of its influence on the assessment dimensions of distributional justice, procedural justice, recognitional justice, and contextual justice. The findings aim to enhance societal understanding of blue equity issues, thereby guiding policymakers in the prioritization of blue equity in the development and utilization of marine resources and in the transformation of global ocean governance.

KEYWORDS

social-ocean systems, blue equity, sustainable development goals, blue economy, marine governance transformation

1 Introduction

Oceans and their biodiversity play a crucial role in providing sustenance and livelihoods for approximately one-third of the global population, especially in coastal least developed countries (LDCs) and small island developing states (SIDSs). In these regions, marine ecosystems are crucial for supporting the productive lives of local communities (Frazão Santos et al., 2022), which are under ongoing strain from human activities influenced by the mentality of utilizing the ocean for resources and growth (Chen

et al., 2023). Human activities have caused significant impacts on the ocean which have reached or surpassed natural variability in terms of intensity, scope, and speed. As a result, human activities are now considered the “third driving force” of the surface system, following solar energy and the internal energy of the Earth system (Li et al., 2004). The utilization of ocean for economic growth may result in limited marine resources being controlled by powerful stakeholders, such as the state and corporations, rather than benefiting coastal communities where resources are located, resulting in an unequal distribution of economic benefits. Coastal communities are exposed to environmental pollution and changes in their production and lifestyle due to marine resource exploitation, exacerbating the unequal impacts of the existing socioeconomic system and resulting in significant social and cultural risks (Bennett et al., 2021; Ayilu et al., 2022). Researchers have highlighted the unequal distribution of advantages and disadvantages related to ocean exploitation among marginalized communities, emphasizing the need for equity and justice (Leach and Mearns, 1998; Schlosberg, 2007; Bennett, 2018; Martin et al., 2019; Bennett et al., 2021).

In order to elucidate the issues of equity and justice occurring in the marine environment, it is first necessary to clarify the conceptual nature of such issues. The ocean, as an ecosystem with the capacity to be self-sustaining and self-renewing, is driven by human society to generate equity issues. As an abstract concept, its connotations are highly inclusive. In different contexts, the concept of blue equity is interpreted and applied in various ways. In different scenarios, we posit that the concept of blue fairness is primarily constituted by the following elements:

Firstly, in essence, blue equity is an abstract, normative moral principle that can be used to discuss or explore ethical issues, guide decision-making and assess specific states of affairs. It is similar to theories such as environmental justice and environmental equity, which articulate the interaction between humans and the natural environment. Secondly, blue equity is an already existing social norm embedded in human-sea relations that prompts some decision makers to consciously adhere to this norm, thus influencing their behaviors and decision-making. As a non-embodied norm, it plays a guiding role in society’s behavioral decision-making. Finally, from a management perspective, blue equity is also the integration of a set of existing policies, mechanisms, standards, or instruments explicitly aimed at achieving equitable outcomes in ocean management. As a nature-based solution, blue equity has the capacity to generate policy effects aimed at promoting the sustainable development and utilization of the oceans. It is important to note that in the majority of application scenarios, blue equity typically exists and generates effects as a means of applying abstract normative principles. From an assessment perspective, the social behaviors generated in the marine environment inevitably have a two-way behavioral policy effect on the marine environment itself and on human society. Such effects also help to refine and evolve the principle of blue equity (Rozzi, 2019). In this paper, we will primarily employ the concept of blue equity as a means of applying the normative principle. Our objective is to conduct an equity analysis of policy behaviors within the socio-oceanic system in order to assess whether blue equity is

explicitly implemented and practiced in these societal norms and policy mechanisms.

The concept of “blue equity” has garnered increasing attention in recent years due to criticisms of the uncontrolled exploitation of marine resources and the recognition of the need for social and economic equity in marine conservation. While related to the well-known concept of “blue justice”, blue equity has distinct emphases but remains closely aligned and complementary. Specifically, blue equity focuses on ensuring that all groups, particularly marginalized and minority communities, have equitable access to and benefits from marine resources. This includes participation in inclusive decision-making processes, access to inherent rights, and cultural acceptance (Bennett et al., 2022). Conversely, blue justice primarily addresses social justice and rights dynamics, aiming to rectify power imbalances across generations (Mohai et al., 2009; Chuenpagdee, 2020). Both concepts share the overarching goals of promoting an ocean policy framework that integrates environmental protection, resource equity, and social justice. This paper explores the intricate relationship between human society and the marine environment through the lenses of equity and justice. By synthesizing the characteristics of both blue equity and blue justice, employing the term “blue equity” as the definitional focus of our research enhances both credibility and clarity. Therefore, our study includes an examination of blue justice within the broader context of blue equity.

The profound impact of human society on the oceans is such that single-discipline studies often fail to capture the complexities of changes in ocean systems. The ocean, exemplifying a coupled system, exhibits complexity, nonlinearity, uncertainty, and multilayered notedness through its interactions with societal systems (Wang et al., 2020). These interactions are evidenced not only by the influence of social systems on the marine environment through political and economic behaviors but also by both the exogenous and endogenous changes within the marine environment. These changes result from social behaviors and geophysical-chemical processes, respectively, and collectively influence the social system. Popova et al. (2023) emphasize that Socio-Ocean Systems (SOSs) encompass all aspects of natural ocean and marine systems, including their physical, chemical, and biological dimensions that interact with human society. SOSs employ an interdisciplinary approach to analyze the mutual impacts between the marine environment and human society. The concept of SOSs, advocated during the United Nations Decade for the Oceans (UNDOOS), utilizes interdisciplinary insights to address scientific, policy, and practical challenges at the intersection of natural and social sciences (Borja et al., 2022; McKinley et al., 2022). While the issue of blue equity originates in the marine environment, it is shaped by societal behaviors that use the ocean as an environmental resource. The phases of planning, implementation, and outcomes of these behaviors have intricate effects on the SOSs. Thus, adopting an interdisciplinary and systematic approach to analyzing the fairness of interactions between society and the marine environment is crucial for studying blue equity.

Previous studies identified specific problems that need clarification in blue equity research. How can a sustainable blue

economy be established with a focus on equality to ensure the fair utilization and allocation of marine resources (Cisneros-Montemayor et al., 2021; Sumaila et al., 2021)? How can blue equity theory be further developed, and can a normative framework system be established to address and enhance blue equity challenges, as suggested by Bennett et al. (2022)? How can equity issues be connected to the Sustainable Development Goals (SDGs) and the blue equity paradigm be used to support the SDGs within the 8-year time frame to enhance human well-being (Haas, 2023)? This article aims to create a universal blue equity evaluation methodology within the context of the SOSs approach to offer insights for the transformation of ocean governance.

The article will be structured into five sections, with part 2 focusing on analyzing the research trend of blue equity concerns using Bibliometrix. Part 3 will focus on the SOSs for study and introduce a blue equity assessment methodology with four main dimensions. Part 4 analyzes the SDGs using the blue equity assessment methodology. It will identify equity dimensions within the SDGs, examine their interrelationships, and emphasize the significance of blue equity in achieving the SDGs. At the end, we discuss how to improve the consideration of blue equity in the current transition of ocean governance to promote sustainable human-sea connections.

