Mercator, Fortaleza, v. 23, e23030, 2024. ISSN:1984-2201

BRAZIL'S PROGRESS IN IMPLEMENTING COASTAL AND MARINE PROTECTED AREAS WITH A FOCUS ON AICHI TARGET 11

https://doi.org/10.4215/rm2024.e23030

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Article history:
Received 05 March, 2024
Accepted 19 September, 2024
Published 10 December, 2024

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Abstract

The rapid global loss of biodiversity has promoted initiatives to develop a global network of Protected Areas (PAs), with the Aichi targets suggesting that countries protect at least 17% of continental areas and 10% of marine and coastal areas. For Brazil, there is a knowledge gap regarding the evaluation of qualitative and quantitative objectives through practical indicators of goal achievement and effective management. This study holistically addresses the conservation status of Brazil concerning Aichi Target 11 for marine and coastal ecosystems, using systematic literature review and marine spatial coverage analysis. The results show an increase to 26% of marine spatial coverage, with greater coverage by Environmental Protection Areas. There is a predominance of studies on "Management Effectiveness," with less focus on equitable management and integration between terrestrial and marine landscapes. Indicators primarily focus on "Ecological" and "Governance" dimensions, neglecting "Social" and "Economic" dimensions. Key challenges include the need for increased financial investment, connectivity between protected areas with different social and ecological contexts, and local community involvement in equitable management. Additionally, there is a need for increased coverage of integral protection areas and standardization of qualitative assessments.

Keywords: Protected areas; Management effectiveness; Aichi Target 11; Conservation policy; Coastal and marine systems.

Resumo / Resumen

PROGRESSO DO BRASIL NA IMPLEMENTAÇÃO DE ÁREAS COSTEIRAS E MARINHAS PROTEGIDAS COM FOCO NA META 11 DE AICHI

A rápida perda global de biodiversidade promoveu iniciativas para desenvolver uma rede global de Áreas Protegidas (APs), com as metas de Aichi sugerindo que os países protejam pelo menos 17% das áreas continentais e 10% das áreas marinhas e costeiras. Para o Brasil, há uma lacuna de conhecimento sobre a avaliação dos objetivos quali-quantitativos por meio de indicadores práticos de atingimento de metas e gestão eficaz. Este estudo aborda holisticamente a situação da conservação do Brasil em relação à Meta 11 de Aichi para ecossistemas marinhos e costeiros, usando revisão sistemática de literatura e análise de cobertura espacial marinha. Os resultados mostram um aumento para 26% de cobertura espacial marinha, com maior cobertura por Áreas de Proteção Ambiental. Destaca-se predomínio de estudos sobre "Eficácia de Gestão", com menos foco na gestão equitativa e integração entre paisagens terrestres e marinhas. Os indicadores concentram-se principalmente nas dimensões "Ecológica" e de "Governança", negligenciando as dimensões "Sociais" e "Econômicas". Os principais desafios incluem a necessidade de mais investimento financeiro, formar uma rede conectada entre áreas protegidas em diferentes contextos sociais e ecológicos, e envolvimento da comunidade local na gestão equitativa. Além de aumento de áreas de proteção integral e a padronização das avaliações qualitativas.

Palavras-chave: Áreas Protegidas; Eficácia de Gestão; Política de Conservação, Sistemas Costeiros e Marinhos.

PROGRESO DE BRASIL EN LA IMPLEMENTACIÓN DE ÁREAS MARINAS Y COSTERAS PROTEGIDAS CON ENFOQUE EN LA META 11 DE AICHI

La rápida pérdida global de biodiversidad ha promovido iniciativas para desarrollar una red global de Áreas Protegidas (AP), y las metas de Aichi sugieren que los países protejan al menos el 17% de las áreas continentales y el 10% de las áreas marinas y costeras. Para Brasil, existe un vacío de conocimiento sobre la evaluación de objetivos cualitativos y cuantitativos a través de indicadores prácticos de logro de metas y gestión efectiva. Este estudio aborda de manera integral el estado de conservación de Brasil en relación con la Meta 11 de Aichi para los ecosistemas marinos y costeros, utilizando una revisión sistemática de la literatura y un análisis de la cobertura espacial marina. Los resultados muestran un aumento al 26% de la cobertura espacial marina, con mayor cobertura por Áreas de Protección Ambiental. Destaca el predominio de estudios sobre “Efectividad de la Gestión”, con menos foco en la gestión equitativa y la integración entre paisajes terrestres y marinos. Los indicadores se centran principalmente en las dimensiones "Ecológica" y "Gobernanza", dejando de lado las dimensiones "Social" y "Económica". Los desafíos clave incluyen la necesidad de una mayor inversión financiera, la formación de una red conectada entre áreas protegidas en diferentes contextos sociales y ecológicos y la participación de las comunidades locales en una gestión equitativa. Además de incrementar las áreas de protección integral y estandarizar las evaluaciones cualitativas.

Palabras-clave: Áreas Protegidas; Eficacia de la Gestión; Meta 11 de Aichi; Política de Conservación; Sistemas Costeros Y Marinos.

INTRODUCTION

Coastal and marine ecosystems are vital to the livelihoods of hundreds of millions of people worldwide, offering economically valuable resources (MARTINEZ, 2007) and ecosystem services (BARBIER, 2017). However, growing anthropogenic threats to biodiversity lead to widespread loss or degradation (BARBIER, 2017), driving the need for an expansion of the global network of protected areas (LOCKE, 2014). This situation led 194 countries, including Brazil, to adopt significant international agreements, such as the commitments under the Convention on Biological Diversity (CBD) in 1992. In 2010 new agreements included the Aichi Targets, which are key for the execution of the United Nations Strategic Plan for Biodiversity 2011-2020 (CBD, 2011).

The Aichi Targets include 20 goals, organized into five long-term strategic objectives, which are closely related to coastal and marine ecosystems. Strategic objective ‘C’ aims to improve the state of biodiversity by protecting ecosystems, species, and genetic diversity. This is where Aichi Target 11 (T11) is situated, which forms the basis of this study. Aichi T11 states that by 2020, the signatory countries should have safeguarded at least 17% of terrestrial ecosystems and 10% of a representative portion of marine and coastal ecosystems through protected areas (PAs).

In addition to the creation of PAs, the qualitative objectives focus on protecting environments that are significant for biodiversity and ecosystem services. Therefore, PAs must demonstrate strong ecological representativeness, be well-connected, and ensure effective and equitable management. They should also adopt other effective conservation measures based on areas integrated into broader marine landscapes (CBD, 2011). In this context, T11 highlights both the need to increase the quantity and spatial coverage of PAs and to improve the effectiveness of conservation within these areas.

In Brazil, the main PAs defined by law are known as Conservation Units (CUs – Unidades de Conservação, in Portuguese). The expansion of these areas in marine ecosystems was initially slow until the mid-2000s. Since then, there has been a rapid and continuous increase in the designation of new CUs (SILVA, 2019), which has encouraged studies evaluating the percentage of coverage by legally protected areas. These studies have been conducted at broader levels, such as the extent of Brazilian territory (PACHECO; NEVES; FERNANDES, 2018), and at more specific levels, like assessments of coverage in specific biomes (TEIXEIRA et al., 2021) and in Brazilian states (SOUSA; SERAFINI, 2018; GOMES et al., 2022).

More recently, Oliveira, Novoa, and Salvio (2023) noted that the contribution of Brazilian terrestrial and marine CU coverage exceeded the targets set by Aichi T11 (17% and 10%, respectively). However, they pointed out weaknesses in the qualitative aspects, which had also been identified as deficient by Pacheco, Neves, and Fernandes (2018), indicating that less progress had been made in these areas.

Addressing this knowledge gap is important because, despite the expansion of legally protected areas, some ecosystems have experienced a decline in biodiversity. This raises concerns about the notion that merely creating new PAs and increasing spatial coverage is sufficient for local protection and the long-term maintenance of regional biodiversity (PITTOCK et al., 2015).

The decline in biodiversity within PAs may be linked to the choice of management category. The study by Françoso et al. (2015) showed that CUs under the category ‘Environmental Protection Area’ (“Área de Proteção Ambiental” or APA) exhibited similar levels of deforestation both inside and around their boundaries, suggesting that this category did not prevent vegetation loss, unlike fully protected CUs. Since APA is the least restrictive category under Brazilian law, Brazil faces a concerning situation, as studies indicate that a larger portion of the coverage is made up of APAs for both terrestrial ecosystems (e.g. TEIXEIRA et al., 2021; GOMES et al., 2022) and coastal and marine ecosystems (SCHIAVETTI et al., 2013; PACHECO, NEVES, and FERNANDES, 2018), compromising conservation goals.

Additionally, uncertainties about the effectiveness of conservation in these areas arise from the interdependence between biological, social, and management processes in protected areas. In this context, Meehan et al. (2020) identified the need to holistically integrate the quantitative and qualitative aspects of T11. They compiled 223 variables, organized into 48 indicators, taking into account the social, ecological, economic, and governance dimensions to evaluate the effectiveness of PAs.

Studies on the effectiveness of CUs and on Brazil's progress in recent years regarding Aichi T11 fail to connect the conceptual principles of the qualitative elements with the quantitative objectives of T11 (MARQUES; ALMEIDA; MEDEIROS, 2016; OLIVEIRA JÚNIOR et al., 2016; PACHECO; NEVES; FERNANDES, 2018; MARETTI et al., 2019; SILVA, 2019; VILAR et al., 2020), despite the importance of combining these two aspects.

Thus, adopting a holistic approach in pursuit of an integrated evaluation of Brazil's progress, even after the expiration of the CBD strategic plan in 2020, is critical. This is because newly established agreements, such as the Sustainable Development Goals (SDGs), continue to stress the need to meet these targets due to the shortcomings in implementing T11 in various countries.

This study analyzes for the first time the progress, limitations and current state of conservation in Brazil within the context of Aichi Target 11 before Aich targets and between the years 2010 and 2020. We evaluate the advances in the designation of new areas covered by CUs in coastal and marine ecosystems – here referred to as MPAs – as well as the qualitative dimensions of the approach. To address the quantitative aspect, we mapped the distribution of CUs in these ecosystems, while for the qualitative evaluation, we conducted a systematic literature review, applying indicators and evaluation elements for CUs in a standardized and systematic manner.

