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Protected Areas—A Challenge for Quirimbas Archipelago (Mozambique)

Hermínio António[1,2*], Jessica Afonso Ferreira[3], Rita Anastácio[4*], Mário Jorge Pereira[3]

[1]Departamento de Biologia, Universidade de Aveiro, Aveiro, Portugal
[2]Parque Nacional das Quirimbas, Administração Nacional das Áreas de Conservação (ANAC), Cabo Delgado, Mozambique
[3]Departamento de Biologia e CESAM, Universidade de Aveiro, Aveiro, Portugal
[4]Independent Researcher, Aveiro, Portugal
Email: *herminio.antonio20@gmail.com, *rita_sofia@msn.com

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Abstract

Population growth, food security, conservation of wildlife, and ecosystem services are topics of huge concern in underdeveloped areas where people rely on what land and sea can provide to support their survival needs. In the North of Mozambique, the reality is not different from other parts of Africa. Despite the natural patrimony of extraordinary landscapes and wildlife and the diversity of cultural heritage, human populations are impoverished, and natural resources are overexploited. Here, the authors present a conceptual proposal for a chain of land and marine protected areas that encompasses not only the Rovuma estuary, but all the islands that belong to the Quirimbas archipelago and part of the coastal zone until Pemba Bay. In this study, this is considered a fundamental action for the recovery of damaged areas, maintenance of ecosystem services, sustainable development of the region, and preservation of several potential biodiversity hotspots. For the proposal's idealization, satellite images were analyzed, and the results of fieldwork and published literature were explored. This chain of areas includes existing protected areas, such as the Quirimbas National Park and the protected area on Vamizi island, and a proposed but currently unestablished area—the Messalo wilderness area. A need for multisectoral involvement in a bottom-up approach is recognized for the management cycle of protected areas in Mozambique.

Keywords

MPA/LPA—Marine and Land Protected Areas, Biodiversity Conservation, Sustainable Development, Ecosystem Services, East Africa, Mozambique

1. Introduction

Protecting the ocean is not a modern exclusive concept. Since pre-colonial times,

tribes in Pacific islands banned fishing for a certain period and even restricted the number of captured animals to allow the recovery of food resources [1] [2]. Although the primary goal of these communities was not marine conservation, they actively contributed to it. The idea of properly protecting the marine environment was introduced in the 19th century when the diversity value of some hotspots in the world, such as Australia, the United States of America, and South Africa, was recognized [2]-[4]. The awareness of human impacts on the ocean increased during the following decades, and its recognition as an indispensable place for both marine and terrestrial life became one of the biggest scientific shifts of the 20th century [5]. Hence, protected areas and the strategies implemented by conservationists were developed and are still to halt the anthropogenic damage to nature.

Currently, there are several definitions for protected areas (PAs), but the International Union for Conservation of Nature (IUCN) considers that "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" can be applied to land, inland water, marine, and coastal protected areas, or a combination of these [6]. To fulfil their founding principle, each area must be ruled by a specific and well-defined legislation, which varies according to the PA categories: Strict Nature Reserve (Ia), Wilderness Area (Ib), National Park (II), Natural Monument (III), Habitat/Species Management Area (IV), Protected Seascape (V), and Protected Area with Sustainable Use of Natural Resources (VI) [7].

Protected areas have scientific, economic, cultural, and ethical objectives; they are intended to restore and maintain ecosystem benefits and processes, which also make them important for scientific research and education, but also to develop activities that generate income for the region (like tourism and recreation activities). By protecting natural habitats and populations (intrinsic value of biodiversity), PAs also preserve historical places and aesthetic cultural values [6] [8] [9].

The Western Indian Ocean (WIO) is one of the regions with higher marine species diversity and endemism in the world [10]. Comprising 32 countries and territories, its productivity is the main support for coastal communities' livelihoods and local economies [10] [11]. However, the health of the WIO's marine ecosystems and, consequently, their services to humans are strongly determined by socioeconomic circumstances since this is "a region where poverty and the geopolitics of biodiversity conservation acutely intersect" [12].

Cabo Delgado, in Mozambique, has significant natural biological, water, and geological resources, although the poverty situation of the population is still considerable. Due to the high unemployment rate, the exploitation of natural gas discovered in the Rovuma Basin is a beacon of hope for the region's development. In fact, natural gas is Mozambique's fourth main export product [13], and it has attracted substantial foreign investment to the region, to the point where there are not enough hotel infrastructures to accommodate the influx of people, noting there are only six hotels, five guesthouses, and four inns in the region [13]. This phenomenon

creates constraints and pressures on the local biodiversity [14] [15].

The Quirimbas Archipelago, part of the Mtwara-Quirimbas Complex, is in the Cabo Delgado province and has been the focus of worldwide attention for many reasons but especially due to the discovery of huge gas reserves [16] [17] and the insurgent conflict which emerged in 2017 [18]. Both events represent a major concern for nature conservation in Cabo Delgado, and significant steps have been taken to define key areas to recover or protect biodiversity since the year 2000. The Quirimbas National Park (QNP) was created in 2002 and links Cabo Delgado's inland and coastal ecosystems. Recognized as a Biosphere Reserve in 2018 [19], it is also considered a World Heritage Site, a place with "works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view" [20]. This definition applies particularly to the Stone Town of Ibo Island, considered "an outstanding material manifestation of cultural interaction and harmonization", and a key biodiversity site (seascapes) of global importance of the Eastern African Marine Ecoregion (EAME) [21]. However, the rich wildlife of this PA is under significant pressure due to the growing number of people living within its boundaries [15] [22] [23].

