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Approaches to Integrated Coastal Management in Brazil in the Light of the Anthropocene

Briana Bombana [I]
Rodrigo Rodrigues de Freitas [II]
Claudia Regina dos Santos [III]

Abstract: This study mapped the literature on Integrated Coastal Management (ICM) approaches in Brazil within the context of the Anthropocene. The bibliographic research used descriptors related to three main areas: 1) Anthropocene; 2) Coastal Management/Governance; and 3) Brazilian Coastal Zones. Eight approaches were identified, with emphasis on risk management and ecosystem-based management. The analysis included both a quantitative review of the approaches and a qualitative analysis, guided by four key characteristics of the Anthropocene: great acceleration, spatial and temporal transcendence, emergent properties, and irreversibility. While the approaches highlight a systemic and cross-sectoral path for ICM, grounded in principles of justice and learning, they reveal limitations in addressing deeper challenges of the Anthropocene. This suggests the need to explore new and less discussed approaches.

Keywords: Anthropocene, great acceleration, integrated coastal management, environmental education, adaptation.

[I] *Grup de Recerca Interfase, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Espanha. Núcleo Transdisciplinar de Meio Ambiente e Desenvolvimento (NMD), Universidade Federal de Santa Catarina, Florianópolis, SC, Brasil.*

[II] *Programa de Pós-Graduação em Educação, PPGE/UNISUL, Tubarão, SC, Brasil.*

[III] *Programa de Pós-Graduação em Educação, PPGE/UNISUL, Tubarão, SC, Brasil.*

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Introduction

At the turn of this century, the concept of Anthropocene was proposed as our current geological epoch (CRUTZEN; STOERMER, 2000). Proceeding from the Holocene, it is distinguished by the fact that the human species has become the primary source of permanent changes in all planetary compartments, e.g. the atmosphere. These, in turn, result in critical global conditions, such as hostile climate and weather, which have increasingly threatened the conditions and systems that support life worldwide without giving them the essential time to adapt (STEFFEN *et al.*, 2018).

Originating from the Earth System sciences, the Anthropocene Working Group (AWG) was established in 2009 to propose the term as an official subunit of geochronology (LORIMER, 2017). Although it recently voted against including the Anthropocene as a geological epoch, the debate highlights the evidence of human impact on the planet, characterizing it as "our era and condition" rather than an environmental crisis that can be solved only by ecological awareness and scientific measures (BONNEUIL; FRESSOZ, 2016).

When adopting this concept as a framework for research, it is important to highlight that accelerated planetary trends transcend scales of time and space, constantly interacting in socio-ecological dynamics that exhibit emergent properties from these interactions in the Earth System. Thus, nonlinear changes and increasing feedback should be expected in our interconnection with the system at all levels (VIEIRA; FLORÊNCIO, 2022). The proposition of the Anthropocene, in particular, reinforces the impossibility of separating nature and culture (BOURG, 2020). This idea has expanded to other disciplines and spheres of society, shaping the contemporary debate about its causes, consequences, and political implications (LORIMER, 2017).

Coastal zones, with their biological, sociocultural, and geological diversity, high population density, and vulnerability, are crucial for adaptation to these global changes (GLAVOVIC et al., 2015; HE; SILLIMAN, 2019). Coastal management, which emerged as a public policy a few decades ago, before the broad discussion of the Anthropocene, follows a cycle of phases: 1. Diagnosis, 2. Planning, 3. Formal adoption, 4. Implementation and 5. Assessment (GESAMP, 1996). Initially focused on local issues, such as waste disposal, it evolved to address broader territorial conflicts, originating the concept of Integrated Coastal Management (ICM) (CICIN-SAIN; KNECHT, 1998). A ICM promotes integration between levels of government, sectors, and scales of space and time, connecting landscapes and ecosystems and aligning short- and long-term goals (PORTMAN *et al.*, 2012).

In Brazil, coastal management emerged from the convergence between awareness of environmental issues and economic demands for exploiting marine resources, such as oil and gas (MORAES, 2007). In the 1970s, this concern began to be incorporated into state planning, initially in a disjointed manner, but gradually integrating economic and environmental needs in the use of coastal and marine spaces (MORAES, 2007). Aligned with international trends, Brazilian coastal management has evolved, despite

facing challenges (GERHARDINGER *et al.*, 2018). The main advances occurred through formalization in laws and decrees at different administrative levels, including the National Coastal Management Plan (1988) and its regulatory decree, as well as the creation of the Coastal Management Integration Group (GIGERCO), which constitutes a permanent inter-institutional forum (GONÇALVES *et al.*, 2021). Ecosystem-based approaches have also recently emerged (NICOLODI *et al.*, 2021), standing out as a territorial management process interrelated with other units, such as watersheds. Currently, integration proposals with Marine Spatial Planning (MSP) have expanded their scope (SCHERER; NICOLODI, 2021).

