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Evaluation of Coastal Management in the Municipality of Paulista/PE in the Light of the Decalogue

Avaliação do Gerenciamento Costeiro no Município do Paulista/PE à Luz do Decálogo

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Abstract

Brazil adopts Integrated Coastal Management as a way of protecting coastal environments through sustainable use and through the National Coastal Management Plan – PNGC structures actions directed at coastal areas, guaranteeing municipalities a prominent position in the integrative process. The structuring of the legal and institutional framework does not remove the picture of degradation borne by coastal cities, which have problems with sanitation, erosion and reduction of biodiversity. The general objective of this article is to analyze the Coastal Management process adopted by the municipality of Paulista, Pernambuco, in order to provide subsidies for institutionalization and sustainable governance. The methodology was structured in two parts. The first part used the Land Use and Land Cover (LULC) dataset available free of charge MapBiomas collection 6. The second part used the methodology proposed by Barragán in the "Decalogue for the Management of Coastal Areas", where the 10 indicators are analyzed fundamental to evaluate actions related to coastal management. The methodology was adapted to include the mapping of the use and occupation of the municipality's coastal area over a period of 36 (thirty-six) years. The results of the analysis of land use and occupancy indicate a steady growth in anthropized areas from 1986 until the end of the 1990s, stabilizing with few changes. After an increase, there was a new stabilization between 2006 and 2012, followed by a notable growth in 2013–2014 and a subsequent period with less pronounced increments until the year 2021. Regarding the matrix analysis, there is a greater advancement in aspects related to Knowledge and Information, Normative and Competencies, whereas items such as Training and Capacity Building, Resources, and Public Policies require better strategic definitions by the municipality. As for the results of the matrix analysis, they reveal the need for the implementation of impact mitigation measures, the strengthening of oversight and monitoring, the development of strategies for climate change adaptation, the promotion of environmental education, and the fostering of scientific research in coastal areas. Finally, there is a suggestion for the continuous evaluation and correction of actions related to coastal and marine areas of the municipality, as well as the use of scientific evidence in decision-making.

Keywords: Decalogue; Integrated coastal management; Use and occupation

Resumo

O Brasil adota a Gestão Costeira Integrada como forma de proteção e uso sustentável dos ambientes costeiros. Através do Plano Nacional de Gerenciamento Costeiro – PNGC prevê as ações dirigidas às áreas litorâneas e garante aos municípios uma posição de destaque no processo integrativo. A estruturação do arcabouço jurídico e institucional não afasta o quadro de degradação suportada pelas cidades costeiras, que apresentam problemas de saneamento, erosão e redução da biodiversidade. Este artigo tem por objetivo geral analisar o processo de Gerenciamento Costeiro adotado pelo município do Paulista, em Pernambuco, a fim de fornecer subsídios de institucionalização e governança sustentáveis. O primeiro corte metodológico utilizou o conjunto de dados de Land Use and Land Cover (LULC) disponível gratuitamente MapBiomas collection 6. Depois, foi utilizada a metodologia proposta por Barragán-Munõz no "Decálogo para a Gestão das Áreas Litorâneas", com análise dos 10 indicadores fundamentais para avaliar as ações relacionadas à gestão litorânea. A metodologia foi adaptada para incluir o mapeamento do uso e ocupação da área costeira do município numa variação temporal de 36 anos. Os resultados da análise do uso e ocupação do solo indicam um crescimento constante da área antropizada do ano de 1986 até o final da década de 1990, estabilizando-se com poucas mudanças. Após um aumento, ocorreu nova estabilização entre 2006 e 2012, seguida por um notável crescimento em 2013–2014 e um período subsequente com incremento menos expressivo até o ano de 2021. Já a análise da matriz revela um maior avanço nos aspectos relacionados ao Conhecimento e Informação, Normativa e Competências; ao passo que os itens Formação e Capacitação, Recursos e Políticas Públicas necessitam de melhores definições estratégicas pelo município. No que tange aos resultados da análise da matriz demonstraram a necessidade da implementação de medidas de mitigação de impactos, o fortalecimento da fiscalização e monitoramento, o desenvolvimento de estratégias de adaptação às mudanças climáticas, a promoção da educação ambiental e o fomento da pesquisa científica na área costeira. Por fim, sugere-se a necessidade de avaliação contínua e correção das ações voltadas para as áreas costeiras e marinhas do município, bem como a utilização de evidências científicas na tomada de decisões.

Palavras-chave: Decálogo; Gestão costeira integrada; Uso e ocupação

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1 Introduction

Climate change has been intensifying the vulnerability of coastal environments, emphasizing the urgency of effective approaches to address constantly evolving challenges. The coastal zone, in particular, emerges as a highly susceptible ecosystem, facing not only coastal erosion but also the impacts of rising sea levels and increasingly frequent and intense climatic events such as floods and cyclones (Neumann, Ott & Kenchington 2017; Rosendo, Celliers & Mechisso 2018; Abadie, Murieta & Galarraga 2020; Assche et al. 2020; Birchall 2020; Nicholls et al. 2021). In the face of this challenging scenario, coastal management plays a crucial role in monitoring, preventing, and mitigating these impacts.

Coastal Management is a process that challenges those involved in the adoption of public policies and governance. Integrative and sustainable practices in the environment are included in the national and international legal guidelines, such as chapter 17 of Agenda 21 (Brasil 1995) and objective number 14 of the Sustainable Development Goals (UN 2015). The need for transnational cooperation arises from the interdependence between coastal states, as mentioned in Schlüter et al. (2020), Magarotto, Costa and Masanet (2021) and Caviedes, Arenas-Granados and Barrangán-Muñoz (2022).

The coastal zone corresponds to the geographical space where the interaction of air, sea and land occurs, with unique characteristics due to the presence of estuarine systems, dunes and beaches (Carapuço et al. 2021). According to Carapuço et al. (2021) and Harris et al. (2019), achieving coastal sustainability is a complex task due to the environmental sensitivity of the region and its inadequate inclusion in managers' strategic planning.

Integrated Coastal Zone Management is a globally used approach to promote the sustainable use, development and protection of coastal areas and marine resources (Elrick-Barr & Smith 2021). Brazil gives the coastal zone the status of national heritage, established by the Federal Constitution (Brasil 1988a) as an area of relevant population concentration, economic and tourist development, as well as ecosystems to be preserved.

In this sense, beaches are fundamental spaces in the coastal environment as they are considered public goods for the common use of the society, guaranteeing free access (Brasil 1988a). Even though owned by the Union, Law 13.240/15 (Brasil 2015) allows the delegation of the management of the beaches of the Federal Patrimony Secretariat (SPU) to the municipalities, being responsible for promoting the adequate use and occupation, conflict management and protection of the environmentally protected areas by legislation.

Brazilian legislation for the coastal zone began with the National Policy for Sea Resources (PNRM), approved by the Interministerial Commission for Sea Resources - CIRM. Subsequently, the National Coastal Management Plan (PNGC), created by Law No. 7.661/88, which is in its second version, the PNGC II (Brasil 1997), establishes the rules for use and occupation of the coastal zone, as well as criteria for management of the waterfront, considered by Jablonski and Filet (2008) as a Public Policy document, integrated with the National Policy for the Resources of the Sea - PNRM (Brasil 2004) and the National Environmental Policy - PNMA (Brasil 1981).

The importance of the subject is undeniable in a country with a coastline of approximately 8,500 km, home to 26.6% of the population, comprising 17 states and 443 municipalities (Brasil 2021; IBGE 2021; Nicolodi et al. 2021). Thus, for Becker, Barboza and Martins (2021), when thinking about coastal management, it is necessary to evaluate the most diverse variables that compose the coastal system, and it is certain that one of the main methods used to analyze coastal management is the Decalogue, proposed by Barragán-Muñoz (2010).