By delving into documentation about PAs of Mozambique, it was found that the Reserva Especial do Niassa was established in 1960. Part of this PA is included in the Cabo Delgado province, being east-limited by the Lugenda River [24]. In this western extreme, Cabo Delgado also has "Coutada Nicage", a biodiversity land patch that links Cabo Delgado and Niassa's wildlife. Other projects like the Fazenda do Bravio for the Cabo Delgado Biodiversity and Tourism Project (or Maluane Project) also delivered important reports and scientific work from 2000 onwards [25]-[27]. As Rosendo *et al.* [14] emphasized, this region was the target of an EU-funded project named the transboundary Marine Protected Area (MPA) network in Coastal Eastern Africa [28] that proposed a Rovuma National Reserve that never materialized into reality. Revisiting the review paper of Naughton-Treves *et al.* [29] about 49 tropical PAs, one finds the same pattern being repeated: "globalization and neoliberal reform have brought greater external funding to developing countries for protected areas" but also "opened remote areas to logging, oil extraction, and mining" [29] [30]. For Cabo Delgado's population, this also brought political insecurity from 2017 onwards, which led people to flee from the northern sites towards Pemba town. This instability, added to the poverty rates and the population growth, caused profound challenges to managing conservation efforts [29]. So, what will the future of Cabo Delgado's PAs be?

In the present work, the authors, supported by their own work and knowledge, but also on what was produced by other authors for the region, present a conceptual proposal for a chain of land and MPAs that encompasses not only the Rovuma estuary, but all the islands that belong to the Quirimbas archipelago and part of the coastal zone until the Pemba Bay. The proposal focuses primarily on the coastal area and islands, where the most vulnerable and pressured habitats are

located.

2. Materials and Methods

Research methods included a literature review of management plans, reports, and scientific papers concerning biodiversity protection in Cabo Delgado province (e.g., QNP) and the Messalo Project. Documentation concerning the political and economic context of the region was assessed. In addition, field research focused on the recognition of important biodiversity sites (e.g., sea turtle nesting habitats) and on dialogues with stakeholders and local communities living inside and outside PAs was integrated into this study.

2.1. The Area

Mozambique, a country in Eastern Africa, is bordered to the east by the WIO, to the north by the United Republic of Tanzania (Tanzania), and to the west by Malawi, Zambia, Zimbabwe, and South Africa, with the latter also bordering the country to the south. The country's area of 799,380 km^2 and coastline from the Rovuma River (north) to Maputo (south), of 2515 km [31] encompass islands, beaches, and mangroves. Mozambique is politically divided into 11 provinces. In 2017, it had a population of 27,909,798 people, with an annual population growth rate of 2.8% [32]. Its population is young, with 51.5% being 18 years old or younger and 27.3% in the 5 - 14 age group [32]. Cabo Delgado, whose capital is Pemba, is one of the Mozambican provinces and is in the extreme northeast of the country, bordered by the WIO and limited to the north by the Rovuma River. With a population density of 27.5 inhabitants/km^2 (Mozambique's average is 35) [31], the province has 2,320,261 inhabitants, 1,124,098 men, and 1,196,163 women [32], the majority of whom live in rural areas where they engage in subsistence fishing and agriculture [22] [25] [33]. It is projected that this province will increase in residents, which is also tied to the discovered energy resources.

Cabo Delgado possesses great scenic and geological wealth, featuring other rivers, such as the Messalo River. North of this coast is the Quirimbas Archipelago, parallel to the northern coast of Mozambique, between Pemba Bay and the Rovuma River estuary. The QNP [34] and the province boast considerable biological heritage, both on land and at sea. In addition to coral reefs, such as those at Vamizi (with 46 coral genera), whose surrounding waters are home to around 400 species of fish [27], there is an important nesting area for two species of sea turtles: *Chelonia mydas*, green turtle and *Eretmochelys imbricata*, hawksbill turtle [35] [36].

2.2. Maps and Figures

Analyses of satellites images from Google Earth, of written documents from previous investigations in the area, and of unpublished data were carried out [33].

The cartographic figures were generated in Adobe Illustrator CC version based on documental analysis of existent charts and fieldwork observations. Fieldwork information corresponded to coordinates of different habitat types, animal tracks, signs and remains on field charts (sightings, kill sites, pellet/droppings), and of photographic and video records in several parts of the area. The coordinates of paths, villages and spots of interest were also registered.

3. Results

3.1. The Proposal

Along the coastline of Cabo Delgado, indented by capes and bays, there are 34 islands (Figure 1, Table 1) that compose the Quirimbas Archipelago. This archipelago forms a chain no more than 17 km away from the coast, stretching from Pemba Bay to Palma.