This territorial policy is supported by a body of research and education that engages with decisions from both public and private spheres, with the main objective of analyzing the interface between coastal ecosystems, humans, and other species (PEREIRA; OLIVEIRA, 2015). It adopts an increasing set of interdisciplinary concepts and tools to do this, incorporating contemporary discussions on global changes. However, this process faces criticism, as in Brazil, classical ICM often subordinates local knowledge to scientific validation, promoting technocratic governance under the pretext of participatory planning (MOURA, 2019). In the Anthropocene scenario, BUSE *et al.* (2018) point out the challenge of dealing with diverse perspectives on this scenario's driving forces and impacts, characterized by the overlap of content, terminological inconsistencies, and marginalization of alternatives.

In this article, we start with ICM as an evolution of traditional coastal management, assuming its greater capacity to face the complex challenges of the Anthropocene. Considering the proliferation of concepts that can support it, we investigated: what are the main characteristics of the concepts that currently influence ICM in Brazil, and how can they support development styles aligned with the Anthropocene? We argue that the current moment requires revitalizing the debate, both politically and in terms of knowledge about the state of coastal areas. To map and analyze the main approaches of ICM in the context of the Anthropocene, we combined strategies for reviewing Brazilian literature. Next, we qualitatively framed these approaches in the context of the Anthropocene and identified the intersections and potentialities arising from socio-ecological perspectives in light of planetary changes.

Methods of Data Collection and Analysis

This study conducted a systematic literature review to identify articles on ICM in Brazil. The review covered publications in Portuguese and English from the SciELO and Scopus databases, from 2000 (the beginning of the debate on the Anthropocene) to August 2022. We use descriptors in three axes: 1) Anthropocene and correlates; 2) Coastal

Management or Governance; and 3) Brazilian Coastal Zones[1]. A total of 257 articles were identified (after removing duplicates), of which 72 were selected for presenting proposals for the ICM, as made available in the Dataverse (BOMBANA, 2024). Recognizing possible bias, our goal was to map the main approaches mobilized. According to Vosgerau & Romanowski (2014), mapping reviews identify indicators that guide more in-depth studies.

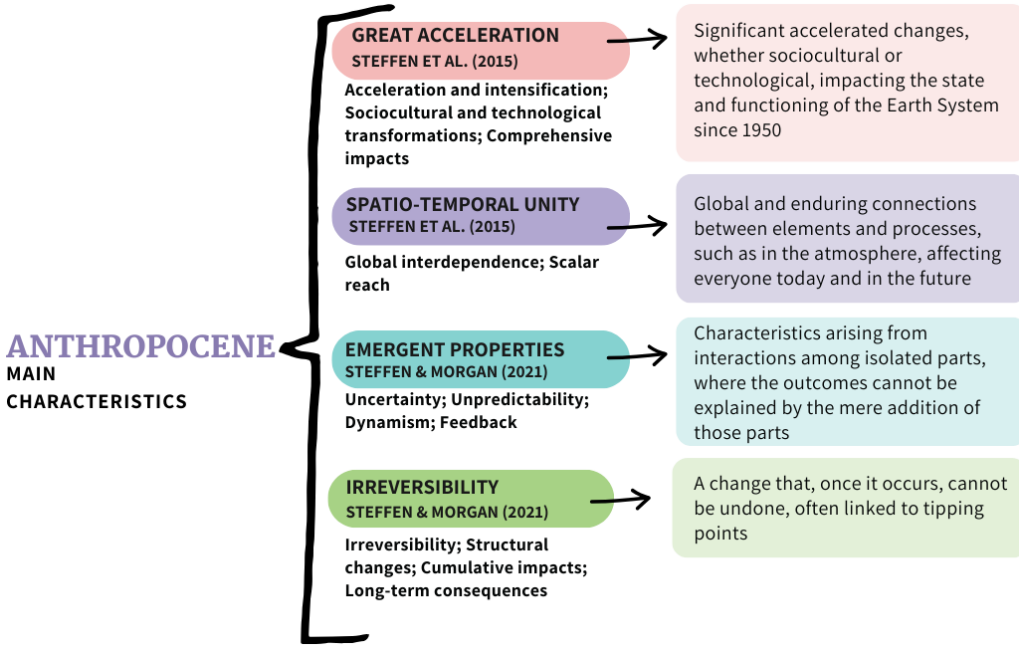
We define an approach as a new or adapted coastal and marine management concept, aiming to meet new guidelines and improve the understanding of problems, often within a broader discipline such as ecology. Inspired by Buse et al. (2018), we selected approaches based on three criteria: i. Traceable academic lineage, including key publications and academic communities; ii. Specific principles or guiding concepts; iii. Articulated strategies with explicit or implicit visions and goals. Additionally, the proposals were restricted to publications from the last 10 years (2012-2022) to ensure timeliness.

After identification, each approach was synthesized and historically contextualized. The synthesis table of the approaches is also available in the Dataverse (BOMBANA, 2024). Subsequently, the approaches were compared with each other and analyzed according to the four characteristics of the Anthropocene (Figure 1), as presented by Bombana, Vieira & Ariza (2022), based on discussions from Earth System sciences (STEFFEN et al., 2015; STEFFEN; MORGAN, 2021). This exercise provided the basis for discussing the potential of approaches to illuminate the ICM in the Anthropocene.