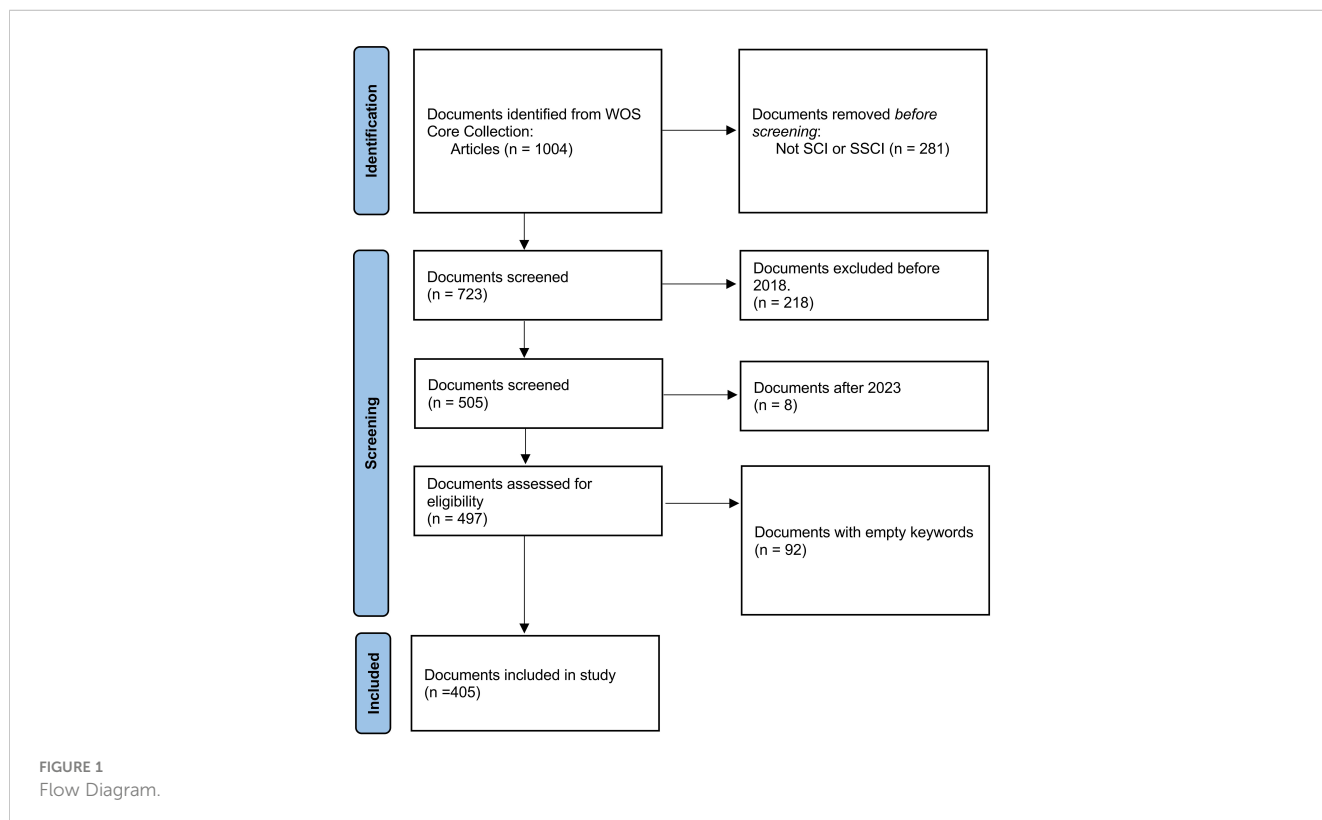
2 Literature analysis

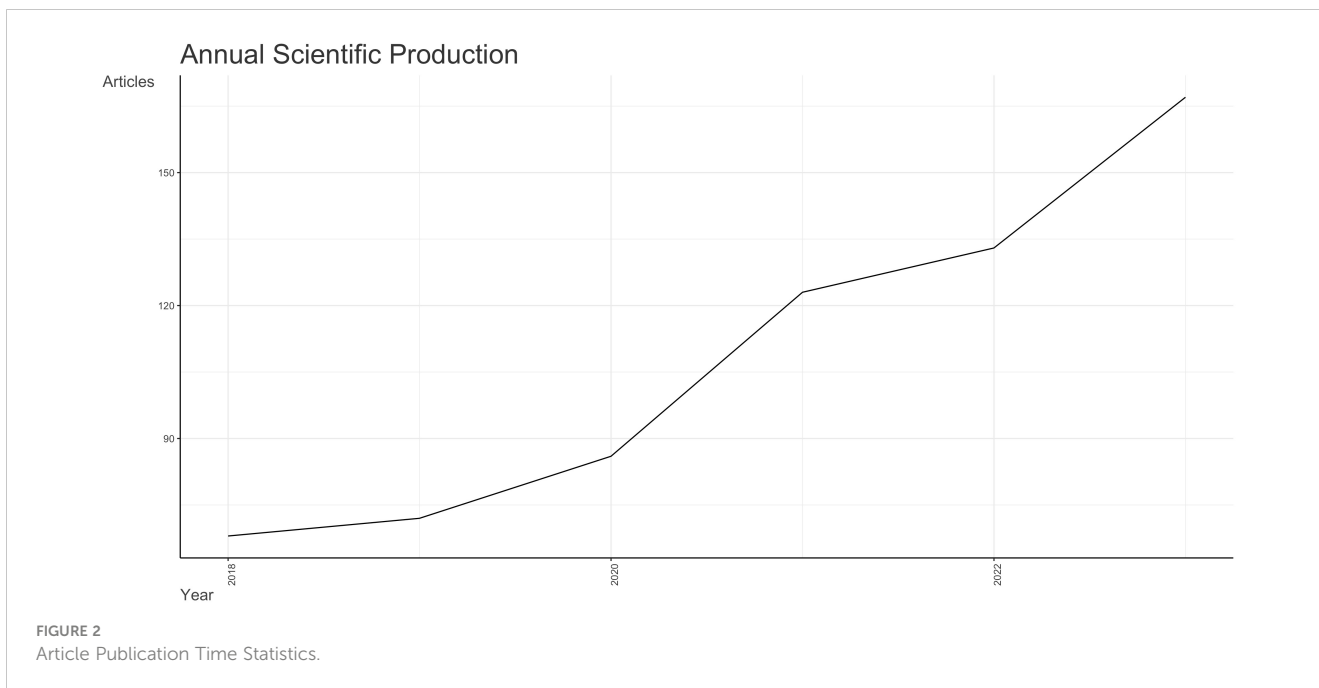
This article utilized Bibliometrix software to conduct a bibliometric analysis of the literature on blue equity, using its capabilities in literature analysis statistics, network analysis, and

knowledge mapping (Li et al., 2018). We conducted a literature search using the Web of Science Core Collection database with the keywords “BLUE EQUITY”, “BLUE JUSTICE”, “OCEAN EQUITY”, and “OCEAN JUSTICE”, resulting in the identification of 1004 relevant publications. As shown in Figure 1, we first excluded literature from non-SCI and non-SSCI search sources. In terms of time scale, since the term “blue justice” was formally introduced and introduced to academia at the 3rd World Congress on Small-Scale Fisheries in Thailand in 2018 (Jentoft et al., 2022), the data period was limited to 2018–2023. The literature samples without keywords were further excluded. The data was retrieved on 26 December 2023, generating a total of 405 valid literature counts.

Based on the number of publications over the years, Figure 2 shows a consistent upward trend in blue equity research since 2018. The number of publications substantially increased from 2018 to 2020, reaching a minor peak in 2021. The data indicate that the average annual growth rate of papers published in the field of blue equity was 19.69% from 2018 to 2023. It can be inferred that blue equity holds significant research value as a developing research area. Specifically, in the last three years, this topic has received considerable attention from the academic community.

Keywords provide a brief summary of the substance and topic of academic papers, and their frequent occurrence indicates the research basis, hot topics, and trends in the field. Figure 3 displays a word cloud map indicating the current research hotspots in the field of blue equity. These include analyses of behavioral equity-specific outcomes, such as benefits and effects, structural components of equity, such as processes, participation, and rights, marine ecosystem content, such as ecosystem services and biodiversity, and marginalized stakeholder groups in the social system, such as



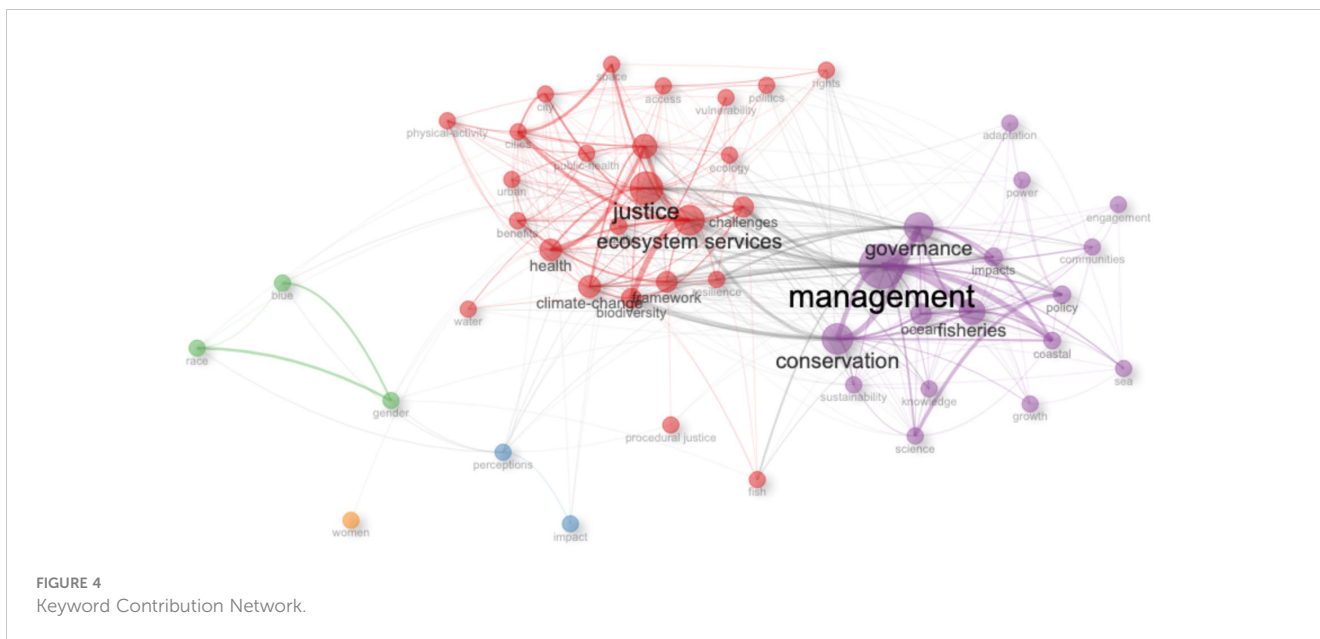


gender, communities, and fishers. Additionally, practical measures of equity, such as governance and policy, are also being studied.