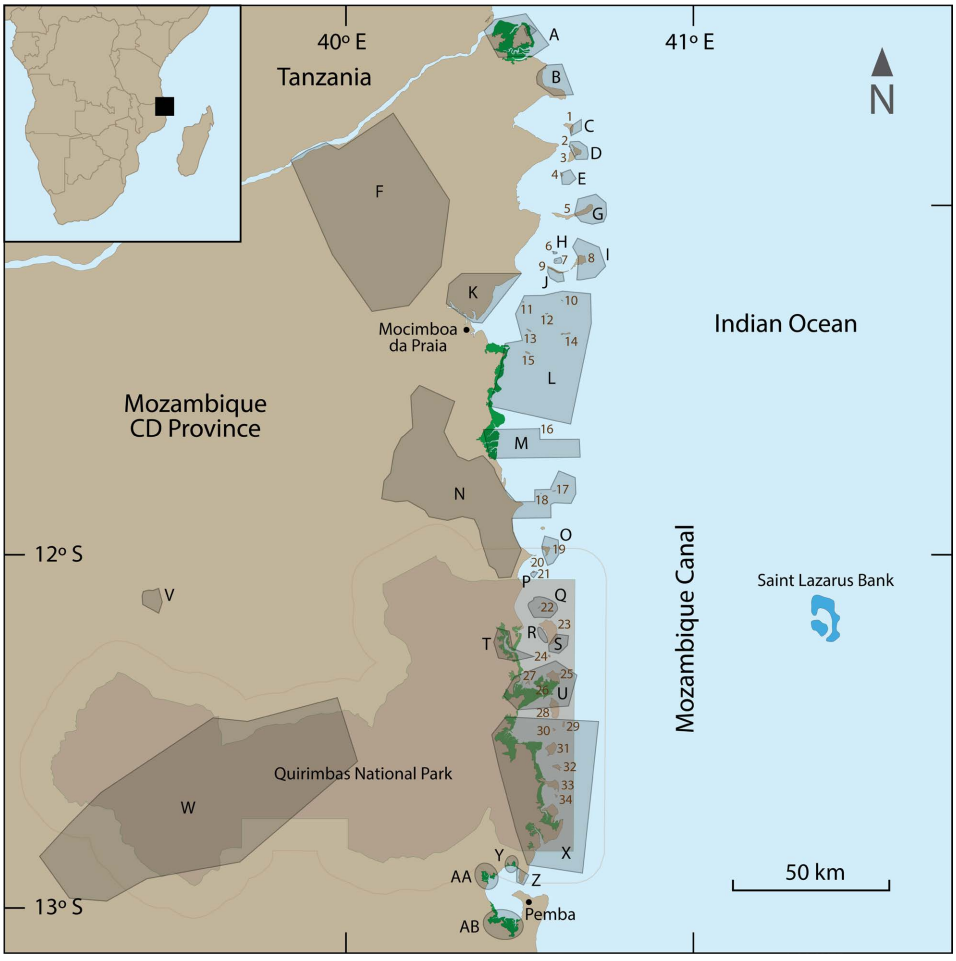

Figure 1. Proposed areas for marine and terrestrial protection or to be considered for protection, distributed along the Cabo Delgado Province, between the Rovuma River and the Quirimbas National Park (QNP) (polygons A to AB). Numbers 1 to 34 correspond to the islands of the archipelago, and their names can be confirmed in Table 1. Figure developed according to charts: Mozambique Channel: Hydrographic chart from the mouth of the Rovuma to Ibo. Chart No. 429. Hydrographic Institute, Lisbon [37] and Google Earth Satellite Image.

Table 1. Zoning islands (protected areas with different use): islands names, locations (geographical coordinates correspond, approximately, to the center of the proposed area), area (ha), and perimeter (km) of the proposed areas to be protected in the Quirimbas Archipelago's islands, listed from the North to the South.

Island Number (N˚), Name	Latitude	Longitude	Area (ha)	Perimeter (km)
N˚1, Tecomagi	10˚47'1.21"S	40˚39'5.94"E[1]	1078	14.0
N˚2, Comezi	10˚50'4.24"S	40˚38'51.25"E	Not applicable	
N˚3, Rongui	10˚50'59.23"S	40˚40'23.83"E	2616 Maluane project, 969	19.6
N˚4, Queraminbi	10˚54'41.04"S	40˚37'24.56"E[1]	1552	15.2
N˚5, Vamizi	11˚1'16.50"S	40˚42'2.54"E	9283 Maluane project, 1181	36.5
N˚6, Vumba	11˚8'11.83"S	40˚36'2.33"E[1]	59	3.4
N˚7, Metundo	11˚9'32.80"S	40˚41'7.0"E	9035	38.6
N˚8, Quisungura	11˚9'38.88"S	40˚36'35.67"E	359	7.39
N˚9, Quifuqui	11˚10'43.96"S	40˚35'5.82"E[1]	1499	16.2
N˚10, Niuni	11˚16'24.53"S	40˚37'32.07"E	*	
N˚11, Congo	11˚16'39.71"S	40˚30'44.61"E	*	
N˚12, Suna	11˚18'40.21"S	40˚34'33.53"E	*	
N˚13, Mechanga	11˚21'19.47"S	40˚31'35.10"E	*	
N˚14, Tambuzi	11˚22'4.21"S	40˚37'56.29"E	*	
N˚15, Mionge	11˚25'14.01"S	40˚31'26.01"E	*	
N˚16, Quero Niuni	11˚38'16.69"S	40˚33'35.61"E	7214	36.6
N˚17, Medjumbe	11˚48'55.21"S	40˚36'25.06"E	6579	31.7
N˚18, Quissanga	11˚49'20.20"S	40˚33'52.76"E	-	
N˚19, Macaloe	11˚59'5.31"S	40˚35'12.04"E	3426 Maluane Project, 387	23.0
N˚20, Quifula	12˚1'3.85"S	40˚32'14.14"E	Not applicable	
N˚21, Mogundula	12˚2'49.66"S	40˚32'39.98"E	247	6.5
N˚22, das Rolas	12˚8'47.52"S	40˚33'38.27"E	4786	26.0
N˚23, Matemo	12˚13'3.33"S	40˚35'33.85"E	826	13.1
N˚24, Manuel da Silva	12˚14'1.12"S	40˚37'16.93"E	2755	20.3
N˚25, Ibo	12˚20'24.60"S	40˚36'5.45"E	25,073	61.8
N˚26, Quirambo	12˚21'42.54"S	40˚34'4.99"E	Not applicable	Included on QNP
N˚27, Fiona	12˚21'40.34"S	40˚31'47.17"E	Not applicable	Included on QNP
N˚28, Quirimba	12˚26'28.61"S	40˚36'21.03"E	Not applicable	Included on QNP
N˚29, Sencar	12˚28'42.22"S	40˚37'52.54"E	Not applicable	Included on QNP
N˚30, Quilaluia	12˚29'37.24"S	40˚36'12.65"E	Not applicable	Included on QNP
N˚31, Mefunvo	12˚32'56.05"S	40˚35'34.74"E	Not applicable	Included on QNP
N˚32, Gamba	12˚32'29.69"S	40˚36'50.53"E	Not applicable	Included on QNP
N˚33, Quisiva	12˚35'59.88"S	40˚36'29.39"E	Not applicable	Included on QNP
N˚34, Quipaco	12˚41'0.67"S	40˚36'36.25"E	Not applicable	Included on QNP