METHODOLOGY

QUANTITATIVE DATA

To understand Brazil's progress in meeting the Aichi quantitative target of protecting at least 10% of marine and coastal ecosystems, and to support the discussions related to the qualitative objectives, we mapped the geographical coverage of CUs, along with the historical evolution and spatial distribution of their creation. Although protected areas are designated in Brazilian legislation for various purposes (such as indigenous and “quilombola” lands, archaeological sites, geoparks, etc.), for the purposes of this study, we focus solely on Conservation Units (CUs) governed by the National System of Conservation Units (“Sistema Nacional de Unidades de Conservação da Natureza” or SNUC), law 9.985/2000 (BRASIL, 2000).

To better estimate coverage by management and governance categories, we divided the 12 categories into three groups. The first group consisted of the Integral Protection (IP) categories, which impose stricter land-use restrictions, allowing only indirect activities such as ecotourism and observation, among others. The Sustainable Use (SU) categories, where varying levels of human interference are permitted (BRASIL, 2000), were further divided into two groups: one that included all categories except APA, and a third group consisting solely of the APA category. Since APA has the lowest level of protection under SNUC, it was evaluated separately.

We used the shapefile of Conservation Units officially registered in the National Registry of Conservation Units (“Cadastro Nacional de Unidades de Conservação” or CNUC) (CNUC, 2023), along with files containing Brazil’s Political Boundaries (IBGE, 2022), the Coastal-Marine System (CMS) (IBGE, 2019), and Brazil's maritime boundaries (MARINHA DO BRASIL, 2008) to create a spatial cartographic overlay. Other CUs registered in the CNUC Official Panel that were not included in the primary shapefile had their data, also in shapefile format, retrieved and downloaded individually from other data platforms.

The CMS shapefile was used as the basis for delimiting the coastal region, and the oceanic boundaries were defined by the line marking 200 nautical miles from the baseline. Oceanic islands were also included for coverage analysis purposes. The data were processed using Quantum GIS TM software, version 3.16.9 (QGIS DEVELOPMENT TEAM, 2021). A summary of the processing procedures is shown in Figure 1. Since the study area spans more than one UTM zone, we used the Albers Equal Area Conic Projection to minimize distortions in area calculations, creating a custom Coordinate Reference System (SRC) in QGIS (IBGE, 2023).

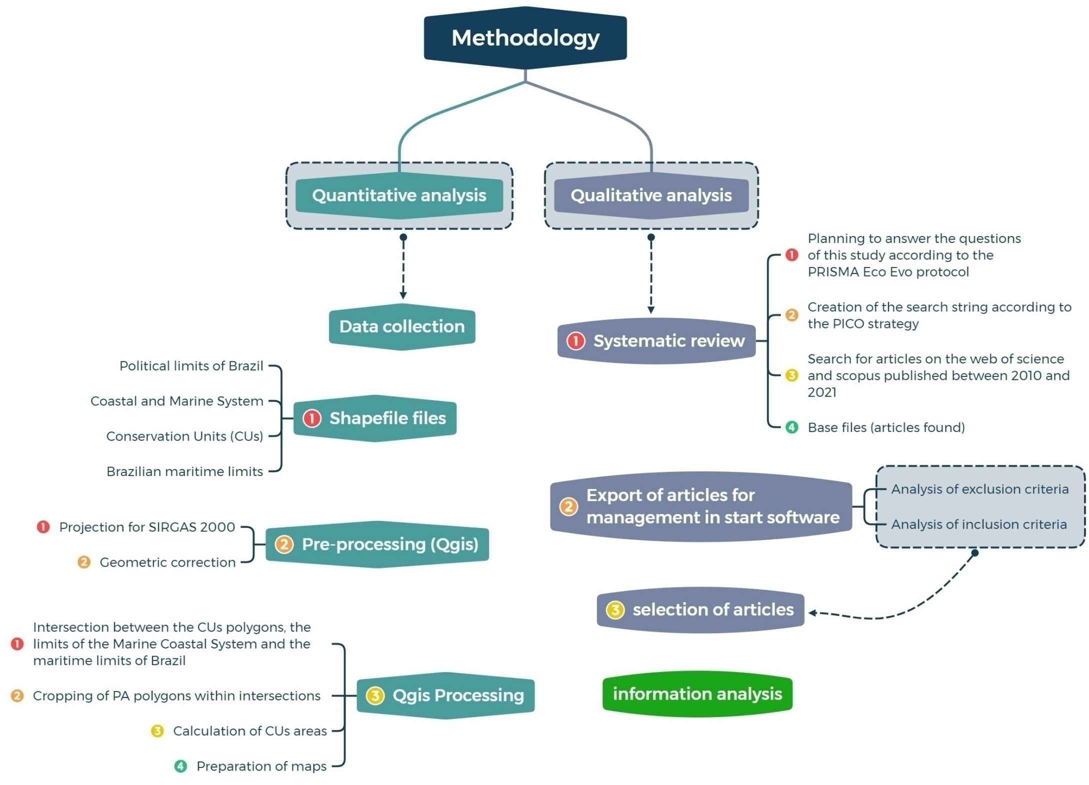

Figure 1 – Flowchart of the methodological stages. Source: Prepared by the authors (2024)

QUALITATIVE DATA

We conducted a systematic literature review to identify the indicators used to evaluate the effectiveness of Brazil's coastal and marine CUs, as well as the progress in conservation between 2010 and 2020, focusing on the qualitative goals of Aichi T11. A summary of these stages is provided in Figure 1. We searched for peer-reviewed academic publications in the Web of Science and Elsevier's Scopus databases. Additionally, we employed the 'citation tracking' method to find references to articles cited in the compiled publications but not available in the databases. All compiled articles, including those retrieved from bibliographic databases and through citation tracking, were included in our systematic analysis.

The approach for addressing the research questions in this study follow the PRISMA – Eco Evo protocol, an adaptation of the PRISMA Protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) tailored for systematic reviews in ecology and evolution (O'DEA et al., 2021). Guided by an initial research question framed by the PICO process, this tool enables authors to provide a detailed account of the literature search process, study selection criteria, data extraction, and analysis methods, allowing readers to assess the validity and reliability of the results presented (FOO et al., 2021).

The PICO mnemonic outlines the key elements to consider when formulating the research question, simplifying the process of searching for and selecting relevant studies during the review. It also ensures the research remains focused on the four main components: "Population" (P): Refers to the group being studied or the condition under investigation; "Intervention" (I): Refers to the variables being examined; "Comparison/Control" (C): Represents the comparison between different interventions; and "Outcome" (O): Refers to the expected results or outcomes (O'DEA et al., 2021; FOO et al., 2021). In our study, we defined these key elements as shown in Chart 1.

Framework Definition	Key Elements
P	Conservation Units that allow for the evaluation of compliance with Aichi Target 11 for Brazil's coastal and marine systems.
I	Assessment of the indicators for the geographical expansion of marine and coastal Conservation Units and all variables related to the effectiveness of CUs management based on these indicators.
C	There are no comparators, as this is not a clinical study comparing experimental and control groups.
O	Expansion of the national network of CUs, achieving Aichi Target 11, and the effectiveness in CU management.

Chart 1 - Definition of the study's key elements according to the PICO framework.

Based on the PICO framework, we selected the study's keywords and constructed specific search strings for each database. The search string included the terms: "Brazil" AND "Aichi target 11" OR "qualitative elements of Aichi Target 11" OR "quantitative elements of Aichi Target 11" OR "Convention on biological diversity" OR "CBD" OR "Global conservation" AND "marine and coastal protected areas" OR "marine and coastal conservation units" AND "Connectivity" OR "governance" OR "effectiveness conservation" OR "Spatial conservation prioritization" OR "Analysis of Progress".

We used the selected combinations of descriptors and their synonyms to expand the article search. The search was conducted in December 2021, applying a date filter to include articles published between 2010 and 2021. All articles retrieved were exported in BIBITEX format to the StArt (State of the Art Through Systematic Review) software (HERNANDES et al., 2012), where we managed and selected them according to the eligibility criteria.

We selected the articles by analyzing their titles, keywords, and abstracts to determine whether the study's approach aligned with our inclusion criteria —specifically, studies presenting quantitative and/or qualitative approaches and/or reviews that, in some way, reflected Brazil's progress on the research topic between 2010 and 2020. For broader studies covering multiple ecosystems, we extracted data relevant to coastal and marine ecosystems. Articles that did not meet these criteria were excluded from the analysis. After completing this process, we interpreted and synthesized the findings.

We conducted a full evaluation of the eligible articles and identified one or more qualitative indicators representative of Aichi T11 targets in each publication through various variables. The flowchart detailing the article selection process is presented in Figure 2.

Eligible articles may present one or more indicators for a single qualitative element or multiple qualitative elements. A description of the qualitative elements is available in Chart 2. We used the same definitions of qualitative elements compiled by Meehan et al. (2020), as well as the same elements and indicators employed by these authors to guide the data interpretation in this study.

The qualitative elements are identified from a variable and may fall into one or more dimensions of analysis. Meehan et al. (2020) relied on the definitions by Pomeroy, Parks, and Watson (2004) and O'Dea et al. (2021), where a "Variable" represents an observed characteristic, factor, or condition that can be quantified and responds to local changes, such as the implementation of a management action (PELLETIER et al., 2005). An "Indicator" is defined as one or more qualitative or quantitative variables (social, environmental, etc.) used to measure the status or changes in characteristics of particular interest in an ecosystem over time. "Dimension" refers to the ecological, economic, governance, and social factors whose management actions may influence or be influenced by socioecological systems (POMEROY; PARKS; WATSON, 2004).

Among the existing dimensions, the "Ecological" dimension helps to understand the state of the system, the species, or the habitats of interest so that interventions can be appropriately tailored to the needs of the species. The "Economic" dimension includes capital and financial resources essential for carrying out conservation initiatives. The "Governance" dimension covers the aspects that help maintain or influence legislation, management, and decision-making processes. Finally, the "Social" dimension includes aspects of compliance, perceptions, participation, and engagement in resource management (POMEROY; PARKS; WATSON, 2004).

