Geodiversity, Geoheritage and Geotourism

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Concepts and Examples in João Pessoa, Brazil

By

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The true heritage is not only what we receive from the past but also the legacy we leave for the future. The narrative written in the rocks and the promotion of geotourism are ways to read and understand this history.

(The authors)

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LIST OF ABBREVIATIONS

AP	Permanent Preservation Areas
BR	Federal highway
CPRM	Brazilian Geological Service
DNOS	National Department of Sanitation Works
DNPM	National Department of Mineral Production
DRM/RJ	Department of Mineral Resources of Rio de Janeiro
IPHAEP	Institute of Historic and Artistic Heritage of Paraíba
IPHAN	National Institute of Historic and Artistic Heritage
IUCN	International Union for Conservations of Nature
MEA	Millennium Ecosystem Assessment
MINEROPAR	Geological Service of Paraná
MMA	Ministry of the Environmente
NGO	Non-governamental organizations
PB-008	State road
PROBIO	Brazilian Biological Diversity
PRONABIO	National Biodiversity Program
SIGEP	Brazilian Commission of Geological and Paleobiological Sites
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization

PREFACE

It is with great enthusiasm that we present the preface of *Geodiversity, Geoheritage and Geotourism: Concepts and Examples in João Pessoa, Paraíba, Brazil*. This book emerges at a crucial moment for the understanding and appreciation of the abiotic resources that shape our planet, offering a comprehensive and enriching perspective on how these elements can be explored sustainably and educationally.

The importance of abiotic heritage is unquestionable; it not only defines the landscape we inhabit but also carries profound cultural and scientific value. The geological richness of the Brazilian Northeast, particularly the city of João Pessoa, serves as a fascinating and inspiring example to understand the interconnectedness of geology and tourism. This book provides an in-depth dive into the nuances of geoheritage and explores how it can be integrated into geotourism in a way that respects and values the integrity of natural resources.

The concepts discussed in this book are approached with clarity and depth, reflecting both the academic knowledge and passion of the authors for the subject. Through detailed analysis and practical examples, the book reveals how abiotic heritage can not only enrich the tourist experience but also promote greater environmental awareness and preservation.

João Pessoa, with its rich geological heritage, offers an ideal stage for the exploration of these ideas. The examples presented in this work are not just theoretical illustrations but case studies that show how theory can transform into practice, bringing tangible benefits to the local community and visitors alike.

I hope this book inspires both professionals and scholars to reflect on the importance of abiotic heritage and to consider new ways to promote tourism that respects and values our natural heritage. The journey through the reading of this book promises to be as enriching as the very exploration of the resources it addresses.

May this work serve as an invitation to discovery, reflection, and conscious action in the preservation of our geological and natural heritage.

With appreciation.

CHAPTER 1

INTRODUCTION

Every element of geodiversity that is important for the dissemination of Earth Sciences, with particular economic, pedagogical, scientific, and cultural interest, among others, meaning they possess values that make them unique, constitute the geoheritage of a location (RODRIGUES AND FONSECA, 2008). Especially in urban and coastal areas, places with higher population density, this abiotic heritage tends to present traces of a geological and geomorphological history that have an intrinsic relationship with the human environment, as they become the substrate for the consolidation of the urban site or their georesources are used for the construction of buildings, such as churches, houses, street paving, among others.

The existence of an interaction among various elements that play an important role in the entirety of urban and coastal systems is clear, including physical, economic, social, and cultural elements. In the case of early cities, the flourishing near riverbeds, which provided water to supply the population and irrigate crops, as well as the choice of a flat surface with fertile soil or the presence of an elevation for the construction of a defense apparatus, denote the importance of the physical environment for the structuring of these settlements. Portuguese colonial cities in Brazil replicated the patterns of cities in Portugal since the 13th century (HOLLANDA, 2000), meaning they had a divided layout into lower and upper cities, whose division reflected the political-economic activities of the time: the lower city designated for commercial activities and the upper city for defense and functioning as an administrative center.

The geographical positioning of cities was thus the result of planning, and the strategy for the consolidation and expansion of João Pessoa, then known as Nossa Senhora das Neves, at the end of the 16th century, was no different. Factors such as the threat of French invasion and the need to safeguard against resistant indigenous settlements marked its positioning on top of the hill, overlooking the river plain, and the expansion towards the coast occurred late, only in the first half of the 20th century, when functionality diversified, including as a national tourist destination. Also

here, the abiotic natural landscape, including specifically the beautiful coastal relief forms, which show the shaping effects of coastal geodynamics, constitutes a valuable contribution of paleoclimatic and paleogeographical information and induced tourism to the region.

The role of geoheritage in the tourist activities of those who visit the region researched in this book is undeniable. João Pessoa has been consolidated for decades as a mass tourism destination, focused on 'sun and sea' tourism, where people seek to enjoy and relax on its paradisiacal beaches, with the cultural heritage of the Historic Center being a complementary destination. Daily, during the high season, dozens of buggies depart for the southern coast carrying tourists eager for landscape appreciation. Upon returning from the tour, they are satisfied with the aesthetic beauty of the visited sites, but without knowledge of this geoheritage from a scientific point of view, and consequently, without the proper awareness of environmental protection of the visited sites. The same occurs with tourist routes through the Historic Center, which mainly focus on the history and architecture of the buildings, neglecting the cultural landscape and the elements of geodiversity associated with them. Thus, those who visit such places have an incomplete visual perception of the location, disconnected from a geoheritage discussion, since, most of the time, they are unaware of the geological and geomorphological features that attracted them to the region.