Notes: [1]west limit; *area (96,211 ha) with a perimeter of 131.0 km, defined by islands (n˚10 - n˚15), shallow waters, and the continent: Congo—Baixo Tambula—Tambuzi—Baixo Viadizi—Vilage Lucete—South of Mocimboa da Praia (Nango River estuary/Ponta Ulú) to Estuary of Bandaze River/South of Baixo Vadiazi/Quisinguite and Cabo Lancumbi.

To develop the PA proposal, the following elements were considered: areas with rich biodiversity (land, coastal zones, sea, abyssal plains), territorial connectivity, ecosystem services, areas used by populations, geological resources (particularly those corresponding to natural gas deposits and their exploitation), and tourism potential (**Figure 1**, **Table 1**). Each polygon at the coast in **Figure 1** can be perceived as an MPA, not isolated, but instead connected to the others, all functioning as sanctuaries for biodiversity.

In the continent, areas such as the following are relevant for flora, fauna, water or scenic value:

- Rovuma—Hydrografic basins of Luenda, Quigode, Meronvi, and Muzama rivers area with 192.519 ha, and 173 km perimeter 173 km (**Figure 1**, F; Latitude: 11˚1'27.09"S; Longitude: 40˚4'25.28"E);
- Messalo area with 117.342 ha (perimeter 184 km) in **Figure 1** (N; North: Latitude: 11˚30'46.98"S; Longitude: 40˚12'59.60"E; West: Latitude: 11˚50'08.60"S; Longitude: 40˚06'12.37"E; South: Latitude: 12˚03'32.36"S; Longitude: 40˚26'40.27"E; Este: Latitude: 11˚51'47.99"S; Longitude: 40˚29'56.48"E);
- Maluane Project, an area with 32,931 ha;
- Bilibiza (**Figure 1**, V; Latitude: 12˚12'5.51"S; Longitude: 39˚28'11.57"E), an area with 42.090 ha;
- Taratibu area with 335.888 ha (perimeter 254 km) (**Figure 1**, W; Bushcamp: Latitude: 12˚48'33.38"S; Longitude: 39˚41'35.20"E).

The proposal represented in **Figure 1** is part of one of the eight hotspots located in the sub-Saharan zone, the Coastal Forests of Eastern Africa, which extends from southern Somalia to southern Mozambique. This hotspot of biodiversity is part of the 2.3% of land on the planet with 50% of existing plant species and "over 40% of all terrestrial vertebrate species" [38]. For this hotspot, authors like Wilson and Primack [38] mention the existence of 4050 plant species, 633 birds, and 198 species of mammals. The Quirimbas area and its islands, distributed along 322 km of the northern coast of Mozambique, is home to hundreds of endemic plant species and is a place of great biodiversity with 53 species of corals, 140 molluscs [39], nudibranchs [40], among other species. Places of unique biodiversity are under threat due, among others, to the over-exploitation of natural resources. The country and the region also include ecological regions of global importance, such as the East African Mangroves and "the Coral Coast Sub-Region" ecosystem distributed from the border of Tanzania to Mozambican islands, where corals are predominant [41].

The Wildlife Conservation Society and other entities are co-authors of the document on the areas of Mozambique as Key Biodiversity Areas (KBAs), like Palma, Vamizi, Quiterajo, and Taratibu, KBAs 3, 4, 5, and 6, respectively [42]. These are sites that contribute "significantly to the global persistence of biodiversity, both in terrestrial, freshwater, marine and underground systems" [42]. Areas of the proposal (**Figure 1**) correspond at least in part to KBA 3: A, B, F, K; KBA 4: G and KBA 5: continental part of L, M and including N; and KBA 6: W (**Figure 1**).

Endemic species with endangered status, included in the list of 17 species that trigger the definition of area 3 as KBA: Ichthyofauna, *Nothobranchius hengstleri* [42] and flora, all endemic and Endangered: *Chassalia colorata*, *Grewia limae*, *Crossopetalum mossambicense*, *Vepris allenii* [42].

Species that triggered the definition of area 4 as KBA [42], which is an important place for their biodiversity, on whose beaches two species of sea turtles lay their eggs: *Chelonia mydas* and *Eretmochelys imbricata* [35] [36], the latter with Critically Endangered status; this area is a marine ecosystem with important biodiversity of corals and other marine biota. [42].