The "Decalogue for the Management of Coastal Areas" was established by Barragán-Muñoz (2003, 2005, 2010, 2014) and is intended to assess the (in)existence of public policy specifically aimed at the coastal environment through the ten indicators previously established. The methodology has been previously tested in several territories and is therefore able to assess the current stage of maturity of the municipality of Paulista, Pernambuco, the subject of this article, as well as providing an opportunity to monitor the evolution of management in future studies. In this study, it was adapted to include a cartographic survey of the use and occupation of the municipality's coastal zone.

In fact, several studies have used the Decalogue methodology to support coastal management in 17 countries and organizations participating in the Ibero-American Network for Integrated Coastal Management (CYTED Project 2008–2012), in which Brazil is included. According to Scherer et al. (2019), the IBERMAR Network primarily aims to ensure the interchange of experiences and management in Latin America and the Iberian countries. In Brazil, the Decalogue methodology has been successfully discussed and applied by Scherer, Asmus and Gandra (2018) and Scherer and Asmus (2021), as well as several states and municipalities.

Therefore, this aim of research is to analyze the Integrated Coastal Management model adopted in the municipality of Paulista, Pernambuco, based on the criteria

proposed by Barrangán-Muñoz (2010) in the Decalogue. According to Barrangán-Muñoz (2010), the coastal zone should be a priority in public policies, in order to better guide government actions and favor sustainable development, making it a relevant instrument for improving public policies, since it integrates technical-scientific knowledge with the practices adopted, avoiding political decisions based on non-technical criteria.

2 Materials

2.1 Study Area

Paulista, a city located in the northern sector of the coastal zone of the state of Pernambuco (Figure 1), has a 14 km stretch of coastline that includes several beaches, such as Janga, Pau Amarelo, Nossa Senhora do Ó, Nossa Senhora da Conceição and Maria Farinha, where there are tourist and commercial activities, historical monuments and residences. With a territorial area of 96.932 km², geographical coordinates of 7° 56' 24" south latitude and 34° 52' 20" west longitude, the municipality has an estimated population of 336,919 inhabitants, with the vast majority living in the urban area, resulting in a demographic density of 3,087.66 inhabitants/km², according to the Brazilian Institute of Geography and Statistics (IBGE 2021).

The annual mapping conducted by MapBiomas revealed that, in terms of the distribution of different land uses, 42% of the municipality's territory consists of urbanized areas, 29% of forest areas, and 4% of mangrove areas in 2022. The municipality of Paulista has 38.61% of its territory covered by native flora, predominantly Atlantic forest.

In addition, the municipality has transitional coastal ecosystems, such as mangroves and restinga. The climate is hot and humid, with an average temperature of 24.5 °C. According to the Köppen-Geiger climate classification, the municipality is classified as (As). Rainfall is most frequent between April and July, with average annual precipitation varying between 380 and 760 mm. In terms of socio-economic aspects, Paulista is a municipality strategically located 17 km from the capital, Recife, which makes it favorable for development and a highlight in Pernambuco.

With access to the main productive sectors of the north coast and a strong tourism and services potential, the municipality attracts real estate investment.

However, despite this positive outlook, only 51.81% of the population has access to a sewage system, which has a negative impact on the coastal environment.

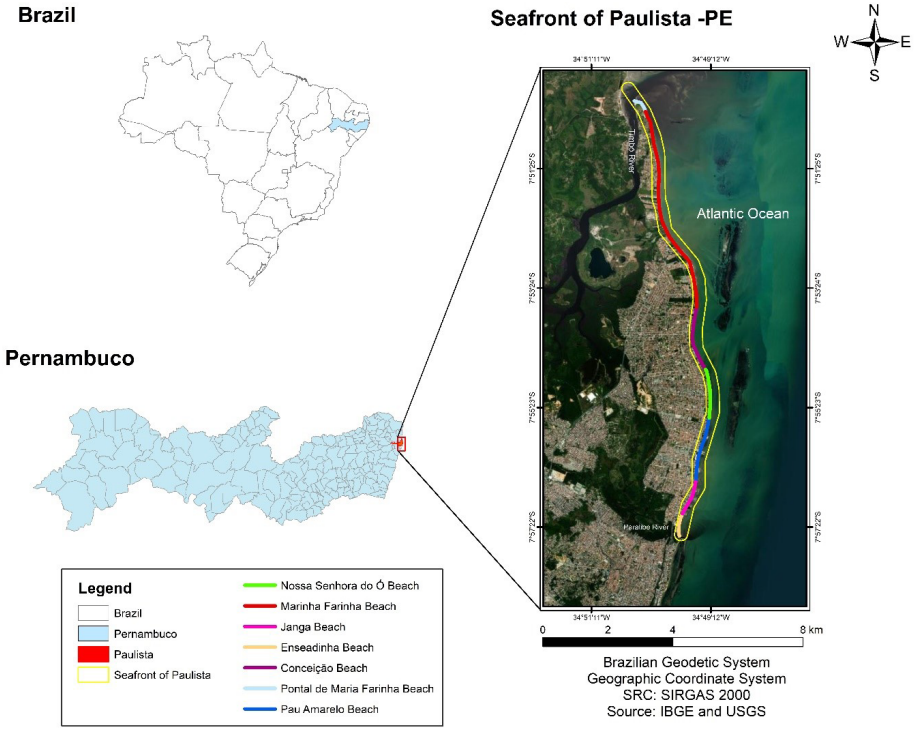

Figure 1 Location Map of the Coastal Zone of the Municipality of Paulista.

Regarding the geological characterization, the study area is situated in the municipality of Paulista, which exhibits distinctive geological features reflecting its formation processes. The municipality is located within the Paraíba Basin, specifically in the Olinda Sub-Basin, bounded by the Pernambuco Basin through the Pernambuco Lineament, and adjacent to the Natal Platform via the Mamanguape Fault. This Basin comprises the formations: Beberibe, Itamaracá, Gramame, Maria Farinha, Barreiras, and Quaternary Sediments (Beurlen, 1967; Mabesoone & Tinoco, 1971; Mabesoone & Silva 1991), which unconformably overlie the crystalline basement, as represented in the stratigraphic column proposed by Barbosa (2007).

Hydrographically, the city of Paulista is traversed by the Timbó River in the west-east direction until the beginning of the estuary, where it flows northeastward to its mouth between Nova Cruz and Maria Farinha Beach. Its main tributaries include the Arroio Desterro, Zumbi, Fábrica, Massapê, and Fundo rivers, in addition to numerous streams and gullies. It forms an estuary of approximately 1,397 hectares that harbors significant vegetation.

The City of Paulista has three ecological preservation areas: the ecological reserve of Mata do Janga, the ecological reserve of Mata de Jaguarana, and the ecological station of Caetés. The municipality of Paulista has 38.61% of its territory covered by native flora, predominantly composed of Atlantic Forest. Additionally, it features transitional coastal ecosystems, such as mangroves and restinga.

3 Methodology

3.1 Land Use and Occupation

In order to identify the anthropized and non-anthropized areas on the edge of the municipality of Paulista, in Pernambuco, the freely available Land Use and Land Cover (LULC) dataset MapBiomas collection 6 (Mapbiomas 2022) was used. This dataset has been considered to be a reference in several studies related to LULC and change (Souza Jr. et al. 2020; Pedruzzi et al. 2022; Santos et al. 2022; Silva et al. 2023). MapBiomas provides annual LULC maps for the entire Brazilian territory, with a spatial resolution of 30 meters, based on automatic pixel-by-pixel classification of Landsat images, using the Random Forest machine learning algorithm implemented in Google Earth Engine (Bonanomi et al. 2019). The method applied in the classification scheme was fully described on the MapBiomas project website (Mapbiomas 2022) and in the reference document (Souza Jr. et al. 2020).