According to Figure 4, the term “management” has the largest node and highest centrality (173.744). Furthermore, the terms “ecosystem services” (71.489), “conservation” (38.609), “governance” (60.134), and “environmental justice” (45.850) have relatively great centrality and influence within the network. It is worth noting, however, that the elements of ecology and ecosystem services that characterize the marine systems in the SOSs are not significantly connected to the elements of fisheries and communities that represent the social systems. There is a lack of significant connectivity between the elements of ocean systems

and social systems, and the elements of governance, such as governance and management, which are the endpoints of blue equity behavior. Blue equity is founded on a behavioral or policy evaluation framework to examine the connections between the equity of behavioral policies and the SOSs in the context of climate change, public safety, and health concerns. However, the current research overlooks the fact that the relationship between humans and the sea is inherently complex within a coupled mega-system. The current analysis lacks a systematic consideration of the joint impacts of blue equity on biodiversity, ecosystem services, and other marine system components. Additionally, it fails to account for the policy effects of marginalized

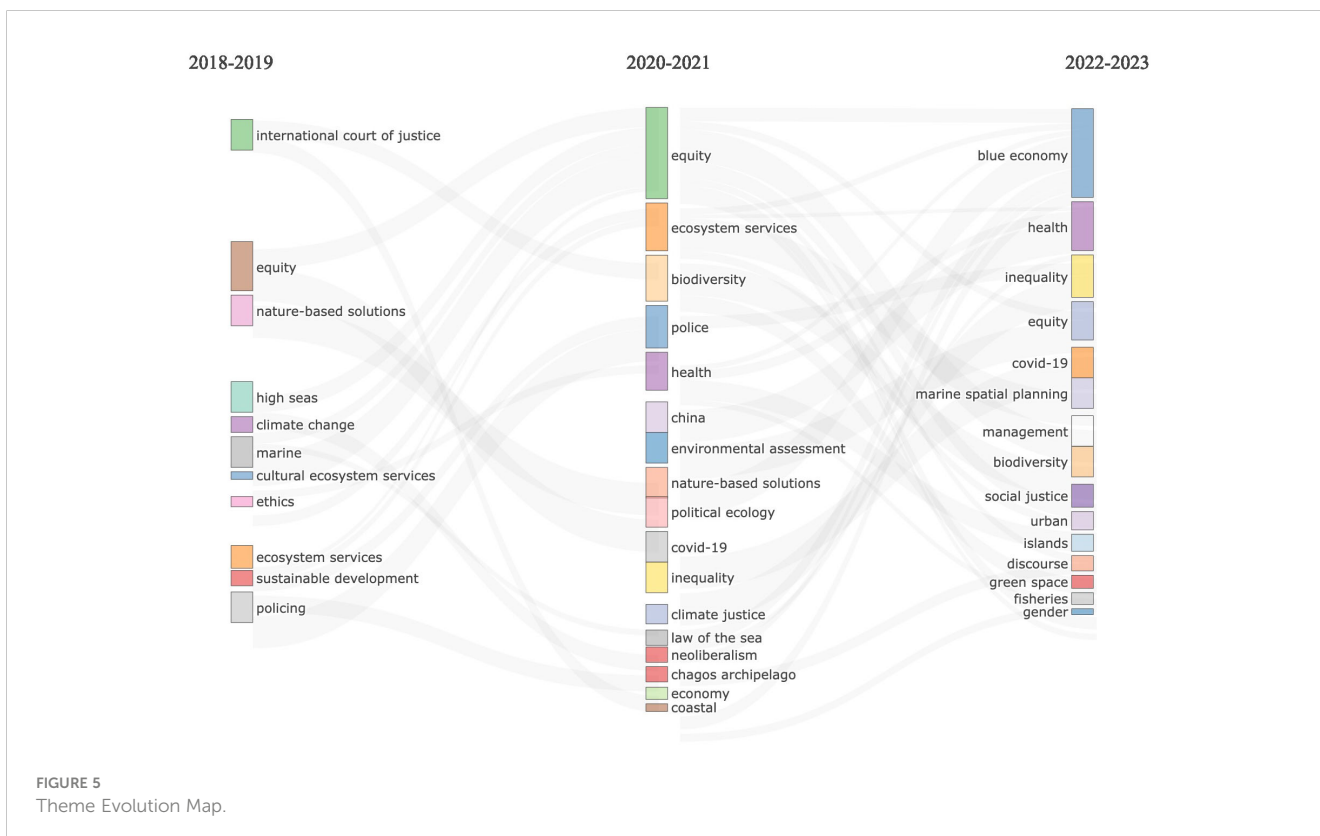




stakeholders within the social system, under the coupled framework of SOSs. Furthermore, it does not adequately consider the role of key effects of ocean governance transformation measures on SOSs. This is a limitation of the present blue equity research.

The evolution of topics in the literature data was analyzed by dividing the time span into three equal parts: 2018-2019, 2020-2021 and 2022-2023. Streamlines were used to connect topics from adjacent time periods based on shared keywords. The width of the streamlines represents the number of shared keywords and

indicates the correlation between the related topics. [Figure 5](#) illustrates the transition of study subjects from fragmentation to unification as the research advances. Recent studies on blue equity have expanded to include not only equity categories and their influence on ecosystem service values and sustainable development but also the interactive aspects of the human-sea connection, such as blue economic advantages, health implications of equity, and blue nonequity factors and their consequences. The research field has shifted its focus from justice for small-scale fishers to addressing



nonequity justice issues faced by women, indigenous peoples, low-income populations, and other marginalized stakeholder groups, including least developed countries and the SIDS. This shift indicates a broader and more systemic approach to the research.

In conclusion, although numerous scholars have achieved notable results in the theoretical definition of equity, feature clustering, and the effects of equity policies, there is a lack of a comprehensive research framework for the assessment of blue equity policies or behaviors within socio-oceanic systems. Furthermore, the operating mechanism of blue equity in SOSs has not been elucidated. Consequently, by integrating the coupled dynamic process of SOSs and considering the specificity of non-equity issues resulting from the development and utilization of marine resources and the environment, a comprehensive analytical framework for the analysis of blue equity in socio-oceanic systems is established. This framework can assist in elucidating the non-equity behaviors of the current ocean utilization, thereby accelerating the transition to a sustainable blue economy through the transformation of ocean governance to fulfill the United Nations' 2030 Agenda for Sustainable Development (Colglazier, 2015).

3 Theoretical concept

Marine ecological systems are threatened by overexploitation, habitat destruction, and environmental pollution caused by intense human activities (Halpern et al., 2013; Reusch et al., 2018). This raises concerns about whether economic development in the marine sector can be balanced with the sustainable use of resources and

ecological conservation (Österblom et al., 2020; Laffoley et al., 2020). Human activities are putting significant pressure on the marine environment, while the integration of the global economy's land-sea connection is increasing at a steady pace. The ocean economy drives the development of the land-based economy and facilitates the connection between the economic systems of land and water (Chen and Han, 2023). Equity is an essential requirement and prerequisite for sustainable development; however, it may not be the only factor. The relationship between equity and sustainable development is closely intertwined (Leach et al., 2018; Cetrulo et al., 2020), representing two inseparable aspects of the same concept. The connection between them is sometimes described as being interdependent. To achieve sustainable ocean economic development, it is crucial to consider blue equity concerns in ocean exploitation and their implications for the SOSs.

By leveraging the research of Popova et al. (2023) and integrating insights from the ecological, environmental, and social sciences, we have developed Figure 6. This figure, created using PowerPoint, illustrates the correlation between blue equity and SOSs. In SOSs, ecological services and resource utilization drive the behaviors of marine ecological processes. Human influences such as overfishing, land reclamation, near-shore pollution, and coastal sedimentation, along with marine management practices including pollution control, ecological restoration, ecological compensation, and regulation of land reclamation, contribute to the interactive effects between the marine ecological environment and human society. Market dynamics, represented by consumption and profit, along with human activities related to resource acquisition, welfare, and the pursuit of social capital, also stimulate marine resource utilization.