Species that triggered the definition of area 5 as KBA, including the continental part of L, M, and even N (**Figure 1**): 15 plant species contribute to the definition of this area as KBA. Of the six with Endangered status, three are endemic (*Grewia limae*, *Vepris allenii*, *Tarenna pembensis*), and *Warneckea cordiformis*, in addition to being endemic, is Critically Endangered [42]. The diverse fauna [33] includes one of the most iconic mega herbivores on the African continent, the African savannah elephant (*Loxodonta africana*) whose population, in decline, presents the status of Endangered [42]. This species is present in other areas, such as Palma and Taratibu (**Figure 1**, F, K, W).

Species that triggered the definition of area 6 as KBA: Taratibu, marked as area W in **Figure 1**, in addition to being partially included in the QNP, has two endemic species: one of flora, *Rytigynia torrei* (Endangered); and the other of an amphibian species, *Nothophryne unilurio* [42], described in 2018 [43] as having the status of Critically Endangered [42]. It is important to note the presence of several important habitats, including inselbergs (mountain habitat), where plant species of the family Velloziaceae (*Euphorbia tirucalli*, *E. unicornis*, *Myrothamnus flabellifolius*, *Strophanthus hypoleucus*) predominate, in particular, *Xerophyta argentea* [44].

In the "Key Biodiversity Areas (KBAs) Identified in Mozambique: Factsheets VOL. II. Red List of threatened species and ecosystems, identification and mapping of key biodiversity areas (KBAs) in Mozambique", there is also a reference to Pemba Bay as being a KBA, although there is no information for its recognition as such [42].

We agree with McCook *et al.* [45] vision in their work entitled "Management under Uncertainty: Guidelines for Incorporating Connectivity into the Protection of Coral Reefs", where they stated the objectives "for networks of protected areas": "comprehensive and spread-protected all biotypes, habitats and processes, etc., to capture as many connections as possible, known and unknown".

3.2. Existent or Potential Sea Turtle Nesting Sites

There are reports of at least two species of sea turtles nesting in the area. Islands or areas on the continent may be visited by green turtles (*C. mydas*), hawksbill turtles (*E. imbricata*), or both. Islands include Rongui, Vamizi, Macaloe, Ibo, Matemo, Quilalea, Sencar, Menfuvo, Rolas, Quisiva, Tambuzi, Muissuni, Metundo,

and Vumba (**Figure 1**, **Table 1**), and beaches on the mainland include Mucojo, Guludo, Darumba, Naunde, Namau, and Quirimise.

4. Discussion

The main conservation goals of PAs rely on their ability to conserve functional, trophic, and species diversity, including preserving vulnerable species and habitats [46]-[48]. In this study, we propose a network of land, transition, and MPAs in Cabo Delgado that not only suggests the preservation of unprotected areas with ecological relevancy, but also ensures the much-needed connectivity between already established protected zones.

4.1. Small MPAs with No-Take Zonation

It has been suggested that MPAs can only be considered ecologically successful if they have twice as many large (>25 cm total length) fish species, five times more large fish biomass, and 14 times more elasmobranch biomass than non-protected areas [49]. In islands with no communities, one proposes to protect the entire area and consider them no-take zones. It has been shown that no-take protected areas can attenuate fisheries' bycatch, help the recovery of overfished stocks, and improve the food security of fishing communities [50]-[53]. Hence, areas fully protected, like Quissungura Island (**Figure 1**, n˚. 8), can contribute to maintaining sustainable fish stocks. Other human activities also benefit from PAs: tourism, which in turn is managed through zonation with different protection and accessibility levels; and scientific research, including citizen science, which has become an important strategy in the management of MPAs [54]-[56]. The Maluane Project serves as an example of best practices in implementing protection strategies, with valuable scientific output (in the form of technical reports and scientific publications) that involves the community, generating added value for it in the form of employment.

Since size and length of protection in MPAs are key factors in modelling ecological effects [57], in the Quirimbas case, it is important to decide to protect more islands beyond the QNP limits and propose for the expansion to include small islands and several shallows and seamounts. To consider some of the new patches as restricted-fishing MPAs would turn into a favorable mechanism for fishing activities of the adjacent communities due to their spillover effect, either ecological spillover (the diversity in different life stages that gets exported from an MPA), or fisheries spillover (the portion of the previous diversity that can be fished) [58] [59].

The QNP Management Plan decrees zoning, establishing the following zones: Total Protection Land Zone, Marine Total Protection Zone, Community Development Zone, and Specific Use Zone [34] [60]. In the present study, nine marine protection zones mentioned in this plan were included, namely Matemo Island (**Figure 1**, nº. 23; **Table 1**), particularly a part of the sea on the western side of this island; part of the coastal habitat in the town of Mussemuco; Ibo mangroves,

comprising the villages of Tandanhangue and Quirambo (**Figure 1**, U, nº. 26; **Table 1**); Rolas Island (**Figure 1**, nº. 22; **Table 1**); and Taratibu (**Figure 1**, W) located, at least in part, in polygon A of total protection [60]. **Figure 2** shows a timeline of relevant projects and conservation actions for the development of the present PA proposal.