MapBiomas Collection 6 presented the annual land use and land cover (LULC) maps from 1985 to 2021, divided into five different classification schemes. At the most detailed level, which is level 3, LULC is classified into 15 categories, while at level 1 and 2, LULC is divided into 13 categories. Level 4 has 5 categories and level 5 has 3 categories. For the municipality of Paulista-PE, considering the LULC classes of levels 3 and 4 during the period from 1985 to 2021, the LULC maps generated by collection 6 presented an annual average overall accuracy of 96.6%, an allocation disagreement of 2.4% and a quantity disagreement of 1.0%. These results demonstrate that MapBiomas accurately identifies the different land use and land cover categories in the municipality of Paulista.

3.2 Integrated Coastal Management

Based on studies conducted on integrated management in the coastal areas of Spain and Andalusia, Barrangán-Muñoz (2010) proposes the analysis of ten strategic elements as a way of identifying the degree of coastal maturity and enabling coastal governance. According to Sanabria et al. (2011), the Decalogue methodology allows for knowledge of the sensitive aspects of coastal management, proving to be a suitable method for evaluating any public system related to the coast - understood as the coastal and marine zone.

The authors define the indicators of the Decalogue and their objectives: 1) Public Policy: to indicate the presence of a public and explicit institutional policy on integrated coastal management in the area; to inform which policy prevails in the practice of coastal zone and marine environment management and whether it is publicly known; 2) Normative Structure: Break down the normative basis regulating integrated coastal management, resource management and coastal activities; 3) Competence: understand the distribution system of public responsibility in the locality for the management of marine space and resources; point out the benefits of distribution for integrated coastal zone management; 4) Public Institutions: verify which public institutions are most involved in matters concerning coastal and marine management; qualitative analysis of the institutions when it comes to integrated management; 5) Instruments and Strategies: verify the existence of strategic and operative instruments relevant to coastal management; analyze the functioning of the instruments as well as their efficiency in guiding harmonious actions between public and private institutions aimed at the integrated management of coastal areas; 6) Training and Capacity Building: evaluate whether the system offers training and capacity building for public

managers linked to coastal management, pointing out the deficiencies in this respect; 7) Economic resources: understand the economic and financial bases supporting coastal management and the economic resources present in the public budget; 8) Knowledge and information: analyze the degree of knowledge of the coastal subsystem, from a physical and natural, social and economic, and legal and administrative perspective; assess the availability of information to citizens; 9) Education for sustainability: verify the existence of environmental education programs related to coastal and marine sustainability issues; report on the existence of an identical theme in schools or non-governmental institutions; 10) Participation: find out if there is popular participation in decision-making on interests related to coastal management; identify the presence of groups interested in coastal management and the level of engagement in actions.

Once the objectives of each item were known, a matrix was drawn up to evaluate the principles addressed in the research, based on the criteria applied by Botero and Sosa (2011); Andrade & Scherer (2014); Asmus et al. (2018) and Scherer et al. (2019). After collecting the data, each descriptor was assigned a value of 1 (one) to 5 (five), depending on the evaluation within the degrees of evolution or absence of the given item.

The value 1 (one) will be assigned when the indicator presents precarious progress and 5 (five) for the hypothesis of significant progress. The values 2 (two), 3 (three), and 4 (four) represent minimal, intermediate, and great progress respectively. The indicated values were extracted from the study proposed by Botero and Sosa (2011). The subjective aspect was minimally relevant when assigning the values in order to make it possible to adopt the methodology in later work aimed at assessing the evolution of coastal management at various levels of government.

The data used in the analysis are based on academic articles, as well as relevant official documents and publications, such as laws, decrees, reports, government programs, and projects. All of which are public and all of which were obtained digitally. The technical information needed to assess the indicators in the Decalogue was obtained directly from the municipality of Paulista and resulted from the author's critical analysis based on her experience as a legal advisor in the municipality's Executive Secretariat for the Environment.

4 Results and Discussions

4.1 Land Use and Land Cover Mapping

Based on the cartographic representation shown in Figure 2, the findings on land use and occupation for 1985, which corresponds to the beginning of the time series, revealed a more intact environmental context in regions not subject to consolidated anthropization processes. It can be noticed that the area not affected by human activity is predominantly located to the south of the coastal zone of the municipality of Paulista and to the north of it. In addition, a central portion of Paulista's coastal region is fully preserved. According to Lin et al. (2021), it is important to understand population growth patterns through a spatial-temporal analysis, as the compatibility of interests and adverse factors guarantees a sustainable development model that does not compromise the use of coastal resources in the future.

The presence of the mentioned areas is maintained in subsequent years due to the existence of the estuarine area of the Paratibe River in the Special Urban and Environmental Conservation Zone (ZECUA) to the south, on Janga beach, and the ZECUA of the Timbó River to the north, in Maria Farinha. The area to the south remains preserved during the period studied, but suffers impacts, presenting de-characterized areas, due to intense urbanization with landfills and waste deposition in the river.

In 2014, the municipality began work on desilting the most critical areas of the Paratibe River, as part of the policy implemented in the PGI-Orla. The Timbó River Environmental Protection Area (APA) guarantees that mangrove areas have been little affected by human activity to date. In this sense, it can be seen that the areas included in the protected areas have more effective protection, corroborating one of the hypotheses discussed in the "instruments and strategies" section of the Decalogue study.

In the center, it is still possible to observe the existence of Special Zones of Historical and Cultural Interest (ZEIHC), whose preservation of historical and cultural heritage is defined by law, taking into account individual aspects, as well as the Poty Management and Development Zone (ZMD).

For the year 1990, according to the map in Figure 2, it can be seen that there was a gain in the non-anthropized area in the northern part of the coastline of the municipality of Paulista. Later, in 1995 (Figure 2), the anthropized area increased significantly along the entire coastline. The anthropized area in the central part of the coastline is also seen to be consolidated. This consolidation is mainly due to the increased occupation of the area whose

occupation is considered prohibited (33 meters after the coastline). According to Ibiapina and Aloufa (2019), these demarcations are intended to regulate the use of coastal space in order to maintain the local environmental balance.

Also, taking into account the map in Figure 2, in 2000, it was revealed that the central portion of the waterfront is already practically occupied, either by housing or other physical equipment. In addition, it is possible to observe that there was a significant increase in the anthropized area in the southern and northern portions of the waterfront of the municipality of Paulista.

Regarding 2005, according to the map shown in Figure 3, the results on land use and occupation indicated the consolidation of the areas already occupied throughout the study period. Additionally, it is noticeable an increase in the anthropized extension above the central portion of the Paulista waterfront. It is important to emphasize that, even so, there are still preserved stretches in the year 2005.

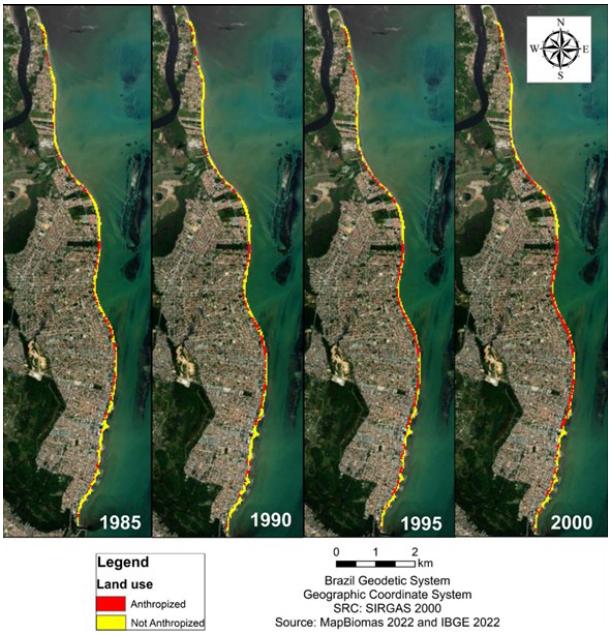

Figure 2 Land use and occupation of the 33-meter strip above the coastline of the municipality of Paulista for the years 1985, 1990, 1995 and 2000.

