Chapter

Landscape-Environmental Heritage in the Coastal Zone of Guinea-Bissau: Current Trends and Design Scenarios in a Changing Climate

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Abstract

The paper presents a study on the landscape system, understanding the landscape in the broadest sense of heritage and common good, with a focus on the identification, analysis, and critical evaluation of the coastal Landscape Systems (LSs) of Guinea-Bissau (GB) in north-western Africa. It examines the major spatial and temporal transformations of a rapidly evolving landscape, particularly in recent years, due to socio-economic dynamics and the impacts of climate change, including a specific assessment of climate change effects on coastal landscape quality. The analysis was conducted at the geographical-territorial scale using the traditional landscape approach in order to highlight homogeneous landscape systems and subsystems, and to propose a coastal perimeter for landscape management in at-risk areas of GB. The research aims to protect and enhance the GB landscape, as well as to manage the territory and its botanical-ecological and historical-cultural heritage. Specifically, it supports coastal-landscape planning towards climate resilience and the safety of communities in the coastal area, from the perspective of sustainable development, which in this context is particularly significant given the widespread poverty, administrative-financial and socio-health challenges, as well as the absence of up-to-date data, studies, or projects on the coastal landscape. The study further develops two complementary GIS-based scenarios: one describing socio-cultural and spatial trends in the absence of planning initiatives, and another resilience-oriented scenario focused on coastal safety, the enhancement of natural and cultural heritage, and the improvement of quality of life.

Keywords: Guinea-Bissau, landscape analysis, landscape planning, urban planning, heritage, natural heritage, GIScience, climate change, sustainable development

1. Introduction

This research examines the coastal Landscape Systems (LSs) of Guinea-Bissau (GB), in north-western Africa (**Figure 1**), emphasising recent spatiotemporal dynamics influenced by socio-economic and political drivers, as well as the impacts of climate change in an area already critical due to geopolitical-geographical reasons [1, 2]. This study is part of a broader framework of research and technical-scientific consultancy activities supporting the development of Guinea-Bissau [3]. These efforts are carried out by international organisations (e.g., UN-Habitat, FAO), NGOs (e.g., Tiniguena, the Organisation for the Protection and Development of Wetlands in Guinea-Bissau—ODZH, the International Union for the Conservation of Nature—IUCN, etc.), specialised companies, and independent researchers. Specifically, this study—following the most up-to-date regulations and strategies in terms of land use and urban planning in GB—provides a multidisciplinary knowledge base to improve and implement coastal land-use planning tools in Guinea-Bissau, ensuring their relevance and applicability [4].

Key priorities include territorial safety and climate adaptation, which are essential pillars for Guinea-Bissau's future [5]. Equally critical are the preservation of heritage in all its forms and the enhancement of the quality of human and natural landscapes. These goals are addressed through measures to ensure the safety and resilience of basic infrastructures, the availability of public services, and the creation of spaces for social interaction, with particular attention to communities living along the coastline and its tributaries.

Figure 1.
Geographical context and administrative division (Regions and Sectors) of Guinea-Bissau (Google © 2025 and OpenStreetMap). Edited by the authors.

The climatic and spatial dynamics are particularly important for GB, which sustains itself mainly through its fishing and agro-industrial economy, that is, for a country dependent on the territorial and subsistence economy and the quantity/quality of productions [4].

In this context, unsustainable agricultural practice has been explored in recent years due to the declining productivity of the 'bolanhas' (i.e., rice cultivation close to mangroves) and the 'rural exodus' to Bissau, or to areas with a high concentration of forestry for agro-commercial purposes (i.e., wood energy or valuable wood for the Chinese market, i.e., Pô-de-Sangue or Pterocarpus erinaceus). In this sense, the abandonment of coastal crops impact on the overuse of natural resources and forest products. Uncontrolled logging and the increased need for cropland or grazing land directly impact forest biomass, which degrades in terms of biodiversity, area, and vegetation composition, as well as the loss of ecosystem services (i.e., supporting, cultural, regulation, production).

As confirmed by scientific discourse, including the IPCC (Intergovernmental Panel on Climate Change) reports [6, 7], human environment interactions significantly contribute to climate change on both spatial and temporal scales. These anthropogenic influences, often referred to as the human footprint, are currently affecting territories worldwide, including GB. Indeed, the coastal zone experiences different phenomena, including heatwaves, flooding and river overflows, sea-level rise, rainfall instability and low rainfall, prolonged drought, etc., which exacerbate the criticality of fires fuelled by dry winds or intentionally set for agricultural and production purposes. In addition, climate and weather variability affect the timing of harvests and sowings due to seasonal changes, with relative uncertainty of food productivity in rural areas [8, 9]. The climate scenarios derived from the Regional Climate Models of the CORDEX Project (Coordinated Regional Climate Downscaling Experiment) predict significant changes in the climate of Guinea-Bissau [9].

- 2016–2045: Temperature increases are projected between 1.2°C (RCP4.5) and 1.3°C (RCP8.5) for the coastal zone and between 1.4°C (RCP4.5) and 1.5°C (RCP8.5) for the inland areas. Average daily precipitation may increase slightly by 3% (RCP4.5) or remain stagnant (RCP8.5), except in the Southwest and the Bijagós Archipelago, where increases between 5 and 10% (RCP4.5) and 2–5% (RCP8.5) are anticipated;

- 2046–2075: Projected temperature increases range from 1.5°C (RCP4.5) to 2.9°C (RCP8.5). Average daily rainfall is expected to increase by 5–10% (RCP4.5) and 2–5% (RCP8.5) in the southern regions, while northern areas, such as Cacheu, may experience slight decreases in rainfall of −2 to −5% (RCP4.5) or − 2 to −10% (RCP8.5).

These scenarios, characterised by rising temperatures, declining or irregular precipitation, rising sea levels, and coastal erosion, pose significant threats to groundwater resources—the primary source of drinking water for the population. Additionally, these changes are likely to intensify malaria transmission and facilitate the spread of waterborne diseases. Prolonged droughts may further increase the risk of meningitis outbreaks, potentially leading to infections and epidemics [8].

Climate instability represents a critical challenge for several climate-sensitive sectors that are vital to Guinea-Bissau's economy and have serious implications for public health [9, 10]. In this context, landscape and urban planning play a crucial role in managing, protecting, and enhancing GB's natural and cultural heritage, particularly

within the coastal zone, which hosts a large part of the inhabitants and the largest amount of natural and economic resources, and currently faces the most severe impacts of climate change. However, the topic remains insufficiently explored, with a notable lack of up-to-date data, studies, and projects addressing these challenges.

Based on this framework, the second section of the paper (Section 2) presents the data collected and used for the development of thematic maps and the identification of the study area (Subsections 2.1 and 2.2). It also includes critical and evaluative discussions on the topics of landscape, climate change, and cultural heritage (Section 2.3 and related subsections), which represent the main technical-scientific contribution to the study of the coastal landscape in Guinea-Bissau.

The final sections aim to summarise the key findings (Section 3), present the main results of the research (Section 4), and provide a general overview of the current state and future advancements in the research (Section 5).

2. Data and methods

2.1 Data

The landscape-environmental heritage analysis was conducted through an integrated reading of the major physical-naturalistic and anthropic phenomena in the area, in order to identify so-called Landscape Systems (LSs). To achieve this objective and to establish a foundation for further studies on Guinea-Bissau, all research outputs were developed within a georeferenced environment (i.e., QGIS), utilising and generating geospatial data through GIScience methodologies and applications [11–13].

Despite a general absence of local data, all the geospatial open data information relevant to the study was collected and systematically organised. These were sourced from publicly accessible national and international databases, offering varying degrees of spatial detail, as well as from technical-scientific documents and reports or cartographic resources developed by international bodies (i.e., UN-Habitat). Additionally, studies and datasets produced during the same period by sector-specific partners were integrated into the analysis.

The following open-access geospatial datasets were utilised directly/indirectly in this study:

- OpenStreetMap (OSM) Geodata – Available for Guinea-Bissau through Geofabrik: *Geofabrik Download Server*
- Global mangrove watch (2020) – Mangrove extent dataset provided by UNEP-WCMC: *Ocean Data Viewer*
- Geospatial data and web-GIS platforms by UN biodiversity lab (UNBL) and UNDP – Developed in collaboration with the Biodiversity Centre UNEP-WCMC, accessible at: *map.unbiodiversitylab.org/location/UNBL/guinea-bissau*
- Copernicus digital elevation model (COP-DEM) – 30 m resolution, provided through Digital Earth Africa: *dem_cop_30 whole collection*
- Population census data – Guinea-Bissau census dataset (2009), available at: *Guinea Bissau Census Data, 2009 - Guinea-Bissau Data Portal*

- ICPAC (IGAD climate prediction and applications centre) data – Climate and environmental datasets accessible through the ICPAC Geoportal: https://www.icpac.net/open-data-sources/.

Building on these data, the following paragraphs critically examine the landscape scale recent and ongoing changes in land use and land cover within the maritime landscapes and seascapes area. The analysis considers the region's geography, key settlements, and the complex interdependencies between land, natural ecosystems, human activities, and climate change.