(RODRIGUES DE FREITAS; SIMÃO SEIXAS; SEIXAS, 2020)

1 - The advanced search was conducted by inserting the following query: (TITLE-ABS-KEY ("Anthropocene" OR "Global Change" OR "Great Acceleration" OR "Impact Acceleration" OR "Irreversibility" OR "Irreversible Impacts" OR "Emergence" OR "Emergent Properties" OR "Cumulative Impacts" OR "Climate Emergency" OR "Climate Change" OR "Biodiversity Loss" OR "Sociodiversity Loss")) AND ((TITLE-ABS-KEY ("Coastal Management" OR "Coastal Governance" OR "Coastal Prevention" OR "Coastal Mitigation" OR "Coastal Adaptation")) AND ((TITLE-ABS-KEY) ("Brazil" OR "Brazilian Coast" OR "Brazilian Coastal Zone")) AND (INCLUDE (PUBYEAR, 2000-2022)).

Figure 1. Brief description of the four characteristics of the Anthropocene considered



Source: Adapted from Bombana, Vieira & Ariza (2022).

Results and Discussion

ESTABLISHED OR UNDER-DEVELOPMENT APPROACHES APPLIED TO ICM IN BRAZIL

Of the 73 articles analyzed (Table 1), the majority (n=51; 67.1%) were directly or indirectly associated with theoretical approaches discussed in this study, some linked to more than one (in this article, we highlight the main approach). In comparison, 18 articles (23.7%) did not specifically relate to any approach. Furthermore, some articles focused on practical tools like environmental impact assessment and ecosystem services. Although governance has been mentioned, it is seen as a component of ICM, which is distinguished by its integrated management capacity for multiple uses through cooperation and coordination at multiple levels (EHLER, 2003). Therefore, it was not included as an independent theoretical approach.

Table 1. Listing and quantity of the approaches mentioned by the analyzed articles.

Mentioned approaches	N	%
Risk management	22	28.9%
Ecosystem-based management (EBM)	15	19.7%
Co-management and adaptive co-management	4	6.6%
Systematic planning for conservation	3	3.9%
Adaptive management	3	3.9%
Sustainable territorial development	1	1.3%
Spatial and/or environmental justice	1	1.3%
NEXUS+	1	1.3%
Subtotal	51	67.1%
None in particular	18	23.7%
Governance	4	5.3%
No access to the text	3	3.9%
Total General	73	100.0%

Source: Prepared by the authors, 2024.

It is noteworthy that risk management and EBM were addressed more frequently than other identified approaches. In the case of risk management, this may be associated with the inclusion of climate change and related topics in our search for literature. These themes relate to international documents, such as the IPCC reports, due to the importance of adapting to and mitigating climate risks (IPCC, 2023). Regarding the prevalence of EBM, it reflects patterns from the international literature, which influence ICM, especially in the legal field (BOTERO *et al.*, 2023). These authors also emphasize adaptive management as relevant to the ICM debate, although less frequent in our analysis.

Although risk management and EBM are predominant, we decided to present the eight approaches mentioned in the articles chronologically to give visibility to less discussed approaches that can also contribute to ICM.

Risk management: It refers to the management of possible damages or failures that do not depend solely on those involved (OLIMPIO; ZANELLA, 2017). The concept of risk involves social and cultural elements, as it depends on the perception of potentially harmful events (FURTADO, 2012). Risk management uses concepts such as risk, hazard, vulnerability, and disaster, combining statistical analyses and mathematical models with social studies. Although with social origins prior to science, the concept of risk has consolidated in contemporary society, as its tools allow for a more structured and comprehensive approach. Historically, it stood out with the Lisbon earthquake (1755), but gained strength only in the 1930s with "hard" interventions for flood control in the

USA (OLIMPIO; ZANELLA, 2017). Over time, structural measures, such as retaining walls, proved to be insufficient on their own, leading to an expansion of management to include mapping, monitoring, prevention, and reconstruction of affected areas. Currently, the Sendai Framework 2015-2030 recommends a people-centered approach, prioritizing risk understanding, strengthening governance, and investing in risk reduction. Alternatives such as nature-based solutions (proposed by IUCN) offer alternatives to ecologically aggressive interventions, such as using natural vegetation instead of rigid structures to mitigate environmental impacts.