Geotourism is a niche tourism that seeks to rescue for future generations those destinations that are not traditional or to give a new look to conventional tourism, as a new product and a new tourist experience. By associating elements of geodiversity and geoheritage with cultural ones, it aims to integrate them into the tourist context (AROUCA DECLARATION, 2011), which may happen in the 'sun and beach' tourism of the Paraiban coast, or in the 'cultural tourism' of the Historic Center, aiming to promote geodiversity and, especially, its geoheritage, respecting local culture and traditions and striving to increase the quality of visits. Thus, not only habitats and ecosystems will be preserved, but also the cultural elements that are part of the local identity, by diversifying and complementing its tourist offer.

Paraíba corresponds to the most eastern state of the Northeast Region and, therefore, of the country. The area covered by the development of this book includes, in its entirety, the municipalities of Cabedelo and João Pessoa to the north, and Conde in the central portion, partially combined with the municipality of Pitimbu to the south, totaling an area of 515 km2, as visualized in Figure 1-1.

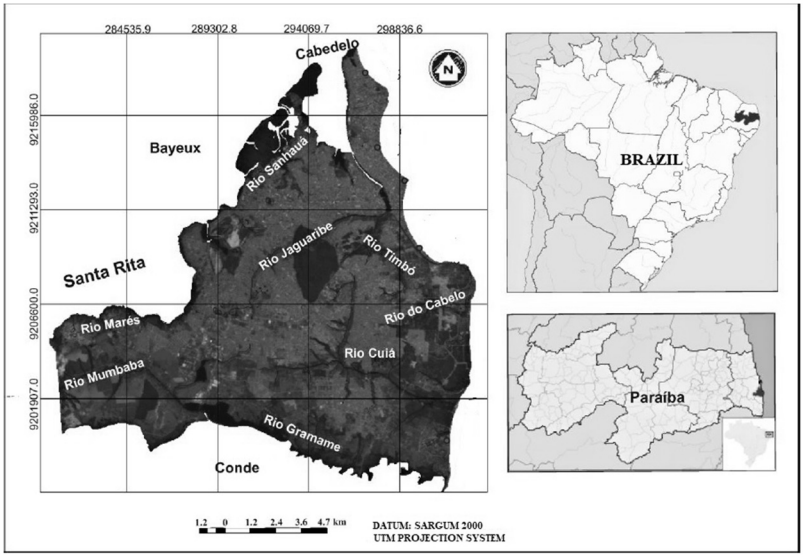

Figure 1-1-Location of João Pessoa, Paraíba.

The area is bounded to the northwest by the municipalities of Santa Rita and Bayeux; to the southwest and south by the municipality of Conde, all belonging to the Metropolitan Region of João Pessoa; to the east by the Atlantic Ocean; and to the north by Cabedelo. The city has good accessibility conditions, with two federal highways (BR) standing out: BR-101, running north-south, connecting the capital to Recife in the south and Natal in the north; and BR-230, running east-west, linking the capital to the interior of the state, passing through Campina Grande, the main municipality in the interior. Additionally, there is a state highway (PB), PB-008, connecting the capital to the southern coast.

João Pessoa was selected for this study based on tourist and historical criteria: i) it is the main tourist destination in the state, although nationally it plays a secondary role; ii) the main tourist flow is directed towards the southern coast, to the detriment of the northern coast, according to the analysis of tourist documentation about the area, which can be justified by the difficulty of access to the northern coast caused by the presence of the Paraíba River, which acts as an obstacle; and iii) one of the main motivations for visiting the region is the natural attractions, combined with a centuries-old history.

Once the potential of geotourism for boosting the economy, promoting geodiversity, and raising environmental awareness is recognized, the big

question is whether João Pessoa has the potential for geotourism activities to be implemented there. In this case, to achieve sustainable tourism, which is based on the concept of sustainable development, namely an activity that meets the needs of the present without compromising the ability of future generations to meet their own needs, it is necessary to map the geodiversity and its geoheritage and the related cultural heritage. The aim of this book is to provide a theoretical framework on the triad of geodiversity-geoheritage-geotourism, as well as to showcase examples of geosites in the city and a geotourism itinerary along the municipality's coastline, and serve as an example for similar studies in other cities in Brazil and around the world.

João Pessoa, besides being the most populous municipality in the state of Paraíba, accounting for about 20% of its population, approximately 800 thousand inhabitants, is a 100% urban municipality. Thus, every day, thousands of people travel through the Historic Center or view its coastal geoheritage without intertwining this beautiful geoheritage with its culture and history, which are deeply rooted in its identity. Geotourism, therefore, also has the role of strengthening the bonds between the community and the associated cultural landscape, helping to create in the local population feelings of identity with the city, the region, and even the country itself.