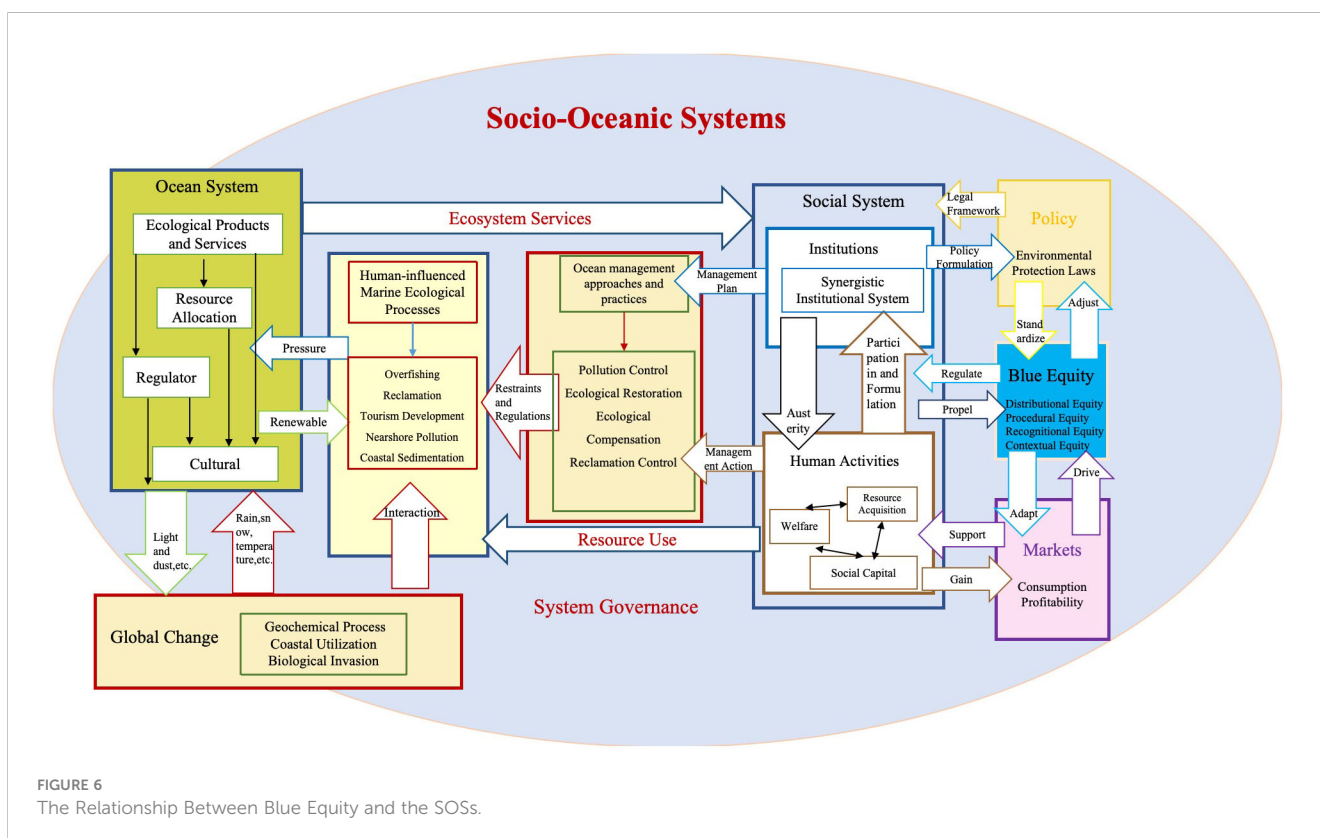


FIGURE 6 The Relationship Between Blue Equity and the SOSs.

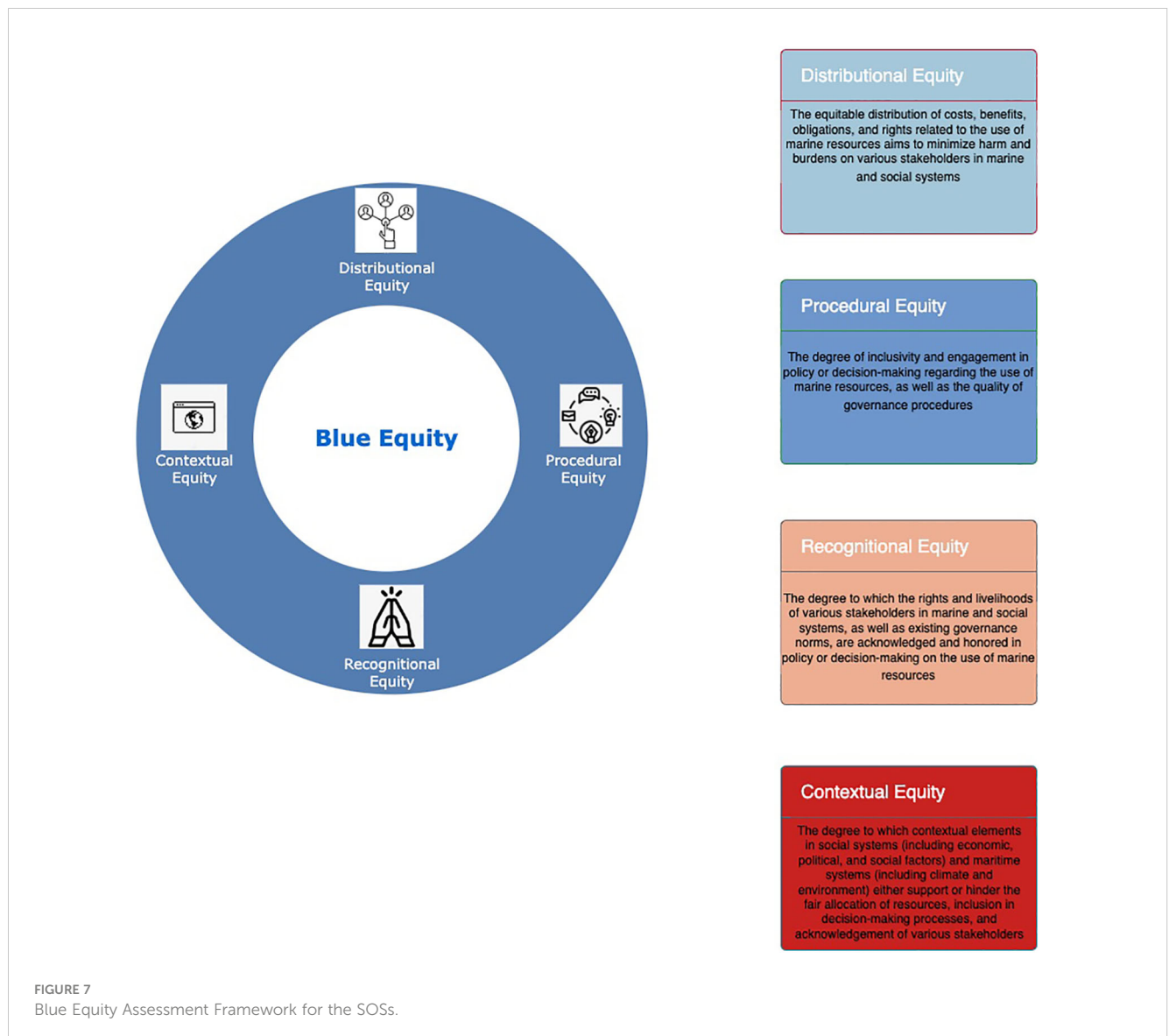
Humans not only participate in but are also constrained by the institutional frameworks governing ocean exploitation. As a crucial intermediary, blue equity adjusts to and adapts policy and market forces, while also responding to their regulatory and driving effects, which significantly impact the social system. At the marine system level, blue equity introduces new pressures through institutional policies and human behaviors, potentially shifting the homeostasis of the marine environmental system. This transition may reverberate back to human society, exacerbating Anthropocene challenges such as resource depletion, disasters, and environmental degradation, thus threatening the livelihoods and well-being of global populations (Rocha et al., 2015; Bennett et al., 2023). Blue equity thus plays a vital regulatory role within SOSs (Sumaila and Walters, 2005; Cisneros-Montemayor et al., 2021; Sumaila et al., 2021).

Equity is a contextual occurrence, and the concept of blue equity encompasses various aspects, such as social equity (equity in public policy formulation and distribution of public services), environmental equity (equity in addressing marine environmental concerns), and equity for nonhuman entities. Chuenpagdee (2020) contends that blue equity is a reaction to the regulations and authorities governing the entry, utilization, and administration of marine resources and oceanic territory. According to Armstrong (2020), blue equity refers to the need for individuals to utilize the opportunities presented by the ocean economy to reduce inequality. This concept is influenced by factors such as geographical location, access to financial resources, and administrative capabilities. In contrast, Bennett (2022) contends that blue equity consists of recognition, procedural, distributional, managerial, environmental, and contextual dimensions, and is concretely characterized in the processes, applications, and outcomes of relevant public policies and organizational practices. Bennett fully summarizes the literature in the fields of conservation, environmental management, and oceans, to explicitly summarize the definition of the dimensionality and composition of blue equity, and points out the direction for the subsequent blue equity research. However, he may have overlooked the systemic nature of blue equity by including management equity and environmental equity in the compositional framework, which has severed the coupling and connectivity between the social system and the ocean system. The effects of blue equity policy practices and organizational behaviors cannot be evaluated solely as isolated marine ecological or social issues. Specifically, within a coupled SOSs, human society, and the marine environment function as two distinct systems that are interconnected through a feedback loop mechanism, facilitating the interaction between society and the ocean system. The implementation of social policies aimed at achieving equity will have significant impacts not only on society but also on the maritime environment. Alterations in the marine system will result in policy responses and interactions related to equity, which in turn will necessitate adjustments in institutions and transitions in governance. Hence, focusing solely on the fair distributional of benefits and resources and the equity of participatory processes within the SOSs (Van Stavel et al., 2021) or solely on environmental protection and sustainable use of the ocean system may result in disregarding the interconnection and intricacy of the SOSs.

This article analyzes the concept and structure of environmental justice theory based on equity and justice as outlined by Pascual et al.