2.2 Rationalising the coastal perimeter

The first step identifies the study area, considering, on the one hand, the delimitation of coastal and inland areas already identified by competent national authorities [10] and, on the other hand, the administrative subdivision into coastal and inland areas commonly accepted by local entities. The former comprises the regions of Bolama, Cacheu, Quinara, and part of Tombali; the latter comprises the regions of Bafatá, Oio, and part of Tombali, with the exception of the administrative region of Gabu.

The values that guided the choice of the perimeter can be summarised as:

- recognisability of the boundary;
- areas most exposed to coastal impacts/effects of climate change;
- areas with a higher concentration of village and/or rural/urban-coastal settlements.

In addition, the physical-naturalistic (forest, agricultural crops, etc.), anthropic (settlements, main roads, etc.), and legal-administrative (national, regional, and/or local sector limits) aspects were considered.

The inland part encompasses flat terrain crossed by a minor hydrographic network, but it has no contact with the ocean or the coastal and deltaic landscape, and lacks large river sections except for a short stretch of the Rio Cacheu and the Rio Geba. Beyond the coastal perimeter, the altimetric profile rises significantly, with elevations of 60–90 metres a.s.l. in the northern and eastern sectors and up to about 270 metres a.s.l. in the Gabu region towards Guinea. Moreover, the settlements in this area do not resemble coastal settlements in terms of location, urban development, dependence on coastal marine activities, and so on. They are away from major water bodies and mainly concentrated in areas adjacent to major road intersections and extensive forest or shrub reserves.

If on the one hand the morphological and hydrological aspect (large rivers, delta or estuary river mouths, low altitude) appears dominant in the coastal landscape of the GB (average altitude within the coastal perimeter: 8,7 m a.s.l.), on the other hand it is not the only discriminating factor considering that the entire country is crossed by a dense hydrographic system and is mostly flat (national average altitude 17,5 m a.s.l) with the exception of a few areas, especially in the east as mentioned (**Figure 2**).

On this basis, the final boundaries (i.e., coastal area) (**Figure 3**) can be summarised and described as follows:

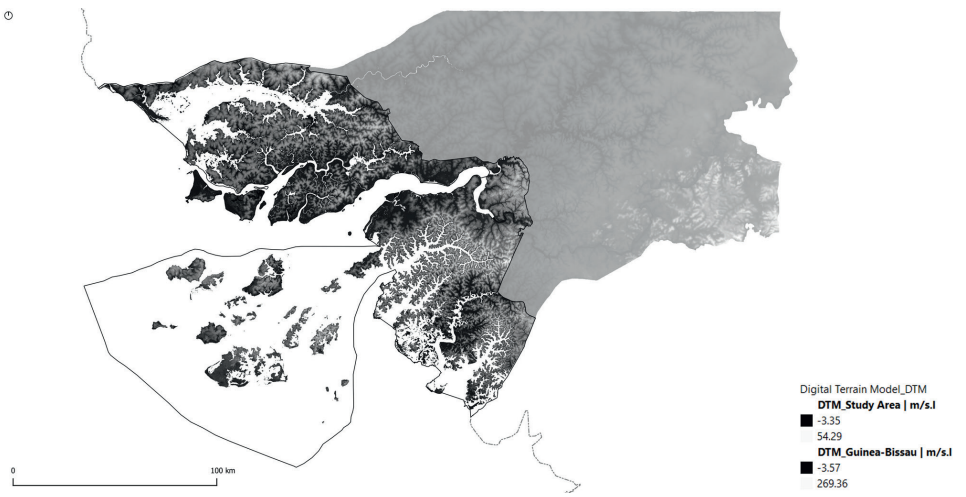

Figure 2.
The morphology of the coastal study area compared to the national altimetry (COP-DEM, 30 m/px). Edited by the authors.

- to the north and south, the perimeter lies on the limits of the neighbouring countries, Senegal (to the north) and Guinea (to the south) respectively;
- to the west (continental slope), the boundary considers the national border of GB, along the coastline;
- to the east (continental slope), the boundary instead follows several limits, mainly anthropic, such as some main roads, the boundaries and potential expansions of the major fringe settlements (Ingoré, Bissorã, Mansoa, Bambadinca, Xitole), some river bends (Río Geba, Río Corubal), and only partially the administrative limits between the various regions;
- to the south (ocean side), the boundary considers the boundary of the Bijagós Archipelago Biosphere Reserve as recognised by UNESCO (United Nations Educational, Scientific and Cultural Organization) in 1996 [14].

Defining a perimeter based on specific criteria helps to overcome the uncertainty regarding the actual extent of Guinea-Bissau's coastal zone, which is commonly delineated as the territory within a 150 km inland buffer from the shoreline—corresponding to the maximum inland reach of the country's major rivers.

In the following paragraphs, a landscape assessment by the so-called LSs (paragraph 2 et seq.) and its impacts on future work in coastal planning adaptation are in-depth described.

2.3 Decomposing and recomposing the landscape: A critical reading by landscape systems

In landscape planning, Landscape Systems (LSs) are defined as areas characterised by a high degree of homogeneity across all landscape elements—biotic and abiotic, visible and intangible—that influence human presence, activities, and natural

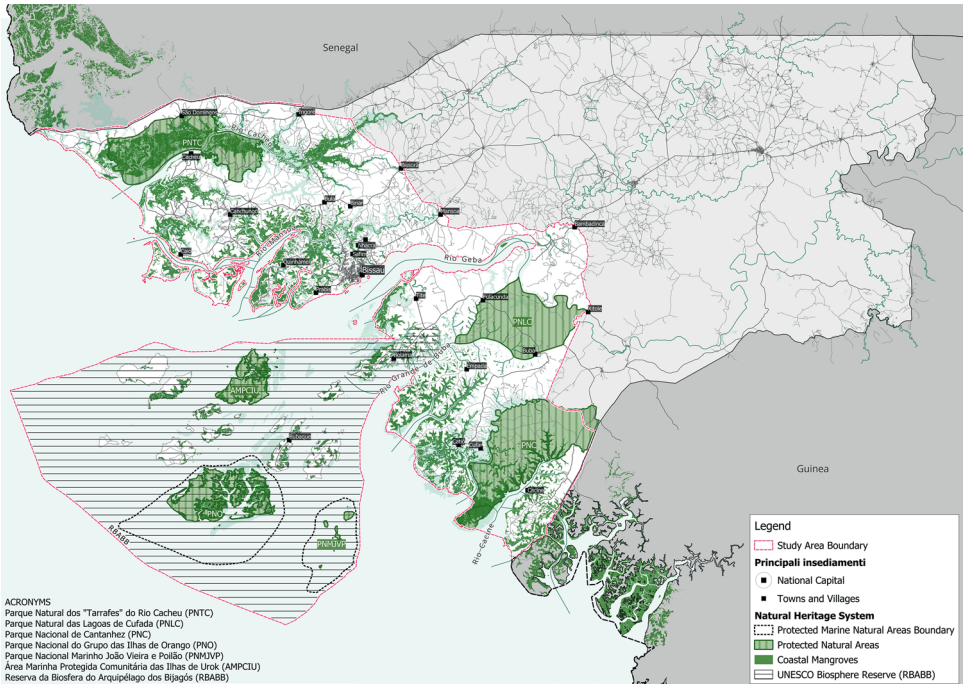

Figure 3.
The perimeter of the coastal study area, its main cities, as well as the system of natural heritage and national protected parks. Edited by the authors.

dynamics [15, 16]. These systems are also subject to evolving and interacting conditions, whether driven by human or natural factors [17].

Each LS within a given territory represents a conceptual synthesis of these elements and their relationships. To this aim, the research guiding criteria refer to the traditional approach of the study of the landscape at the various scales, its character-vocations, its transformations, and its different functionalities [18, 19]. This means a critical evaluation of the analysed territory, divided into two large systems or 'reading categories' that include within them different subsystems or 'layers': the physical-naturalistic system (morphology, hydrography, natural and semi-natural environments, etc.), the anthropic-settlement and infrastructural system (settlements, roads, infrastructures, etc.).Moreover, traditional art and customs were considered an integral part of GB's heritage, closely tied to animist religion and rituals. Art functions as a medium of communication with the Irãs (deities) and ancestors, fostering a connection to the supernatural. These cultural expressions often manifest in sacred sites, particularly within forests. Consequently, the concept of cultural heritage, typically viewed through a Western lens, is expanded here to include various forms of intangible heritage, warranting equal protection and preservation.

Adopting this analysis framework, the study identifies and evaluates key climate-altering processes (e.g., land use) and climate-affected changes (e.g., land cover transformation) within all LSs as identified through three basic components/criteria: (i) the morphology of the territory; (ii) the prevailing land cover and land use; and (iii) the dynamics of transformation that, in some cases, characterise their environmental and landscape arrangements.