The tourist activity in João Pessoa is well-established, based on its emblematic privileged location as the 'easternmost point of the Americas', in a sunny tropical climate, with a dry summer, and in a natural landscape with internationally renowned elements, such as the famous 'Ponta do Seixas' and Solon de Lucena Park, among others. Coupled with a rich history and a beautiful cultural heritage dating back to the end of the first century of colonization, as it is the third oldest city in the country.

The mapping of the geotouristic potential of the Historic Center of João Pessoa still is in a initial phase in the Geosciences (PEREIRA, 2019), and the development of geotourism provides an opportunity to promote a unique identity for the city. The knowledge of the cultural heritage of João Pessoa and its surroundings is extensive (BARBOSA, 1953; AGUIAR and MELO, 1985; TARGINO, 2003; among others), lacking the filling of a gap associated with the knowledge of the raw materials that sedimented the urban settlements of this capital, their origin, mineralogical and textural characteristics, age, and provenance, as well as those of the elements of geodiversity and geoheritage, from the perspective of Cultural Landscape.

Added to this, we have the fact that, from a geological, geomorphological, pedological, and hydrological point of view, mapping in the area was carried out primarily for scientific, economic, or environmental purposes, including, in some cases, at a detailed scale. However, none of these works were executed with a heritage vision or for geotouristic purposes, a reason

that also justified the elaboration of this book, so that this knowledge could be shared with the local community, students, researchers, and tourists as a tool for the dissemination of Geosciences, with emphasis on local geodiversity and geoheritage, and as a promoter of development and geoconservation.

In summary, the central objective of this book was to recognize the importance of certain elements of geodiversity and geoheritage for the consolidation and urban expansion of João Pessoa, as well as to map the abiotic environment and cultural heritage of the area, with the aim of proposing new urban and coastal geotouristic routes, in order to add value to the already traditional tourist activities of 'sun and sea' and 'cultural' developed in the city. Indirectly, this research aims to disseminate themes of Geosciences, specifically about the local geodiversity and its heritage significance, as well as the cultural landscape that surrounds it, to visitors and the community at large, to assist in the preservation and conservation of the mapped geoheritage for future generations through sustainable tourism and to promote all the positive consequences, whether from an economic perspective or from a structural point of view, that tourism activity entails by incorporating the elements of geodiversity into its context, which previously participated in the process unconsciously, now elevated to a higher status of relevance.

CHAPTER 2

THEORETICAL FRAMEWORK

2.1. Geodiversity (concepts, values and threats)

Concepts

The term 'Geodiversity' emerged in geoscientific literature in opposition to the concept of 'Biodiversity', where the role of biologists, particularly ecologists, was crucial for its dissemination and consolidation (NIETO, 2001). Although the concept of Biodiversity is well established in scientific circles, especially after the Rio Conference (1992), the amount of materials developed on the subject is uneven when compared to Geodiversity, partly because its conceptualization and systematization predate it.

Nascimento (2018, oral communication), one of the most enthusiastic brazilian researchers on the subject, in his lectures and classes, reflects as follows: if we type the word 'Biodiversity' into the Google search engine, in July 2018, for example, the result is approximately 21,600,000 items; for the term 'Geodiversity', the result is 85,000, which is a ratio of about 1:254. If we conduct the search in English, the ratio worsens (1:2053), giving an idea of the significant inequality in the publication of articles, projects, or the dissemination of topics on social networks, which results in a lack of theoretical-methodological bases that allow for a systematic assessment of geodiversity. This lack was only slowly addressed in the mid-2000s, when the theme of geodiversity began to be recognized beyond academic circles, mainly thanks to the efforts of European geologists and geographers. However, its scientific, economic, environmental, and particularly political importance is inferior when compared to the theme of 'biodiversity', as civil society has not yet been effectively impacted on the importance of conserving the abiotic elements of nature, similar to how they recognize the biotic environment and its heritage potential.

The widespread use of the term 'geodiversity', with a naturalistic connotation in the 1990s. Burek and Potter (2002, as cited in PANIZZA and PIACENTE, 2009) suggest the year 1991, during an international conference on geoconservation. According to Gray (2008), the term would have

emerged from the Biodiversity Convention, a parallel event to the Rio Conference in 1992. For Nieto (2001), its probable origin would have occurred at the Malvern Conference on Geological and Landscape Conservation in 1993.

With the works of Sharples (1993; 1995), Kiernan (1997, as cited in GRAY, 2004), and Johansson et al. (1999), the first concrete definitions of geodiversity emerged, especially in studies involving geoconservation in Tasmania or Northern Europe.

The first definitions of the concept of 'geodiversity' focused on the diversity of the Earth's physical features, including geological characteristics (rock layers), geomorphological features (landforms), and edaphic features, along with their assemblages, systems, and processes (SHARPLES, 1993; DIXON, 1996, as cited in PIACENTE, 2005; KIERNAN, 1997, as cited in GRAY, 2004; JOHANSSON et al., 1999; GRAY, 2004; RODRIGUES and FONSECA, 2008). Over time, new elements were added to the concept or divided into categories such as geological structures (sedimentary, tectonic, geomorphological, hydrogeological, petrologic), geological materials (minerals, rocks, soils, and fossils, as defined by NIETO, 2001), and water resources (ALEXANDROWICZ and KOLZOWSKI, 1999; KOZLOWSKI et al., 2004, as cited in KOZLOWSKI, 2004; SERRANO and RUIZ-FLAÑO, 2007a; RODRIGUES and FONSECA, 2008).