Figure 2. Timeline of major documents/events related to the Quirimbas archipelago and its coastal zone. See the documents for more details. 1998 Maluane Conservation & Community Project (Cabo Delgado Biodiversity and Tourism Project), an initiative related with tourism and conservation involving Rongui, Vamizi (District of Palma) and Macaloe islands and the Messalo wilderness area (Fazenda do Bravio, District of Macomia); 2000, 2001 Approval of the Maluane Project management plan for 2003-2006; 2002 Quirimbas National Park (QNP) is established [61]; 2008 (2005-2008) TRANSMAP project (Transboundary networks of MPAs) is created [62]; 2008 Creation of the former Faculdade de Engenharia e Ciências Naturais (Univ. Lúrio); Discovery of hydrocarbons in Rovuma Basin; 2013 Report of aerial survey and census of QNP and adjoining areas describes several hundreds (811; 609-1094, 95% confidence range) of elephant carcasses accumulated between 2011 and 2013, with more than 100 elephants found in the Taratibu area; 2014 Anastácio and co-authors start to publish information related to the Macomia district (Messalo area) [33] and sea turtle nesting ecology in Vamizi island [35]; the Environmental Impact Assessment (EIA) Report is submitted to the government [63]; 2017 local instability and population displacement [18]; Diversity of *Eretmochelys imbricata* [36] and conservation [64]; 2018 QNP is declared a UNESCO Biosphere reserve [65]; Mucova and co-authors [66] publish information about the evolution of land cover in QNP area; 2019 Executive Summary and Update (ESHIA) provides an overview of the various environmental, social, and health studies that comprise the Environmental, Social and Health Impact Assessment for the Mozambique Liquefied Natural Gas (LNG) Project [67]; Ibo, Uma Ilha entre Natureza e Cultura/Ibo. Une île entre nature et culture [68]; 2020 Shapiro *et al.* [69] and World Wildlife Fund [70] review QNP boundaries; 2021, Mucova and co-authors [71] publish a projection associated with sea level rise for the center and North of Mozambique; 2023 QNP Plan Management 2023-2032 is produced; The Wildlife Conservation Society and other entities are co-authors of the document on the areas of Mozambique as KBA (Key Biodiversity Areas), like Palma, Vamizi, Quiterajo and Taratibu, KBA respectively 3, 4, 5 and 6 [42]; WWF reports possible scenarios for Quirimbas archipelago protection [34].

4.2. Challenges of the Management Cycle of PAs

MPAs are a broadly applied method for marine resource protection in the WIO, but their own management is hampered by the conditions that sustain their implementation. For example, the political conflict between conservationists—who value and monitor no-take zones—and fishermen—who not only defend their right but also their necessity to harvest—can often originate illegal, unreported, and unregulated (IUU) fishing [72]. Therefore, an integrated knowledge of human dimensions is needed to effectively reconcile human activities with MPAs' social acceptance in the WIO. The work of Rosendo *et al.* [14] addresses this issue by collecting the perceptions and attitudes of communities to MPAs in Cabo Delgado. Following Rosendo *et al.*, [14] work or other types of well-being assessment would be of great value to ensure the engagement of local people in the implementation process. Perhaps the most challenging aspect in the implementation process of any proposal ambitioning the expansion of the PAs in the Cabo Delgado province is the armed conflict, which is still present [18]. A locally managed (bottom-up) strategy for the Quirimbas MPAs is highly recommended to ensure communities' involvement in the administration process and to guarantee their best interests are being met [73]. International cooperation would be of great importance,

especially in what concerns developing scientific partnerships and training of local investigators, but also in funding the implementation of conservation strategies. For instance, the World Wildlife Fund's (WWF) Ecoregion Programme, the Global 200, recognized the East African coast as an ecoregion, the East African Marine Ecoregion, encompassing the coastlines of Somalia, Kenya, Tanzania, Mozambique, and South Africa—since the marine ecosystems of this region are not only physically but also ecologically connected, thus requiring a large-scale conservation strategy as an addition to individual national approaches [74]. Similarly, transboundary MPAs can be important instruments for the protection framework in this marine biogeographic region [75] [76].