Adaptive management: Strategy that recognizes the complexity and dynamism of socio-ecological systems. Instead of simplifying them, it emphasizes understanding this complexity, while recognizing uncertainties and gaps in knowledge as parts of the process. Proposes a dialogue between scientific observers and decision-makers. Rooted in ecology and systems analysis, it aims for practical applicability for management (HOLLING, 1978), focusing on experiential and experimental learning (WALTERS, 1986). Currently, it is recognized as a structured and interactive learning process consisting of two phases: the deliberative phase, which involves gathering information, defining objectives, evaluating alternatives, and designing monitoring protocols, and the interactive phase, where actions are implemented, monitored, and evaluated. At this stage, monitoring and evaluation are central to identifying new information or changes and adjusting actions, promoting technical and institutional learning about the managed system. Institutional rigidity can limit the application of adaptive management but practices that favor "learning by doing" can increase flexibility in decision-making, considering resource limitations, uncertainties, and political dynamics. It is crucial, however, to avoid insufficiently detailed monitoring protocols, often classified as "adaptive management lite," as this undermines the principles of adaptive management and results in generic or improvised actions, delaying critical decisions (FROHLICH *et al.*, 2018). Frohlich *et al.* (2022) discuss legal barriers to adaptive coastal management and examine erosion at Armação Beach (Florianópolis, SC).

Spatial and/or Environmental Justice: The concept of spatial justice is considered a term in critical geography related to the spatial distribution of factors that promote equality of opportunities, the protection of natural and human resources, and the reduction of vulnerabilities (MILANÉS *et al.*, 2020). Environmental justice, in turn, shapes the set of principles that ensure that no group of people bears a disproportionate share of the degradation of the collective space. This emerged from the social movements in the USA in the 1960s that advocated for the rights of populations discriminated against due to racial issues and communities exposed to toxic contamination risks. Both concepts intersect through the re-signification of the environmental issue in relation to geographic space, in addition to being related to social justice through elements that allow for covering the needs of the population within each territory (HARVEY, 1977). Especially, environmental justice arises from a particular appropriation of the theme of the environment by sociopolitical dynamics classically involved with the construction of social justice. In this sense, it is important to ensure institutional, organizational, political, and economic

mechanisms for less favored territories.

Sustainable territorial development (STD): This concept promotes the mobilization of actors to develop adaptation strategies to external limits, based on collective identification with culture and territory, as well as including reciprocity (PECQUEUR, 2005). Formulated through established debates at the intersection of economics and geography, it is initially linked to the local scale and the endogenous processes of self-organization for the formation of productive systems (VIEIRA; CAZELLA, 2009). Currently, it is preferable to evolve from the concept of local development to territorial development in order not to be constrained by the "localist" dimension. It refers, therefore, to a flexible and adaptable model in which the specificity of the actors and their relationships (e.g., cultural characteristics and modes of organization) contributes to the revelation of innovations and specific resources of each territory that is, at the same time, the "environment" and the result of a process of collective elaboration. Thus, it is not something to be instituted by decree but emerges from the response to the pressures of globalization. The bonds of trust and cooperation established by geographic proximity (but also economic, organizational, and sociocultural) help to mitigate uncertainties of globalization and promote a "plural economy," differentiating territories instead of competing for standardized products (VIEIRA; CAZELLA, 2009). Primarily focused on socioeconomic relations in the rural environment and their spatial balance with the urban environment, this perspective has been incorporating ecological (PECQUEUR; VIEIRA, 2015) and coastal-marine dimensions (DE FREITAS; SEIXAS; SEIXAS, 2020).

Ecosystemic, systemic, or ecosystem-based management (EBM): Interdisciplinary approach that balances ecological, social, and governance principles, adapting to appropriate temporal and spatial scales to promote the sustainable use of resources. Unlike traditional management of "resources", EBM focuses on the "sources" of resources, emphasizing the interdependence of system elements (GRUMBINE, 1994). Although reflections from ecologists on this approach date back to 1930, it was only in 1988 that the first book on EBM emerged, establishing a theoretical framework for the management of parks and wilderness areas with processes aimed at achieving goals (AGEE; JOHNSON, 1988; GRUMBINE, 1994). To this end, it recognizes the interconnection between socio-ecological systems, involving stakeholders interested in a process of integrated and adaptable management, where decisions reflect the choice of society (LONG; CHARLES; STEPHENSON, 2015). In continuous evolution, EBM is based on fifteen key principles (See Dataverse; BOMBANA, 2024), which present as the center the connections between: (1) the structure, functioning, and services of the ecosystem, (2) land and sea, (3) marine habitats, (4) species, (5) various stressors, and (6) knowledge and uncertainties (GUERRY, 2005), as well as the participation of different actors and their values (AGEE; JOHNSON, 1988).