According to Din et al. (2017), the loss of morphological and typological identity is the result of informal occupations and constructions in the waterfront region, the landfilling of mangroves, subdivisions with speculative objectives, as well as the obstruction of access to the beach.

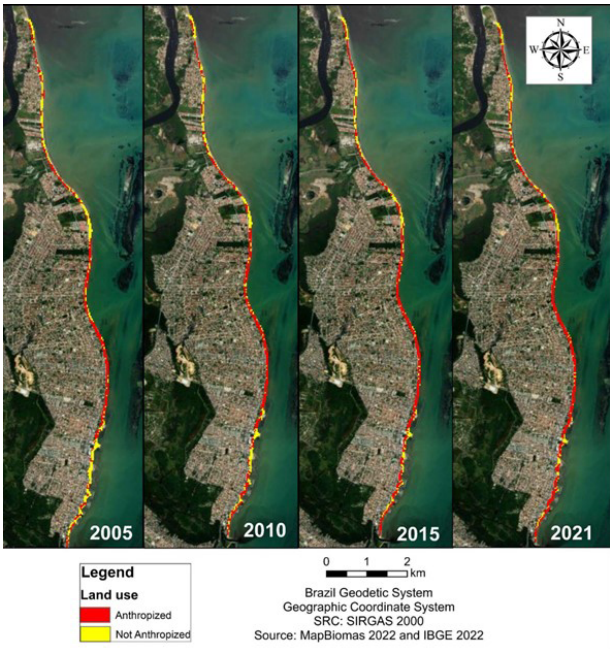

Figure 3 Land use and occupation of the 33-meter strip above the coastline of the municipality of Paulista for the years 2005, 2010, 2015 and 2021.

With regard to 2010, according to the map in Figure 3, there is an increase in the anthropized area in the southern portion of the Paulista waterfront. Regarding 2015, according to the map in Figure 3, there is a loss of almost all the non-anthropized area on the edge of the municipality of Paulista. In addition, it is possible to observe minor stretches with areas not yet occupied, with stretches of planned urban expansion and the presence of mangroves. Finally, according to the map in Figure 3, it was observed that, in the last studied year, 2021, the entire waterfront area is practically occupied by housing, urban equipment, in addition to other works built irregularly along this area. The municipality has defined the rules of Land Use and Occupation of the urban space, Municipal Law No. 3,772/03, with the adoption of urban criteria and through integration with the organic law of the Municipality and the Master Plan. This law has not been updated in order to be compatible with the changes implemented by the 2018 Participatory Master Plan, which emphasizes the observance of the recommendations of the ZEEC - Coastal Ecological Economic Zoning for the North Coast of Pernambuco in the process.

In this sense, the use of the area must meet the environmental goals foreseen for the waterfront, especially regarding the recovery of public areas, clearance of access roads, revitalization of the beach strip and monitoring of

coastal erosion. However, as found by Becker, Barboza and Martins (2021), in the municipality of Paulista there is invasion of APP areas by the urbanized zone.

The coastal strip of the municipality is comprised almost entirely in the ZAD – High Density Zone, where there is urban equipment and road infrastructure installed, so that law stimulates orderly occupation of the soil. The water pollution caused by the dumping of sewage and garbage in a relevant portion of the beaches of the municipality of Paulista is a result of the occupation carried out by residential and commercial condominiums that in large part do not meet the determination regarding the limit of 33 meters for fixing construction (Cabral, Silva & Girão 2014).

The growing anthropization of the area revealed in the historical series highlights one of the main problems faced by the municipality when it comes to coastal management, which is the issue of erosion and coastal works. On Janga Beach and on a significant part of Pau Amarelo Beach, there is a process of erosion, unlike Maria Farinha Beach (Figure 4), where gradual processes are evident. As a result, coastal erosion containment works have been carried out, mainly on the beaches to the south, resulting in a visible change to the natural landscape.

The first construction works carried out in the municipality were the construction of breakwaters and between 2012 and 2018 the construction of bagwalls, initially in Pau Amarelo. According to Silva, Mallmann and Pereira (2015), the transfer of erosion generated by the municipality of Olinda requires the construction of a set of works in Paulista. On this subject, they ponder the need to be careful when deciding to build rigid structures, taking into account the strong impact on coastal dynamics, as well as the direct impact on the budget item studied in the Decalogue. In 2021, the municipality began the Environmental Licensing process with the aim of installing rockfills on Janga beach, since the coastal protection structures using bagwalls have collapsed on some stretches of the shore.

The northernmost portion of the municipality's coastal area is characterized by high tourism, leisure and real estate potential (Medium Density Zone – ZDM). From the years analyzed, it remains an area of lower density and occupation, with the preservation of vegetation and medium-density construction standards, despite the encouragement of incentivized uses, provided for by law. Despite this, Nicolodi et al. (2018) warns of the impacts of seasonal tourism, as the seasonal flow of people and services to coastal areas significantly affects the distribution of water and electricity and affects waste collection.

As for the total area of the two classes of land use and occupation, that is, the anthropized area and the non-anthropized area, the results shown in Figure 5 indicated that the anthropized area decreased slightly between 1985 and 1986, followed by continuous growth until 2000, when it stabilized with little change. Subsequently, the anthropized area increased again, presenting a new stabilization between 2006 and 2012. There was considerable growth from 2013 to 2014, followed by a period of negligible growth.

Figure 4 Breakwaters of Maria Farinha beach. Source: Authors (2024).

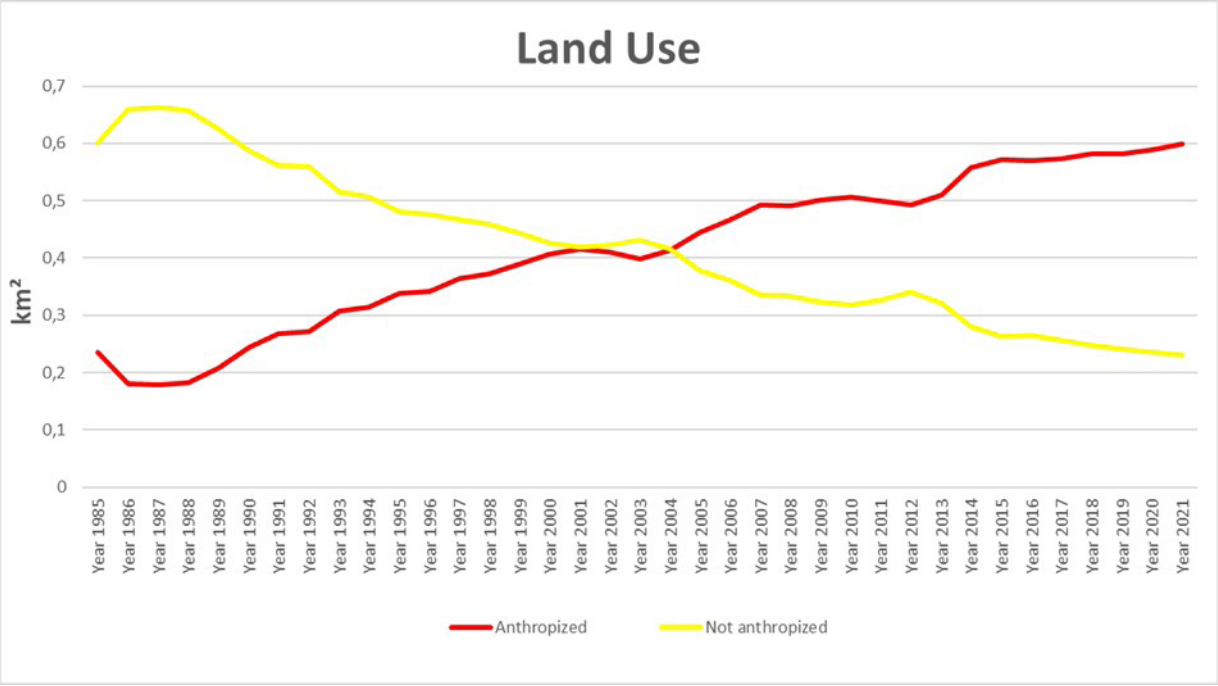

Figure 5 Evolution of the anthropized area x non-anthropized area of the edge of the municipality of Paulista.