In 2004, the first book specifically on the subject was published, re-edited in 2013, titled "Geodiversity-valuing and conserving abiotic nature," written by the English geographer Murray Gray. It focuses, as the title suggests, on definitions, values, threats, and the need for protection, through case studies in various countries around the world, with an integrative vision between geodiversity and biodiversity. According to Gray (2004), geodiversity is the natural variety of geological elements (rocks, minerals, and fossils), geomorphological features (landforms, deposits, and processes), and soils, including their relationships, correlations, interpretations, systems, and properties.

Some authors describe the importance of properly maintaining this geodiversity through geoconservation strategies. Eberhard (1997) adds heritage value to geodiversity, where the valuation of geodiversity for its use was followed by other authors, such as Pereira (2010).

The important role of geodiversity as a support for biodiversity has also been considered in the definitions of some authors, through the analysis of nature's elements in an integrated manner (ERIKSTAD, 1999 as cited in PANIZZA and PIACENTE, 2009; PEMBERTON, 2001; PANIZZA and PIACENTE, 2003; BRUSCHI, 2007), with humans playing a fundamental role (SERRANO and RUIZ-FLAÑO, 2009; PANIZZA and PIACENTE,

2009). For example, Panizza and Piacente (2009) argue that biodiversity and geodiversity should be seen as integral parts of a larger system, helping to promote Earth sciences for the maintenance of terrestrial resources. Therefore, geodiversity has been fundamental for the development of civilizations throughout history.

This holistic view of the link between people, landscape, and culture served as the basis for Stanley's (2001) definition. It includes sensitive and integrative elements, with these elements being restricted to geological processes, such as the variety of geological environments, phenomena, and processes that shape landscapes, rocks, minerals, fossils, and soils, playing a fundamental role in the consolidation of life on the planet. Thus, geological or environmental phenomena had a significant impact on the definition of the concept.

According to Kozlowski et al. (2004) as cited in Kozlowski (2004), from the perspective of the geosystem, where changes occur in the geosphere and can be divided into four groups (planetary, endogenous, exogenous, and anthropogenic), the concept of geodiversity was expanded to consist of the natural variety of the Earth's surface, concerning geological and geomorphological aspects, soils, and freshwater surfaces, as well as other systems created as a result of natural processes (endogenous and exogenous) and human activity (KOZLOWSKI, 2004, p. 834), where the time factor is essential for the establishment of biodiversity, which exists as a function of geodiversity. This broad concept is similar to that of González-Trueba (2007), who proposes adding saltwater surfaces such as oceans and seas, along with oceanic physical elements and their processes.

In Brazil, the political recognition of the importance of geodiversity for the maintenance of biodiversity, even indirectly, came in the form of a document, jointly produced by the public sector (Ministry of the Environment-MMA, State Secretariat of Science, Technology and Environment of Pará, Institute of Economic Development and Environment of Rio Grande do Norte, Northeastern Society of Ecology, Environmental Secretariat of the State of São Paulo, and the Henrique Luis Roessler State Environmental Protection Foundation of Rio Grande do Sul) and the third sector (BIORIO Foundation and Conservation International of Brazil).

The Project for the Conservation and Sustainable Use of Brazilian Biological Diversity (PROBIO), under the MMA's National Biodiversity Program (PRONABIO), was subdivided into several subprojects, including the Assessment and Priority Actions for the Conservation of Biodiversity in the Coastal and Marine Zones Subproject. This sub-project resulted in a technical report, published in 2000, in which various elements of geodiversity are identified, even though the report makes a clear apology

for biodiversity. The presence of oil on the ocean floor, details of coastal geomorphology such as sandy and muddy beaches, sandbanks and sandy shores and water resources such as coastal lagoons, estuaries and their mangroves are some of the examples of abiotic elements mentioned in the document.

The dissemination of the geodiversity of Brazilian territory began at the beginning of this millennium, with the project called 'Caminhos Geológicos' (Geological Paths), developed by the Department of Mineral Resources of Rio de Janeiro (DRM/RJ), since 2001 (MANSUR and SILVA, 2011) and later, through the Geological Service of Paraná (MINEROPAR), in 2003, with the 'Geological and Paleontological Sites of Paraná Program' (PIEKARZ and LICCARDO, 2006), which ended up spreading to other Brazilian states (Rio Grande do Norte, Bahia, São Paulo, Minas Gerais, etc., sensu NASCIMENTO et al., 2007, NASCIMENTO et al., 2008 and MANSUR, 2010). In 2005, the National Department of Mineral Production (DNPM) began a project called 'Series of Studies on the Geodiversity of Brazil', with the production of booklets and collections of minerals and rocks (NASCIMENTO et al., 2008). In the academic field, several course conclusion papers, master's dissertations, doctoral theses and publications in national and international journals have dealt with the subject in its various aspects, such as Covello (2011), Manosso (2012), Pierri (2015), Santos (2016), among others.