Adaptive Co-management: Co-management or shared management of natural resources (BERKES, 2009; PINKERTON, 1989) refers to the sharing of power and responsibility between resource users and the State (ARMITAGE; BERKES; DOUBLEDAY, 2010). Originating in the social sciences, it focuses on the interactions between users and

public organizations in environmental management. Participatory management documents Local Ecological Knowledge and facilitates its circulation across scales (SEIXAS, 2004). Co-management requires full participation, not superficial forms that legitimize the status quo (ARNSTEIN, 1969). Integrated with adaptive management to deal with the complexity involved in the governance of socio-ecological systems, the concept of Adaptive Co-management emerges (OLSSON *et al.*, 2007), which also emphasizes learning (experiential and experimental) and collaboration (horizontal and vertical) (ARMITAGE *et al.*, 2009). Experiential learning involves monitoring based on users' experiences, and experimental learning involves programmed and tested experiments (WALTERS, 1986). Collaboration involves horizontal institutional relationships (across geographic space) or vertical ones (between organizational levels) (NATIONAL RESEARCH COUNCIL, 2002). Adaptation, knowledge, and socio-ecological resilience are also fundamental (PLUMMER *et al.*, 2012), in addition to innovative institutional arrangements and the integration of science and public policies (ARMITAGE *et al.*, 2009).

Systematic planning for conservation: It emerges as an application of landscape ecology and aims to protect environmental attributes for future generations, ensuring management efficiency and minimizing impacts on the economy (MARGULES; PRESSEY, 2000). This is a process that can be applied on multiple scales. On a broader scale, it can point out important locations for the future planning of Marine Protected Areas (MPAs, including categories provided by SNUC, 2000; BOTTRILL *et al.*, 2012), and on a localized scale, it can focus on the zoning of MPAs (for example, of a UC; FERNANDES *et al.*, 2005). To this end, it requires information about the ecological and social values of the marine area in question, the conservation targets, and their threats. Two phases are recognized in this prioritization process: (1) the identification of areas for conservation that encompasses all targets for conservation at minimum economic cost (WILSON *et al.*, 2006), (2) the use of results from the first analysis and the degree of threat of each area to determine the urgency of actions in each area. The first phase is the most widely used around the world and indicates areas where conservation can be as efficient as possible, while the second (known as scheduling) prioritizes areas with the highest ecological value that are most threatened by conservation (PRESSEY *et al.*, 1996).

NEXUS:+ Since the 1990s, the Water, Energy, and Food (WEF) nexus approach discusses the interdependence of these systems, modeling their interactions (COUTINHO *et al.*, 2020). Simulation models allow for the assessment of the effects of direct and indirect quantitative interaction of the WEF in response to changes in technology and/or demand (HOFF, 2011). The resource nexus considers complex interconnections and connects scientific research to policy formulation and the community of practice. In interaction with these target groups, he identifies and creates awareness of synergies and trade-offs when managing multiple environmental resources (KURIAN; ARDAKANIAN, 2015). This conception arises from an international effort to recognize the limitations of water scarcity, discussed since 2008 at the World Economic Forum (GIATTI *et al.*, 2016). The concept gained prominence at international events, such as Rio+20, and appears in documents from the European Commission, Global Water Partnership, and World Bank (FERRAÇO; MORAES, 2018). Recently, the term "security" has been integrated into

the Nexus approach, expanding the response to climate change and focusing not only on availability but also on equitable access and distribution of resources (COUTINHO *et al.*, 2020).

INTERSECTIONS BETWEEN APPROACHES, THEIR RELATIONSHIP WITH ICM, AND POTENTIAL FOR ACTION IN THE ANTHROPOCENE

The identified approaches present differences in principles, strategies, and scopes (see Dataverse; BOMBANA, 2024). Despite the intersections and mutual influences — such as adaptive management, which is a principle of EBM — their histories and epistemological positions reflect the diversity of contexts, disciplines, and priorities of the scientists and institutions involved, covering various areas such as engineering, ecology, and economics. This diversity can be explained by the need for an interdisciplinary approach to ICM, given the complexity of coastal zones (PEREIRA; OLIVEIRA, 2015). Additionally, there is a strong influence of international documents on national debates, such as risk management, supported by the IPCC (IPCC, 2023), and the EBM, endorsed by COP5. Although valid, international approaches must be contextualized in Brazil, where the absence of local or Latin American perspectives has been observed, such as post/decolonial coastal management (MOURA, 2019). Proposals like this offer relevant critiques to address the sociocultural, historical, and ecological specificities of the country, often ignored in globalized analyses.

At the same time, thinking about the diversity of origins and applications of these approaches reveals a wealth of conceptual foundations that assist in understanding and addressing the complex and irreversible problems of the Anthropocene, applicable to coastal areas. Next, the intersection between these approaches is explored based on the four main characteristics of the Anthropocene (Table 2). Although conceptual and not deeply exploring each approach, this exercise highlights the support that each one can offer to understand the issue. It also suggests a productive dialogue that values the strengths and specific tools of each approach, avoiding the notion that a single one of them is sufficient to comprehensively and effectively deal with ICM in the face of current challenges.