According to Figure 5, there was a small increase in the unmanaged area from 1985 to 1986. After that, the area decreased steadily over the 36 years. It is also possible to see that there was a slight increase from 2011 to 2012 and then it continued to lose area.

In Paulista, the urban occupation is concentrated in the center and on the south coast. Thus, during the period studied, there was no significant change in land use, and the graph in Figure 4 shows growth in occupation towards the sea and consequently increased suppression of the coastal ecosystem and erosion processes. According to Nicolodi et al. (2018), Brazil has a historical deficiency in planning and organizing maritime space, with disputes between various social sectors.

In the municipality of Paulista, a relative stabilization of the anthropization of the coastal area is observed between 2001 and 2004, suggesting that the coincidence between the realization of relevant studies, aimed at regulating the north coast of Pernambuco, had an impact on containing the advance. A similar movement is observed between 2012 and 2013, when the Integrated Management Plan - PGI Orla was consolidated in the municipality. As discussed in the Decalogue, this plan is considered the main municipal management instrument directed to the coastal area, according to Sherer, Asmus and Gandra (2018).

As discussed in the Decalogue, the planning of interventions related to the coastal ecosystem of the municipality of Paulista is largely focused on erosion containment measures. Nevertheless, it is possible to see a persistence of the erosive process in the area under analysis, particularly on the beaches of Janga and Pau Amarelo. According to Rangel-Buitrago, de Jonge and Neal (2018), coastal erosion poses challenges to the quality of the coastal landscape and beaches, requiring significant financial investments in protection structures.

According to Barreto (2014), there is growing interest in the study of the geomorphological vulnerability of beaches located on the Pernambuco coast, especially in critical areas affected by coastal erosion, with the aim of providing managers with a basis for decision-making on this matter. The context of climate change increases the inherent challenges related to predicting trends in coastal erosion. According to Frohlich et al. (2021), adopting an adaptive coastal management approach allows managers to carry out more adequate coastal planning, avoiding decision-making in emergency situations, when the discretionary powers provided for in disaster and emergency management legislation are expanded.

In addition, according to data from Mapbiomas and IBGE, urbanized area had a gradual increase over the 36 years studied. As for the area of vegetation, there was

an increase from 1985 to 1986. The area of vegetation remained without any significant losses until 1990. After that year, the area of vegetation only decreased, showing a slight increase in 2007 and remaining linear until 2009, decreasing again until the last year of the studied series.

The temporal analysis of land use must take into account the social and economic conditions of the place studied. According to Barragán-Muñoz (2003), sustainable planning and management of the coastal zone require prior physical-natural, socio-economic and legal-administrative subsystems knowledge. With the loss of its industrial cluster characteristics, the municipality has undergone changes in occupational characteristics. It became a dormitory town, with a growing number of low-income residences built through investments in housing developments, and currently occupies a prominent position in the development context of the state of Pernambuco.

The weakness of specific legislation, coupled with poor urban control conditions, has led to a disorderly exploitation of the area under analysis. In this sense, the participation of civil society in decision-making as well as the allocation of effective sustainable education actions is essential for the preservation of the coastal environment. According to Nicolodi et al. (2018), the complexity of the coastal environment requires making the conservation of natural spaces compatible with the quality of life of the population as a way of valuing it from an environmental, economic, social, and cultural point of view.

4.2 Analysis of the Decalogue

Based on the methodological structure proposed in the Decalogue, the results corresponding to each indicator were presented as a way of assessing the degree of maturity of the municipality of Paulista in terms of coastal management. In order to optimize understanding, some items have been combined, as shown in Table 1.

In this way, several studies have utilized the Decalogue methodology as a support for coastal management in 17 countries, involving organizations participating in the Ibero-American Integrated Coastal Management Network (CYTED Project 2008–2012), in which Brazil is included. According to Scherer et al. (2019), the IBERMAR Network primarily aims to ensure the exchange of experiences and management in Latin America and Iberian countries, along with a cooperation program between them. Noteworthy works include those of Caviedes, Arenas-Granados and Barrangán-Muñoz (2022) in the Gulf of Honduras and Central America; Barragán-Muñoz (2003, 2010) in Latin America, the Caribbean, and Spain; Barragán-Muñoz and Lazo (2018) in Peru; Caviedes, Arenas-Granados and Carrasco (2014) in Honduras; and Fuentes, Granados and Martins (2018) in Mexico.

In Brazil, the Decalogue methodology was discussed and successfully applied by Scherer, Asmus and Gandra (2018) and Scherer and Asmus (2021). In the state of Santa Catarina, it was applied by Andrade and Scherer (2014), in Rio Grande do Sul by Gruber et al. (2014), in Rio Grande do Norte by Ibiapina and Aloufa (2019), and in Rio de Janeiro by Frohlich (2018). In the municipality of Florianópolis/SC, it was studied by Diederichsen et al. (2013), in Jaguaruna/SC by Becker, Barboza and Martins (2021), and in Biguaçu/SC by Pfuetzenreuter et al. (2023).

Scientific literature highlights the need for coastal municipalities to implement effective approaches to address the challenges associated with coastal management due to the higher vulnerability of these areas to the impacts of climate change. Therefore, the importance of the study is magnified as it is directly related to the urgent need to adopt effective measures in the current discussions on climate change. This approach not only resonates with the implementation of mitigation strategies but, above all, emphasizes the promotion of adaptive measures specific to each coastal locality.

The coastal management system of Brazil was evaluated by Scherer and Asmus (2021), highlighting a similar result found in the municipality of Paulista, which struggles with the difficulty of integrating coastal management components. On the other hand, it emphasized scientific information as an important data source for the manager's decision-making, reinforcing the need for continuous and systematic study of the coastal environment.

In the study conducted by Becker, Barboza and Martins (2021), the Decalogue methodology proved to be an efficient tool for addressing complex challenges related to land use mapping. This is especially considering the role of municipalities in the economic dynamics of the state and frequent conflicts in Permanent Preservation Areas. The study not only underscores the existence of a legislative framework but also emphasizes the importance of organic municipal management to ensure the effectiveness of laws. In this context, when applying the Decalogue in the municipality of Jaguaruna, researchers identified a harmonious relationship between the methodology and land use mapping.