We analyzed the articles and categorized the publications under one or more of the six qualitative elements of Aichi Target 11 (Chart 2) and into one or more dimensions — ecological, social, economic, or governance — covered by the research, according to the provided definitions. Each measurement of a qualitative element was treated as a variable, although the variables were not always explicitly identified in the publications (PELLETIER et al., 2005).

Qualitative Elements for Aichi Target 11	Definition
Areas of particular importance for biodiversity	Areas of importance are "geographically or oceanographically discrete areas that provide important [biodiversity and ecosystem] services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the criteria as identified in annex I to decision IX/20" (CDB, 2008)
Management effectiveness	Describes the extent to which management achieves goals and objectives designated for a particular area (Hockings, 2006). This includes design issues relating to individual PAs and protected area systems; adequacy and of management systems and processes; effective public participation and social policy processes, and delivery of protected area objectives (Woodley *et al.*, 2012)
Equitable management	Highlights the impact and benefit of conservation actions on human well-being and social systems, including the fair distribution of economic benefits and livelihood opportunities (distributional equity); the process for involvement and inclusion of stakeholders in planning, implementing, and administering (procedural equity); and the process of acknowledging and accepting the legitimacy of rights, values, interests, and priorities of different actors and respecting their human dignity (recognitional equity) (Schreckenberg *et al.*, 2016; Juffe-Bignoli *et al.*, 2018).
Ecological representativeness	Representativeness is considered the inclusion of areas that represent the entire suite of "different biogeographical subdivisions of the global oceans and regional seas that reasonably reflect the full range of ecosystems, including the biotic and habitat diversity of these marine ecosystems" (CDB, 2008). Representative includes the element of replication to ensure risk is minimized in the event of unforeseen or catastrophic events (Rees *et al.*, 2018).
Connectivity	Connectivity in relation to marine PAs networks concerns the "linkages whereby protected sites benefit from larval and/or species exchanges, and functional linkages from other network sites" (CDB, 2008).
Integration of seascapes with landscapes	In recognition that protected areas cannot work in isolation, this element identifies the importance of integrating Marine Protected Areas with other conservation and management tools, such as fisheries management or land use plans for land-based sources of pollution. Other considerations for this element include potential cumulative impacts stemming from climate change, ocean acidification, ocean noise, and pollution (Juffe-Bignoli *et al.*, 2018; Ress *et al.*, 2018).

Chart 2 - Definition of the six qualitative elements for the Aichi Target 11 adopted in this review, as identified and compiled by Meehan et al. (2020) based on various official documents and studies.
Source: Meehan et al. (2020).

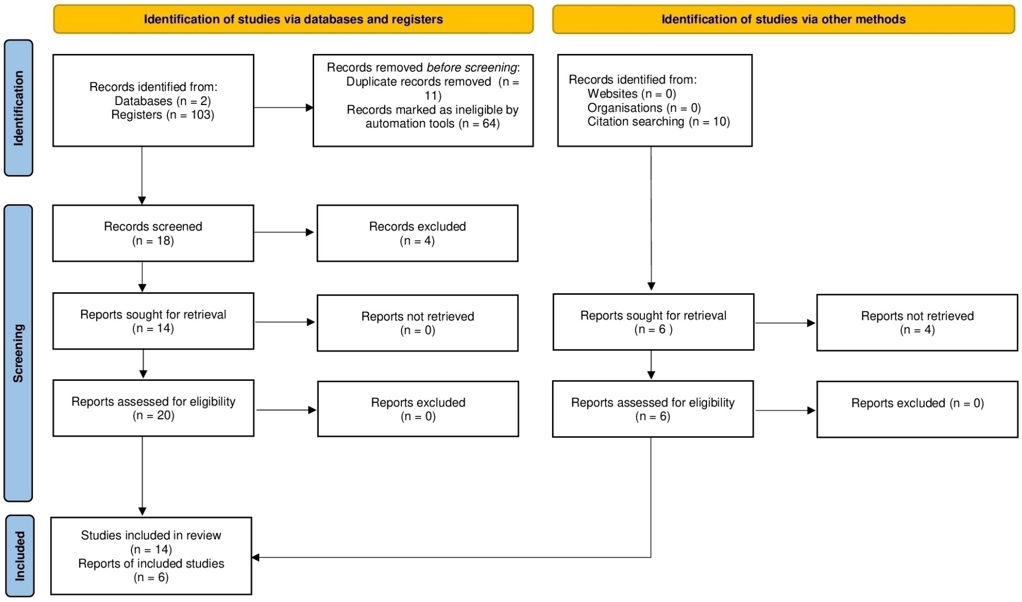

Figure 2 - Flowchart of the literature search stages and the process for reviewing and selecting articles, following the "Preferred Reporting Items for Systematic Reviews' (PRISMA) and the systematic review flow diagram. Source: Prepared by the authors (2024), based on Page et al. (2021).

We hierarchically classified each site-specific variable into indicators to reduce redundancy and to combine the indicators into a comparable measurement scale (LEVERINGTON et al., 2010). This classification was based on the compilation of indicators by Meehan et al. (2020) regarding the existing aspects of evaluating individual PAs, both hierarchically LEVERINGTON et al. (2010), POMEROY, PARKS, and WATSON (2004) and in networks (GANNON et al., 2017). Finally, we assigned these indicators to their respective dimensions and counted the number of times each qualitative element was evaluated based on the types of indicators identified in the assessment (MEEHAN et al., 2020).

To illustrate the distribution of the set of indicators that measure the qualitative elements and how this distribution is represented, we developed a flowchart using SankeyMATIC (BOGART, 2016). This flow reflects the frequency with which each indicator is linked to the stages, dimensions and qualitative elements of effective CU management. The colors in the flowchart serve as a visual aid for identifying the qualitative elements, dimensions and indicators, as described in the diagram. Each node, represented by a rectangle, corresponds to a qualitative element, dimension or indicator, while the thickness of each line and node is proportional to the number of times the indicator was used to evaluate the respective component. The colors in the indicator nodes represent the qualitative elements of Aichi Target 11 used in the article evaluation.

We presented the distribution of indicators among the qualitative elements and the results of ecological diversity indices through graphs and tables. Shannon's diversity index and Pielou's evenness (J), although typically used to assess species diversity, helped us observe the diversity of indicators within qualitative elements and analyze how the indicators were distributed across each qualitative element of Aichi T11. We adapted the use of these indices for our study, following the approach used by Meehan et al. (2020). This allowed us to disclose which indicators require further evaluation to better assess effectiveness.

Shannon's diversity index incorporates both the total number and the distribution of individuals among species and is sensitive to rare species, which is necessary for capturing the rare presence of indicators in certain dimensions. In our analysis, we calculated Shannon's diversity using the formula: $H' = -\Sigma ni/N \times \ln(ni/N)$, where ni is the number of indicators used to individually evaluate each quantitative element i, and N is the total number of indicators used across all qualitative elements. In this adaptation, a high diversity score indicates that many different indicators are being used to evaluate a specific qualitative element, while a low score indicates that only one or a few indicators are being used to evaluate an element (MEEHAN et al., 2020).

We also calculated Pielou's evenness (E), which represents the uniformity in the distribution of individuals among different species, and is derived from Shannon's diversity index (Pielou, 1966). In this study, we adapted it to analyze the distribution of indicators used to measure each qualitative element, using the formula E = H'/ ln (S), where S refers to indicator richness, meaning the number of different indicators used to measure a qualitative element (VERBERK et al., 2011). Its value ranges from 0 (minimal uniformity) to 1 (maximum uniformity). A value close to or equal to 1 indicates that a given qualitative element is evaluated by a wide variety of indicators, with no single indicator dominating the evaluations. A low uniformity score indicates that few indicators (or just one) are predominantly used to evaluate the element (MEEHAN et al., 2020). The analyses were conducted using Microsoft Excel spreadsheet software.

Finally, we report the main gaps in the indicators used in the literature so far, with the aim of guiding future evaluations and identifying which qualitative aspects require further evaluation. This includes considering the composition of the indicators, specifically the dimensions and stages associated with each indicator.

RESULTS

QUANTITATIVE PROGRESS

We found that 79.4% of all MPAs (a total of 173 marine or coastal CUs) were created between 1961, the year the first coastal/marine CU was established, and 2009, while 20.6% (45 CUs) were created between 2010 and 2020, during the decade focused on the Aichi Targets, showing a significant quantitative increase. Our data indicate that the establishment of the Aichi Targets was a driver for the creation of marine and coastal CUs. It is important to note that the number of CU areas calculated here may vary when compared to other researchers, as the geographical boundaries used to define “costal and marine areas” differ from other studies (e.g., SANTOS; SCHIAVETTI, 2014), meaning they are geographically divergent datasets.

Of the 45 CUs created between 2010 and 2020, 24 are under Integral Protection and 21 are under Sustainable Use. When evaluating the distribution of CUs by management categories during this period, Parks (IP) accounted for the largest number of CUs created, with 33.3% (15 CUs), followed by APAs (SU) with 31.1% (14 CUs). Together, these two categories represent 64.4% (29 CUs) of all CUs created in that period, while 35.6% (16 CUs) were distributed among other management categories (Table 1). Although fewer Extractive Reserves (“Reserva Extrativista” or RESEX) were created compared to APAs and Parks, with only six new CUs established between 2010 and 2020, the territorial extension of these areas, combined with all previously designated RESEX areas, was significant for the coverage of coastal and marine ecosystems by CUs. This category accounted for 13,558 km² of coverage, second only to the territorial coverage of APAs (Table 1).

We found that, between 1961 and 2009, a total of 109,348 km² of coastal and marine areas were protected, and from 2010 to 2020, this figure increased to 912,020 km². Currently, Brazil has surpassed the quantitative target of protecting 10% of its marine and coastal environments through CUs, with 1,021,368 km² now under protection. These areas are distributed across 10 CU categories, with the largest coverage coming from the extensive APAs, which account for 876,509 km² (Table 1).