When the Brazilian Geological Service (CPRM) published the “Map of Brazil's Geodiversity, scale 1: 2,500,000”, it defined geodiversity as the abiotic nature (physical environment) made up of a variety of environments, phenomena and geological processes that give rise to landscapes, rocks, minerals, soils, waters, fossils and other surface deposits that provide for the development of life on Earth, having as intrinsic values culture, aesthetics, economics, science, education and tourism (CPRM, 2006).

This pioneering work by the DNPM and CPRM resulted in a mapping of geodiversity that covered every Brazilian state. In the Northeast, for example, all the states have already been mapped, and all of them have a book with a complete survey of the geological and geomorphological elements mapped, without taking into account the attribution of heritage values.

Almost 30 years after the term 'geodiversity' was introduced to scientific circles, its definition remains controversial and subject to heated debate. It has been concluded that geodiversity, the result of a slow evolution since the dawn of the Earth, refers to the diversity of abiotic materials, in solid or liquid form, which are located at the lithosphere-atmosphere interface. This diversity includes geological materials (rocks and their elements-textures,

structures, minerals and fossils, as well as the processes that generated or deformed them, such as tectonics, generating folds, faults and breccias), geomorphological materials (deposits, landforms and the processes that gave rise to them), pedological materials (soils) and hydrological materials (surface or subsurface-sweet or salty); in situ (at the place of origin) or ex situ (collected and exposed elsewhere, in the case of rocks and their elements), analyzed at all scales and with anthropogenic action playing a fundamental role in interfering with the characteristics of these elements. In this book, the term 'georesources' will be used as a synonym for the elements of ex situ geodiversity, especially rocks, which are used in buildings, floors and monuments, ultimately integrating the concept with the cultural elements of society.

Until the 2000s, the subject of geodiversity was not directly on the agenda of discussions aimed at protecting heritage. This can be explained, in part, by the fact that the discussions on this topic were little dedicated to the applicability of these concepts in territorial planning and analysis, based on a reflection on the values that these elements have. Some of these values will be discussed in the next subchapter.

From Geodiversity to Geoheritage: the values of geodiversity

Ecosystem Services

Several authors since the late 1970s have defined the Ecosystem Services (ES) and created classifications associated with the term. Over the past 40 years, discussions on ecosystem services have been ongoing and their application has expanded, especially after the United Nations (UN) realized the Millennium Ecosystem Assessment (MEA) in the early 2000s (McDonough et al. 2017).

Several studies have sought to show the relationship between human beings and nature, and propose actions to ensure that this relationship is stable and lasting for the entire ecosystem in a sustainable manner; examples are Balmford et al. (2002), Hopwood et al. (2005), and Raufflet et al. (2014). More in intense scientific discussions on how to protect the elements of nature began in the second half of the twentieth century. Economists have pointed out that the most efficient way would be to determine a value for such resources. Westman (1977) then creates what he calls the value of nature, which is associated with a loss of monetary value owing to the degradation of an ecosystem or part of it. Alternatively, it would be associated with the amount needed to reverse environmental

impacts. Ehrlich & Mooney (1983) were the first to use the term ecosystem services, which continues to this day.

The definition of these services sought to demon strate how a massive loss of species would affect the ecosystem and how environmental changes would affect the stability and resilience of the Earth's systems (Mooney & Ehrlich 1997). Daily (1997) defined ecosystem services as the conditions and processes through which natural ecosystems, and the species that compose them, sustain and enhance human life.

By applying the Delphi method, Ruppert & Duncan (2017) conceptualized ecosystem services as a wide range of direct and indirect, monetary and non-monetary, benefits that humans obtain as a result of being involved within an active, native or modified ecosystem. The human activity that changes the structure of the ecosystem is the ma jor contributor to changes in ESs. Including ESs in decision-making can provide incentives to preserve native ecosystems or restore ecosystem functioning. In all definitions, despite slight vari ations, the importance of the relationship between human beings and nature remains, in addition to the benefits, understood here as services, that this relationship provides for the human being.

Ecosystem Services and Geodiversity

Ecosystem services are a broadly consolidated category for biodiversity and conservation studies. The work of English Nature (2002) indicates that it is possible to apply nature's ecosystem ser vices to geodiversity studies, as a way of describ ing nature's contribution to the quality of life on the planet and promoting a good relationship be tween geodiversity studies and those of biodiver sity. Gray (2008), in turn, reports the importance of abiotic elements for ecosystems as a whole, as well as for life on the planet.

Gray (2011) recognizes geosystems services as "the goods and functions associated with geodiversity", in parallel to the definitions of ecosystem services made years earlier via the MEA. The author developed the concept and adapted the definition of MEA ecosystem services to geodiversity. The regulation, support, cultural, provisioning, and knowledge services were thereby defined. Brilha et al. (2018) point out that the ecosystem services approach is currently a fundamental key in decision-making involving sustainable development, especially in the definition of qualitative and quantitative values. This indicates a specific assessment system based on the contribution of geodiversity to establishing and maintaining environmental conditions. In this paper, the authors integrated the knowledge service, elucidated by Gray (2013), with the cultural service.