Table 1 Analysis of the Decalogue for the municipality of Paulista/PE

Aspect	Valuation	Weaknesses	Fortresses
Public Policy	2	The municipality does not have a public policy on coastal management.	The municipality follows the guidance of the National and State Public Policy on Integrated Coastal Management. Existence of sectoral Public Policies focused on solid waste management and climate change.
Normative	4	Existing regulations should be reviewed, especially regarding the PMGC. Increase in normative acts without the necessary integration with other actions related to coastal zone management.	Existence of Law No. 4.726/17, which guides the preparation of the PMGC. The municipality has its own legislation for certain instruments, such as the Orla Project.
Competencies	4	The powers assigned to municipal coastal management have not been fully exercised by the public authorities.	The municipality has established the competences for coastal management, even without a specific law on the subject, following state and federal definitions. The competent body is part of SISNAMA.
Public Institutions	3	Little integration between institutions working in coastal management. Absence of a governance system capable of fostering articulation between the parties involved.	Presence of public institutions to work with coastal management. In the municipality there is an individual with great knowledge about coastal management in the agencies with related work on the subject. Existence of a control body and non-governmental institutions in the supervision of actions related to the theme.
Tools and Strategies	3	The municipality has not developed or implemented important instruments	The municipality's legal regulations define the instruments and strategies for coastal management. It has implemented the ZEEC and the PGI - Orla
Training and Capacity Building	1	The municipality lacks actions aimed specifically at capacity building for coastal managers.	In the municipality there are no universities able to provide training for coastal management. The municipality benefits indirectly from academic courses located in the State.
Resources	2	There is no specific budget allocation for the preparation of the PMGC in the PPA (2022 to 2025). SEMMA has a reduced technical team for actions related to coastal management.	Capacity of the municipality to attract federal and state resources to carry out coastal works. Existence of resources in the Municipal Environment Fund that can be allocated to actions related to the coastal environment.
Knowledge and Information	4	The knowledge generated on socio-economic aspects and public policies for coastal management exists at an intermediate level. There is a gap in the availability of information and data in a clear and accessible way on the municipality's communication portals.	The municipality is inserted in an area of the state of Pernambuco with great academic production of basic information for coastal management. Existence of quality technical studies, such as EIA/RIMA and Socio-environmental Diagnosis of the north coast. The municipality has a digital portal suitable for disseminating information and propagating actions related to the coastal zone.
Education for Sustainability	3	In the scope of Coastal Management there are no education actions for sustainability.	In the municipality there are isolated actions aimed at education for coastal and marine sustainability. The NGOs established in the municipality develop projects related to the theme.
Participation	3	There is still little culture of participation in decision-making. Documents and studies are not easily available to the population.	The municipality has a participating structure in place, especially in the licensing processes for coastal works. Equal popular participation in the composition of the Municipal Environment Council.

Source: The author, adapted from Andrade and Scherer (2014).

The results of the diagnosis and evaluation of the management structure of the mentioned municipalities from the Decalogue coincide with those found at the federal level, as they identify important strengths related to the legal framework and established institutional competencies. In the state of Santa Catarina, after the application of the method, normative aspects received a higher score, as it has specific legislation for coastal management and instruments such as the Orla Project. Additionally, the information item reinforces the existence of a good academic production related to the coastal area. In the municipality of Florianópolis, it is important to highlight the relevant scientific production, contributing to knowledge about marine and terrestrial coastal systems. In Biguaçu, attention is drawn to the normative and competency aspects.

In the application of the Decalogue proposed by Becker, Barboza and Martins (2021) in the municipality of Jaguaruna, there is an association of the Decalogue methodology with land use mapping, given the significant role of the municipality in the economic context of the state and frequent conflicts in Permanent Preservation Areas. The study revealed the existence of an important legislative framework but was deemed ineffective in the face of inefficient municipal management.

4.3 Public Policy and Regulatory Framework

In the state of Pernambuco, an effective public coastal management policy was established through State Law 14.258/2010. The state's specific legislation includes the Ecological-Economic Zoning of the South Coast (State Decree No. 21.972/99) and the North Coast (State Decree No. 24.017/02); it also includes State Decree No. 34.387/09, which establishes the State Technical Commission for the Waterfront Project in the State of Pernambuco - CTE/PE, and State Decree No. 35.709/10, which establishes the Pernambuco Coastal Management Forum.

Even though the municipality of Paulista has a Municipal Coastal Management Plan - PMGC, established by Law No. 4.726/17, which mentions the PNGC and PEGC as its foundations, it does not have a Municipal Coastal Management Policy. The two-year deadline for drafting the PMGC, established by Art. 25, single paragraph, of the aforementioned law, has not been met yet. Therefore, like the result found by Diederichsen et al. (2013), the municipal law represents a programmatic norm for the PMGC, establishing its objectives and guidelines.

In the municipality evaluated, the Climate Change Policy, Law No. 4,546/2015, stands out as one of the sectoral policies related to coastal management (Paulista 2015). The municipality incorporates concepts of adaptation, which involves measures to reduce the vulnerability of natural and human systems to the present and future effects of climate change, and mitigation, which includes strategies to reduce greenhouse gas emissions and increase sinks. The formulation of climate policies is considered by the authors Scherer et al. (2019) to be one of the main advances related to the interests of the coastal zone.

Moreover, Paulista has approved the Participative Master Plan, approved by Complementary Law No. 4.253/2012 and revised by Law No. 4.821/2018, and the Integrated Solid Waste Management Plan, strengthening actions in the coastal zone.

In practice, the main municipal actions for coastal management are focused on containing sea erosion and restructuring the damage over time. Important maritime defense works were based on emergency decrees issued by the head of the municipal executive branch, which may indicate a lack of continuity between governments and hinder coastal management.

In this context, it is necessary to address the lack of continuity between municipal governments and promote a more effective and sustainable approach to coastal management. This involves adopting measures that encourage social participation, institutional integration, and investment in prevention and environmental education. These actions can contribute significantly to the protection and sustainable development of municipal coastal areas.

4.4 Competence and Public Institutions

National legislation requires integration between the federal, state and municipal levels for coastal management. Coastal zone management is the responsibility of the bodies linked to the National Environment System (SISNAMA), coordinated by the Ministry of the Environment. In the municipality of Paulista, the municipal environmental agency is responsible for coordinating, managing and updating the Municipal Coastal Management Plan (PMGC), with the support of the Integrated Municipal Management Committee (CGMI), which has yet to be created. The lack of this committee focuses discussions on coastal management on the Integrated Waterfront Management Plan (PGI-Orla) and the Municipal Environment Council.

The Executive Secretariat for the Environment (SEMMA), linked to the Secretariat for Urban Development, Technology and the Environment and a member of SISNAMA, is responsible for coastal management initiatives, although the Executive Secretary does not have

financial and budgetary autonomy. However, SEMMA does not have a specific team to deal with coastal management, although it does have qualified professionals on its staff. On the other hand, the Infrastructure Secretary, responsible for preparing and carrying out structural works in the coastal zone, has individuals with specific knowledge of integrated coastal management. The level of qualification and multidisciplinarity of the civil servants in the two secretariats is noteworthy.

The CONSEMA/PE Resolution 001/2022 altered the rules for licensing and supervising construction works and activities to contain coastal erosion, which made it impossible to renew the Delegation Agreement signed by the CPRH with the municipality of Paulista, which allowed the municipality to carry out licensing for coastal intervention works and the advance of the sea with a local impact. In this respect, the institution's capacity to manage the coastal zone has been diminished.

In summary, the municipality of Paulista must act proactively and strategically to address changes in licensing rules and supervision of coastal erosion control works. This involves seeking viable alternatives, negotiating with involved parties, strengthening institutional capacity, and engaging the local community.

4.5 Tools and Strategies

Federal Law 7.661/88 and Federal Decree 5.300/04 establish the coastal management instruments, which must be applied in an integrated manner with state and municipal guidelines (Brasil 1988b, 2004). These instruments include the National Coastal Management Plan (PNGC), the State Coastal Management Plan (PEGC), the Municipal Coastal Management Plan (PMGC), the Integrated Waterfront Management Project (Orla Project) and the Ecological-Economic Coastal Zoning (ZEEC). In the state of Pernambuco, the ZEEC and the Orla Project are mentioned as territorial planning and management tools. State Decree No. 42.010/15 establishes environmental protection criteria, such as non-building areas within the coastal strip. The Municipal Coastal Management Plan of the municipality of Paulista includes instruments such as the Participatory Master Plan, the Orla Project, SIGERCO, SMARCO, ZEEC and SIMGERCO, the latter part of the National Information System for Coastal and Marine Management (SIGERCOM).