(2014), and incorporating insights from Bennett (2022); Blythe et al. (2023), among others. At the same time, it combines the mobility and public resource attribute characteristics of oceans and seas with the whole-systems thinking of socio-oceanography to pay attention to the impacts of equity behaviors on societal elements of the marine environment and the effects of feedback between them. This is done in order to revise the connotation of environmental justice. In the context of normative principles, blue equity behaviors can be defined as the practical behaviors of whether all stakeholders within a socio-oceanic system enjoy equitable contexts, are recognized, meaningfully engaged, and receive equitable treatment. The four dimensions of blue equity behaviors are distributional equity, procedural equity, recognition equity, and contextual equity. These dimensions correspond to the implementation context, implementation principles, implementation procedures, and distribution of outcomes that may result from the policy behaviors, respectively. The four dimensions are logically related and relatively independent, yet interconnected, and collectively serve as the structural elements of the blue equity assessment system for the policy behaviors. The establishment of a systematic assessment framework permits the summary and analysis of whether a policy action is blue equity throughout its entire life cycle. As shown in Figure 7, the definitions and descriptions of the assessment dimensions are as follows:

The concept of distributional equity (DE) refers to the degree of equity in the distribution of costs and benefits, responsibilities, and rights in the use of marine resources. The objective is to minimize the harms and burdens to different stakeholders within the SOS. The concept of distributional equity emerged from the perception of socio-economic systems as unjust, and thus, the assessment of economic costs and benefits, as well as social rights and obligations, is a central concern of DE. In the utilization of marine resources, the majority of marine industries are resource-intensive or technology-intensive. This, in conjunction with the path-dependence of capital, technology, social status, and other characteristics, results in the existence of a relatively obvious scale agglomeration effect in most marine industries. Developed countries, large and medium-sized enterprises, and other powerful stakeholders often possess a high degree of integration capacity in the behavior generated by marine resources, and occupy a dominant and dominant position in the development and utilization of marine resources (Issifu et al., 2023). This asymmetric behavior prompted them to seize the resources or rights of the least developed countries (LDCs), small island developing states (SIDS), marginalized groups such as women, indigenous populations, and small-scale fishermen, or to asymmetrically threaten marginalized groups in other similar ways (Campling and Colás, 2018). This prevented them from enjoying the benefits of ocean resources and instead took on more of the risks and challenges associated with resource exploitation (Klain et al., 2014; Felipe-Lucia et al., 2015). Similarly, from the perspective of marine systems, the marine environment continues to be negatively impacted by the influence of social system behaviors, despite the existence of behaviors such as ecosystem compensation and restoration. This pattern of non-equity in distribution persists. For example, the European Union (EU) fishes heavily for economic fish in the exclusive economic zones (EEZs) of African countries, but the catch is attributed to the flag state of the fishing vessel, and the



social systems (governments, stakeholders such as small-scale fishers, etc.) Furthermore, the marine ecosystems of African countries are negatively impacted by resource depletion and habitat destruction. However, they are unable to receive any economic benefits from the harvesting of fishery resources or environmental restoration support. Coastal small-scale fishers are particularly vulnerable to livelihood loss and environmental threats (Okafor-Yarwood and Belhabib, 2020; Andriamahefazafy et al., 2022; Davis et al., 2022). This unequal distribution of benefits and risks has the potential to result in imbalances among some stakeholder groups in SOS, which could impede the sustainable development process.

Procedural equity (PE) is defined as the degree of inclusiveness and participation in behaviors or policies related to the use of marine resources, as well as the quality of the overall governance process. PE is not only concerned with procedural equity in behavioral decision-making, but should also emphasize inclusiveness of the marine environment in the implementation process. The absence of procedural participation of key stakeholders in marine development and utilization behaviors has the potential to produce non-equity

effects. This non-equity effect has the potential to have a negative impact on both systems in the SOS. For instance, in response to SDG 14 (life below water) and to attract investment from the international community, the Seychelles developed a Marine Spatial Plan (MSP) to designate 30% of the sea area as a Marine Protected Area (MPA) in the future. Although the Seychelles government has invited some fishermen representatives to participate in the planning process of the MSP, there are still many small-scale fishermen who feel that their own sustainable livelihoods are not adequately safeguarded by the program (Silver and Campbell, 2018). Furthermore, the program does not have the participation and buy-in of all fishermen groups, and there are procedural problems, which ultimately exacerbate the MSP conflict (Clifton et al., 2021). It was demonstrated that PE may directly affect stakeholders' perceptions of DE. This reflects the dynamic character of trade-offs and synergies between dimensions of blue equity that influence each other (Pascual et al., 2014; Lau, 2020).

Recognitional Equity (RE) is concerned with the extent to which the rights of all stakeholder groups are acknowledged and upheld in

the context of behavior and decision-making. For stakeholders, such rights are often considered to be innate, including identity, history, values, and traditional knowledge systems. It is argued that when assessing equity in behavioral decision-making, the RE dimension elements usually include guarantees for the above rights of stakeholders. The rights of stakeholders in SOS are characterized differently, and whatever they are, they should be recognized, respected, and guaranteed in behavioral decision-making (Franks and Schreckenberg, 2016; Zafra-Calvo et al., 2017). Such recognition, respect, and guarantee should be explicitly expressed within the regulations, institutions, laws, and other vectors of behavioral decision-making in order to reflect the recognition of equity in behavioral decision-making. Consequently, RE is frequently a prerequisite for DE and PE (Young, 2006).

Contextual equity (CE) is a concept that examines whether policy actions address the issue of disparities in the capacity of stakeholders to participate, be recognized, and distributed. It also assesses whether adequate consideration and safeguards are given. In conducting a blue equity assessment, CE is often a primary focus of the assessment process. In essence, a blue equity assessment should initially ascertain the spatial and temporal scales at which behaviors are situated (Pascual et al., 2014), the environmental quality of the marine system, and the degree of capacity of the social system. These are pivotal characteristics that define the capacity of CE. The assessment dimensions, such as DE, PE, and RE, are typically based on the CE dimension, and all four of them collectively constitute the SOS Blue Equity Assessment Framework, which encapsulates the multidimensional concept. Consequently, CE serves as the pivotal nexus between DE, PE, and RE (Schlosberg, 2007).

In summary, the blue equity assessment of policies or behaviors in SOSs is a kind of attribute dimensional assessment. The DE, PE, RE, and CE dimensions, which are interrelated and interact with each other, collectively constitute the blue equity assessment framework. The DE dimension is concerned with the equitable distribution and burden of economic gains and losses as well as rights and obligations among the stakeholder groups of the behaviors or policies under consideration. The PE dimension, in contrast, is focused on the equitable participation of these same stakeholder groups in the planning, implementation, and evaluation of the behaviors or policies in question. The PE dimension concerns the extent to which stakeholder groups have been engaged in the planning, implementation, and evaluation of the behavior or policy in question. The core of the PE dimension is the question of whether procedural issues are fair or not. The RE dimension concerns the extent to which the inherent rights or attributes of the stakeholders in the behavior or policy have been directly recognized and respected in equity. This often necessitates the explicit embodiment of these rights or attributes in the behavior or policy. In contrast to the preceding three dimensions, the CE dimension is based on the attributes of the stakeholder group and assesses whether the policy has taken adequate consideration. Consequently, we posit that when conducting the blue equity assessment of policy behaviors in SOSs, it is imperative to ascertain whether the differences between stakeholders are explicitly acknowledged and safeguarded in the policy behaviors, that is, by focusing on the CE dimension. Secondly, the RE, PE, and

DE nature dimensions are evaluated with regard to the recognition and respect of the content of the policy behaviors for stakeholders, the procedural design and implementation of the policy behaviors, and the equity distribution of the outcome of the policy behaviors, respectively. It should be noted, however, that since blue equity is typically conceptualized as an abstract principle, there may be instances of ambiguity, overlap, and intersection among the four dimensions we propose. This may be due to the inherent complexity of the assessment object. Consequently, when conducting a blue equity assessment of policy behaviors in SOSs, it is recommended that the focus of attention be shifted to the assessment context and the assessment object, and that the logic of 'CE-RE-PE-DE' be used in conjunction with the actual situation. This is also consistent with the typical sequence of assessment, which is known as the 'Before – During – After' approach.

4 Interlinkages between blue equity and SDGs

In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development, establishing a system of SDGs comprising 17 goals, 169 targets, and 231 indicators (UN, 2015). This agenda underscores the urgency for human societies to eradicate poverty, support local livelihoods, uphold dignity for all, and foster economic development in harmony with nature (Nilsson et al., 2016). The SDGs encompass three dimensions—economic, social, and environmental—and serve as a blueprint for achieving a sustainable future for all. Central to these goals is equity, reflecting the Agenda 2030 mandate to “leave no one behind”. From the perspective of the socio-oceanic system, the SDGs address both historical and contemporary equity issues (CE), combat discrimination and exclusion (PE & RE), enhance the well-being of the poorest (DE), and the objective is to provide for the sustainable development of oceans and seas through the implementation of a blue equity strategy (Ota et al., 2022). Despite significant efforts toward sustainable development, the latest progress report (UN, 2022) indicates a substantial gap between most SDG targets and their expected outcomes, with global efforts largely off track. The governance of global oceans lags, marine biodiversity's capacity is diminishing, and the resilience of SOSs is critically challenged, reflecting a grim reality for blue equity. The 2023 UN Summit on SDGs reported that only 15% of the goals are on track, with half either moderately or severely off track, and a third regressing. Specifically, SDG14 (Life Below Water), integral to blue equity, shows that no country is near achieving its targets (Andriamahefazafy et al., 2022; Sachs et al., 2022), highlighting severe inequities in the utilization of marine resources and the distribution of international costs and benefits. There is an urgent call for universal action programs to foster sustainable development in SOSs. Therefore, analyzing the interplay between blue equity and the SDGs within SOSs not only tests the viability of the blue equity assessment framework but also promotes the swift realization of the SDGs.