It is possible to integrate geodiversity studies with those of biodiversity, analyzing the natural diversity of the planet (Parks & Mulligan 2010; Anderson et al. 2015; Hjort et al. 2015; Silva 2018). Thus, several actions can be combined for the conservation of the environment. The specialized literature already recognizes geodiversity as the fundamental provider of ecosystem services, examples of this are Gordon & Barron (2013), Silva (2016), Rabelo et al. (2018), Garcia (2019), and Reverte (2019). Works that have this focus on the evaluation of abiotic nature should be encouraged so that there is more dialogue on this subject in environmental studies.

Supported by MEA definition of ecosystem services, Gray (2013) defined a system that fits in with the method already employed for biodiversity. The author defined five ecosystem services of geodiversity with which 25 goods and processes are associated. The aim was to elucidate the relationship between abiotic elements and local natural diversity and the communities in the region, providing a theoretical basis for geoconservation actions, and identifying the importance of geodiversity for all nature. For this process, the definitions of Gray (2013) were used, synthesized in figure 2-1, in addition to the following descriptions.

- Intrinsic Value: this refers to the ethical belief that some things are of value simply because of what they are, and not for their use by humans. Washington (2018) provides two reasons for geodiversity to have an intrinsic value: for being the substratum of life and for being unique and susceptible to degradation and destruction.
- Regulating Services*:* geodiversity regulation services are responsible for maintaining the balance and stability of processes and phenomena on the planet, thus con trolling the natural dynamics. Associated with this service are: atmospheric and oceanic process es, terrestrial processes, flood control, and water quality.
- Supporting Services: when geodiversity is used by natural beings, humans included, as a substrate for the development of their activities, as housing, or even for reproduction, it defines the so-called abiotic supporting service, to which the following assets and processes are associated: soil processes, habitat provision, platform, burial, and storage.
- Provisioning Services: these are related to the physical environment making available material goods for use by human societies. It is usually associated with a monetary value, sometimes extremely high, which facilitates its identification. Seven types of goods and processes made available by geodiversity enable the determination of a provisioning service: food and beverage, nutrients and minerals

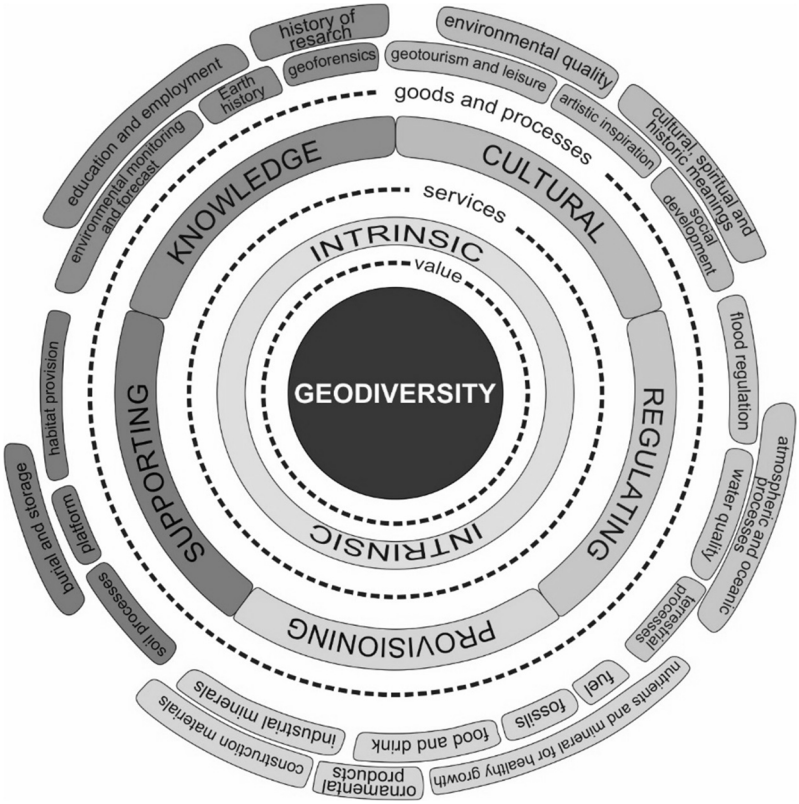

Figure 2-1-Classification of the geodiversity values according the ecosystem services sensu Murray Gray. Source: Silva (2016).

for healthy growth, mineral fuels, construction materials, industrial and metallic minerals, and gems and fossils.

- Cultural Services: these include the social or community meanings of some aspects of the physical environment, which have been common in human societies since prehistory, by its identification with the environment. Five categories of goods and processes are related to geodiversity: environmental quality; geotourism and leisure activities; cultural, historical, and spiritual meaning; artistic inspiration; and social development.
- Knowledge Services: knowledge services relate the physical environment to a research laboratory and stress on its importance as a source of information for science and education. The following

goods and processes are related to it: earth history, research history, environmental monitoring, geoforensics, and education and employment.