Table 2. Intersection between ICM approaches in Brazil in the context of the Anthropocene and its influence on ICM

Great acceleration		Characteristics of the Anthropocene			
		Great acceleration	**Spatio-temporal unit**	**Emergent properties**	**Irreversibility**
Influence on ICM		Questions the causes of transformations and highlights the urgency of sociocultural, economic, and technological actions, which breaks with the linearity of ICM and suggests "learning by doing," oriented towards implementation with system feedback.	Frames coastal issues as part of historical and global processes, even when observed routinely and locally, highlighting their trajectory of irreversible changes, non-linearity, and cumulative impacts.	They question the belief that more scientific efforts can fully clarify coastal systems, highlighting that uncertainties persist at all stages of the ICM, from problem identification to policy formulation and monitoring (WARDEKKER *et al*., 2008).	Highlights the occurrence of profound changes in coastal areas, underscoring the need to anticipate negative impacts whenever possible and, above all, to learn to live with these impacts.
Approaches	**Risk management**	Fosters the capabilities for prevention, risk reduction, and response to the comprehensive impacts of accelerated changes.	Assume that we live in the "risk society" (BECK, 1992) which calls for a multi-scalar understanding of the causes and interrelations that lead to the possibility of harm.	Seeks to identify uncertainties and potential feedback to increase risk management capacity.	Draw routes and maps to reduce irreversible damage, as well as to increase recovery capacity when they occur.
	Adaptive management	Quick and effective responses, applying agility and coordination in the face of acceleration.	Vertical and horizontal collaboration improves coordination, and the response to feedback and changes.	Flexible responses to challenges, continuously adjusting to changes and uncertainties.	Facilitates adaptation to mitigate structural changes and long-term impacts.
	Spatial and/or environmental justice	Mitigates inequalities exacerbated by rapid changes, addressing impacts more effectively.	Facilitates territorial management at different scales, adapting strategies to the needs of less favored areas.	Fair access to resources and decisions aids in responding to the unpredictability and feedback of transformations.	Uses institutional and political mechanisms to implement policies that promote resilience in less favored areas.
	Sustainable territorial development	Autonomous alternative to global socioeconomic transformations with reduced contribution to acceleration.	Incorporates the notion of the globalized world, offering collective responses adapted to local realities.	It enhances a network of cooperation that has a greater capacity to face uncertainties and feedback.	This same network of cooperation acts to adapt to structural changes.
	EBM	The systemic approach addresses stressors and allows for managing rapid transformations in a multidimensional way.	The focus on the "sources" of resources highlights the interdependence of the system and promotes a multi-scalar and participatory approach.	Promotes resilience and adaptation by integrating elements and processes of the system with multi-level participation.	Focusing on the appropriate connections and scales of ecosystems improves the ability to deal with structural changes and impacts.
	Adaptive co-management	Focus on the application of learning through dialogue between different knowledge in response to changes in socio-ecological systems.	Choice of the socio-ecological system based on management criteria and creation of baselines for participatory monitoring.	Emphasizes the quick response to changes through a governance architecture focused on collaboration across levels.	Focuses on answers based on the learning generated by monitoring previously agreed-upon parameters of the socio-ecological system.
	Systematic planning for conservation	The planning of priority areas for biodiversity conservation increases socio-ecological resilience.	It can be applied from AMP (local) to a national level, ensuring the representation of all forms of biodiversity.	The redundancy of areas with similar structure and function ensures resilience in planning.	The planning must include a set of preventive actions aimed at avoiding or mitigating the identified threats.
	NEXUS+	The nexus of water, energy, and food analyzes the interactions between these sectors, assessing their direct and indirect effects in the face of changes or demands.	It considers complex interconnections and connects scientific research to policy formulation and the community of practice.	Fosters awareness of synergies and trade-offs when managing multiple environmental resources.	It requires the integration of the impacts of water, energy, and food use, offering alternatives to mitigate irreversible effects among these sectors.

Source: Prepared by the authors, 2024.

We start from the idea that the Anthropocene is characterized, above all, by accelerated transformations of a sociocultural and technological nature, resulting in profound impacts on the life support systems. Most of the approaches analyzed provide a basis for understanding and responding to these changes or their impacts, focusing on different issues and mechanisms according to the emphasis of each one. Risk management, for example, deals with probability calculations, risk mapping, identification of vulnerabilities, and prevention, mitigation, and response actions. Despite the particularities of each approach, we believe it is possible to outline a general direction that aims to provide a systemic understanding of the transformations to think about responses collectively and intersectorally, with a multi-scalar vision, open to learning from feedback and guided by principles such as justice and autonomy.

However, these approaches seem not to address the underlying causes of acceleration, linked to the current socioeconomic system (STEFFEN *et al.* 2015). Some timid advances are observed. For example, the DTS proposes economic alternatives adjusted to territorial limitations, offering a more organic approach to addressing the structural causes of transformations in the Anthropocene. Although the main role of the ICM is not to criticize the socioeconomic system, it is crucial that it is open to these reflections and actions, something that could be further explored through approaches that have not yet been discussed.