The analysis of climate vulnerabilities, that is, impending and ongoing hazards, as well as the areas most exposed to climate change phenomena, was conducted with a cross-sectional analysis of some of the most recent texts and dossiers produced [8, 9, 20–22] for Guinea and/or in the African coastal area.

Within the identified perimeter of coastal areas (see **Figure 3**), the following four LSs have been identified (**Figure 4**).

- *LS no.1. The coastal wetlands system*: the boundaries consist of the coastline and the boundary identified by the cartography; within this perimeter, oceanic coastal areas, mangrove systems, and coastal areas along rivers near the estuary itself are recognisable;

- *LS no.2. The agroforestry and fringe settlement system*: the boundaries consist of the inner boundary of the wetlands and mangrove system. It is basically a filter area between the inner boundary of the wetlands and the larger system of inland areas towards the north of the country;

- *LS no. 3. The urban system of Bissau*: the country's capital is the only major urban settlement, such that it constitutes a system in its own right, as also documented by the transformation and development dynamics identified in the Strategic 2030 study [23], and for this reason it was deemed appropriate to take the perimeter of the entire municipality as the boundary, and to which the northern expansion area was added;

- *LS no. 4. The Bijagos Archipelago system*: it is classified as the Reserva da Biosfera do Arquipélago Bolama Bijagós (RBBB), where there are three protected areas: Parque Nacional do Grupo das Ilhas de Orango (PNO), Parque Nacional Marinho João Vieira e Poilão (PNMJVP), and the Area Marinha Comunitária de Ilha de Urok (AMCIU); the boundaries of this system consist of the institutional perimeter of RBBB.

Figure 4.
The four landscape systems. Edited by the authors.

Once the LSs had been identified and mapped out, as a metaproject action, the main critical trends, the most severe impacts, and the effects of these on land use and landscape and urban dynamics were analysed and reported for each LS, as follows.

2.3.1 The coastal wetlands system

LS no.1 (**Figure 5**) is an easily recognisable system, as it mainly follows the mainstream hydrographic network. The boundary was produced by relating, in the GIS environment, the geometric boundaries of wetlands from OSM data with the most recent ones provided by Global Mangrove Watch (2020). It is characterised by the wetlands system and, in particular, the mangrove forest system. In general, mangroves form the dominant land cover of the GB maritime interface and perform important ecosystem services: protection from coastal erosion, food security and medicinal purposes for local communities, carbon uptake, and refuge areas for biodiversity (terrestrial and fish fauna) [24, 25]. According to some estimates, mangroves cover approximately 8% of the national territory and their concentration within the study area is prevalent in the northern sector of the study area at the 'Tarrafas do Rio Cacheu National Park' (approximately 40% of the park area) and in the south within the 'Cantanhez National Park', as well as along all the main river loops (Rio Cacheu, Rio Mansoa, Rio Tombali, Rio Combidjam, Rio Cacine, Río Geba) up to the limit of the wetland-pluvial forest [26]. In addition to the two protected national reserves mentioned, this LS also includes the natural park 'das Lagoas de Cufada', in the centre-south, between Buba, Xilotè, and Calafunda villages, and two islands between the Canal de Jata and the Rio Mansoa (to the north) and the island Ilhéu de Melo (to the south), also predominantly covered by mangroves and wetlands.

The concentration of reserves and consolidated parks reflects the ecological and landscape importance of this LS, where mangroves are considered a natural and socio-economic heritage, given the ecosystem benefits they provide to the population. Although some local differentiations, it appears homogeneous and entirely naturalistic, where the landscape is structured by a main and secondary hydric-morphological

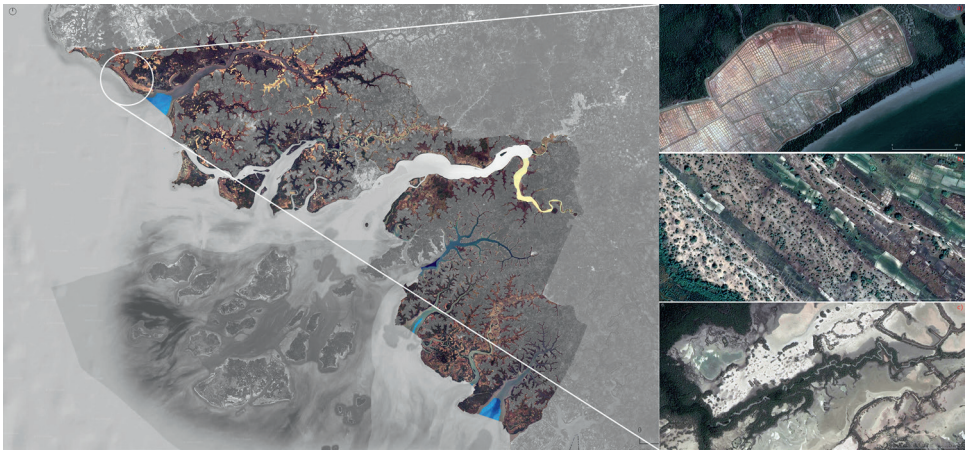

Figure 5.
LS no.1: Coastal wetland system. On the right, from top to bottom, the three LSSs: Rice paddies ('Bolanhas') and a strip of coastal savannah in the Varela area; a patch of coastal halophytic vegetation. Credits: Google Maps. Edited by the authors.

system, an altitude of no more than 20–25 metres a.s.l., the massive presence of mangroves, and the agricultural system of rice paddies. The vegetation aspect is therefore the most relevant, and in detail, it is possible to distinguish several Landscape Subsystems, LSSs, with naturalistic and/or productive dominance, including:

- LSS no. 1.1. *The 'bolanhas':* these are lowland agricultural areas devoted to rice cultivation that are mainly developed on mangrove soils by means of anti-salt dykes and water retention systems. This land use determines a seascape mosaic of 'cells/chambers', whose tesserae are perfectly recognisable both in their overall configuration and in their internal compositional rules;

- LSS no. 1.2. *Coastal shrub savannas:* this LSS is found on soils with low fertility and a sandy texture, the result of the evolution of marine sediments. Its physical-vegetational composition is simple: a predominantly herbaceous layer (1-2 m), and a sparse shrub layer;

- LSS no. 1.3. *The 'tannes':* these are salt flat areas of bare ground with halophilic and hydrophilic herbaceous vegetation associated with mangroves and can be found at the edge of coastal herbaceous savannas, recognisable because they are clustered in islets between mangroves, especially in the Cacheu areas but also near Cumbidja and Cacine.

Land use and land-change nowadays evolve due to social and economic needs, making the boundary between wetland-mangroves, wet forest, and wooded savannah more discontinuous. Furthermore, sea-level rise and increased temperature of sea and delta waters are damaging coastal soils and shoreline erosion with consequent loss of riparian-dunal biodiversity, shoreline modification, and excessive salinisation of wetlands and 'bolanhas'. These trigger indirect effects, such as the decrease/modification of fish stocks, the abandonment of rice fields, food insecurity of coastal areas, the degradation of mangroves, and, in general, the modification of the composition/structure of marine species, as well as their route/direction within watersheds, affecting fisheries. The degradation of mangrove ecosystems is primarily driven by unsustainable commercial logging activities, unregulated artisanal mining, the conversion of mangrove forests into agricultural plantations, and the extraction of timber for construction and fuelwood [27].

At the end, this LS includes several small settlements and villages along the Varela area (northern border with Senegal), as well as Cacheu (north) and Cacine (south), and other scattered villages throughout the area. These are generally linearly located along the river-coastal limits and mangrove boundaries, in close contact with the water resource on which they depend for their daily subsistence (see Appendix A). Varela areas differ from other sites by a humid and dense secondary coastal forest with a predominance of palm groves, subject to a strong erosion phenomenon.

2.3.2 Agroforestry and fringe settlement system

This LS (**Figure 6**) is based on the limits of the wetland and mangrove area and expands inland, up to the eastern limit of the study area, which can be identified along the main N-S crossing road on which minor urban-rural settlements linearly develop. Among these are those of São Domingo, Bissora, Ingorè (north), Mansoa, Bambadinca, Xitole (centre), Buba (south), as well as a series of more inland

settlements. Others, such as Canchungo, Bula (north), Quinhamel, Falacunda, Tite (centre), Empada, and Cufar (south), to name but a few, develop linearly along the internal E-W roads, that is, in the filter areas between the LSs no. 1 and 2 (see Appendix B).

Most of the settlements are in areas slightly elevated from the coastal plain, especially those in the linear 'crown' along the continental limit of the study area, to the east. The LS no. 2 has an elevation between 25 and 50 m a.s.m., characterised by slight foot-hill relief and a ridge to the south, at the edge of the 'Rio Grande de Buba'. Furthermore, the entire LS has a forest and agro-sylvo-pastoral vocation, dotted with small rural centres mostly dedicated to subsistence farming, cashew monoculture, and the felling of specific tree-vegetable species, which on the one hand are among the most profitable activities in the country but on the other threaten the forest ecosystem, that is, the dominant landscape matrix [28]. The rainforest today appears more dense and homogeneous in the southern area, in the Tombali region (i.e., Cantanhez forest), where it is associated with the mangrove system and, to a lesser extent, with the 'bolanhas' rice fields.