The threats to geodiversity

The erroneous mentality that georesources, being composed essentially of rocky elements and their derivatives, with the exception of water resources, have a greater power of resistance, has led to few efforts being made to include them in discussions about their geoconservation (Sharples, 2002; Brilha, 2005; Gray, 2004). Gray (2004) enumerated a series of threats, especially anthropogenic ones. Considering that many of these threats have already been widely identified and discussed in the literature, such as the exploitation of mineral resources, fires, the construction of landfills and quarries, forestry/deforestation, river maintenance and engineering works, agriculture, and military activity, as well as geotourism sites, which are inventoried and semi-quantitatively assessed in the project area, will be properly characterized regarding these threats, the description below will be limited to the major threats. They are:

- Urban expansion and construction works: the role of the construction industry in expanding. Urban verticalization impacts geodiversity by building on rock outcrops with peculiar structures or fossils, or by causing soil removal and compaction. Urban infrastructure can accelerate erosive processes, such as road construction, deforestation, irregular occupation of slopes, or water source areas, exacerbating floods and mass movements on slopes. Minimizing these impacts should be part of urbanization projects.
- Tourist/recreational pressure: tourism activities cause serious damage to geodiversity when not developed sustainably and properly planned. In natural parks with intense visitation during peak seasons, there is an increase in littering, noise, air pollution, and vegetation deterioration on unauthorized trails. During cave visits, guides typically emphasize the need for tourists to avoid touching the walls to prevent damage to the rock. In coastal areas, such as those studied in this book, the expansion of tourist facilities has caused significant damage to the original terrain, as well as to the natural dynamics of the coastline. Notably, the construction of resorts atop the cliffs in Paraíba, offering panoramic ocean views, has increased pressure on the cliffs, heightening the risk of collapse. Another aggravating factor is the tourist trails along the coastline,

which exacerbate the collapse of slopes in steep areas, such as cliffs, for example.

- Removal of geological specimens for non-scientific purposes: rocks, minerals, gems, and fossils, especially those that appear colorful and exotic, have increasingly attracted the attention of collectors worldwide. Consequently, it is common for visitors to certain locations, whether they are collectors or not, who are mainly drawn to the abiotic environment, to end up removing samples from outcrops, causing irreversible damage since these materials are non-renewable. Additionally, the damage caused to outcrops in attempts to extract specific specimens, such as fossils or amethyst geodes, often involves the systematic use of powerful explosives in mines. Although extraction for scientific purposes has a similar impact, it is justified for scientific knowledge (Brilha, 2005).
- Climate change and sea level rise: apart from the controversial discussion about global warming, it is known that, particularly in high-latitude areas, some changes are occurring that pose serious threats to geodiversity. Among them is the thawing of permafrost in Siberia, causing surface subsidence and erosion of the thawed areas, affecting constructions, vegetation, and roads built on them. The melting of glaciers in mountainous areas exposes the rocky surface beneath them, leading to consequent weathering. However, it is in coastal zones that the impacts are most intense.

  The area of this book has about 10 km of coastline, consisting of 8 beaches. The sediment balance alternates between areas of deposition and marine erosion, which is considered a natural and necessary process for the equilibrium of coastal ecosystems. However, the construction of structures that extend into the coastline or to contain the sea's advance causes changes in oceanographic dynamics and sediment balance. At Ponta do Bessa, for example, the sea level rise caused the partial destruction of the Yacht Club and some neighboring residences, and efforts to minimize marine erosion in that area were in vain. This natural phenomenon is exacerbated by human intervention through real estate speculation and poorly planned construction.
- Cultural illiteracy: this is a consequence of ignorance and lack of knowledge about geodiversity and geoheritage. It results from the exclusion of Earth Sciences researchers from discussions focusing on nature conservation, which tend to concentrate on the biotic environment. To reverse this situation, academic entities dealing with the subject need to mobilize, be present in public and administrative

forums, and establish their field of action, demonstrating that geodiversity is as important as, if not more important than, biodiversity. It cannot be denied that this effort intensified in the 1990s, but it can still be strengthened further. For example, some Geology and/or Geography courses in the country do not include subjects related to 'Geoheritage,' 'Geodiversity,' 'Geoconservation,' or 'Geotourism' in their curricula, which is a significant shortcoming that needs urgente correction to be addressed.

It is concluded that geodiversity includes geological, geomorphological, pedological, and hydrological materials. These materials have values that qualify them for protection as geoheritage assets, which will be detailed in the next chapter. Human action plays a fundamental role in interfering with the characteristics of these elements, which therefore requires strict actions aimed at their geoconservation.

2.2. Heritage(s): cultural and natural heritage

Dissecting the word ‘Heritage’, whose etymology descends from the Latin ‘Pater’ – of the father or Patriotic, in the sense of ancestor, and ‘Nomos’ – law, customs and practices, it is commonly defined as a set of assets that an individual owns and will pass on as paternal inheritance.

Thus, part of the heritage includes all those assets, whether material or immaterial, that possess undeniable value—whether historical, cultural, artistic, social, economic, scientific, aesthetic, among others—that must be safeguarded so they can be transmitted to future generations. Human perception and time are irrefutable premises that enhance this valuation, as the exceptional nature of an asset lies in the eye of the beholder, which may limit the number of assets considered as heritage. In increasingly broader dimensions, an intrinsic perspective of the concept involves elements of development, memory, identity, and formative-educational value, which supports the obligation of its preservation.