The SDGs represent a comprehensive systemic strategy centered on advancing sustainable human development grounded in social

justice and equity, facilitated through the monitoring, evaluation, and adaptive management of indicators for each goal and sub-goal (Hutton et al., 2018). However, as a complete system, the SDGs may not always yield the hypothesized “win-win” outcomes, particularly when navigating conflicting social, economic, and ecological objectives. Such conflicts often lead to equity and well-being disparities among different stakeholders, invariably resulting in policy winners and losers (Butler and Oluoch-Kosura, 2006). Within SOSs, a dynamic system driven by ecological, environmental, social, and economic factors, policies or behaviors act as exogenous forces impacting the feedback loop mechanisms. This interaction often results in complex outcomes of fairness or unfairness, directly influencing the SDGs and ultimately the trajectory of the overall SDG framework. Consequently, there is a distinct correlation between blue equity and the SDGs. Analyzing this relationship from the perspective of policies or behaviors reveals trade-offs or synergistic interrelationships (Rodríguez et al., 2006; Cavender-Bares et al., 2015). Blue equity initiatives can alter the direction and scale of SDG progress; when the influence of blue equity undermines specific SDG achievements, a trade-off occurs, indicating a negative correlation. Conversely, the successful implementation of blue equity can bolster the attainment of certain SDGs, resulting in a synergistic effect and a positive correlation.

In SOSs, we thoroughly consider the complexity of policy actions and employ a systematic approach to analyze and understand the intricate interactions between blue equity effects and the SDGs system. Utilizing the blue equity assessment framework for SOSs, we systematically assess these interactions across the four dimensions previously described, aiming to promote synergies and mitigate trade-offs (Le Blanc et al., 2017; Fu et al., 2019). Drawing on the methodologies of Fuso Nerini et al. (2018) and Parikh et al. (2021) for assessing SDG interrelationships, we explore potential synergies or trade-offs between blue equity and relevant SDGs based on literature reviews and rational empirical judgment derived from common sense. Discussions in the literature regarding the connections between blue equity and related SDGs, or logical empirical judgments based on common sense, serve as the foundation for identifying synergies or trade-offs. For instance, through both qualitative and quantitative research, Kyvelou et al. (2023) discovered that Greek Fisheries Local Action Groups (FLAGs) contribute to developing a sustainable blue economy by enhancing the use of renewable energy sources in fishing communities and improving energy efficiency. Based on the PE dimension, this transition empowers communities to participate equitably in the benefits derived from the ocean economy. The increased adoption of renewable energy also supports the achievement of SDG 7.1, which aims to “ensure universal access to affordable, reliable, and modern energy services” by 2030. Consequently, we posit that blue equity may exhibit significant synergy with SDG 7.1. The findings from our literature review are detailed in the accompanying table and illustrated in Figures 8 and 9.

It is crucial to acknowledge that synergistic or trade-off relationships may exist among the SDGs themselves. Furthermore, blue equity could influence these interconnections, subsequently affecting the implementation of specific SDGs (Elmhirst et al., 2019). However, due to the absence of extensive data on SDG

implementation, this paper will temporarily omit the analysis of inter-SDG correlations. Instead, we will concentrate solely on the interactions between blue equity and individual SDGs.

Our study reveals the presence of interdependencies between blue equity and the SDGs, and in the majority of instances, blue equity actively helps to achieve the SDGs. There is a lack of clear evidence linking SDG15 (Life On Land) and blue equality, as determined after a thorough examination of relevant arguments in the literature and logical empirical judgments based on common sense. Despite the clear connections between marine and terrestrial ecosystems, such as the direct influence of land-based agricultural and industrial emissions on the marine environment through atmospheric cycling, and the direct impact of changes in temperature and salinity in the oceans on land-based climate patterns. Hence, the absence of monitoring data on land-ocean interactions could impede our comprehension and evaluation of the interplay between these two entities. Thus, we have temporarily disregarded the associations between blue equity and SDG15 as discussed (Samhouri and Levin, 2012; Barcelo et al., 2023). Hence, we examined all sustainability indicators with the exception of SDG15 and determined that out of a total of 157 indicators, 86 (54.78%) indicators exhibited just synergies, 2 (1.27%) indicators exhibited only trade-offs, and 52 (33.12%) indicators exhibited both trade-offs and synergies. When comparing trade-offs to blue equity, it is evident that blue equity has a greater positive impact on the SDGs. This implies that implementing blue equity policies or behaviors adds significantly to achieving most of the SDGs, making blue equity a powerful driver of sustainable development. As shown in Figure 10, to validate the blue equity assessment methodology, we conduct a thorough examination of the interaction relationship and influence mechanism between blue equity and SDGs. This assessment is based on the dimensional perspectives of allocation, process, recognition, and context.

The DE dimension is concerned with the group of stakeholders in the behavior or policy and whether they receive an equitable distribution and burden of economic gains and losses, rights, and obligations. There could be compromises or mutually beneficial connections between the distributional equity aspect and 121 (63%) indicators, indicating that the distributional equity aspect is a key component of blue equity. Based on a literature review, distributional equity is strongly connected to the SDGs in the areas of fundamental human needs and economic advancement, including SDGs 1 (No Poverty), 3 (Good Health And Well-being), 4 (Quality Education), and 8 (Decent Work And Economic Growth). This is also in line with the idea of “risk-bearing allocation” of distributional equity, which is based on common sense or logical judgment (Wynberg and Hauck, 2014; McCauley et al., 2018). The scarcity of marine resources is an objective reality, and the availability of these resources is determined by the level of development of resource stocks, environmental carrying capacity, resource extraction capability, and other relevant criteria. Marine resources possess unique public attributes and can be transformed into economic or material value within society. These values should be distributed to LDCs and SIDs that have experienced damage to their marine resources. This distribution is based on the principle of distributional equity and aims to assist these Southern countries in

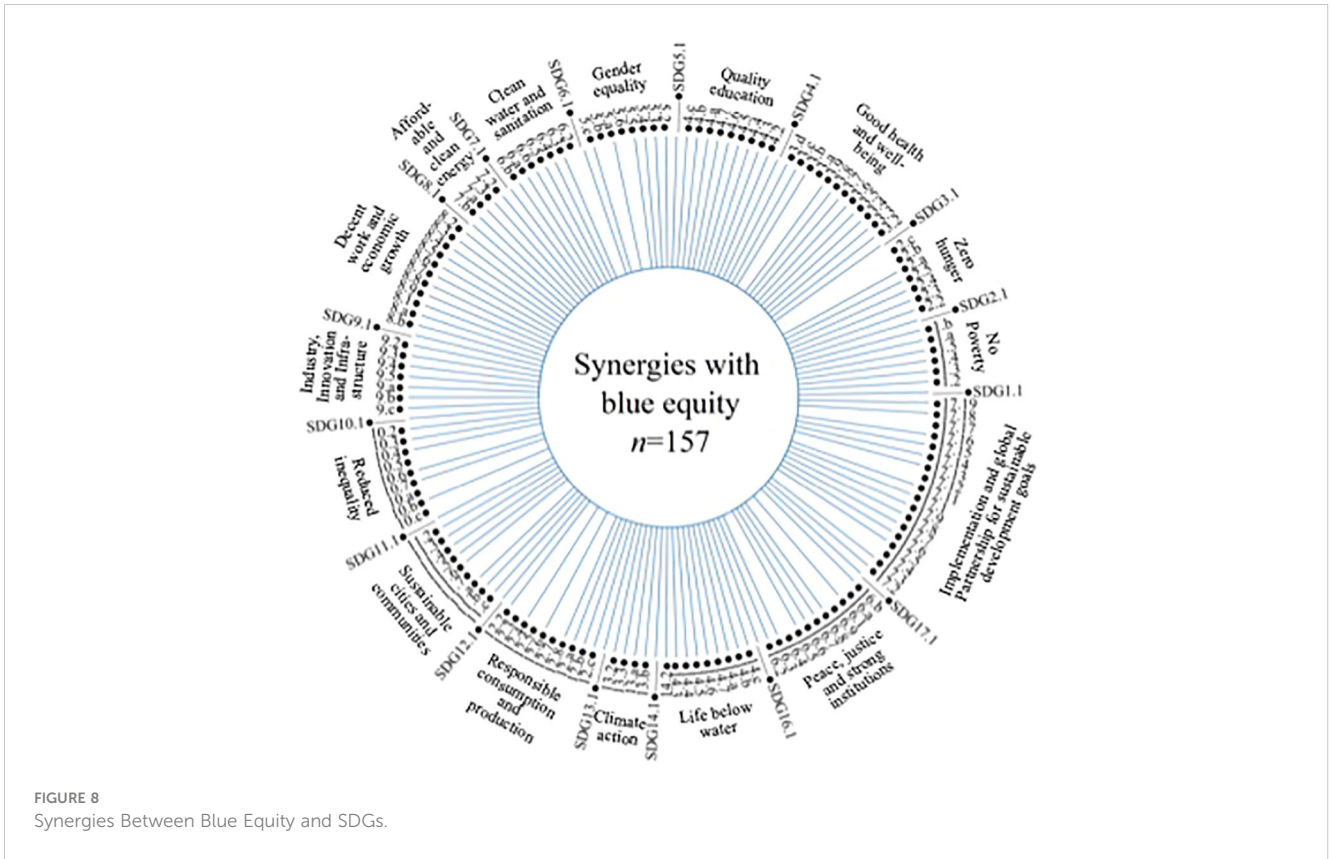


FIGURE 8
Synergies Between Blue Equity and SDGs.