It is an LS in transformation to meet the needs of local rural communities where (i) cashew monoculture, (ii) socio-economic pressure due to marked poverty, and (iii) the continuing lack of control and enforcement of environmental matrix laws, are severely threatening the stability and regenerative capacity of the present natural heritage and the biodiversity/heterogeneity of the natural landscape.

Despite its morphological and agro-ecological homogeneity, the LS can be read through three main LSSs (**Figure 6**).

- LSS no. 2.1. *The edge rainforest:* it is located at the mangrove margins and is dominated by humid and dry forest, depending on the different locations and climatic-pedological conditions. The dry forest is more present in the protected area 'das Lagoas de Cufada', while the main patches of humid forest are found in the south, where rainfall regimes are more consistent (e.g., Cantanhez forest). The natural park is part of this area as the main centre of biodiversity for aquatic and terrestrial fauna,

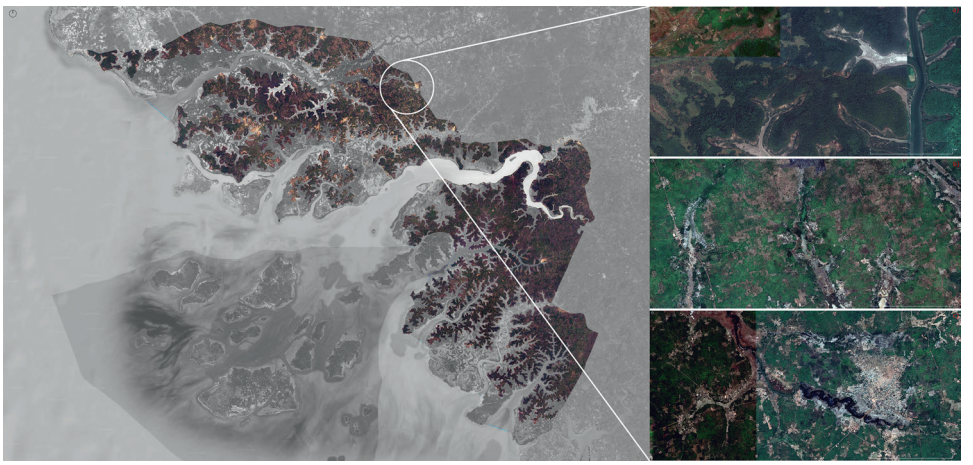

Figure 6.
LS no. 2: agroforestry and fringe settlement system. At the right, from top to bottom, the three LSSs: the edge rainforest, inland areas with an agro-sylvo-pastoral matrix, and the system of minor rural-urban settlements (Bissora area). Credits: Google Maps. Edited by the authors.

and at the same time hosts all the typical vegetation formations of this LSS: dry and semi-dry forest, humid forest, sub-humid and humid savannah;

- LSS no. 2.2. *Inland areas with an agro-sylvo-pastoral matrix:* this area, with different land uses and cover, consists of forest vegetation and annual and semi-permanent crops as well as extensive pastures. It is also characterised by so-called itinerant farming ('mpam-pam') and cashew fruit farming (especially in the northern area of Biombo and Oio, and in Cacheu, and Quinará).

- LSS no. 2.3. *The system of minor urban-rural settlements:* the LSS, despite its apparent discontinuity/fragmentation, develops linearly along the main roads connecting the various local communities. In some cases, these centres present a semi-urban or village-like character, particularly along the north-western border of the study area and close to the wetland hydrographic system (i.e., Bissorã, Mansoa). These predominantly residential areas maintain a close link with the natural heritage and its resources, which sustain the economy. Examples are Canchungo and Quinhamel (approximately 43,000 inhabitants each), Mansoa (46,000), Empada and Buba (17,000 each).

- Last but not least, the LS includes intangible heritage sites, such as sacred areas within the Colage forest in the northwest, revered by local ethnic communities as spaces for initiation, knowledge transmission, and the preservation of community traditions [29].

2.3.3 Urban system of Bissau

The LS of the country's capital, Bissau (**Figure** 7), unlike the others, is characterised by its urban-settlement matrix (approximately 500,000 inhabitants). The city is located in the central coastal area of GB, and is characterised by a very low altitude (approximately 39 m a.s.l.). The morphology, albeit slightly, changes within the compact city and along the northern expansion axis, where the terrain is slightly raised. The vegetation, in general, belongs to the sub-Guinean type of landscape, consisting mainly of rainforests, mangroves, and vegetable-cereal crops. The territory is marked by a low plain and by slight depressions in the river area of the Rio Geba and to the east in the Safim area; the prevailing destination is agricultural and rice-growing, almost always obtained in deforested areas. Nevertheless, there is an observable reduction of agricultural areas and a process of abandonment of rice fields along the wetlands due to water salinisation and acidification. This entails a transformation of the peri-urban agricultural landscape with a reduction in the size and quality of forest areas due to generalised urban sprawl and agro-food production.

Even so, Bissau presents socio-health criticalities due to territorial fragilities (i.e., flooding and river overflows), the uncontrolled expansion or compaction of the city and its forms/materials (i.e., heat island phenomena) [22]. Other studies highlight that there are potential increases in malaria cases caused by the proliferation of mosquitoes in marshy areas due to the lack of rainfall and rising temperatures, which will increase according to trend scenarios [1].

On this basis, three LSSs can be identified within the LS no. 3:

- LSS no.3.1. *The compact urban-metropolitan landscape:* the central and heavily urbanised area of Bissau is subdivided into four districts, which represent

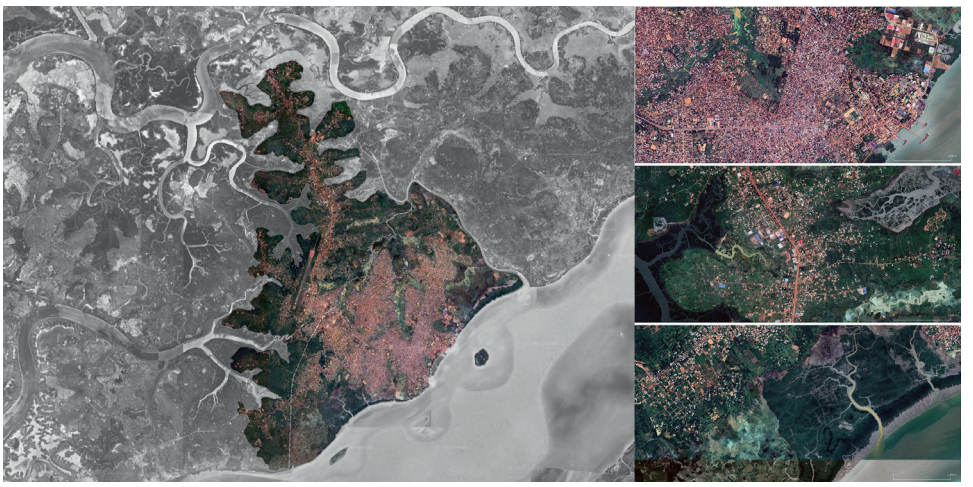

Figure 7.
LS no. 3: Urban landscape of Bissau. From top to bottom, the three LSSs are the compact urban landscape of Bissau, the changing peri-urban landscape, and the agroforestry edge landscape. Credits: Google Maps. Edited by the authors.

different land-use categories, such as (i) a mixed urban fabric with varying densities, between the city centre and the rest of the urbanised residential area, (ii) agricultural areas located mostly on the city periphery and near the coastal areas, (iii) existing and expanding port and industrial areas, on the edges of the city, and iv) wetlands, which characterise both the mangrove and rice-growing coastal landscape both the edges of settlements;

- LSS no.3.2: *The changing peri-urban landscape:* the urban sprawl of Bissau develops linearly (i) in a northerly direction towards Safim, along a main road/morphological ridge on which several expanding internal roads are located; (ii) in a south-westerly direction along the coast towards Prabis. This dynamic entails significant ecological and environmental impacts but also reflects the contemporary demand for land and the metropolitan expansion of Bissau along the N-NW axis.

- LSS no. 3.3. *The agroforestry landscape on the margins:* forested areas on the edge of the compact and diffuse urban fabric are located along wetlands and dominant hydrological and morphological systems. In contrast, denser and more compact development is found along the E-W coastal zone and the central areas of the city, crossed by multiple river tributaries. Here, vegetation prevails, surrounded by extensive rice fields or various agricultural fields that support food subsistence.

The boundary of LS no. 3 is based on the administrative perimeter of the city and the urban expansion areas that reflect a recognisable LS (predominantly urban-residential) with three LSSs strongly dependent on each other. Although with a different vocation/use inside the areas, those cannot be separated from the dynamics of urbanisation, evolution, and transformation of Bissau that cross its administrative boundaries.

Especially in the latter two LSSs, there are phenomena typical of the urban fringes of large cities, that is, linear expansion dynamics close to the main roads, along higher-level facilities (airport and port) and along watercourses, with a relative decrease in agricultural and/or forest land of landscape value.