The municipality of Paulista has not implemented the Municipal Coastal Management Information System (SIGERCO) and the Municipal Coastal Environmental Monitoring and Assessment System (SMARCO). The Municipal Participatory Master Plan of Paulista establishes principles to order municipal development, such as the social function of the city, social function of property, urban sustainability and democratic and participatory management. The Coastal Ecological Economic Zoning (ZEEC) in the South and North Sectors of Pernambuco has been implemented and represents an important instrument to guide local planning and harmonize public policies related to Integrated Coastal Zone Management (ICZM). However, the ZEEC of the North coast was not submitted to the analysis of the Municipal Council of Environment of the municipality of Paulista and the lack of updating brought conflicts with the delimitations of zones and subzones presented by the Master Plan.

The municipality of Paulista has joined the Integrated Waterfront Management Project (PGI - Orla) and drew up the Orla Project in 2013, with guidelines for the use and occupation of the waterfront, supporting decision-making by municipal managers (Paulista 2013).

According to Scherer, Asmus and Gandra (2018), it is the instrument most often targeted by coastal states and municipalities, despite being incompletely implemented. Nevertheless, by delegating attributions to the local level, the decentralized model proposed by the PGI - Orla generates an overlap of competences in the coastal and marine zone (Costa, Asmus & Sales 2020).

However, the PGI Orla of the municipality of Paulista has been inactive since 2019, when it was most recently implemented, weakening the intentions of the instrument. Another related weakness is the unavailability of information and documents via the Municipal Portal, which makes it impossible for the other parties involved to know and control them.

Finally, it is important to point out that the environmental management instruments set out in Federal Law 6.938/1981 are also relevant to the coastal area, especially the assessment of environmental impacts, environmental licensing, and the creation of protected spaces. Even so, Paulista has a Socio-Environmental Diagnosis for the North Coast, carried out by the state's Environmental Agency (CPRH 2003).

It is important to note that in Paulista there are 7 municipal and 3 state Conservation Units, of which 2 are coastal, titled in 1986 as the Environmental Protection Area - APA Estuarina do Rio Timbó and the other the Rio Paratibe. These municipal protected areas do not have a Management Plan, nor does the municipality have a Waterfront Management Plan. In this respect, the municipality has made relatively limited progress, despite the understanding of Scherer et al. (2019) that the creation of Coastal-Marine Protected Areas is an important step forward in coastal management.

To resolve the identified gaps, the municipality of Paulista should prioritize the development of Management Plans for its municipal conservation units, such as the Estuarine APA of the Timbó River and the Paratibe River. These plans are intended to guide conservation actions and promote sustainable use of natural resources. Additionally, it is essential to develop a comprehensive Coastal Management Plan, involving the local community, seeking financial resources, and establishing monitoring systems to enhance the protection and proper management of coastal areas. This should align with state and federal environmental conservation guidelines.

4.6 Training and Capacity Building

The National Policy for Marine Resources (PNRM) aims to improve human resources for Coastal Management, improving the quality of undergraduate and graduate programs and research in marine sciences and the engagement of professionals (Andrade 2013). Pernambuco's Coastal Management Policy provides support for the training of municipal officials in the coastal zone, in accordance with its specific objectives, which helps to strengthen the technical staff related to coastal management in municipalities.

Training in coastal management covers several study areas, including exact sciences and humanities. Pernambuco offers courses related to the theme in teaching and research institutes, such as Geography, Oceanography, Environmental Engineering, among others. The universities UFPE, UPE and UNICAP play an important role in training professionals from this area. The state also offers a postgraduate course in environmental technology at ITEP/OS, with a line of research specifically focused on Integrated Coastal Management, which benefits the municipality (ITEP 2012). However, in the municipality of Paulista, the offer of specific courses is limited, with the exception of the technical course in Environment of SENAC - National Service of National Learning. Training initiatives for municipal public managers for coastal management are insufficient and not continuous.

Given the above, it is opportune to highlight that the municipality of Paulista should, in turn, enhance the training of personnel in coastal management through partnerships with educational institutions such as UFPE, UPE, and UNICAP universities. This involves developing specific training programs and utilizing available state and federal resources. Additionally, the municipality can promote technical and vocational courses in collaboration with SENAC, establishing continuous training programs to ensure that employees are up-to-date with the best practices in the field. These initiatives would strengthen the municipality's capacity to effectively manage coastal areas, promote sustainable development, and address the demands of the National Policy for Marine Resources and the Coastal Management Policy of Pernambuco.

4.7 Economic Resources

In Paulista's Municipal Coastal Management Plan, funding sources for coastal activities are not specified. The plan relies on partnerships and contracts to achieve its objectives, potentially accessing funds from federal, state, and private sources. However, the Multiannual Plan for 2022–2025 predominantly assigns coastal management responsibilities to the Infrastructure Department, focusing on coastline protection. Notably, there's no dedicated funding in the Department of Urban Development and the Environment, revealing a gap in structured public policy for coastal sustainability.

The Multi-Year Plan of the Municipality of Paulista for the quadrennium 2022/2025 includes the Coastal Valorization Program, aimed at promoting the enhancement of the coastline through improvements to its tourist infrastructure. This program outlines an allocation of approximately R$ 25,873,681.00 (twenty-five million, eight hundred and seventy-three thousand, six hundred and eighty-one Brazilian Reais) for the Coastal Project and R$ 2,155,063.00 (two million, one hundred and fifty-five thousand, and sixty-three Brazilian Reais) for actions on coastal protection works against the advance of the sea.

However, there is no provision of detailed information about the so-called Coastal Project and the planned protection works, such as the location of interventions and sources of funds, whether from the municipal budget, external sources, or through loans from financial institutions.

It is worth noting that between 2011 and 2014, the Municipality of Paulista received approximately 26 million from the now-extinct Ministry of National Integration for emergency coastal protection works designated as bagwall. Due to the collapse of structures in some sections, the municipality is currently executing, with its own funds, a Recovery Project for Coastal Structures, involving adherent revetments and drainage, in areas considered emergency zones in Janga and Pau Amarelo. As of the completion of this work, there has been no budget execution as the project was in the phase of obtaining licenses for the implementation of the works. The municipality has an existing financing agreement with Caixa Econômica Federal, with provisions for coastal protection, although the funds have not yet been utilized.

As for environmental Education, the Multiannual Plan allocates resources to the Urban Development, Housing and Environment Secretary, but does not specify actions related to the coastal environment. For specific projects, it is common to seek opportunities on the +Brasil Platform through proposals for agreements. However, no projects were found that were aligned with the coastal management instruments in the Municipal Coastal Management Plan. In the past, the municipality received funds for emergency coastal protection works and is currently implementing a project with its own funds for coastal recovery and protection on the beaches of Janga and Pau Amarelo.

There are no voluntary contributions from the private sector for socio-environmental actions related to coastal management, nor have any resources from environmental compensation been identified for the coastal environment. The study conducted by Kong et al. (2021) highlighted the compensation of marine ecological damage as an effective mechanism for protecting the marine environment, involving payment for damage caused or the provision of environmental services, such as the replanting of mangroves.

The municipality of Paulista has resources from the Municipal Environment Fund, created to support initiatives of environmental interest, but no specific transfers were listed for the study's analysis. Similarly, there is a lack of information on strategies for the coastal zone for the use of ICMS ecologic by the Pernambuco state government.

In this context, it should adopt a proactive approach to improve economic resource management and promote coastal sustainability. This may include actively seeking diversified sources of funding, developing specific resource mobilization projects, and engaging in public-private partnerships, as well as strengthening the integration of coastal management into municipal budget plans. Additionally, it is crucial for the municipality to raise awareness about the significance of coastal conservation and environmental education, aiming to ensure the protection of Paulista's coastal areas for future generations.

4.8 Knowledge and Information

Pernambuco has made a significant contribution to academic studies on the coastal environment, as found in Barreto (2014) and Mallmann, Araújo and Droguett (2014) and Câmara, Holanda and Costa (2023). Coastal management in Paulista is approached in a sectoral way, focusing on physical-natural aspects and limited in relation to integrated management, as found in Andrade and Scherer (2014). In the municipality of Paulista, however, there are no higher education institutions specializing in marine and terrestrial coastal systems.