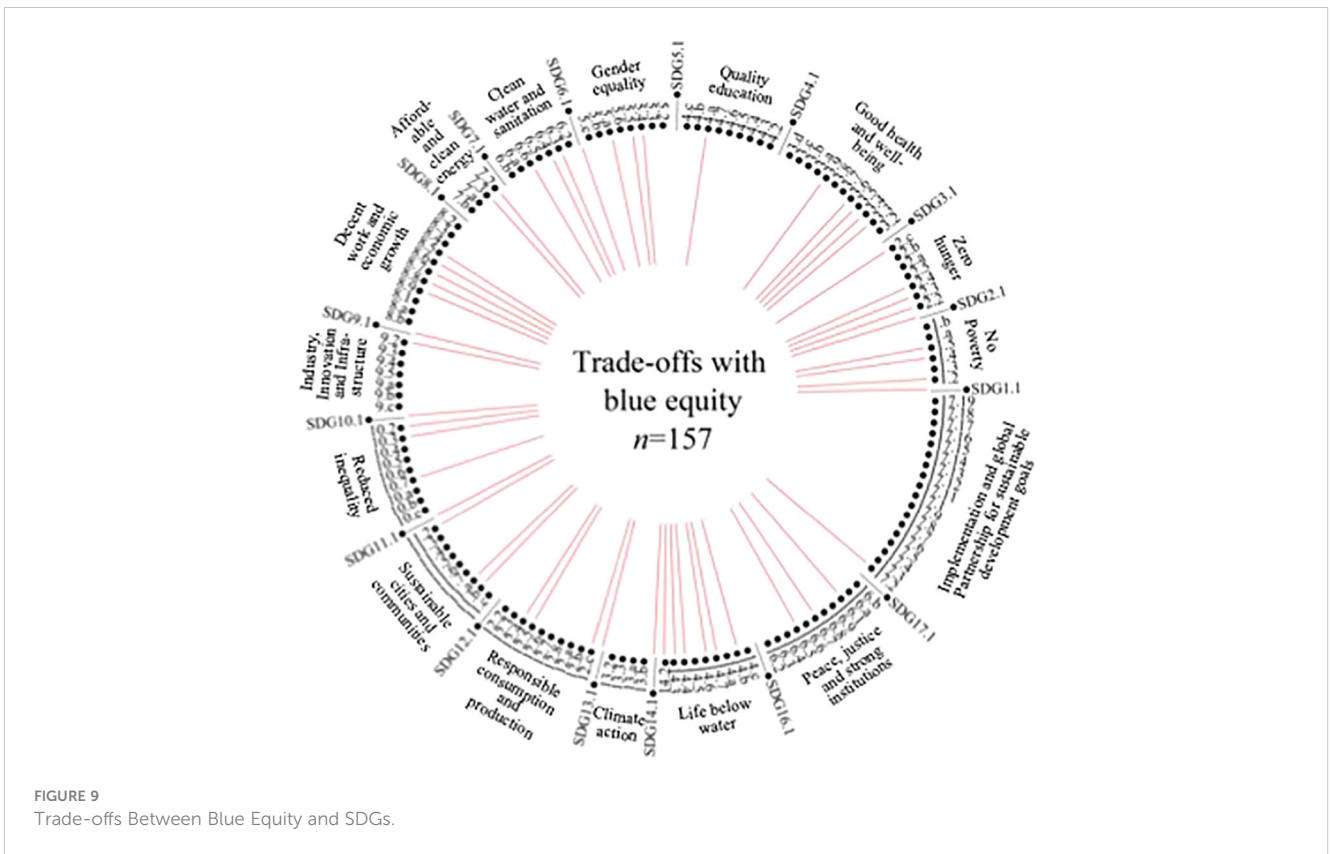


FIGURE 9
Trade-offs Between Blue Equity and SDGs.

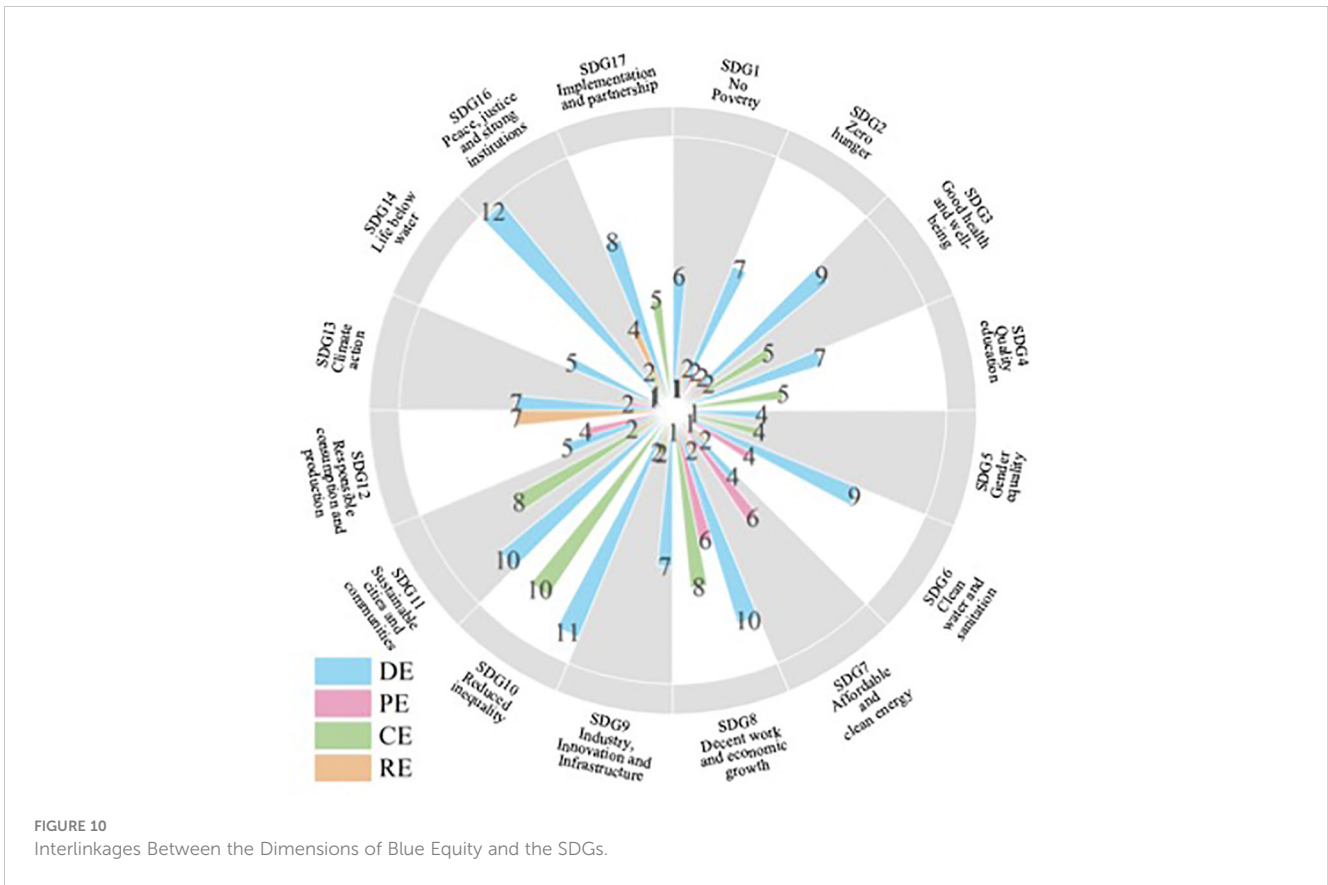


FIGURE 10 Interlinkages Between the Dimensions of Blue Equity and the SDGs.

alleviating poverty and hunger, improving access to healthcare and education, and promoting economic development and infrastructure construction. When upgrading the level of resource utilization, it is important to consider the damage caused to the marine system. This can be addressed by implementing ecological compensation, which involves restoring the ecosystem and implementing environmental and economic policies that are based on the value of ecosystem services. These measures help to enhance the capacity of the marine environment and create favorable conditions for ensuring the sustainable development of the economy (Pereira et al., 2017). From the standpoint of distributional equity, blue equity plays a crucial role in advancing the achievement of SDGs in areas such as meeting human needs and fostering economic growth.

The PE dimension concerns the extent to which the behavior or policy in question is planned, implemented, and evaluated with the participation of relevant stakeholder groups. Within the blue equity assessment system, procedural equity is linked to 29 indicators, accounting for 15% of the total. These indicators specifically address social equity and international cooperation, including SDG5 (Gender Equality), 16 (Peace, Justice And Strong Institutions), 17 (Partnerships For The Goals), as well as the broader categories of social equity and international cooperation. One potential explanation for procedural inequality in SOSs is that the formulation and execution of policies or practices related to ocean resource utilization are frequently controlled by stakeholders who benefit more from the outcomes. Powerful stakeholders perpetuate the exclusion and marginalization of disadvantaged stakeholder groups through systems of inequity in

terms of income or social standing. This has the potential to exacerbate existing disparities and erode the credibility of marginalized stakeholders' involvement in the utilization of maritime resources (Bell and Carrick, 2017). The absence of involvement from marginalized stakeholders intensifies the conflicts in human-sea interactions, ultimately posing a potential threat to both society and the marine environment. The lack of fairness in the process is evident not only in the absence of the South's involvement in the global ocean governance system, but also in its direct connection to gender equality. Women in some LDCs and SIDS often have a diminished social standing. The exclusion of women from marine resource use policies exacerbates their marginalization in society and prevents them from accessing the benefits and security provided by these resources. This exclusion undermines the achievement of SDG5 (Hapke and Ayyankaril, 2004; Weeratunge et al., 2010; Peprah, 2011; Locke et al., 2017; Josse et al., 2019). Therefore, procedural equity may have a positive correlation with SDGs in areas such as social equity.