CU Groups	Management Group (SNUC)	Management Category	1961-2009 No. of CUs	1961-2009 Coverage (km²)	2010-2020 No. of CUs	2010-2020 Coverage (km²)	1961-2020 Total No. of CUs	1961-2020 Total coverage (km²)
Group I	IP	REVIS	5	32	4	857	9	889
	IP	ESEC	9	1,627	0	0	9	1,627
	IP	PARK	35	10,462	15	1,026	50	11,488
	IP	MN	5	44	5	114,925	10	114,969
	IP	REBIO	8	1,958	0	0	8	1,958
Subtotal	IP		**62**	**14,123**	**24**	**116,808**	**86**	**130,931**
Group II	SU	RESEX	18	8,912	6	4,646	24	13,558
	SU	RDS	3	131	1	12	4	143
	SU	RPPN	5	5	0	0	5	5
	SU	ARIE	9	222	0	0	9	222
Subtotal	SU		**35**	**9,270**	**7**	**4,658**	**42**	**13,928**
Group III	SU	APA	**76**	**85,955**	**14**	**790,554**	**90**	**876,509**
	Total		**173**	**109,348**	**45**	**912,020**	**218**	**1,021,368**

Table 1 – Total coverage (in km²) of Protected Areas, by CU Groups with different levels of legal protection, according to Law 9.985/2000, in two time periods: between 1961 and 2009, and between 2010-2020. Legend: REVIS - Refúgio da Vida Silvestre (Wildlife Refuge); ESEC - Estação Ecológica (Ecological Station); PARK – National, State, and Municipal Parks; MN – Monumento Natural (Natural Monument); REBIO – Reserva Biológica (Biological Reserve); RESEX - Reserva extrativista (Extractive Reserve); RDS - Reserva de Desenvolvimento Sustentável (Sustainable Development Reserve); RPPN - Reserva Particular do Patrimônio Natural (Private Natural Heritage Reserve); ARIE - Área de Relevante Interesse Ecológico (Area of Relevant Ecological Interest); APA - Área de Proteção Ambiental (Environmental Protection Area). Source: Prepared by the authors (2024).

The temporal evolution of the creation of coastal and marine CUs, along with their spatial distribution, is illustrated in Figure 3.

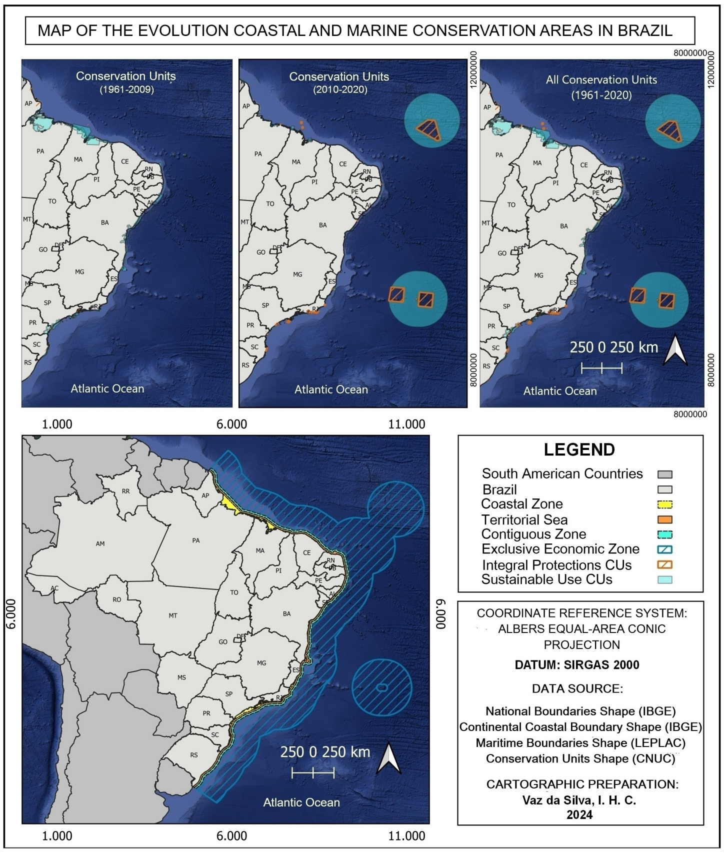

Figure 3 – Map of the Evolution of the Creation of Coastal and Marine Conservation Units in Brazil between 1961 and 2020. Source: Prepared by the authors (2024)

QUALITATIVE PROGRESS

Our study identified 20 articles that examined the advancements in Brazil's marine and coastal conservation network between 2010 and 2020 and provided approaches that enabled the characterization of the qualitative aspects of Aichi T11 included in the research (Table 2). The analysis of these articles identified 134 variables, organized into 40 indicators, that can contribute to assessing Brazil's progress in meeting Aichi T11.

The reviewed studies analyzed coastal and marine PAs from different perspectives. They ranged from evaluations of the effectiveness of a single marine/coastal PA to broader studies that included the entire national network of protected marine and coastal areas, from North to South of the country. These studies assessed the PAs across various dimensions of the qualitative approach and included evaluations of PA conservation using biological biodiversity data, considering marine birds, mollusks, mammals, turtles, invertebrates, fish, and vertebrates (see VILAR et al., 2015; FREITAS et al., 2019; VILAR et al., 2020; MAGRIS et al., 2021; VILAR et al., 2021), as well as the social context of PA management through interviews with managers. However, the approaches showed an uneven distribution in the number of articles found.

	First Author	Journal	Year of publication
1	ARAUJO, Júlio Lustosa	**Ocean & Coastal Management**	2016
2	DE FREITAS, João Eduardo Pereira	**Regional Studies in Marine Science**	2019
3	DE OLIVEIRA SOARES, Marcelo	**Marine Policy**	2018
4	GERHARDINGER, Leopoldo C.	**Environmental management**	2011
5	GIRALDI-COSTA, Ana Clara	**Marine Policy**	2020
6	GIGLIO, Vinicius J.	**Marine Policy**	2018
7	LIMA JUNIOR, Dilermando Pereira	**Ambio**	2018
8	MAGRIS, Rafael A.	**Nat. Conserv**	2013
9	MAGRIS, Rafael A.	**Diversity and Distributions**	2021
10	MAGRIS, Rafael A	**Science**	2018
11	MARETTI, Cláudio C.	**Aquatic Conservation: Marine and Freshwater Ecosystems**	2019
12	MARQUES, Simone	**Marine Policy**	2016
13	OLIVEIRA JÚNIOR, José Gilmar C.	**Marine Policy**	2016
14	PACHECO, André A.	**Perspectives in Ecology and Conservation**	2018
15	SANTOS, Cleverson Z.	**Journal for nature conservation**	2014
16	SCHIAVETTI, Alexandre	**Ocean & Coastal Management**	2013
17	SILVA, Alexandre Pereira da	**Ocean & Coastal Management**	2019
18	VILAR, Ciro C	**Animal Conservation**	2021
19	VILAR, Ciro C.	**Ocean & Coastal Management**	2015
20	VILAR, Ciro C.	**Aquatic Conservation: Marine and Freshwater Ecosystems**	2020

Table 2 – Articles included in the systematic review, according to eligibility criteria. Source: Prepared by the authors (2024)

Brazil's coastal and marine PAs were mostly evaluated in terms of management effectiveness. The reviewed publications covered PAs under public management at the municipal, state, and federal levels, and included at least one of the management categories from the National System of Conservation Units (SNUC). Four studies focused on the discussion surrounding the designation of large oceanic Marine Protected Areas (MPAs) in 2017-2018, which aimed to meet the Aichi Targets just before the deadline. These studies discussed various aspects of their designation and contribution to the progress of environmental policies and the achievement of global conservation goals, particularly Aichi Target 11.

Six studies evaluated the management of coastal and marine PAs along the entire Brazilian coastline, while the remaining studies conducted more focused assessments, ranging from the evaluation of a single CU to 387 CUs analyzed in one article. Five studies specifically addressed the need to expand geographic coverage through a network of PAs in priority areas still lacking CU coverage, as well as priority ecoregions and species in need of protection, based on their distribution data.

The other studies focused their investigations on various approaches, such as evaluating success indicators for Brazil's marine and coastal areas and the country's progress toward Aichi Biodiversity Protection Targets through the use of these indicators. Some studies presented the context of management models based on strategic initiatives developed for MPAs, such as the Brazilian Blue

Initiative (BBI), which aims to expand, promote, coordinate, and catalyze programs, projects, and activities directed at conserving and sustainably using marine and coastal ecosystems, in line with Brazil's national and international commitments (Maretti et al., 2019). Other studies highlighted the main challenges to effective conservation, stemming from the expansion of MPAs, financial issues related to CU management, main lessons, and public participation.

Finally, some studies reported the initial results from 2010 to 2021 on Brazil's progress in reaching 10% coverage of coastal and marine regions through CUs. Our study builds on this by evaluating both the qualitative and quantitative aspects of Aichi T11, making it a distinctive approach of this research.

In terms of geographic scope, most studies (n=6) focused on evaluations of coastal and marine PAs across Brazil, followed by evaluations of the large marine protected areas designated in 2018 in the Trindade and Martim Vaz Archipelago, and the São Pedro and São Paulo Archipelago (n=4).

QUALITATIVE ELEMENTS OF AICHI TARGET 11

Among the six qualitative elements, "Management Effectiveness" was the most frequently evaluated (80 times) using 24 of the 40 indicators listed across all dimensions, representing 60% of the identified indicators. These indicators were associated with all dimensions of the approach. Specifically, 37.5% (15) were linked to the "Governance" dimension, 45% (18) to the "Ecological" dimension, and the remaining 17.5% corresponded to the "Economic" and "Social" dimensions (10% and 7.5%, respectively) (Figure 4b). The element "Ecological Representativeness" was evaluated 24 times, using three indicators. These indicators were applied 15 times to evaluate "CU Coverage across Marine Ecoregions" in Brazil (62.5%), five times to evaluate the "Proportion of Species Distribution Covered by MPAs" (20.83%), and four times to evaluate "Habitat Distribution and Complexity" (16.67%), all within the "Ecological" dimension (Figures 4b and 5).