Haskell *et al.* (2021) argue that, to face the Anthropocene, it is necessary to change harmful social practices, highlighting the importance of the conceptual dimension. To exemplify this point, they highlight that the term "resource," often used in approaches to sustainability (such as EBM), reveals an ideological burden of an economic view that categorizes and limits options (HASKELL; BONNEDAHL; STÅL, 2021). Furthermore, we question whether ICM's limitation in considering critical approaches is linked to its emphasis on "control" of transformations, which makes it difficult to include alternatives outside this framework (ISON; ALEXANDRA; WALLIS, 2018). Going further, Taddei, Shiratori & Bulamah (2022) argue that the Anthropocene requires rejecting the domestication of reality by limiting concepts, destabilizing conventional schemes, fostering transformative alliances between humans and other beings, and adopting decolonial and pragmatic perspectives.

Additional challenges arise from the spatial and temporal interconnection of the Anthropocene. Transformations from the past or from other regions affect our surroundings, revealing an interconnected world in time and space. Some approaches already propose a management that dialogues between different geographical scales, with a historical perspective and a medium to long-term view. Adaptive co-management, for example, emphasizes the importance of inter-level relationships, both horizontal and vertical (NATIONAL RESEARCH COUNCIL, 2002). However, these approaches still operate within the current management structures, which face limitations in dealing with interconnection. An example is the focus of this article on coastal management in the context of Brazil and its legal frameworks. Franchini, Viola & Barros-Platiau (2017) emphasize that the main obstacle to governance in the Anthropocene is the global

mechanisms based on institutions created in recent decades (for example, agreements and understandings between nation-states), which do not reflect the deep interdependence among societies. Overcoming this limitation would require profound changes in behavior, both individual and institutional.

On the other hand, it is from the perspective of the human scale (of time and space) that decisions and actions taken will influence such global processes, for which initiatives aimed at maintaining and promoting ecological integrity such as EBM and establishing areas for conservation like Systematic Conservation Planning are relevant, and are usually associated with mitigating impacts. Furthermore, given the current landscape, in the latest IPCC report (2023), mitigation is integrated with adaptation, which is no longer a topic for future research and is elevated to the center of recommendations. This adaptation often manifests as risk assessment and management; however, even with recent developments to integrate community participation, it can still present a technocratic character, focusing on targeted and standardized approaches (e.g. MARÍN-PUIG; ARIZA; CASELLAS, 2022).

Thus, we must evolve to treat management as systems of continuous experiments, where learning communities (ARMITAGE *et al.*, 2009) monitor policies and actions (WALTERS, 1986). These communities, of learning or practice (WENGER, 1998), encompass broader notions of facts and data, allowing for a collective response to uncertainties. This leads us to consider the emerging properties of the Anthropocene, which emphasize uncertainties, unpredictability, and feedback in coastal systems. The approaches analyzed recognize these complexities, for example, with adaptive management and EBM dealing with uncertainties. An ICM, as a policy, should be seen as a hypothesis in the face of these uncertainties (WALTERS, 1986), which refer to deviations from the ideal of complete deterministic knowledge (WALKER *et al.*, 2003).

When addressing socio-environmental issues at the interface between science and politics, technical, methodological, ontological, and epistemological uncertainties stand out (FUNTOWICZ; RAVETZ, 1993). The first refer to the limitations of calculations and methods; the ontological refer to what we do not know that we do not know, due to the dynamism of systems; and the epistemological refer to our limited ability to perceive systems due to personal interests and values. Recognizing these uncertainties does not guarantee their reduction, especially the ontological ones, which may require decisions before conclusive evidence. Therefore, it is essential to conceive and communicate these uncertainties effectively.

The studied approaches reveal a widespread perception of the need for involvement of learning communities, although at varying levels. Risk management, for example, proposes flexible participation to enhance the understanding of risk and management alternatives. Spatial justice advocates for the participation of underprivileged communities, while Systematic Planning for Conservation uses technical bases to stimulate debate regarding zoning scenarios, relevant for ICM and MSP instruments. At advanced levels, co-management seeks full participation through the sharing of power and responsibility, and the DTS promotes collective self-organization, based on cultures and territories, to

form productive systems and relationships of reciprocity. The autonomy and empowerment associated with greater involvement show potential to increase adaptation and response in the Anthropocene (VIEIRA; FLORÊNCIO, 2022).

Finally, the potential irreversibility of the impacts of the Anthropocene highlights the emergence of new conditions in coastal areas, marked by more severe and indiscriminately distributed degradations, although they affect vulnerable populations more intensely. From a critical perspective, ICM must stop viewing these problems as future issues, recognizing them as challenges that are already present, for which it will not always be possible to find solutions within the current management structures, pointing out limitations in the very idea of 'management' itself — it is not a crisis, but a new condition (VIEIRA; FLORÊNCIO, 2022). In Brazil, evidence such as the extinction of aquatic species illustrates the irreversible loss of environmental quality and life in coastal areas (MARQUES, 2015). Recognizing this irreversibility not only allows for new approaches to the present and the future but also provokes a deep reflection on how to act and intervene in these regions.

Conclusions

The approaches analyzed offer remarkable perspectives for ICM in the Anthropocene, although with biases linked to distinct disciplines and historical and geographical contexts. The predominance of risk management and EBM stands out, influenced by international trends, especially regarding climate change.