The RE dimension assesses whether the inherent rights or attributes of the stakeholders in the behavior or policy are directly recognized and respected by equity. Our assessment reveals that there are 25 (13%) indicators in SDGs 5, 8, and 14 that are linked to the recognitional equity. These indicators span across the areas of social equity, economic growth, and resource use. Society's utilization of marine resources in SOSs is frequently motivated by the requirements of economic progress and accomplished through economic privatization. Within the framework of economic globalization, actions that involve the exploitation of marine resources, disregard for the rights and interests of stakeholders in

these resources, and are carried out for economic benefit, have the potential to worsen the vulnerability of SOSs (Martin et al., 2016). Underprivileged individuals are compelled to change their customary ways of life and intensify their exploitation of ocean resources in order to meet their basic needs, resulting in a disregard for their rights. This unintentionally worsens the existing inequality, as evidenced by studies conducted (Fraser, 2000; Pauly et al., 2014; Sikor et al., 2014; Bennett et al., 2015). Hence, it is acknowledged that there exists a correlation between the recognitional equity and the accomplishment of interconnected sustainable development objectives, such as social fairness, robust economic expansion, and sustainable utilization of resources.

In the context of social impact assessments (SOSs), the CE dimension is concerned with the extent to which policy behaviors is attentive to differences in the capacity of stakeholders to participate, be recognized and distributed. Contextual equity is linked to 50 indicators, which account for 26% of the indicators in the social well-being and international cooperation categories of SDG3, 4, 10 (Reduced Inequalities), and 17. Blue equity strategies in SOSs are typically developed considering contextual dependencies. When assessing equity issues, it is crucial to incorporate temporal and spatial scales alongside the chosen dimensions. In order to ensure fairness in the distribution of benefits from ocean development and usage, it is important that the traditional stakeholders, such as countries, communities, and indigenous peoples residing in the areas where the resources are situated, are the ones who benefit from these activities. By implementing governance transformation strategies such as collaboration, education, and assistance, we can empower traditional stakeholders to effectively contribute to the equitable distribution of benefits and prioritize the overall welfare of all individuals. This approach will facilitate the achievement of the SDGs related to equality and prosperity (Decker Sparks and Sliva, 2019).

To summarize, the blue equity evaluation methodology, which is based on the principles of distributional equity, procedural equity, recognitional equity, and contextual equity, has a positive impact on the majority of the SDGs. The implementation of blue equity, in the majority of instances, can advance the goals of the sustainable development agenda. Nevertheless, it is important to acknowledge that blue equality might have a trade-off impact on certain SDGs. In specific situations, blue equity might impede the long-term sustainability of socio-oceanic systems. In our assessment, the existing implementation of the system exhibits some flaws and could contribute to the disparity between blue equity and the achievement of the SDGs.

From a SOSs perspective, certain sustainable development goals may be influenced by limitations during the planning phase. Consider SDG 14.7 as an illustration. This goal aims to enhance the economic advantages that SIDS and LDCs obtain from the sustainable exploitation of marine resources. This can be achieved by effectively managing fisheries, aquaculture, and tourism in a sustainable manner. Nevertheless, certain states face limitations due to their own economic, scientific, technological, and infrastructural constraints. Consequently, they are unable to fully exploit marine resources in a sustainable manner, unlike developed countries. This situation disregards the principle of contextual equity among nations. As an illustration, the Government of Timor-Leste,

which is a typical least developed country, has implemented several sustainable blue economy policies to tackle issues such as poverty, food security, and sustainable livelihoods. Nevertheless, the effectiveness of the policy is hindered by the lack of strong connections between different administrative sectors and the insufficiency of the overall governance system. This leads to difficulties in achieving social goals and adapting to climate change, as well as the necessity for enhancements in cross-sectoral policy linkages and other areas, as stated by Voyer et al. (2020). The SDG system lacks adequate focus on blue equity. SDG10 addresses a range of disparities, although its primary emphasis is on economic and social outcomes. Notably, none of the specified indicators directly addresses equity in the natural environment. This implies that blue equality is implemented in an indirect manner via achieving other SDGs (Oestreich, 2018). This is expected to exacerbate the limitations and obstacles experienced by marginalized groups or countries with low and middle income in their progress, and ultimately result in the expansion of current disparities. Hence, it is imperative to acknowledge the significant contribution of blue equity to the SDGs and contemplate necessary modifications and revisions to the goal framework in the upcoming sustainable development phase. This will effectively emphasize the importance of blue equity and foster the balanced and enduring development of human-sea interactions.

5 Conclusion

In the current era of a multipolar world and accelerated globalization, humankind is experiencing economic globalization, cultural diversification, and information socialization. As a result, we have entered a highly interdependent society where the development and utilization of marine resources are gaining more and more attention. Nevertheless, the interconnectedness and fluidity of the oceans, along with the lack of clear boundaries, pose a challenge for countries in effectively curbing pollution that originates beyond their territorial waters. The conventional ocean governance model is plagued by several limitations, including inequitable resource distribution, ecological harm, inadequate international collaboration, and a strained capacity of the marine ecosystem. As a result, it fails to meet the requirements of a fair and sustainable society. We propose that, in line with the principles of fairness, long-term viability, and collaboration, the following measures should be implemented to advance the transformation of ocean governance and foster the implementation of blue equity: Firstly, enhancing marine scientific research serves as the foundation for achieving the transition in ocean governance and advancing the concept of equitable utilization of marine resources. An accurate assessment of the potential and vulnerability of marine resources, fair treatment of marine ecosystems, and the formulation of environmentally equitable marine policies can be achieved through a comprehensive understanding of the structure, function, and dynamic changes of marine ecosystems. Secondly, promoting technological innovation is crucial for achieving blue equity. Utilize advanced scientific and technological methods, including remote sensing technology, geographic information

systems, artificial intelligence, etc., to enhance the efficiency of developing and utilizing marine resources. This will facilitate the equitable distribution of benefits derived from marine resources and minimize the adverse effects on the marine environment. Simultaneously, technological advancements are employed to enhance the surveillance and safeguarding of marine ecosystems, as well as to ensure the sustainable exploitation of marine resources. Thirdly, the development and enforcement of policies serve as a guarantee for expediting the shift in marine governance and advancing equitable utilization of marine resources. We will promote the sharing of advanced technology and experience in the distribution of marine resources through practical measures such as marine protected areas and other area-based management tools. Additionally, we will establish benefit-sharing systems for marine genetic resources and strengthen international cooperation and exchanges. These efforts aim to enhance the capacity of countries to participate in the distribution of marine resources, ensure a fair distribution of benefits among countries, particularly the least developed countries and small island developing States, and uphold blue equity rights such as procedural participation and recognition of the rights of marginalized stakeholder countries or groups. Lastly, it should facilitate the enhancement of worldwide ocean governance and significantly contribute to global sustainable development.

The well-being of humans is contingent upon the natural resources provided by the biosphere, including marine ecosystems (Brodie Rudolph et al., 2020). The equitable utilization of marine resources and the maintenance of healthy and sustainable marine ecosystems are crucial for the implementation of the United Nations sustainable development agenda and the well-being of all human beings. The results of equity assessments of social policies have significant and far-reaching impact effects on society and the marine environment. In light of these considerations, we propose a blue equity assessment framework that draws on environmental equity theory and related studies, taking into account the externality characteristics of the oceans. This framework is centered on four equity dimensions: distributional, procedural, recognition, and contextual equity. It is designed to assess and measure the fairness of policy behaviors in the use of marine resources. We utilize the interaction effect of blue equity with SDGs as a case study, integrating peer-reviewed articles and logical judgments based on common sense to demonstrate that blue equity has a synergistic positive effect on the vast majority of SDGs. The practical feasibility of the blue equity assessment framework is demonstrated through the analysis of the path of action and the mechanism of influence, based on the four dimensions of distribution, procedure, recognition, and contextual equity. The findings of this paper are intended to enhance the comprehension of blue equity in society, particularly in the context of mounting climate change and the Anthropocene. It is hoped that the insights gleaned from this study will inform policymakers on the pivotal role of blue equity in marine resource utilization and conservation, and to facilitate the transformation of global ocean governance. Nevertheless, this paper is subject to certain limitations. The absence of monitoring data

precludes an analysis and research on the scale and intensity of the effect between blue equity and SOSs. SOSs exhibit prominent geospatial characteristics that necessitate substantial physical, chemical, and ecological monitoring data. To identify the key elements and the process changes, and to quantify the impacts of the interaction between blue equity and SOSs, it is necessary to collect and analyze chemical, ecological and monitoring data at different scales (Liu et al., 2007). This can be achieved through the construction of a complex network system model at different scales (Fu et al., 2024). Consequently, future research will concentrate on the analysis of the influence mechanism of blue equity and SOSs, the simulation of complex network system models in different dimensions/regions/scales, and the typical cases of blue equity and the optimization path of ocean governance transformation. This will further enrich the practicality of blue equity.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#), and further inquiries can be directed to the corresponding author/s.

Author contributions

MC: Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. YW: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Data curation. ZX: Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation.

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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.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2024.1403194/full#supplementary-material>

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