Next, the qualitative element "Ecological Connectivity" was evaluated 12 times, followed by the element "Areas of Importance", which was evaluated 9 times using four indicators. All of the indicators for these elements were assigned entirely to the "Ecological" dimension (Figure 4b). The indicators for "Ecological Connectivity" focused on assessing the size and spatial arrangement of coastal and marine PAs, as well as species dispersal and distribution. Meanwhile, the indicators for "Areas of Importance" primarily addressed the evaluation of biodiversity main areas covered by PAs, followed by the evaluation of species richness hotspots and centers of endemism or intact wilderness areas (Figure 5).

In comparison, evaluations related to "Integration" and "Equitable Management" were less frequent (5 and 4 times, respectively), using three and two indicators. The indicators for "Integration" were used to evaluate the "Governance" and "Ecological" dimensions (Figure 4b). The "Governance" indicator— "Existence of integrated management measures in management plans" —poses the need for promoting integrated coastal and ocean management. Meanwhile, the "Level of regional cooperation and coordination" indicator was used to evaluate regular collaboration between MPA management, partners, local communities, and other organizations to identify strengths and weaknesses in management. The only "Integration" indicator within the "Ecological" dimension was used to evaluate the influence of terrestrial sediment on the marine environment, considering the impact of land-based pollution on the marine ecosystem.

The indicators for "Equitable Management" were used to evaluate the "Governance" and "Social" dimensions. In the "Governance" dimension, the primary evaluation type was the "Level of stakeholder support and satisfaction with management", while in the "Social" dimension, the focus was on the "Perception of the effects of PAs on livelihoods". These indicators mainly reflect the level of satisfaction among populations affected by the designation of certain MPAs in Brazil and their implications. Qualitative elements can be assigned to one or more indicators identified in the literature, and these indicators may belong to one or more dimensions. Indicators that evaluate the integration of coastal and marine PAs with other management tools, and their impact on human well-being and social systems, lack sufficient information and evaluation. Proportionally, 100% of the indicators evaluating the elements "Representativeness", "Areas of Importance" and "Connectivity" fall under the "Ecological" dimension (Figure 4c).

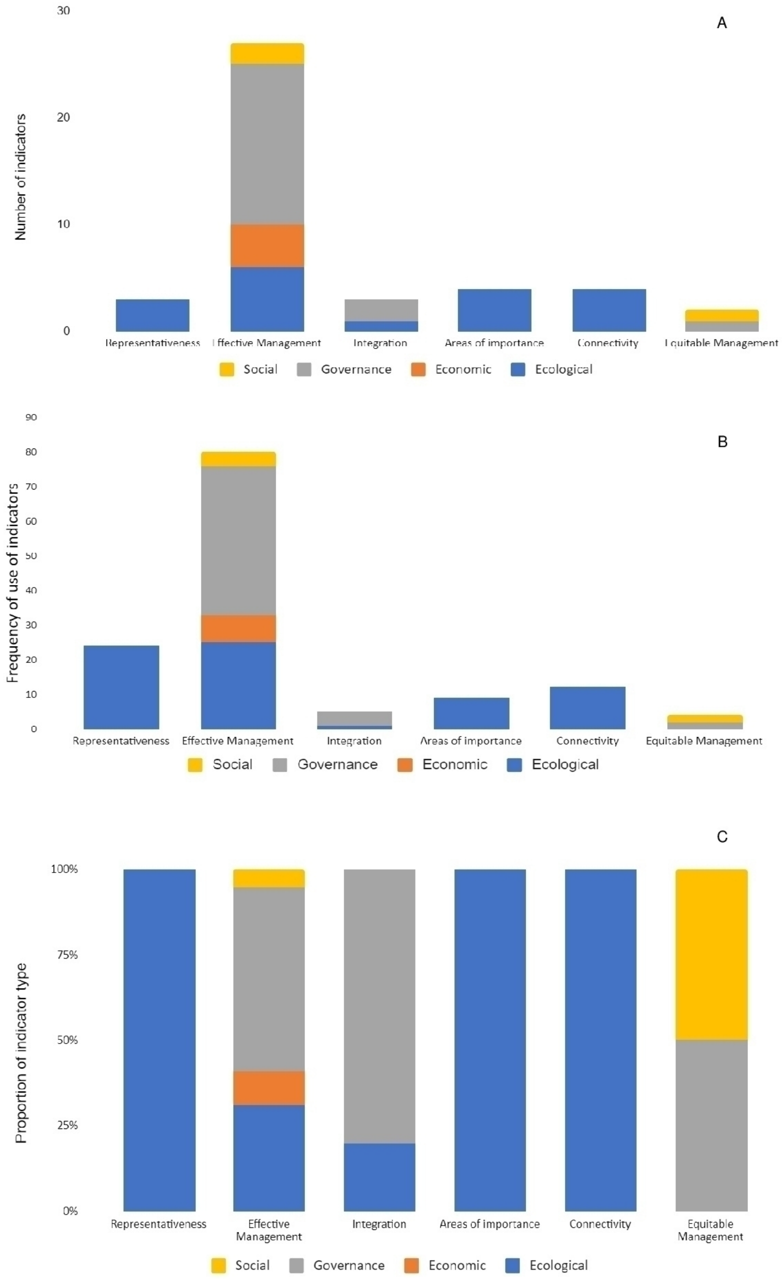

Figure 4 - Quantitative plots of the qualitative indicators used in each dimension of the approach. (A) Number of indicators for each qualitative element, (B) Frequency of use of the indicators for each qualitative element, and (C) Proportion of use of the indicators for each qualitative element. Source: Prepared by the authors (2024).

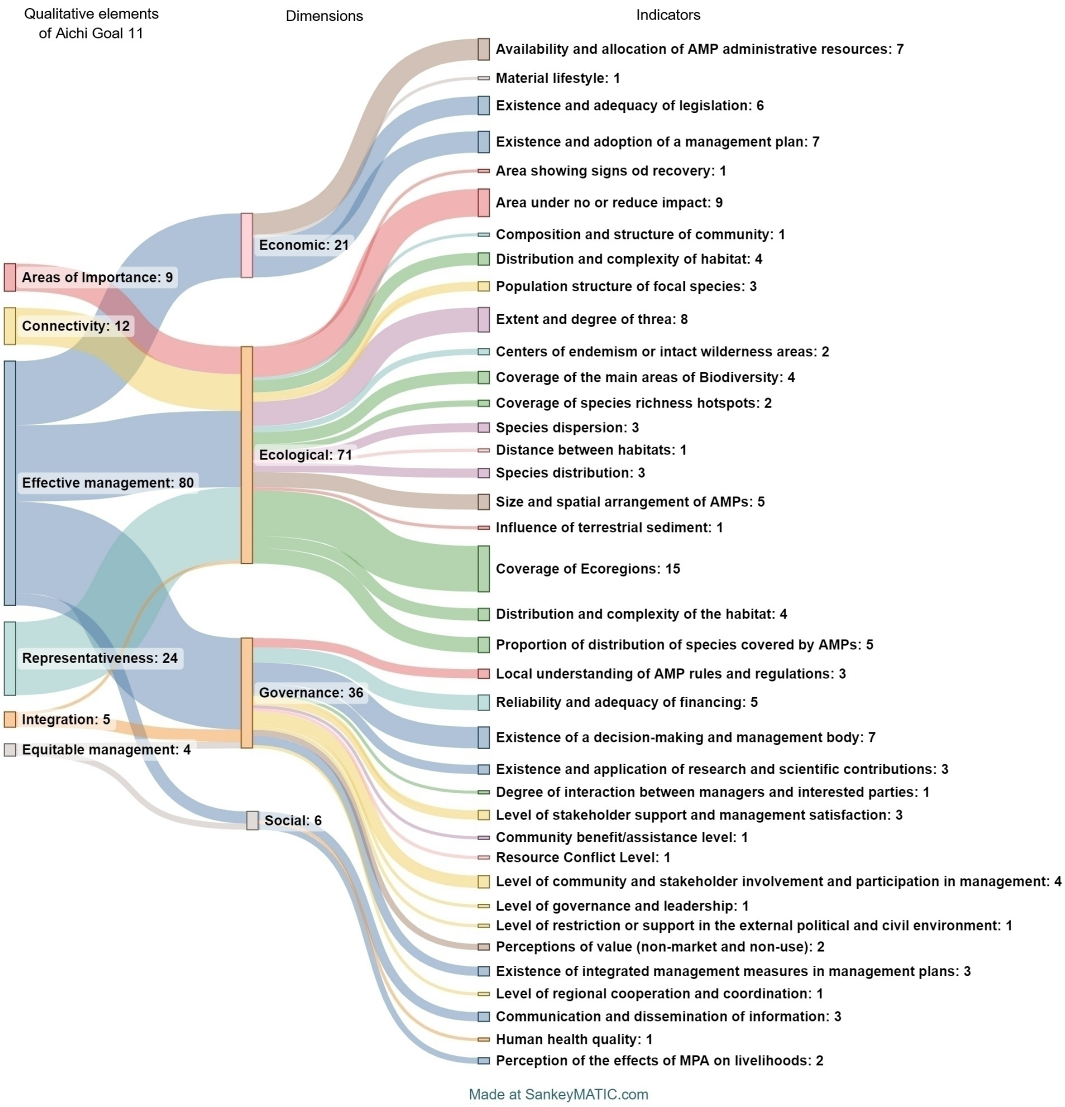

Figure 5 - Flow diagram representing the qualitative elements of Aichi Target 11 and their respective indicators and dimensions. The definitions of the qualitative elements of Target 11 are available in Chart 2. Source: Prepared by the authors (2024).