The urban centre of Bissau is characterised by a lack of urban identity and the presence of unregulated construction projects. The central area, generally identified as the urban zone surrounding the presidential palace, consists of multi-story residential buildings interspersed with low-rise structures (one to two stories), predominantly residential, some of which exhibit architectural influences from the colonial period. These buildings are mostly two-storey structures with a high ground floor, typically used for commercial purposes such as shops or warehouses, while the upper floor serves as housing [30]. Similarly, administrative, political, and institutional headquarters (e.g., embassies, ministries) are concentrated in this area. In contrast, the neighbourhoods near Bissau's harbour, historically characterised by colonial architecture (i.e., 'Old Bissau'), are in an advanced state of decay (**Figure 8**). Only a few buildings have been recently renovated for residential use or, more commonly, converted into commercial spaces on the ground floor. In recent years, the municipality has promoted the enhancement of certain public urban spaces—such as the central axis connecting the presidential palace to the port—and the restoration of both public and private buildings, including hotels, schools, and ministerial offices. However, as one moves away from the city centre, informal settlements become predominant, housing the majority of Bissau's urban population.

Finally, the geostrategic position of the city makes it an attractive pole for the inhabitants of the rural area and for investors. This gives and will give rise to migratory phenomena and the related increase in demand for land acquisitions, new realisations, and/or increase in industrial areas, such as to promote processes of urban development and landscape transformation along the city's fringes, where such phenomena are already found. This process is resulting in spontaneous urbanisation and the 'metropolitanization' of Bissau, characterised by continuous built expansion and sprawling developments lacking services, infrastructure, and adequate social housing. For all these reasons, the capital, like other cities and villages in GB, is the focus of plans and strategies developed by NGOs and international actors [23] aimed at guiding urban and building development, managing land use, and regulating various sectors that impact the quality of places, natural environments, and public health. This is particularly crucial in contexts where planning tools are either entirely absent or exist but remain unimplemented.

2.3.4 Bijagos archipelago system

The landscape system of the Bijagós archipelago (**Figure 9**), due to its overall forest homogeneity and insularity, is considered unique here and corresponds to the limits of the Biosphere Reserve [31]. It is worth noting that of the four identified LS, this is the only one to have an accepted management strategy and, in the near future, could be managed by an integrated management plan, currently ongoing on the basis of previous studies [32].

The Bijagos is the only active deltaic archipelago on the Atlantic coast of Africa and is morphologically made up of islands and islets separated from each other by a network of channels of varying width and depth. The size of the archipelago is approximately 85 km in diameter from east to west and 65 km from north to south. Administratively, it is divided into four distinct sectors, namely Bolama and Bubaque, which are the main urban-coastal centres (see Annex A), and Uno and Caravela, with a total emerging surface area of approximately 900 km^2.

The maritime interface and the marine areas around the landmasses, that is, channels and shallow areas characterised by the retreat of waters by the tides, characterise

Figure 8.
'Bissau Velha': selected views of the colonial-era urban fabric near the port area of Bissau (February 2025). Edited by the authors.

more than 85% of the Biosphere Reserve's surface area and are one of the dominant seascape elements of the entire system that are associated with the 'mudflats' complex. The latter represent a dynamic and changing element of the landscape perception, since when the tide is low, almost a third of the archipelago dries up, while when the tide is high, only the islands emerge in their scenery of beaches or mangroves. Taken together, these two elements constitute two subsystems in their own right of significant ecological-naturalistic value.

Within the LS thus described, two prevailing LSSs can be traced:

- *LSS no.4.1, the forest system:* is the dominant landscape matrix within the entire system. It dominates the landscape of all the islands with the exception of a couple of cases where the dense forest cover gives way to wooded savannah and areas with irregular and sparse tree cover. This subsystem is characterised by the

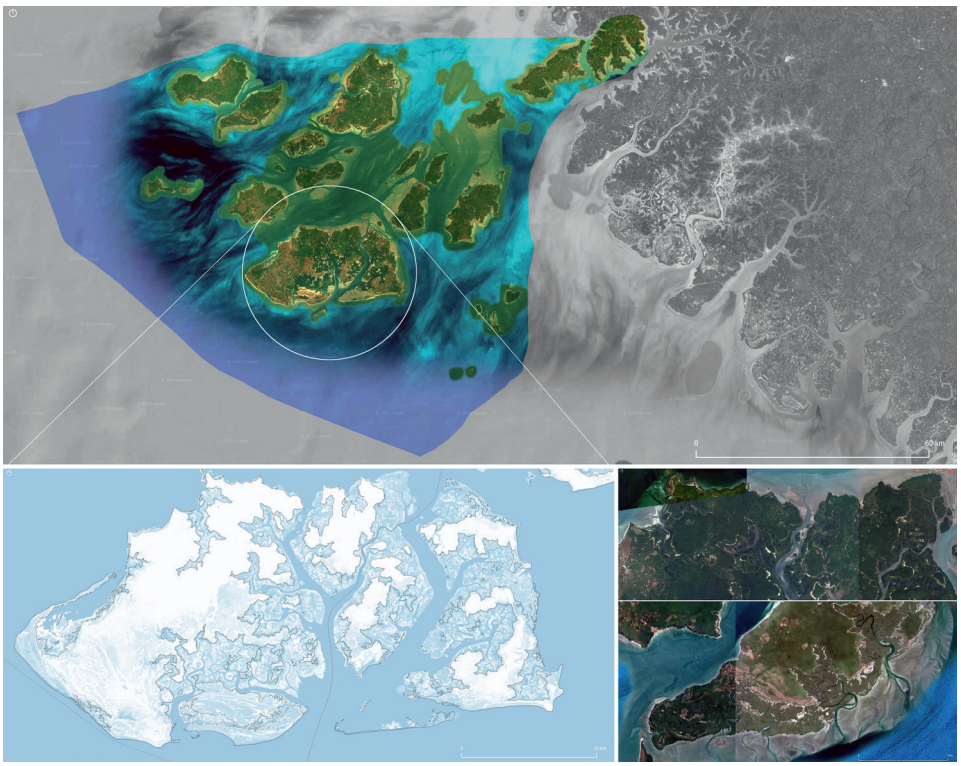

Figure 9.
LS no. 4: Bijagos Archipelago system. Below, the blue scale, limited to 10 m a.s.l., reflects the system of wetlands and dynamic mudflats as an added system beyond the national perimeter (in hatching). On the right, from top to bottom, the two LSSs: the forest system between the 'Ilha de Orango' and the 'Ilha de Bubaque', and the coastal and mangrove system on the coast of the 'Ilha de Carache'. Credits: Copernicus, COP-DEM, and Google Maps. Edited by the authors.

presence of the three protected areas consisting of the 'Orango Islands National Park', the 'João Vieira e Poilão National Marine Park', and the 'Urok Islands Community Protected Marine Area'. Many of these areas are considered sacred and have a cultural-historical and identity value safeguarded by the strategies and policies on the subject and, before that, by the inhabitants themselves. The settlement component in these areas is limited to small inland or coastal villages, devoted to fishing and agro-sylvo-pastoral activities, and interconnected by a network of roads and paths that follow the morphology of the terrain.

- *LSS no.4.2, the coastline and mangrove system:* this subsystem is landscape-dominated by mudflats, mangrove-dominated wetlands, coastal marine areas, and the minor hydrographic network. It is affected by tidal dynamics and thus by the immersion/emergence of land. Here too, mangroves have priority ecological and morphological importance, and are mostly concentrated in the central-southern island complex of the reserve. In close contact with the marine-coastal areas, on the other hand, are the two settlements of Bolama and Bubaque, which emerge as the only urban centres in the Archipelago. Around these two areas, other small rural settlements are developing, linked by a network of connections that appears to be expanding.

The social and economic life of the archipelago, based on traditional relational structures, customary rights, and a degree of self-sufficiency, is fundamental for the present/future management of the entire LS. Bijagós communities are able to meet almost all their needs independently; agriculture and animal husbandry are conducted without special recourse to imported products, and society is not dependent on state subsidies or services [33]. This model has a very low environmental impact on the landscape, reinforcing the broader concept of landscape as a social product of the people who inhabit it, design it, manage it, and perceive it over time [34, 35]. A traditional community model has the effect of protecting resources and biological diversity, which are closely linked to the daily rituals and practices of the inhabitants. For instance, each island has sacred forests reserved for male/female initiation ceremonies and other religious-magic ceremonies. These customs and traditions, within the context of a vast flora and fauna heritage protected by UNESCO, constitute a widespread intangible cultural heritage that must be preserved. Examples of these sites are found in the Bijagos Islands (especially in Orango, Uno, or Soga islands).

The zoning of the reserve, inspired by this community model, protects the various forms of sociality in line with the traditional organisation of the space. This orientation, in general, has guided the creation of the two national parks and the marine protected area mentioned above. Indeed, the strong cultural sense gives a high level of protection, allowing the preservation of the natural heritage and the regulation of the use of resources available to the inhabitants [32].