Once it belongs to the heritage framework of the National Institute of Historic and Artistic Heritage (IPHAN) and its state agencies (such as the Institute of Historic and Artistic Heritage of Paraíba - IPHAEP, in Paraíba, for example), the object is safeguarded from human actions. Preservation plays a fundamental role in ensuring that the concept is applied, meaning the transmission to future generations and, therefore, its appreciation and permanence.

Cultural and natural assets possess a heritage character, and the objective of this chapter is to present a theoretical discussion, supported by scientific

literature, on Natural Heritage, particularly in its abiotic aspect, known as Geoheritage. Additionally, it aims to discuss the disparities given by the responsible bodies regarding the classification between biotic and abiotic natural heritage.

Furthermore, the imbalance between cultural and natural sites, as well as in relation to the developed world, was a concern for United Nations Educational, Scientific and Cultural Organization-UNESCO, which, in 1994, launched a Global Strategy for a 'representative, balanced, and credible' World Heritage List. This list, with all its nuances and inequalities, will also be a subject of discussion in the chapter.

In 1937, through Decree-Law No. 25, in its Article 1, the Historical and National Heritage was established as "the set of movable and immovable assets existing in the country and whose conservation is of public interest, either due to their association with memorable events in Brazil's history or because of their exceptional archaeological, ethnographic, bibliographic, or artistic value," including 'natural monuments,' subject to registration and protection. In 1988, in a different national historical context where Brazil had transitioned from an underdeveloped country to a developing, clearly industrialized country, this concept was reviewed and expanded, and the designation was changed to Cultural Heritage, recognizing its intangible value in response to the contribution of the different groups that form Brazilian society (website http://portal.iphan.gov.br/pagina/detalhes/218). The foundations of the policy and the regime of protection and valorization, as well as the definition and characteristics of Cultural Heritage, were proposed by the 1988 Federal Constitution, Article 216.

This article begins with a reference to the concept of cultural heritage, emphasizing in items I and II, intangible assets such as practices and domains of social life that manifest in knowledge and ways of doing, celebrations, forms of performance art, music, visual arts, markets, fairs, sanctuaries, gastronomy, etc. In items III, IV, and V, it addresses tangible assets, including architecture, arts (sculptures and paintings), and history (archaeology, documents, ethnography, among others). It is important to highlight the mention in item V of fossil sites, represented by paleontology, and ecological and scientific sites, which can encompass a wide range of products, such as the biotic environment, broadly speaking, with fauna and flora, as well as the support of all forms of life, the abiotic environment. In this case, it is represented by rocks, soils, rivers, groundwater, minerals, landforms, and other natural elements that deserve equal protection measures, which, in practice, does not happen.

It is worth noting that the concept of 'Cultural Heritage' has become broader over time, encompassing a new range of heritage, especially from

the 1990s onwards. This range includes railway, Jewish, underwater, military, tile, industrial heritage, stone grammars, among others, which are responsible for niche and/or creative tourism. These new languages and representations of so-called modern heritage have an anthropogenic aspect, making it a constructed heritage, which differentiates it from Natural Heritage, despite the interconnection between them, considering the perspective of the 'Cultural Landscape'.

In Brazil, any asset that deserves preservation for its heritage value is included in the Books of Registration, totaling four: the Book of Historical Registration, the Book of Fine Arts Registration, the Book of Applied Arts Registration, and the Book of Archaeological, Ethnographic, and Landscape Registration (DELPHIM, 2004). The latter encompasses part of the Natural Heritage, especially the Biotic Heritage, as encouraged in the 1988 Constitution in the chapter on the Environment. The text advocates for an ecologically balanced environment, the preservation and restoration of essential ecological processes, biodiversity, and the integrity of genetic heritage, with this protection regime being the responsibility of environmental agencies. It is evident that little attention is given to the abiotic heritage, something that would be repeated in other places for some time.

The old and abandoned urban complexes in the Historic Centers of major Brazilian cities have been revitalized in recent decades, serving as tourism catalysts, as seen in the case of João Pessoa, promoting sun and sea tourism. The revaluation of these spaces is crucial, particularly in one of the oldest cities in the country, where the rediscovery of indigenous cultural roots not only stimulates tourism but, more importantly, strengthens local identity based on the renewal of its historical past.

The Natural Heritage is a relatively new theme in Geosciences, and there is no unanimity in its definition and characterization. The International Union for Conservation of Nature and Natural Resources was created in 1948, marking the inception of the first global environmental organization responsible for recognizing different categories of protected areas (from 'strict nature reserves' to 'managed resource protected areas'), initiating a heritage-oriented approach towards nature. Its vision is "a just world that values and conserves nature," and its mission is "to influence, encourage, and assist societies around the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable" (https://www.iucn.org/about).

Following the United Nations Conference on the Human Environment, held in June 1972 in Stockholm, environmental issues began to be discussed on a larger scale, involving actors who had previously been marginalized in these discussions. Subsequently, in October and November of the same