In general, the set of approaches seeks a systemic understanding of the transformations in ICM in the Anthropocene, promoting collective and intersectoral responses, with a multi-scalar vision, open to feedback and guided by justice and autonomy. In light of the characteristics of the Anthropocene, the need for a ICM focused on implementation becomes evident, considering that some urgent decisions need to be made before a complete analysis of the causes. Also, a broader understanding of uncertainties is necessary, the types of which were mentioned to highlight our limitations in predicting and acting in this context. To this end, learning communities in management systems serve to frame problems and solutions collectively, with a broader view of facts, data, and values.

At the same time, there was a lack of national or regional approaches. This finding, in dialogue with the debate on the concept of Anthropocene, highlighted the urgency of transcending traditional approaches. This would involve questioning dominant paradigms, such as through encouraging collaborations between humans and other beings, integrating critical and practical approaches, with the aim of promoting a necessary reconfiguration to address the complexities of the Anthropocene in a more inclusive and interconnected way.

Thus, it is pertinent to think of a ICM that not only mitigates human impacts in the Anthropocene but also seeks ways to adapt and coexist with coastal areas in this "new condition." To this end, it is essential to rethink conceptual and practical analysis, considering that the multidimensional challenges of the Anthropocene are complex and,

in some cases, have not yet been incorporated by the approaches used by ICM in Brazil (such as the underlying causes of acceleration), suggesting the need to explore paths that have been little or not at all traversed so far.

Finally, the selection of keywords and the focus on the SciELO and Scopus databases may have excluded relevant studies. Filtering by abstracts and the qualitative analysis of only eight approaches may have introduced biases, not reflecting the diversity of perspectives on ICM in Brazil in the context of the Anthropocene. Future studies could deepen the analysis of each approach or broaden the review to include other terminologies, aiming for a more holistic understanding of the debates in ICM. It would also be valuable to investigate the practical application of these approaches through case studies, providing concrete examples of how ICM adapts to the demands of the Anthropocene and identifying areas for improvement.

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Briana Bombana

✉ brianaab@gmail.com

ORCiD: https://orcid.org/0000-0002-6044-3116

Rodrigo Rodrigues de Freitas

✉ rodrigo.manejo@gmail.com

ORCiD: https://orcid.org/0000-0002-7051-1610

Claudia Regina dos Santos

✉ biolsantos@gmail.com

ORCiD: https://orcid.org/0000-0002-2852-1268

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Abordagens Da Gestão Costeira Integrada No Brasil À Luz Do Antropoceno

Briana Bombana
Rodrigo Rodrigues de Freitas
Claudia Regina dos Santos

Resumo: Este estudo mapeou a literatura sobre as abordagens da Gestão Costeira Integrada (GCI) no Brasil no contexto do Antropoceno. A pesquisa bibliográfica utilizou descritores relacionados a três eixos: 1) Antropoceno; 2) Gestão/Governança Costeira; e 3) Zonas Costeiras Brasileiras. Foram identificadas oito abordagens, com destaque para a gestão de riscos e a gestão de base ecossistêmica. A análise incluiu tanto uma revisão quantitativa das abordagens quanto uma análise qualitativa, guiada por quatro características do Antropoceno: grande aceleração, transcendência espacial e temporal, propriedades emergentes e irreversibilidade. Embora as abordagens revelem um caminho sistêmico e intersetorial para a GCI, com princípios de justiça e aprendizado, elas demonstram limitações para enfrentar desafios mais profundos do Antropoceno. Isso sugere a necessidade de explorar novas abordagens ainda pouco discutidas.

Palavras-chave: Antropoceno, grande aceleração, gestão costeira integrada, educação ambiental, adaptação.

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SciELO

Abordajes De La Gestión Costera Integrada En Brasil A La Luz Del Antropoceno

Briana Bombana
Rodrigo Rodrigues de Freitas
Claudia Regina dos Santos

Resumen: Este estudio mapeó la literatura sobre los enfoques de la Gestión Costera Integrada (GCI) en Brasil en el contexto del Antropoceno. La investigación bibliográfica utilizó descriptores relacionados con tres ejes principales: 1) Antropoceno; 2) Gestión/Gobernanza Costera; y 3) Zonas Costeras Brasileñas. Se identificaron ocho enfoques, destacándose la gestión de riesgos y la gestión basada en ecosistemas. El análisis incluyó tanto una revisión cuantitativa de los enfoques como un análisis cualitativo, guiado por cuatro características clave del Antropoceno: gran aceleración, trascendencia espacial y temporal, propiedades emergentes e irreversibilidad. Aunque los enfoques revelan un camino sistémico e intersectorial para la GCI, con principios de justicia y aprendizaje, demuestran limitaciones para enfrentar los desafíos más profundos del Antropoceno. Esto sugiere la necesidad de explorar nuevos enfoques aún poco discutidos.

Palabras-clave: Antropoceno, gran aceleración, manejo costero integrado, educación ambiental, adaptación.

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