This level of protection restricts agro-productive activity (e.g., in Rubane, Tufo, Maju-Inorei, Maju-Anchorupe, Ebenga, João Vieira, Meio, Cavalos, Poilão, and Cute) and prohibits ploughing and tree cutting in some areas. These traditional management measures reflect the cultural and identity aspects of the place and the more noble and broader meaning of cultural heritage.

On the contrary, different climatic and land-use dynamics are affecting the LS [36]. The development of cashew cultivation (as in other areas of GB) threatens the community/natural environment relationship and is transforming the relationship of the islanders with their land, which is generally managed communally for rice production and food subsistence. At the same time, increased temperature and ocean salinisation are destined to reduce agricultural productivity and land and marine biodiversity. Nevertheless, coastal flooding and coastal erosion, as well as salinisation of water, evapotranspiration, changes in moisture levels, and reduced precipitation affect the LSSs. In particular, the eastern part of Formosa and the eastern islands of 'Orango Park', which are the most populated, have to be focused on. The impacts of climate change in a humid territory such as Bijagos will increase the transmission of diseases such as malaria, meningitis, and other infections.

3. Discussion of the coastal landscape analysis

Critically examining the interim results achieved through landscape analysis, it is possible to briefly highlight and summarise the direct/indirect impacts/effects of climate change on the coastal area and the relative soil/land-use changes described.

The main threats to the coastal landscape are:

- rising mean sea level and coastal erosion;
- heat waves and thermal stress;

- intensification of extreme flooding phenomena;
- prolongation of aridity/drought periods;
- increase in mean sea/river and estuarine temperatures.

Due to these climate-related phenomena, two key dynamics emerge. On one hand, there is the spatial transformation and reconfiguration of degraded, hazardous, or unproductive landscapes, including their use and abandonment. On the other hand, there is a continuous search for arable land and economic resources to sustain a growing population, manifested in rural migration and the process of Bissau's 'metropolization'.

Linked to these aspects, the following cause-and-effect relationships characterise the study area:

- *Coastal flooding and consequent salinisation of 'bolanha' and coastal crops*: this problem is exacerbated by rural exodus, inadequate maintenance and infrastructure, and the widespread presence of coastal settlements in areas of high flood risk;
- *Nutrient depletion and soil compaction due to prolonged drought*: these problems are intensified by soil depletion due to monoculture and socio-productive practices, exacerbated by sewage problems in settlements and poor management of waste that flows into cultivation areas;
- *Coastal erosion:* this is the result of rising sea levels, tidal phenomena, and ocean wave dynamics (i.e., Varela). Erosion drives the search for cultivable land and leads to the abandonment of crops and improperly built coastal structures.
- All these aspects individually serve as analytical criteria and synthetic qualitative-quantitative indicators used to study each Landscape System (LS). They are then compared and systematically organised in a matrix table (**Table 1**).

As highlighted in this study, the coastal study area, as well as Guinea-Bissau as a whole, possesses a significant natural and cultural heritage, deeply intertwined with site-specific social customs and sacred or spiritual values.

By categorising Guinea-Bissau's heritage into tangible and intangible dimensions, we can state that:

- The natural heritage is predominant and holds clear economic, socio-cultural, and ecological value [37], responding to the needs of local inhabitants while also mitigating the impacts of contemporary climate change. Furthermore, it has a crucial cultural significance, as these landscapes are inhabited by diverse communities whose knowledge, traditions, and ways of life are intrinsically connected to them. Socio-ethno-anthropological practices—such as religious beliefs, tribal customs, and initiatory rites—find spatial expression within various 'sacred sites' and protected forests (e.g., Cobiana, Colage).
- Heritage sites and architectural structures, on the other hand, are primarily concentrated in historic centres, such as Bolama, Bubaque, and Bissau, though they remain widely dispersed. These constructions reflect the colonial Portuguese

Indicators and analysis criteria	**LS no. 1**	**LS no. 2**	**LS no. 3**	**LS no. 4**
Geomorphology	Very low elevation and flat ground	Low elevation, flat ground, and light slopes	Low elevation and predominantly flat ground	Very low elevation and flat ground
Elevation (metres a.s.l.)	min: −2.32 mean: 0.35 max: 34.74	min: 0 mean: 3.71 max: 68.77	min: −0.02 mean: 6.84 max: 55.80	min: 0.0 mean: 1.55 max: 47.47
Main land cover	Mangroves, coastal savannahs, and rice fields	Humid forests and agro-mosaic	Urbanised environment and agroforestry mosaic	Forest, mangroves and coastal mudflats
Natural protected areas	yes (PNTC, PNLC)	yes (PNTC, PNLC)	no	yes (PNO, PNMJVP, RBBB, Ilhas Urok)
Degree of transformation	medium	medium	high	low
Human impact	high	high	high	low
Cultural-identity values	yes	no data	no data	yes
Diffuse Urban/ rural settlements	yes	yes	no	yes
Main urban settlements	no	yes	yes	no
Urban planning tools	no	no	yes (not applied)	yes
Climate change impacts	Sea level rise, coastal flooding, coastal erosion, extreme weather phenomena, rising sea/river temperatures	Extreme weather phenomena, droughts, heat waves, and rainfall instability	Extreme weather phenomena, sea level rise, coastal flooding, heat waves, heat islands, rainfall instability, droughts	Sea level rise, rising sea/river temperatures, evapotranspiration, and changes in humidity levels

Table 1.
Critical summary of the main indicators and qualitative-quantitative analytical criteria for each LS.

architectural style—characterised by concrete blocks and tiled or fibre-cement panel roofs—or serve as examples of post-colonial African architecture [30]. In Bissau, the degradation of urban buildings, coupled with a housing deficit and a massive influx of impoverished rural migrants, has led to unplanned urban expansion and low-quality living conditions [30]. In Bolama, buildings of great historical interest are entirely neglected, lacking maintenance and facing the risk of collapse. In other coastal urban and rural settlements, which constitute a significant portion of inhabited areas within the LSs, architectural forms and materials reflect a traditional-vernacular style. Traditional dwellings, historically built with rammed earth or adobe walls and thatched straw roofs, are now undergoing a gradual shift towards zinc sheet roofing [38];

- While tangible heritage is fragmented and deteriorating—partly due to its association with a historically contentious colonial period—intangible heritage remains extensive and deeply tied to natural landscapes [39], as previously noted.

The natural and human-induced phenomena discussed in Sections 2 and 3 define GB's landscape systems and subsystems that are largely undergoing transformation. In general—and particularly evident in Bissau (LS no. 3)—population growth and the demand for new spaces for residential settlements, productive activities, and subsistence agriculture are driving the transformation of urban, rural, and peri-urban areas, along with their associated landscape resources. These dynamics are exacerbated by the absence or non-implementation of urban and territorial plans, the accelerating impacts of climate change, and the interlinked challenges of demographic growth and widespread poverty. All these factors, combined with institutional fragility, governance disorganisation, and the inefficiency of responsible bodies, contribute to environmental degradation and the progressive fragmentation of the coastal and inland natural landscape [40].

4. Results

The rationalisation of the coastal perimeter (see **Figure 3**) is the first outcome of this research, as it highlights the area most exposed to climate-coastal challenges, which is the focus of specific international projects to which this study has contributed directly as applied research [3]. This area establishes a clearly defined and recognisable boundary, anchored to known or easily identifiable territorial markers. Defining such a perimeter can provide clarity regarding the zones subject to future plans and projects, thus preventing or at least reducing confusion among competent land-use planning and management authorities. In this regard, delineating the coastal zone constitutes a fundamental outcome, instrumental for both the research presented here and future studies on this topic.

The identification of LSs and LSSs serves as both a methodological approach to landscape analysis and a planning tool for homogeneous spatial units. These units can support strategies and projects with either similar or differentiated characteristics and functions, depending on the specific context. Thus, LSs and LSSs represent the second research outcome, offering a framework that can be further developed, monitored, and updated both spatially and in terms of content.

The social, economic, cultural, and ecological functions of the four LSs, along with the spatiotemporal dynamics of land use and resource consumption in the coastal area, as presented in Section 2, have been spatialised into a critical up-to-date GIS-based map of coastal resources and vulnerabilities. This constitutes one of the two key outcomes, synthesising ongoing territorial trends and representing the 'business-as-usual reality' (i.e., 'Scenario 0') (**Figure 10**). This baseline scenario (i.e., scarce effectiveness scenario) illustrates the expected developments in the absence of intervention [41].

In particular, the map highlights the previously discussed aspects, emphasising the natural heritage (e.g., terrestrial and marine protected areas, mangroves, traditional agricultural systems) and cultural heritage (e.g., sacred sites, colonial-era historical centres). At the same time, it illustrates the range of observable impacts threatening their integrity and landscape quality as highlighted in Section 3 (e.g., sea level rise, coastal salinisation, monoculture expansion, urban sprawl).