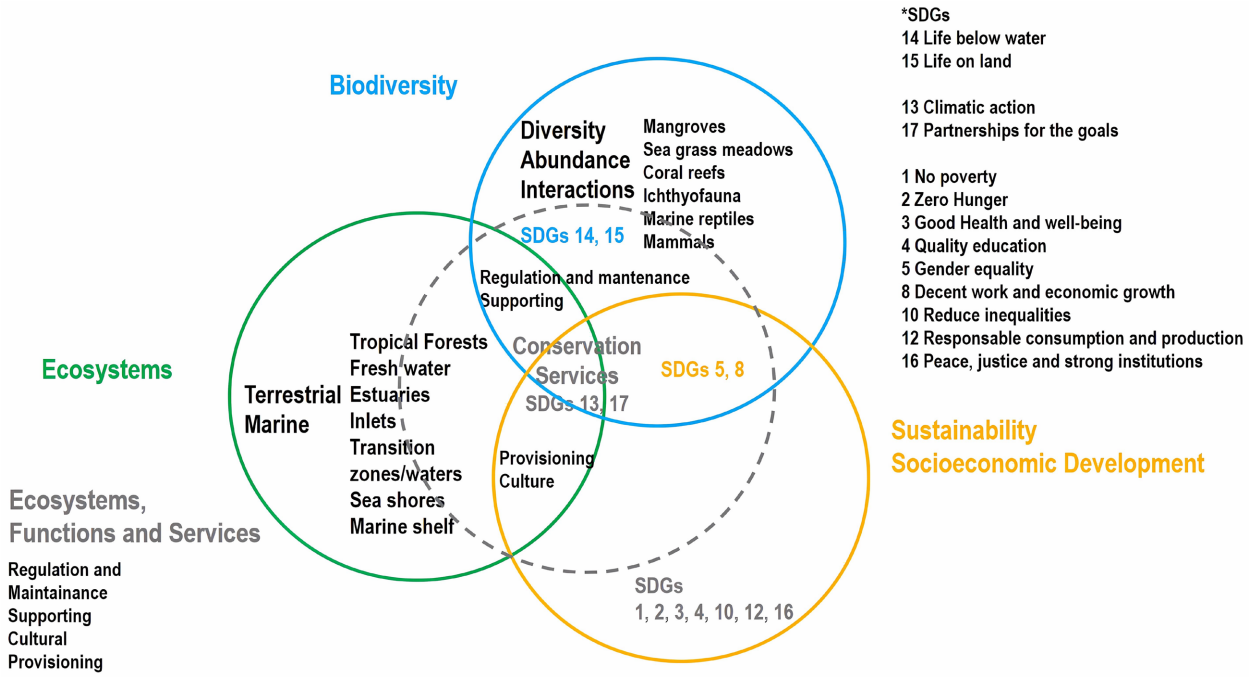

Figure 3. Relation between biodiversity, ecosystems, ecosystem services, socioeconomic development, and United Nations (UN) 2030 Sustainable Development Goals (SDGs). Blue circle: Biodiversity in the land, transition, coastal zones, and marine environment; Green circle: Considered ecosystems, e.g., tropical forests; Yellow circle: Socioeconomic development. Grey circle (Interception of circles): Conservation and governance for the SDGs. Figure adapted from Anastácio *et al.* [33], Keith *et al.* [78]; *Sustainable Development Goals [79]. *"Biodiversity is the variety of life on Earth, it includes all organisms, species, and populations; the genetic variation among these; and their complex assemblages of communities and ecosystems" [77]; **"Natural capital includes non-renewable resource stocks, renewable natural resource flows and the ecosystems that provide humans with ecosystem services, which are all essential to human well-being and the economy." [80]; ***"Ecosystem services are defined as the contributions that ecosystems make to human well-being (services that depend on living systems (*i.e.,* biodiversity in its broadest sense) or to include the non-living parts of ecosystems that can also contribute to human well-being)" [81].

The connection between biodiversity, ecosystems and their services are explored in diverse publications [33] regarding their potential contribution to the welfare of local communities. The previously cited study and **Figure 3** explore the different relationships between biodiversity—assuming for this effect the definition of biodiversity* provided by Benn & Darani [77], in a safeguard of natural capital**, ecosystem services***—and sustainable development, illustrating the

potential contribution to the implementation of the development goals defined by the United Nations (UN). Thus, a possible mechanism of governance based on local communities, different stakeholders, and cooperation, for example, with financial and scientific advisers, is preconized.

In 2006, the Convention on Biological Diversity (CBD) Eighth Conference of the Parties (COP8) declared a target for 2010 of "at least 10% of each of the world's ecological regions effectively conserved." [82]. By 2008, there was an estimate of 5000 established MPAs, but it was predicted the 2010 goal of COP8 would only be achieved in 2067 [83] [84]. In this way, the 2010 Aichi Biodiversity Targets of the CBD COP10 set the same ambition for 2020 [85], but again, this objective was not accomplished [86]. The same situation was repeated for Target 14.5: "By 2020, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on the best available scientific information" of the 2030 Agenda for Sustainable Development [87]. More recently, in 2022, CBD COP15 established Target 3 "Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas"…"are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures"… [88] Now (17th September 2024), there is an estimate of 18,868 designated MPAs, which occupy 30,258,127 km^2 (8.01%) of ocean area. While 19.17% of national waters (39% of total ocean area) are protected, only 1.44% of areas beyond national jurisdiction (ABNJ, 61% of total ocean area) are covered by MPAs [89]. Despite some efforts regarding the establishment of ABNJ MPAs [90] [91], the high seas belonging to international waters raises several issues about legislation, management, and monitoring [92] [93]. There is also a notable imbalance in terms of geographical distribution of MPAs coverage. While 45.5% of Polar and 25.2% of Latin American and Caribbean waters are under protection, only 8.76% of European and 15.09% of North American marine areas are within MPAs [94]. In addition, the number of MPAs is around 15 times lower than the number of land/inland water PAs—an estimate of 284.314 areas, 16.34% land coverage [95]—which demonstrates the disparity of success of PA implementation in different environments. Thus, it is crucial to increase global efforts for MPA implementation.

If MPAs are well-managed and frequently monitored, they can present multiple benefits and be one of the most valuable marine conservation tools, especially if they are widely supported by civil society [96]. In the case of the Quirimbas, frequent and effective monitoring may not be realistic, at least in the short term. Therefore, educating community members about the process and the plan's strategies (training guards and monitors to collect biological parameters in situ) through, for example, workshops and community meetings could be essential. This is especially important when displaced people start to feel safe enough to return to the places they abandoned during the outbreak of armed conflicts. They will need guidance to make effective use of natural resources and to reconcile this

use with the recovery of habitats and populations. In time, an efficient monitoring of MPAs could be achieved for the adaptive management of biodiversity. Updated knowledge of the status of the habitats and communities confirms if the current zonation is the most adequate for the area or if it needs to be changed [97]. In some cases, regular MPA sampling may support the expansion of the area [98].