On the other hand, it is important to highlight that the production of scientific knowledge is not the only criterion assessed, as pointed out by Diederichsen et al. (2013). It also evaluates non-scientific production, as long as it is related to Coastal Management, as well as the way in which knowledge is brought to society. In other words, how accessible the data is to the population. Information related to Coastal Management is made available to the population through the virtual portal of Paulista City Hall, including legal information in accordance with the Access to Information Law, as well as general data on the coastal environment. The population also has access to the Municipal Ombudsman service, available in person, by telephone or by e-mail, as mentioned by Pfuetzenreuter et al. (2023).

An agreement was signed between the city of Paulista, the Federal University of Pernambuco (UFPE), and the UFPE Development Support Foundation (FADE/UFPE) to monitor and simulate coastal dynamics in the city. Despite the fact that the agreement has expired, the results have contributed to the technical improvement of managers. The Socio-Environmental Diagnosis of the North Coast of Pernambuco (CPRH 2003) and the Environmental Impact Study/Environmental Impact Report (EIA/RIMA) for the Recovery of the Waterfront in the municipalities of Jaboatão dos Guararapes, Recife, Olinda and Paulista, drawn up by the Pernambuco Institute of Technology (ITEP 2012), stand out for organizing and making information available to managers and society.

However, these studies face criticism due to the lack of updates, as well as the absence of a systematized database accessible to the public on the municipal websites. Therefore, it is necessary to carry out constant research and compilations to keep the data up to date.

In this perspective, the municipality of Paulista should adopt measures to enhance access and availability of information related to coastal management. This includes implementing a publicly accessible database system and promoting transparency in disseminating information about the coastal environment. Additionally, it is essential to strengthen partnerships with academic and research institutions, such as the Federal University of Pernambuco, to continue monitoring and assessing coastal dynamics, ensuring that municipal managers have access to the latest research and studies to inform their decisions. By investing in the training of its staff and improving communication and information dissemination processes, the municipality of Paulista will be taking a significant step towards more efficient and transparent coastal management, in line with the best practices and governance standards.

4.9 Education for Sustainability

The state of Pernambuco implemented the Environmental Education Policy (PEA) through Law No. 16.688/2019, in line with the National Environmental Education Policy (PNEA), providing foundations for educational actions related to the environment.

However, the municipality of Paulista does not have a specific education policy for coastal and marine sustainability. Despite this, the municipality has an authorization from the Chico Mendes Institute for Biodiversity Conservation (ICMBio) to manage the Sea Turtle Monitoring and Conservation Project in Paulista/PE. This authorization includes Environmental Education and Monitoring actions and training for the professionals involved (Paulista 2021).

There are also occasional initiatives in the elaboration of educational material related to the coastal zone, as well as its correlated dissemination - being it formal or informal. Thus, even though the municipality does not have its own municipal program for this purpose, it arouses the interest of several actors on environmental education issues through internal programs developed by the Centers of the Executive Secretariat for the Environment. The SEMA project in schools stands out, which brings environmental education to the main multipliers, the children.

Therefore, the municipality of Paulista should develop a specific policy for education on coastal and marine sustainability, aligned with the National Environmental Education Policy (NEEP) and the Environmental Education Policy (EEP) of the state of Pernambuco. This may include the creation of educational programs focused on marine and coastal conservation, as well as the promotion of partnerships with local institutions and governmental organizations to implement awareness and environmental monitoring actions, ensuring community participation and engagement of various stakeholders in the protection of the municipality's natural resources.

4.10 Participation

Popular participation is a consequence of the Democratic Rule of Law and essential to collect information on problems faced by the population and direct actions to solve them. Popular participation in the management of the sea includes the involvement of various social actors in the preparation and implementation of the ZEEC, Participatory Master Plan and PGI Orla. Municipal Law No. 4,726/17 provides for popular participation in the process of preparing the PMGC, whose legitimization will be ensured during the phases of the process.

Within the Municipal Environment Council, popular participation is guaranteed by law, with equal representation, and the participation of the State and Federal Public Prosecutor's Offices as guests, exercising a supervisory role, stands out. Although it is not a specific coastal management body, the participation of popular or community organizations in decisions related to the area is assessed positively. However, the municipality faces difficulties in providing relevant information about the coastal environment, which has an impact on encouraging participation and environmental education. These limitations reflect the lack of a culture of public participation, as pointed out by Scherer et al. (2019).

Paulista has a significant involvement of Non-Governmental Organizations (NGOs) in issues related to the coastal environment, as described by Kong et al. (2021). The *Meu Mundo Mais Verde* Institute stands out for its work in training stakeholders and volunteers, as well as promoting ecological awareness through the "Reviveirando" and "Restinga" projects. These initiatives aim to protect the coastal ecosystem by mapping degraded areas for scientific purposes.

5 Conclusions

The Federal Constitution grants the coastal zone a protection linked to preservation and sustainable development, in order to guarantee a balanced environment for future generations. In this context, local entities have a fundamental role in the management of these spaces, since the intense process of urbanization of coastal areas has given them significant socio-environmental problems. And since it occupies a prominent position in the development context of the state of Pernambuco, the analysis of the coastal management structure adopted by the municipality of Paulista becomes even more relevant.

The main results obtained from the analysis of coastal management in the municipality of Paulista revealed the lack of implementation of instruments and strategies, the deterioration of environmental quality and the direct impacts on the physical and natural environment. From the proposed method it is possible to state that overall coastal management in the municipality of Paulista is at an early stage of development, despite the existence of most of the aspects analyzed by the Decalogue.

It is important to prioritize the coastal environment and related actions in the public agenda and planning, which translates into a continuous improvement of these aspects.

Once the problems and challenges have been identified, concrete measures can be taken to improve coastal management in the municipality of Paulista. Particular attention should be paid to updating legislation and official documents related to the coastal environment, as well as strengthening the human, technological, and financial resources allocated to coastal management.

It was also clear how important it is for civil society to participate and be involved in the coastal management process, from understanding the intentions of the public authorities to legitimizing decision-making. Conflicts of interest over the development model in the municipality can sometimes prevent people, the scientific community, and non-governmental organizations from participating in the process. It is therefore necessary to promote the active and collaborative participation of all actors in order to guarantee the sustainability and effectiveness of actions.

Given the primacy of municipal autonomy in the integrative and sustainable process, it is important that local actions are aligned with national policies and relevant legislation. The integrative approach, which involves the various players at all levels of government, makes it possible to achieve effective results in the integrated coastal management process. It is essential that there is a convergence between political and technical understanding, especially when interventions with rigid engineering structures are required since the discontinuity of public positions ends up interrupting the cycle of the public policy adopted.

The future use of the proposed method will allow for a new evaluation and correction of actions, as a way of guaranteeing the improvement of coastal management in the municipality of Paulista. A key part of the strategy is the implementation of impact mitigation measures, the strengthening of inspection and monitoring, the development of climate change adaptation strategies, the promotion of environmental education, and the promotion of scientific research in the coastal area.

Therefore, that promoting integration among various stakeholders involved in coastal management is crucial. In this regard, the active participation of civil society can play a fundamental role in promoting sustainability and effectiveness in coastal management actions. Through the active engagement of the local community, the scientific community, and non-governmental organizations, it is possible to ensure a more transparent, inclusive, and responsible management of coastal resources. Civil society participation also contributes to legitimizing decision-making, promoting environmental awareness, and enhancing monitoring and oversight of coastal activities. Therefore, it is essential to foster and strengthen this participation by creating spaces and mechanisms that allow effective engagement of diverse social actors in the management and preservation of the coastal environment.

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Conflict of interest

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