DIMENSIONS OF THE QUALITATIVE INDICATORS OF AICHI TARGET 11

When analyzing the distribution of the 40 identified indicators, we found that the “Governance” and “Ecological” dimensions were the most represented, with 17 and 16 indicators, respectively. The “Economic” and “Social” dimensions had only four and three indicators. While the “Governance” indicators appeared in three of the four qualitative elements, the “Ecological” indicators were included in all the elements. The “Economic” dimension was identified only in the “Management Effectiveness” element, and the evaluation of the “Social” dimension indicators was found only in the “Management Effectiveness” and “Equitable Management” qualitative elements. In terms of the number of times indicators were cited, the “Ecological” dimension was the most represented, with 73 citations (Figure 5).

In regard to the number of variables, the “Social” dimension had the fewest, associated with only six variables. It is important to note that a variable represents the factor, condition, or observed characteristic that reflects a local change resulting from a management action (O'DEA et al., 2021).

INDICATOR DIVERSITY

Each set of indicators representing a qualitative element of Aichi Target 11 was evaluated for its diversity (Table 3). Shannon's diversity index (H') confirmed that "Management Effectiveness", being the most evaluated element, had the greatest abundance and diversity of indicators (H' = 2.02). The element "Equitable Management" presented the lowest diversity of indicators (H' = 0.12) and was the least evaluated.

Other elements also showed low diversity, such as "Ecological Representativeness" (H' = 0.47), "Ecological Connectivity" (H' = 0.32), "Areas of Importance" (H' = 0.26), and "Integration" (H' = 0.15). Evenness ranged from 0.03 to 0.55. The highest evenness was found for the element "Management Effectiveness" (0.55), indicating that 55% of the theoretical maximum diversity of indicators was achieved through the conducted sampling (Table 3).

Qualitative element	No. of indicators	Frequency of indicator use	Shannon's diversity (*H'*)	Pielou's evenness (J)
Management effectiveness	24	80	2.029883	0.550270
Ecological representativeness	3	24	0.47265	0.128128
Ecological connectivity	4	12	0.329367	0.089286
Areas of importance	4	9	0.266887	0.072348
Integration	3	5	0.158159	0.042874
Equitable management	2	4	0.125513	0.034024
TOTAL:	**40**	**134**	**3.382459**	**0.916933**

Table 3 - Number and frequency of use of indicators, Shannon diversity (H'), and Pielou's evenness (J) for each qualitative element. Source: Prepared by the authors (2024)

MAIN INDICATORS

Indicators were always identified based on the evaluation context of the research. A single study could present more than one indicator. In our review, the indicator "Ecoregion coverage" was the most commonly used in studies evaluating the representativeness of coastal and marine PAs (15 times) and represents the qualitative element "Representativeness". The second most frequently used indicator was "Area with no impact or reduced impact" (9 times), which also belongs to the same qualitative element. These are the most significant indicators in this study (Figure 3, Table 3).

Next, the indicator "Degree of threat" was the most used in studies (8 times) and represents the element "Management Effectiveness", followed by three indicators, each used seven times: "Availability and allocation of administrative resources for MPAs", "Existence of a deliberative and management body", and "Existence and adoption of a management plan". All of these indicators are also related to the "Management Effectiveness" element. On the other hand, most indicators (MARQUES; STEINER; MEDEIROS, 2016) were identified only once in the studies; 10 of these indicators belong to the "Management Effectiveness" element.

Although "Management Effectiveness" was identified as the most important qualitative element in terms of number, frequency of use, and indicator diversity (Table 3), many of its representative evaluation indicators were rarely identified in the approaches used in the studies. This evidences the need for further research in this area. In contrast, the qualitative element "Representativeness" showed more consistency in the approaches, with repeated identification of its indicators. Table 4 presents the main indicators for each qualitative element.

Qualitative element	Indicators	Quantity
Management Effectiveness	"Degree of Threat"	8
	"Availability and allocation of administrative resources for MPAs"	7
	"Existence of a deliberative and management body"	7
Ecological representativeness	"Existence and adoption of a management plan"	7
	"Ecoregion Coverage"	15
	"Area with no impact or reduced impact"	9
Ecological Connectivity	Size and spatial arrangement of MPAs	5
	Species dispersal	3
	Species distribution	3
Areas of Importance	Coverage of main Biodiversity areas	4
	Centers of endemism or intact wilderness areas	2
	Coverage of species richness hotspots	2
Integration	Existence of integrated management measures in management plans	3
Equitable Management	Perception of MPA effects on livelihoods	2
	Level of stakeholder support and satisfaction with management	2
Total:		**40**

Table 4 - Main indicators for each qualitative element identified in this review. Source: Prepared by the authors (2024)

DISCUSSION

According to the analysis of the results, in 2020 there were 1,021,370 km² of protected areas. This value is higher than the one recorded in the CNUC for the same year, as we included polygons from other CUs that were registered in the official panel but not included in the CNUC shapefiles. On that platform, there were 964,921.02 km² of coastal and marine areas covered by CUs, corresponding to 26.49%.

By 2017, Brazil had only 1.25% of its coastal territory and Exclusive Economic Zone (EEZ) protected by CUs. Shortly after, in 2017-2018, large marine CUs were created, including: the Environmental Protection Area of the Trindade and Martim Vaz Archipelago, the Natural Monument of Trindade Islands, the Environmental Protection Area of the São Pedro and São Paulo Archipelago, and the Natural Monument of the São Pedro and São Paulo Archipelago. The two APAs cover 809,429.4 km² (87.4% of the total protected area created), and the two MNs cover 116,418.5 km² (only 12.6% of the MPAs) and are located within the APAs.

In 2018, there was a substantial increase in MPA coverage within EEZ waters, with 902,863 km² designated in just one year. This allowed Brazil to easily surpass the quantitative target, exceeding the 10% MPA coverage goal.

Although Brazil committed to expanding its network of Marine Protected Areas (MPAs) by 2020 (MAGRIS et al., 2013), Magris and Pressey (2018) argue that this expansion does not meet conservation objectives. They and other authors claim that the creation of large MPAs was a political strategy aimed at improving the government's image regarding environmental policies (GIGLIO et al., 2018; MAGRIS; PRESSEY, 2018; SILVA, 2019). Additionally, the area covered by fully protected MPAs remains very limited, and 57% of them do not even have a management plan, resulting in unsatisfactory progress in management effectiveness.

Conservation of protected areas in Brazil is deficient, particularly due to the lack of attention to qualitative aspects in the expansion of Conservation Units (CUs). This expansion does not ensure effective protection, as some sites fail to meet their conservation objectives due to planning or management issues (SILVA, 2019). Vilar and Joyeux (2021) analyzed the expansion of CUs and found that marine vertebrates are still poorly protected, with only the ecoregions of the Northeast reaching 10% coverage, while important areas for threatened species remain unprotected. They conclude that

Brazil has not met Aichi Target 11.

It is still important to acknowledge the federal government's political effort to meet the quantitative target and significantly expand the total area of protected spaces, which is meritorious. Nonetheless, the real attainment of conservation goals depends on additional measures beyond the creation of these areas, such as management, governance, enforcement, and more.

Gerhardinger et al. (2011) had already warned that the implementation phase of new CUs is a critical step for their future success and therefore requires special attention. However, this care was not observed in the designation of the new CUs that increased Brazil's coverage percentage, as the focus was on large APAs, deviating from the initial planning without consulting experts (SILVA, 2019).

Another important issue in the evaluation context is that the total extent of fully protected MPAs (i.e., areas considered fully protected according to International Union for Conservation of Nature - IUCN categories) is only 3.47%, which does not necessarily ensure species conservation. APAs, for instance, have the largest coverage but are the most permissive type of PA under Brazilian legislation, allowing uses that often do not guarantee biodiversity protection.

RESEX areas also allow the extraction of natural resources within their boundaries. According to our analysis, these CUs have good coverage of coastal and marine areas, second only to the territorial coverage of APAs. However, since their objective also includes protecting the livelihoods of traditional populations living in the surrounding areas, their effectiveness in practice will depend on the awareness efforts made by managers to ensure that resources are extracted sustainably, as shown in the study by Assis et al. (2020). Furthermore, our literature review points out a limitation in financial resources.

Regarding the qualitative aspects of Aichi T11, which is the primary focus of our review, we found that not all the indicators compiled in Meehan et al.'s (2020) global review were identified in our Brazil-focused review. However, it is worth noting that the number of studies included in our search, which concentrated solely on Brazil, was significantly smaller than the global number of studies they evaluated, which may account for the lower number of variables and indicators.

We found that many important aspects necessary to ensure the effective protection of these environments and to achieve several conservation targets still require more attention, particularly in the evaluation of indicators for the qualitative elements: “Equitable Management”, “Integration” and “Areas of Importance”. In contrast, the qualitative element “Management Effectiveness” was the most addressed in the literature, especially through indicators related to the “Degree of Threat to PAs”, “Availability and Allocation of Administrative Resources for MPAs”, “Existence of a Deliberative and Management Body”, and “Existence and Adoption of a Management Plan”.

Although Franks, Booker, and Roe (2018) emphasize the importance of this type of evaluation for guiding future conservation strategies, we believe that, in relation to Aichi T11 targets, it is equally important to consider the other qualitative elements to achieve a holistic assessment of PAs. In this context, “Management Effectiveness” is typically the most frequently evaluated qualitative element in other countries as well (MEEHAN et al., 2020; O'DEA et al., 2021).

Furthermore, even though “Management Effectiveness” is well represented in the literature, the indicators for the “Social” and “Economic” approaches still require more research, as noted by Meehan et al. (2020). According to Franks, Booker, and Roe (2018), assessing progress toward social goals is more challenging than measuring concrete elements, which may explain the scarcity of “Social” indicators in our review. Similarly, the qualitative element “Equitable Management” was among the least evaluated in the reviewed literature.

Even if some qualitative elements indicating management effectiveness were identified in the analyzed CUs, this does not necessarily mean that PAs in Brazil are managed effectively, nor that they are effective in conserving biodiversity. A more in-depth analysis is needed for more accurate conclusions about effectiveness, which should include coherence in planning. For example, it is important to verify whether the planned biological connectivity is being established between areas with similar objectives (MACKELWORTH et al., 2019), and whether there is functional connectivity between individual components (WOODLEY et al., 2012).