One good example of cooperation is the iSimangaliso Wetland Park, a World Heritage Site and the largest coastal MPA in South Africa. This MPA is linked to others in its South (uThukela, Protea Banks, and Aliwal Shoal in South Africa) and North (Ponta do Ouro Partial Marine Reserve, Bazaruto Archipelago National Marine Park, and Vamizi-Quifuki-Metundo Island Complex in Mozambique), since its upper delimitation is the Mozambican border [99]. iSimangaliso is in a transition zone between the tropical Indo-West Pacific province (Maputaland subprovince, in Mozambique) and the subtropical East Coast province (Natal subprovince, in South Africa) [99]. In this way, it protects endemic subtropical and tropical African biodiversity and provides migration corridors for marine species [100] [101]. However, biodiversity relevance is not necessarily matched by physical MPA connectivity along the entire East African Coast. Although it has been shown that Mozambique holds high ecological connectivity (e.g., larvae dispersal) [102] [103], there are still several unprotected gaps throughout its coastline [104].

4.3. Concerns

The fluid, three-dimensional, large-scale and without physical boundaries environment of the ocean makes managing MPAs more demanding than managing land areas [105]. This applies particularly to large MPAs whose monitoring not only requires a greater expense (e.g., human resources needed for vigilance), but also cooperation between different entities [106], which may raise conflicts of interest. Therefore, MPA performance should be improved by management capacity-building. The developing regions hold the greatest marine biodiversity in the world, but the lack of structured governance systems and the difficulty of reconciling marine conservation with human activities represent serious threats to MPA enforcement [107].

Although there are numerous coastal MPAs, their effectiveness is questionable since many are either only partially protected or are simply implemented but lack regular surveillance plans [108]. These areas can be considered "paper parks" since they are designated under legal terms, but they do not contribute significantly to marine protection [109] [110]. This situation is also referred to by Jones *et al.* [104] for Mozambique's MPAs.

Cabo Delgado has a high poverty rate. It was likely the discontent and difficulties of the people that led many younglings to join the terrorist movement that settled in northern Mozambique in 2017 [18]. However, Cabo Delgado still has various riches: the culture of its friendly and welcoming people; the biological diversity, with its variety of ecosystems and emblematic and/or endemic species; the

scenic beauty, with beaches and tropical waters, inselbergs, among others; the geological wealth, with natural gas reserves, and gemstones. In 2011, Rosendo *et al.* [14] warned that the top-down approach implemented in MPAs in Mozambique was counterproductive: "Mozambique, like in many other developing countries, establishing centrally planned MPAs based primarily on international conservation targets and the desire to promote tourism by the government is likely to fail to alleviate poverty, while potentially also having limited success at conserving marine biodiversity." One can also add that the PAs in Cabo Delgado, while not as effective as hoped, have managed to achieve some of their objectives. Part of the population was involved in activities related to the implementation of the designed plans. The QNP has been the site of several pioneering scientific studies, and more are expected to follow. The discovery of gas reserves will attract more investors, which will bring opportunities for them to help lift people out of poverty while ensuring that their resource exploitation activities do not significantly impact the local biodiversity. This is, however, a major concern, considering the impacts these activities can have on coastal areas: chronic leakages, coastal development for infrastructures, seismic testing, and negative alterations to the economies, markets, and livelihoods of local communities [111].

The limits, extent, and justification of the inclusion of areas identified in this work in one of the various protected area categories will certainly depend on the diversity that exists there. But, regardless of the uniqueness of what justifies it, one must mention that, no matter how common the constituents of the communities are, they are at risk, as are the services and support provided by them to human populations, essentially rural, in exponential growth, and which depend on nature for subsistence, for a development that is desired sustainable in a clear contribution to the well-being of communities and regional stability.

5. Conclusion

Cabo Delgado is a region of extraordinary scenic beauty, provided with geological resources such as graphite, rubies, and hydrocarbon reserves. Its high diversity of coastal and terrestrial ecosystems, including coral reefs, mangrove forests, and seagrass meadows, sustain high plant and animal biodiversity—nudibranchs, ichthyofauna such as elasmobranchs, resident and seasonal marine mammals, sea turtles—including endemic species. Besides the need to preserve marine areas beyond the boundaries of QNP, protection should also be implemented in transition areas at the basin of large rivers, which not only are sources of freshwater resources but also constitute key ecosystems of the region. Fauna studies—primarily based on aerial counts—performed in the region have recorded megafauna occurrences outside the boundaries of QNP, drawing attention to the need to extend conservation limits. However, nature's protection should align with the creation of means of life for local communities and be shared through environmental education to promote awareness towards sustainable use of natural resources, highlighting their value and multidimensional contribution to human wellbeing. With

this work, we aim to share a vision and the arguments that support it so that the natural beauty of Cabo Delgado does not fade away. This is a contribution that does not intend to invalidate other proposals; its premise is that it may add value to what will be decided upon in the future by the government and its decision-makers.

Authors' Contributions

Conceptualization: R. Anastácio, Hermínio António. and M.J. Pereira; Methodology: R. Anastácio, H. António, and M.J. Pereira; Software: R. Anastácio; Validation, R. Anastácio, Hermínio António, and M.J. Pereira; Formal analysis (analyzed the data, prepared figures and/or tables): R. Anastácio, Hermínio António. and M.J. Pereira; Investigation: R. Anastácio, Hermínio António. and M.J. Pereira; Field work: Hermínio António. and M.J. Pereira; Resources: R. Anastácio, Hermínio António. and M.J. Pereira; Data curation: Hermínio António. and M.J. Pereira; Writing, review, and editing: J.A. Ferreira, Hermínio António, M.J. Pereira and R. Anastácio; Visualization: R. Anastácio, Hermínio António. and M.J. Pereira; Supervision: M.J. Pereira and R. Anastácio; Project administration: M.J. Pereira and R. Anastácio. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

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