Based on this analytical framework, nine objectives and nineteen strategies have been defined, collectively shaping the planning scenario for the coastal area (i.e., 'Scenario 1') (**Table 2**). This represents the key outcome and the main objective of the research that is based on the principles of 'Integrated Coastal Zone Management', 'Sustainable Land Management', 'Land Degradation Neutrality', and 'Climate Adaptation' [4].

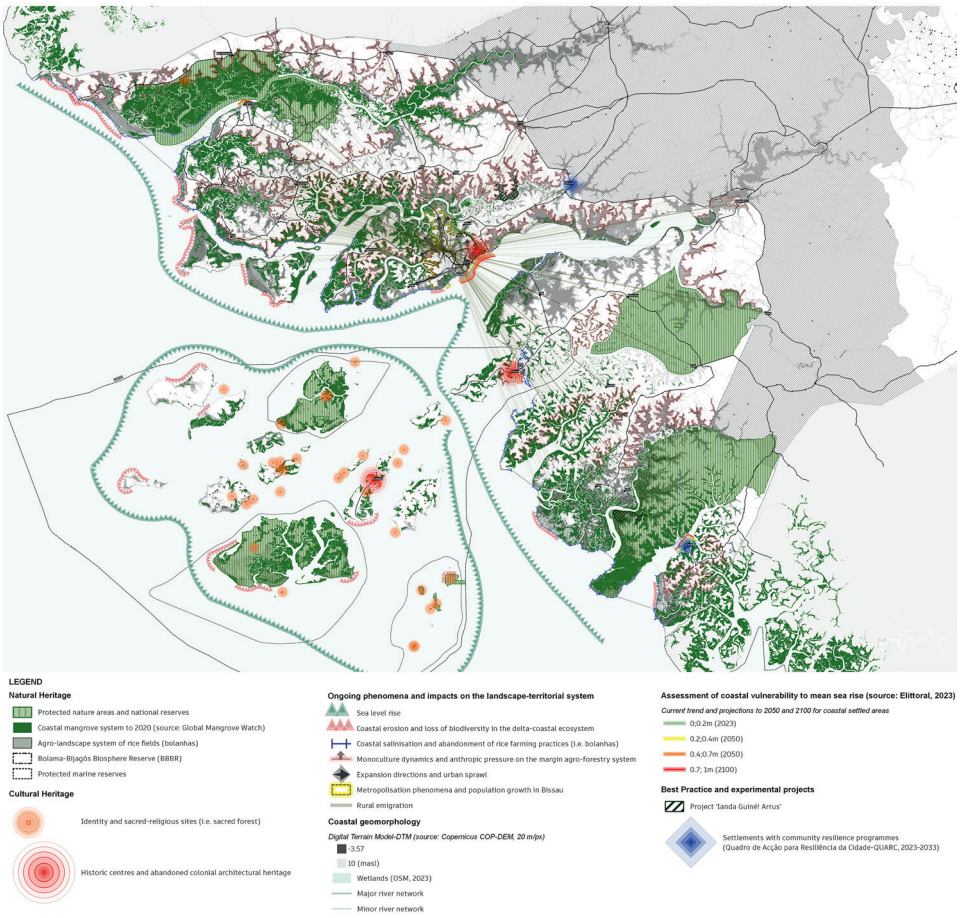

Figure 10.
'Scenario 0 - baseline scenario'. An updated overview of the criticalities and strengths of the GB coastal landscape and related LSs and LSSs. Edited by the authors.

These guidelines align with the landscape study presented while also adapting to the existing national legislative framework [41–46]. Furthermore, they draw upon the extensive fieldwork and research experience of a portion of the research team. Additionally, the proposed actions specifically target urban and landscape planning, as well as cultural heritage enhancement. They take into account ongoing projects (e.g., Project 'Ianda Guinè! Arrus', Quadro de Acção para Resiliência de Cidade, QUARC) and active strategies [23, 36, 47, 48].

The proposed scenario (i.e., cost-effectiveness scenario) (**Figure 11**) identifies objectives and actions to ensure adequate levels of liveability, territorial security, and environmental quality, in line with local socio-cultural traditions. It also aims to strengthen technical-administrative and political-institutional capacities [4, 49, 50] and align with national strategic policies [51, 52].

This initial set of strategies (i.e., environmental system) can be incrementally implemented in the short, medium, and long term, following a strategic vision that enhances: (i) the country's natural heritage, (ii) the quantity and quality of ecosystem services available to local populations, and (iii) the biophysical resilience (e.g., vegetation-soil systems) of landscape elements in response to extreme events and

Sl. No	Objectives
1	Ensuring sustainable use of coastal natural resources
2	Conservation of critical habitats
3	Land degradation neutrality
4	Strengthening coastal communities' resilience
5	Adapting land use and protecting critical public assets and services
6	Ensuring resilient economy through inclusive development
7	Ensuring effective planning and implementation through prioritization and continuous monitoring
8	Protecting indigenous cultural heritage
9	Increasing the available funds for local communities and institutions, by leveraging financial values of coastal ecosystems (climate finance)

Strategies					
Environmental and landscape system		Historical-cultural and settlement system		Governance	
1	Preservation of the protected areas	9	Promotion of social and agro-productive projects for food security and landscape enhancement (i.e ARRUS Project)	18	Strengthening the governance of coastal and metropolitan areas
2	Extension of the National System of Protected Areas (SNAP)	10	Mainstreaming landscape enhancement, biodiversity conservation and climate change adaptation in the tourism sector	19	Developing and implementing climate finance mechanisms
3	Protection of the sacred areas	11	Strengthening the adaptation and resilience capacity of coastal communities to the climate change impacts		
4	Strengthening the ecological connectivity	12	Promoting active safeguarding of intangible identity heritage and traditional culture		
5	Protection and conservation of carbon sinks (mangroves, other forest, seagrass, ecc.)	13	Urban and architectural recovery of minor historic centers and widespread assets		
6	Reforestation of bare / sparse areas of the mangrove system	14	Containment of land take and urban sprawl and urban regeneration interventions		
7	Securing the coastal strip in response to climate change effects (sea level rise, coastal erosion, floods, etc.)	15	Coastal settlements' adaptation to climate resilience projects		

8	Landscape enhancement through the recovery and diversification of subsistence agro-forestry pastoral activities and the reforestation of the sparse rainforest	16	Update of existing plan (Bissau) and development of urban plans for the main centers
		17	Development of urban planning tools for climate-environmental sustainability and community resilience

Table 2.
Objectives and project strategies, adapted from SETIN and PD consult [4].

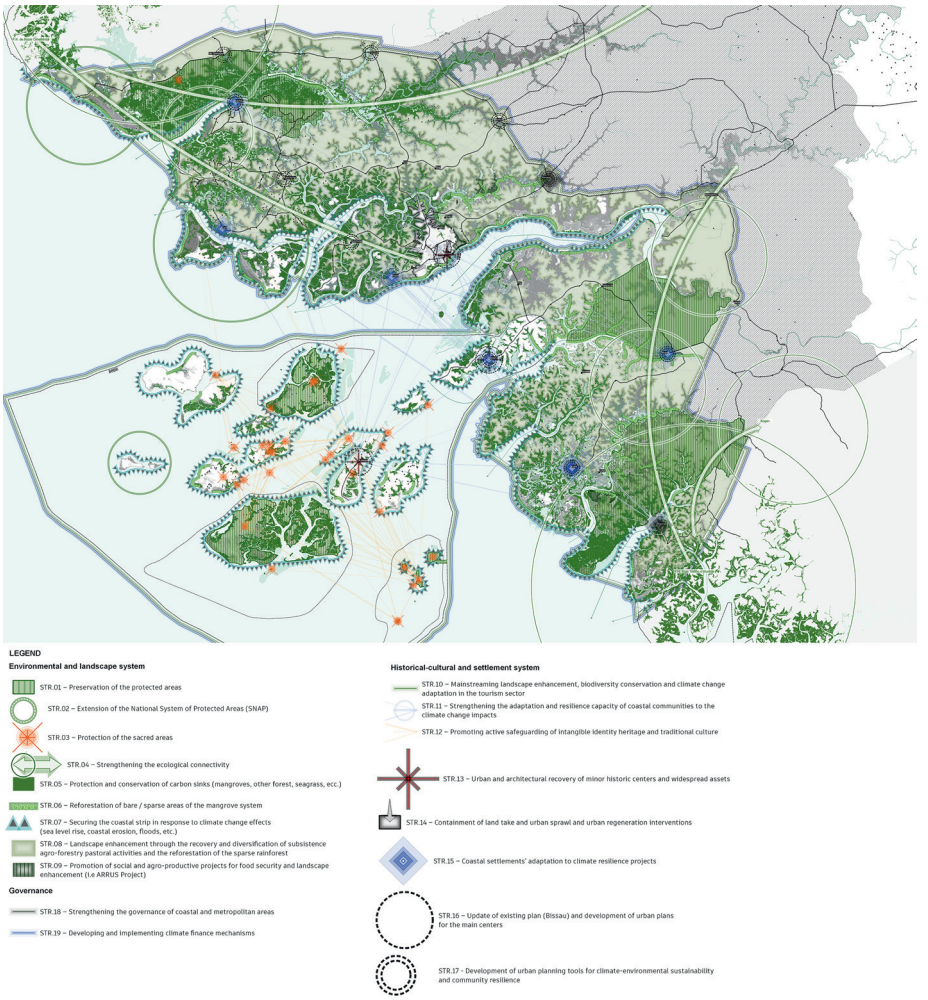

Figure 11.
'Scenario 1 - coastal resilience scenario'. The nineteen spatialised strategic goals. Edited by the authors.

ongoing environmental transformations. Conversely, safety measures function as a cross-cutting strategy affecting both the physical and infrastructural systems and coastal communities. These measures provide tools, viable alternatives (e.g., adaptation and resilience projects), and awareness-raising activities. Such guidelines could lead to a network of informed and equipped coastal communities capable of adapting to global and local changes while maintaining their strong connection with the deltaic and fluvial settlement patterns that characterise GB's seascape.