The “Management Effectiveness” element reveals that PA management in Brazil faces financial infrastructure challenges and a shortage of human resources, leading to poor management. Since 2016, there has been a significant decline in Brazilian environmental policy. Pacheco, Neves, and Fernandes (2018) pointed out that the budget required to manage the entire CU system was estimated between US$ 942.3 million and US$ 2.14 billion annually from 2017 to 2020. This decline worsened during the Bolsonaro administration (2019-2022), which allocated the lowest funding for protected areas in 17 years (FREITAS; CARVALHO; OVIEDO, 2022).

The lack of financial investment is one of the main obstacles to improving conservation goals, hindering the fulfillment of post-2020 targets and stressing the need to improve social and economic indicators related to “Management Effectiveness” (MEEHAN et al., 2020). This situation calls for a reformulation of Brazilian public policies to improve the management and funding of PAs and meet international environmental agreements. Pacheco, Neves, and Fernandes (2018) also highlighted the scarcity of fully protected coastal and marine PAs compared to Sustainable Use areas, which was also confirmed in our quantitative analysis.

Some researchers also emphasize that adequately protecting biodiversity and meeting socioeconomic goals will likely require a much higher level of protection than 10%, with estimates suggesting that 30 to 50% of the ocean should be covered by Marine Protected Areas (MPAs) (O'LEARY et al., 2016; WILSON, 2016). However, based on our assessment, we underline that Brazil still needs to ensure the proper management of existing PAs and develop plans that guarantee connectivity between them. Additionally, financial investments are necessary to improve infrastructure, address issues related to management and effective area governance, while involving society in these processes.

Although the ecological approach was more frequently evaluated in this review, we identified gaps that require further investigation, such as issues related to the local-scale distribution of biodiversity, associated with existing threats to biodiversity and connectivity (MAGRIS et al., 2021). Another area requiring more attention is the “Social” dimension, which is directly linked to society's involvement and participation in resource management.

The evaluation of effectiveness shows inequality among the qualitative elements. Even when some indicators are used in the Brazilian literature for coastal and marine PAs (ARAÚJO; BERNARD, 2016; MARQUES; STEINER; MEDEIROS, 2016; PACHECO; NEVES; FERNANDES, 2018), they are not explored in an integrated and systematic way. Many variables do not directly measure the qualitative elements of Aichi T11, relying only on a limited subset of indicators. This lack of equitable assessment and the difficulty in methodological development may lead to incorrect conclusions about the success of conservation targets (MEEHAN et al., 2020).

More restrictive evaluations, directed at a specific qualitative element, can also reveal priorities for a small subset of gaps that need to be addressed but may not be representative of the most affected qualitative elements. Thus, we believe that our review can help in setting priorities for future studies and reaffirm the importance of incorporating a wide range of information to improve our understanding of the overall conservation situation in Brazil.

CONCLUSIONS

Despite the controversial discussions in the literature regarding Brazil's success in meeting the Aichi diversity targets, our study indicates that Brazil has made progress in conservation effectiveness concerning its network of marine and coastal PAs. However, fundamental and important management approaches for PAs are still under-implemented. Therefore, although the minimum quantitative target of protecting 10% of coastal and marine areas has been achieved, this may not ensure the long-term persistence of biodiversity.

By expanding its protected area coverage to over 26%, Brazil surpasses the percentage of protected areas defined by Aichi target. In spite of this, most of the protected areas in Brazil are classified as APAs, which offer a lower degree of legal protection, while fully protected areas, which provide a higher level of protection, account for only 3.5% of the country's coastal and marine areas. This suggests the need to reassess the effectiveness of the protection provided by CUs, especially considering that APAs, being the most extensive and least restrictive to human use, dominate the country's protected areas.

Another important point, given that RESEX areas also present extensive coverage, is the need to widely implement collaborative initiatives with traditional communities living inside or around the reserve. These efforts would help raise awareness, promote the sustainable use of natural resources, and bring the community closer to sustainably manage the local ecosystems.

We found that many qualitative aspects lack sufficient attention to effectively promote the conservation of coastal and marine ecosystems. The country shows an imbalance in the evaluation of the qualitative elements of Aichi T11, with a predominant focus on the "Ecological" and "Governance" dimensions. Although the ecological dimension was the most assessed by the qualitative element indicators, the reviewed literature does not indicate any planning to promote connectivity between MPAs, despite extensive research on MPA coverage across ecoregions and spatial distribution.

Accordingly, our work identifies this gap and highlights the need to operationalize both quantitative and qualitative evaluations of CU effectiveness to meet international agreements, which must now be integrated with other post-2010-2020 CBD targets. It is noted that the country lacks a standardized and practical evaluation framework for PAs to assess progress toward global conservation goals.

Specific and systematic evaluations for each qualitative element are essential to addressing gaps in marine and coastal conservation policy. These tools can help PA managers prioritize effective management practices based on scientific evidence, as suggested by Mascia et al. (2014). However, these authors stress the lack of human resources, investments and incentives for evaluations that could improve CU management. This situation limits conservation actions and undermines the holistic planning needed to meet Aichi Target 11.

NOTES

1- Protected areas can also be implemented by state or municipal governments and are not strictly "national".

2-The National Forest type was not considered in this study due to the type of ecosystem being evaluated.

3- No Fauna Reserve CUs were identified in our study. This category is not recognized by the IUCN.

REFERENCES

ARAÚJO, Júlio Lustosa; BERNARD, Enrico. Management effectiveness of a large marine protected area in Northeastern Brazil. Ocean & Coastal Management, v. 130, p. 43-49, 2016. DOI: 10.1016/j.ocecoaman.2016.05.009

ASSIS, Davison Márcio Silva de et al. Percepção ambiental em comunidades tradicionais: um estudo na Reserva Extrativista Marinha de Soure, Pará, Brasil. Ambiente & sociedade, v. 23, p. e01481, 2020. DOI: http://dx.doi.org/10.1590/1809-4422asoc20190148r1vu2020L6AO

BARBIER, Edward B. Marine ecosystem services. Current Biology, v. 27, n. 11, p. R507-R510, 2017. DOI: 10.1016/j.cub.2017.03.020.

BOGART, S. SankeyMATIC., SankeyMATIC. A Sankey diagram builder for everyone. 2016. Disponível em: http://sankeymatic.com/. Acesso em: 22 abr 2022.

BRASIL. [Constituição (1988)]. Constituição da República Federativa do Brasil de 1988. Brasília, DF: Presidência da República, [2016]. Disponível em: http://www.planalto.gov.br/ccivil_03/Constituicao/Constituiçao.htm. Acesso em: 2 fev. 2024.

BRASIL. Lei nº 9.985, de 18 de julho de 2000. Institui o Sistema Nacional de Unidades de Conservação da Natureza, regulamenta o art. 225, § 1o, incisos I, II, III e VII da Constituição Federal, e dá outras providências. Brasília, DF: Diário Oficial da União, [2000]. Disponível em: https://www.planalto.gov.br/ccivil_03/leis/l9985.htm. Acesso em: 05 ago. 2023

CADASTRO NACIONAL DE UNIDADES DE CONSERVAÇÃO. Unidades de Conservação do Brasil. Dados. Brasil, 2023. Shapefile. Base de Dados em formato shapefile. Disponível em: https://cnuc.mma.gov.br/powerbi. Acesso em: 05 ago. 2023.

CBD - Convention on Biological Diversity. Strategic Plan for Biodiversity 2011-2020. COP 10 Decision X/2. Japan: Nagoya, 2011. Disponível em: https://www.cbd.int/decision/cop?id=12268. Acesso em: 03/07/2021

CBD – Decision adopted by the Conference Of the Parties to the Convention on Biological Diversity at its ninth meeting ix/20. Marine and coastal biodiversity, UNEP/CBD/COP/DEC/IX/20. 2008. Disponível em: https://www.cbd.int/doc/decisions/cop-09/cop-09-dec-20-en.pdf

FOO, Yong Zhi et al. A practical guide to question formation, systematic searching and study screening for literature reviews in ecology and evolution. Methods in Ecology and Evolution, v. 12, n. 9, p. 1705-1720, 2021. DOI: https://doi.org/10.1111/2041-210X.13654

FRANÇOSO, Renata. D. et al. Habitat loss and the effectiveness of protected areas in the Cerrado Biodiversity Hotspot. Natureza & Conservacão, v. 13, n. 1, p. 35–40, 2015. DOI: https://doi.org/10.1016/j.ncon.2015.04.001

FRANKS, Phil; BOOKER, Francesca; ROE, Dilys. Understanding and assessing equity in protected area conservation. IIED Issue Paper, p. 38, 2018. Disponível em: https://www.iied.org/14671iied

FREITAS, Camila Rizzini.; CARVALHO, Rodrigo Abreu.; OVIEDO, Antonio Francisco Perrone. O Financiamento da Gestão Ambiental no Brasil: Uma Avaliação a Partir do Orçamento Público Federal (2005–2022). Instituto Socioambiental: São Paulo, Brasil, 2022.

FREITAS, João Eduardo Pereira de; DE ARAUJO, Maria Elisabeth; DA CRUZ LOTUFO, Tito Monteiro. Composition and structure of the ichthyofauna in a marine protected area in the western equatorial Atlantic: A baseline to support conservation management. Regional Studies in Marine Science, v. 25, p. 100488, 2019. DOI: 10.1016/j.rsma.2018.100488

GANNON, Patrick. et al. Status and prospects for achieving Aichi Biodiversity Target 11: implications of national commitments and priority actions. Parks, v. 23, n. 2, p. 13-26, 2017. DOI: 10.2305/IUCN.CH.2017.PARKS-23-2PG.en

GERHARDINGER, Leopoldo. C. et al. Marine protected dramas: the flaws of the Brazilian national system of marine protected areas. Environmental management, v. 47, n. 4, p. 630-643, 2011. DOI 10.1007/s00267-010-9554-7

GIGLIO, Vinicius. J. et al. Large and remote marine protected areas in the South Atlantic Ocean are flawed and raise concerns: Comments on Soares and Lucas (2018). Marine Policy, v. 96, p. 13-17, 2018. DOI: https://doi.org/10.1016/j.marpol.2018.07.017

GOMES, Francisco Vladimir Silva et al. Ecological representativeness and total extension of protected areas by conservation units in the state of Ceará, Brazil. Sociedade & Natureza, v. 34, p. e64481, 2022. DOI: https://doi.org/10.14393/SN-v34-2022-64481x

HERNANDES, Elis et al. Using GQM and TAM to evaluate StArt – a tool that supports Systematic Review. CLEI Electronic Journal, v. 15, n. 1, p. 1–13, 2012.

IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. Limites do Sistema Costeiro-Marinho do Brasil. Dados. Brasil, 2019. Shapefile. Base de Dados em formato shapefile. Disponível em: https://www.ibge.gov.br/geociencias/informacoes-ambientais/estudos-ambientais/15842-biomas.html?=&t=acesso-ao-produto. Acesso em: 19/07/2023

_______ Malha Municipal Digital e Áreas Territoriais 2022: Informações Técnicas e Legais para a Utilização dos Dados Publicados. Rio de Janeiro, 2023. Disponível em: https://biblioteca.ibge.gov.br/visualizacao/livros/liv101998.pdf Acesso em: 03/01/2024.

______ Unidades Da Federação. Dados. Brasil, 2022. Shapefile. Base de Dados em formato shapefile.

JUFFE-BIGNOLI, Diego et al. Protected Planet Report 2018. International Union for the Conservation of Nature (IUCN), 2018.

LEVERINGTON, Fiona et al. A global analysis of protected area management effectiveness. Environmental management, v. 46, n. 5, p. 685-698, 2010. DOI 10.1007/s00267-010-9564-5

LOCKE, Harvey. Nature needs half: a necessary and hopeful new agenda for protected areas. Nature New South Wales, v. 58, n. 3, p. 7-17, 2014.

MACKELWORTH, Peter Charles et al. Geopolitics and marine conservation: synergies and conflicts. Frontiers in Marine Science, v.6, p. 759, 2019. DOI: https://doi.org/10.3389/fmars.2019.00759

MAGRIS, Rafael Almeida. et al. Analysis of progress towards a comprehensive system of marine protected areas in Brazil. Nat. Conserv, v. 11, n. 1, p. 1-7, 2013.

MAGRIS, Rafael Ameida.; PRESSEY, R. L. Marine protected areas: Just for show?. Science, v. 360, n. 6390, p. 723-724, 2018. DOI: 10.1126/science.aat6215

MAGRIS, Rafael Almeida et al. A blueprint for securing Brazil's marine biodiversity and supporting the achievement of global conservation goals. Diversity and Distributions, v. 27, n. 2, p. 198-215, 2021. DOI: https://doi.org/10.1111/ddi.13183

MARETTI, Cláudio. C. et al. Marine and coastal protected and conserved areas strategy in Brazil: Context, lessons, challenges, finance, participation, new management models, and first results. Aquatic Conservation: Marine and Freshwater Ecosystems, v. 29, p. 44-70, 2019. DOI:

https://doi.org/10.1002/aqc.3169

MARINHA DO BRASIL. Diretoria de Hidrografia e Navegação: Plano de Levantamento da Plataforma Continental Brasileira – LEPLAC. Limites Marítimos. Dados. Brasil, 2008. Shapefile. Disponível em: https://www.marinha.mil.br/dhn/?q=node/169.

Acesso em: 05 ago. 2023.

MARTÍNEZ, Maria Luiza. et al. The coasts of our world: Ecological, economic and social importance. Ecological economics, v. 63, n. 2-3, p. 254-272, 2007. DOI: https://doi.org/10.1016/j.ecolecon.2006.10.022

MARQUES, Simone.; STEINER, Andrea. Q.; ALMEIDA Medeiros Marcelo. Assessing the performance of the Aichi Biodiversity Targets in Brazil: a test using two regional-scale indices related to coastal and marine ecosystem conservation. Marine Policy, v. 67, p. 130-138, 2016. DOI: https://doi.org/10.1016/j.marpol.2016.01.030

MEEHAN, M. C. et al. How far have we come? A review of MPA network performance indicators in reaching qualitative elements of Aichi Target 11. Conservation Letters, v. 13, n. 6, p. e12746, 2020. DOI: https://doi.org/10.1111/conl.12746

O'DEA, Rose. E. et al. Preferred reporting items for systematic reviews and meta-analyses in ecology and evolutionary biology: a PRISMA extension. Biological Reviews, v. 96, n. 5, p. 1695-1722, 2021. DOI: https://doi.org/10.1111/brv.12721

O'LEARY, Bethan. C. et al. Effective coverage targets for ocean protection. Conservation Letters, v. 9, n. 6, p. 398-404, 2016. DOI: https://doi.org/10.1111/conl.12247

OLIVEIRA JÚNIOR, José Gilmar C. et al. Measuring what matters–Identifying indicators of success for Brazilian marine protected areas. Marine Policy, v. 74, p. 91-98, 2016. DOI: https://doi.org/10.1016/j.marpol.2016.09.018

PACHECO, André. A.; NEVES, Ana Carolina. O.; FERNANDES, G. Wilson. Uneven conservation efforts compromise Brazil to meet the Target 11 of Convention on Biological Diversity. Perspectives in Ecology and Conservation, v. 16, n. 1, p. 43-48, 2018. DOI: https://doi.org/10.1016/j.pecon.2017.12.001

PELLETIER, Dominique et al. Designing indicators for assessing the effects of marine protected areas on coral reef ecosystems: a multidisciplinary tandpoint. Aquatic Living Resources, v. 18, n. 1, p. 15-33, 2005. DOI: https://doi.org/10.1051/alr:2005011

PIELOU, Evelyn. C. Species diversity and pattern diversity in the study of ecological succession. Journal of Theoretical Biology , v. 10, n. 2, p. 370-383, 1966. DOI: https://doi.org/10.1016/0022-5193(66)90133-0

PITTOCK, Jamie. et al. Managing freshwater, river, wetland and estuarine protected areas. Protected area governance and management. ANU E Press, 2015 p. 569-608. Disponível em: https://researchoutput.csu.edu.au/files/45991945/10009429_peer_review.pdf

POMEROY, Robert S.; PARKS, John E.; WATSON, Lani M. How is your MPA doing?: a guidebook of natural and social indicators for evaluating marine protected area management effectiveness. IUCN, 2004.

QUANTUM GIS Development Team. Versão 3.16.9. QGIS Geographic Information System. [S. l.]: Open Source Geospatial Foundation Project, 2022. Disponível em: https://download.qgis.org/downloads/.

REES, Siân E. et al. Defining the qualitative elements of Aichi Biodiversity Target 11 with regard to the marine and coastal environment in order to strengthen global efforts for marine biodiversity conservation outlined in the United Nations Sustainable Development Goal 14. Marine Policy, v. 93, p. 241-250, 2018. DOI: https://doi.org/10.1016/j.marpol.2017.05.016

SANTOS, Cleverson. Z.; SCHIAVETTI, Alexandre. Spatial analysis of Protected Areas of the coastal/marine environment of Brazil. Journal for nature conservation, v. 22, n. 5, p. 453-461, 2014. DOI: https://doi.org/10.1016/j.jnc.2014.05.001Get rights and content

SCHRECKENBERG, K. et al. Unpacking equity for protected area conservation. Parks, v. 22, n. 2, p. 11-26, 2016. DOI: https://doi.org/10.2305/IUCN.CH.2016.PARKS-22-2KS.en.

SILVA, Alexandre Pereira da. Brazilian large-scale marine protected areas: Other “paper parks”?. Ocean & Coastal Management, v. 169, p. 104-112, 2019. DOI: https://doi.org/10.1016/j.ocecoaman.2018.12.012

SOUSA, Evelin Eugênia de; SERAFINI, Thiago Zagonel. Panorama das Unidades de Conservação na zona costeira e marinha do estado de São Paulo. Desenvolv. Meio Ambiente, v. 44, 2018. DOI: 10.5380/dma.v44i0.55115

TEIXEIRA, Lucas Peixoto. et al. How much of the Caatinga is legally protected? An analysis of temporal and geographical coverage of protected areas in the Brazilian semiarid region. Acta Botanica Brasilica, v. 35, n. 3, p. 473–485, 2021. DOI: https://doi.org/10.1590/0102-33062020abb0492

VERBERK, Wilco. C. E. P. et al. Explaining general patterns in species abundance and distributions. Nature Education Knowledge, v. 3, n. 10, p. 38. 2011.

VILAR, C. C.; JOYEUX, J.-C. Brazil’s marine protected areas fail to meet global conservation goals. Animal Conservation, v. 24, n. 6, p. 1013-1020, 2021. DOI:

https://doi.org/10.1111/acv.12703

VILAR, Ciro. C. et al. Setting priorities for the conservation of marine vertebrates in Brazilian waters. Ocean & Coastal Management, v. 107, p. 28-36, 2015. DOI: https://doi.org/10.1016/j.ocecoaman.2015.01.018

VILAR, Ciro. C. et al. Strengthening the synergies among global biodiversity targets to reconcile conservation and socio-economic demands. Aquatic Conservation: Marine and Freshwater Ecosystems, v. 30, n. 3, p. 497-513, 2020. DOI: https://doi.org/10.1002/aqc.3269

WILSON, B. Might marine protected areas for mobile megafauna suit their proponents more than the animals?: MPAs for magefauna or people?. Aquatic Conservation-Marine and Freshwater Ecosystems, v. 26, n. 1, p. 3-8, 2016. DOI: https://doi.org/10.1002/aqc.2619

WOODLEY, Stephen. et al. Meeting Aichi Target 11: what does success look like for protected area systems. Parks, v. 18, n. 1, p. 23-36, 2012. Disponível em: https://www.researchgate.net/profile/Dan-Laffoley/publication/233858803_SAFEGUARDING_THE_BLUE_PLANET_SIX_STRATEGIES_FOR_ACCELERATING_OCEAN_PROTECTION/links/0c96052c6d116929a0000000/SAFEGUARDING-THE-BLUE-PLANET-SIX-STRATEGIES-FOR-ACCELERATING-OCEAN-PROTECTION.pdf

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