While natural heritage serves as a 'resilient infrastructure' in response to ongoing transformations, adaptive capacity cannot be fully realised without the implementation of (i) land and landscape governance tools, (ii) climate-proof urban plans, and (iii) recovery, restoration, and renovation plans for housing and historical architecture, particularly in historical centres. Planning instruments can address housing and social demands, particularly in Bissau, while simultaneously tackling contemporary challenges (e.g., climate, habitability, employment, resources, energy). These goals can be achieved through citizen engagement and a top-down/bottom-up approach (i.e., information-knowledge-planning). Where possible, these strategies could also support ecologically and culturally sustainable tourism.

The strategic scenario envisions a renewed coastal-landscape system for Guinea-Bissau, where both residents and institutions play a key role in responding to contemporary issues impacting the sustainability of coastal communities and their heritage.

5. Conclusions

The study contributes to the disciplinary debate on updating and developing knowledge frameworks in the era of climate change and multiple transitions, particularly in a region where updated data and applied research are critically scarce. The findings advance disciplinary approaches within the context of climate change, offering methods and insights to support coastal landscape planning, strengthen climate resilience, and promote sustainable development in West Africa. Conversely, the critical-evaluative analysis presented here is based primarily on indirect sources (e.g., reports, publications). This limitation may be addressed in the continuation of the research through field missions and the collection of specific data, which will support the development of analytical and strategic scenarios at the appropriate scales.

Given the interconnected dynamics between human activities (e.g., subsistence, mobility, trade, and production) and the quality of landscape primary elements—particularly soil and water, which are fundamental to human well-being—territorial governance plays a crucial role. In this context, identifying LSs and LSSs is a key step in advancing landscape knowledge and planning (protection, valorisation, and management). It provides a foundation for managing landscape quality and guiding transformations over time, both within and beyond formal landscape planning frameworks. As previously noted, defining these coastal landscape units is not a theoretical exercise. The four LSs represent the minimum landscape units at the macro scale, for which—while maintaining flexibility and allowing for finer-scale adjustments—specific planning guidelines can be established. These guidelines can then be refined at the micro scale for technical and design-oriented applications. The LSs and their respective LSSs are therefore instrumental in achieving the ultimate objective: adapting the coastal area to ongoing and projected climate impacts, considering cultural and natural diversity as well as the economic needs.

The establishment of a clearly defined coastal perimeter, the LSs approach, the 'baseline' and 'resilience' scenarios, and the broader reflections presented here serve as a

foundation for future work on Guinea-Bissau's maritime landscapes and seascapes or to other areas that present similar characteristics of transformation due to natural causes, human intervention, or both. This work must be carried out in collaboration with competent institutions and local communities to achieve landscape quality objectives while ensuring public safety and protecting both natural and cultural heritage.

While those and/or other strategies have yet to be implemented, it is important to underline that coastal landscape and urban planning is today a matter of significant interest for both the government and professionals in Guinea-Bissau (e.g., Law for Territorial and Urban Planning - 'Lei do Ordenamento Territorial e Urbano-LOTU'—currently a Draft Law pending approval by República da Guiné-Bissau (RGB)). In this regard, it is hoped that the research will be further developed, with a focus on high-priority intervention areas, through a downscaling approach applied to selected pilot areas.

In conclusion, the current trends and challenges are already affecting Guinea-Bissau's coastal area, local communities, and economic sectors due to weak planning capacities, lack of funding, limited human resources, and difficulties in implementing the extensive range of national and local strategies and programmes. In addition to these critical issues, there is a need to build an up-to-date knowledge base for coastal and urban planning processes, with a particular focus on: (i) establishing and regularly updating a multi-scale territorial topographic database using GIS-based techniques and geospatial tools (e.g., photogrammetry and drone mapping); (ii) exploiting existing and emerging satellite data archives to implement remote sensing analysis for environmental monitoring (e.g., through machine learning and geo-AI); and (iii) systematising existing knowledge and historical-archival sources in open-source geospatial formats, where possible (e.g., through WebGIS platforms). These ICT-oriented strategies can play a key role in supporting the management of spatial transformations and the conservation of natural and cultural heritage, particularly in view of future opportunities to develop predictive models based on temporal dynamics and time-series data.

Addressing these challenges requires political stability, capacity-building initiatives, and a comprehensive review of governance processes related to urban and landscape planning at all levels, taking into account site-specific issues. While these aspects extend beyond the scope of this paper, they are fundamental to ensuring that the proposed strategic objectives translate into concrete actions and become integral to the everyday management of Guinea-Bissau's landscape-environmental heritage.

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Conflict of interest

The authors declare no conflict of interest.

Appendix A

See **Figure A1**.

Figure A1
Other important coastal urban-rural settlements. From top to bottom, Cacheu and Cacine within LS no. 1, and Bolama and Bubaque within LS no. 4, are both in close contact with the coastal wetland system. Credits: Google Maps. Edited by the authors.

Appendix B

See **Figure B1**.

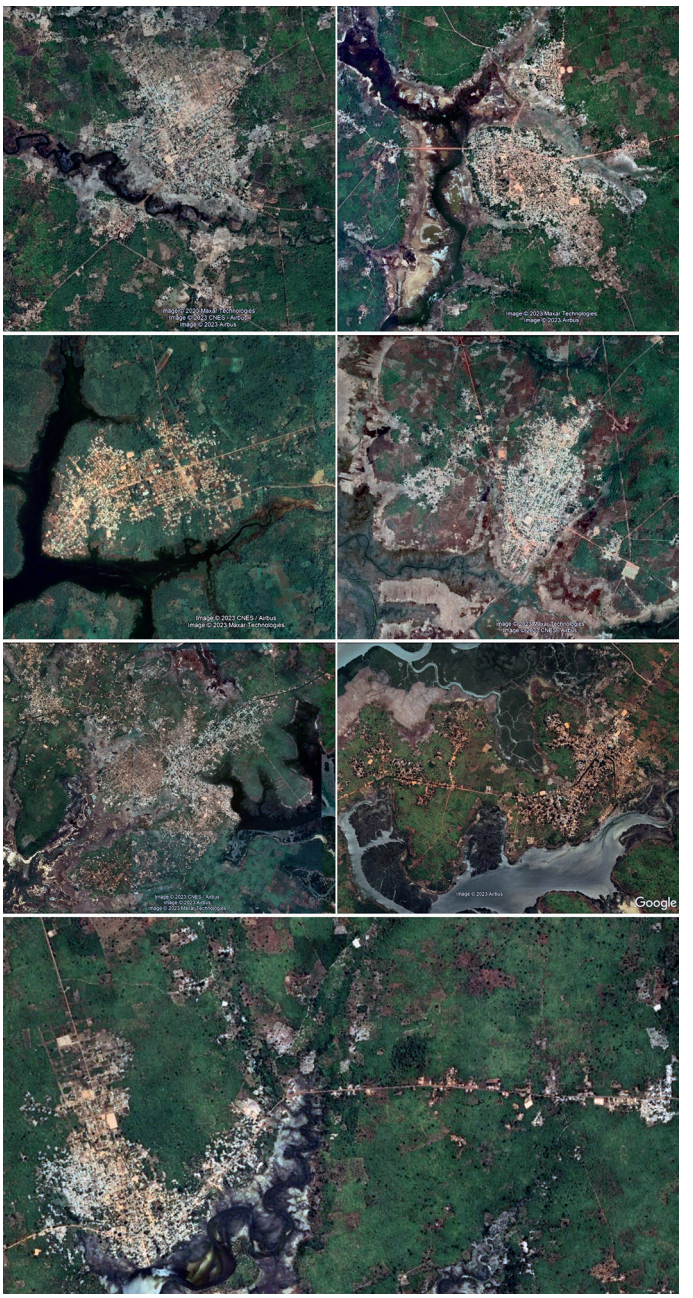

Figure B1.
Some of the urban-rural fringe settlements within LS no. 2 are in close contact with major rivers and the agroforestry landscape. From top to bottom: Bissorã, Buba, Canchungo (left side), Ingoré, Mansôa, São Domingos (right side), and Quinhamel (bottom). Credits: Google Maps. Edited by the authors.

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