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Evaluation of The Bamboung Community Marine Protected Area (Senegal) as a geosite

Adama Gueye[1], Ibrahima Sory Sow[2], Cheikh Ibrahima Youm[1], El Hadji Sow[1], Mbemba Fabou Doumbouya[1], and Cheikh Abdoul Kader Fofana[1]

[1]Département de Géologie, Faculté des Sciences et Techniques, Université Cheikh Anta Diop de Dakar, Dakar-Fann, Senegal

[2]Département d'Histoire, Faculté des Lettres et Sciences Humaines, Université Cheikh Anta Diop de Dakar, Dakar-Fann, Senegal

ABSTRACT: The Bamboung Community Marine Protected Area is located in the Saloum Delta Biosphere Reserve located in the estuarian part of the Sine-Saloum watershed, administrative region of Fatick. It was set up in 2004 with the aim of preserving marine biodiversity, rebuilding habitats and improving the living conditions of local communities. It was followed by the creation of six other Marine Protected Areas, including 2 in the Saloum Delta Biosphere Reserve. Based on our observations and the results of previous work, we have carried out an evaluation of the criteria retained by the authors for the creation of a geosite in this Marine Protected Area of Bamboung. Thus, the scientific value (representativeness, integrity, rarity and degree of scientific knowledge), ecological, cultural, touristic, socio-economic, scientific and educational values evaluated seem relevant to us. It benefits from a national and regional policy supported by international conventions. However, we recommend to modernize and improve tourist infrastructure, promote effective resource management mechanisms in the polarized area, prohibit or regulate the exploitation of shell middens and further explore the educational side by setting up a secure educational circuit.

KEYWORDS: Geodiversity, biodiversity, cultural, touristic, socio-economics, scientific, educational.

1 INTRODUCTION

Between 2004 and 2014, Senegal set up seven Marine Protected Area (MPAs) covering a total of 206.162 ha, with the aim of preserving marine biodiversity, rebuilding habitats and improving the living conditions of local communities. These MPAs are placed under the supervision of the Ministry of the Environment and the DAMPC (Directorate of Community Marine Protected Areas), although they are managed at the community level [1].

The notion of Marine Protected Area is more noticeable with the definition of the Convention on Biological Diversity (CBD) held in Kuala Lumpur (Malaysia) in 2004. According to this Convention, a marine protected area refers to "any area within or near the marine environment, with its overlying waters, the associated fauna and flora and the historical and cultural elements found therein, which has been set aside by law or other useful provisions, including custom, for the purpose of granting biological, marine or coastal diversity, a higher degree of protection than that enjoyed by the surrounding environment" [2], [3]. Over the years, this definition has undergone several changes. The IUCN recently proposed the following definition: "an MPA is a clearly defined geographical area, recognized, dedicated and administered, legally or by other effective means, which aims to conserve in the long term nature, ecosystem services and the cultural values associated with it" [4].

The establishment of an MPA "limits, prohibits or otherwise controls human use patterns and activity through a structured set of rights and rules" [5].

As part of the Narou Heuleuk (tomorrow's share) project, the Océanium, a Senegalese association for the protection of marine resources, financed by the FFEM (Fond Français pour l'Environnement Mondial), has proposed the establishment MPAs in Senegal. It was only in 2002 that the first MPA in Senegal was created in the region of Fatick, department of Foundiougne,

Corresponding Author: El Hadji Sow

sub-prefecture of Toubacouta) (figure 1), commune of Toubacouta at the level of the "bolon" (term used by [6] to designate tidal channels inside the mangrove) of Bamboung (Bamboung Community MPA with 6,800 ha [7] (figure 2). It was endorsed by presidential decree n°. 2004-1408 signed on November 4, 2004 [8]. MPAs aim to sensitize artisanal fishermen to sustainable management of the environment.

An integral part of the RBDS ("Réserve de Biosphère du Delta du Saloum" = Saloum Delta Biosphere Reserve), the Bamboung Community MPA (BCMPA) is surrounded by 14 villages [3]. Its limits were fixed by the populations with the Oceanium who made it a zone completely prohibited to fishing after a negotiation which lasted nearly two years [8]. It is bordered to the north by the Diomboss inlet, to the south by the village of Sipo and the forest of Kolé, to the east by the bolon of Bandiala and to the west by the forests of Diogaye and Kabaye [3] with about twenty shell middens including Diorom Boumack. The BCMPA is the first of a series of three Community MPAs located in the Saloum estuary, within the RBDS. The other two are that of Gandoul (GCMPA) in the North and that of Sangomar (SCMPA) in the North-West. Each of the three has geosite value. Thus, the evaluation of the BCMPA as a geosite will be the first step towards the establishment of a geopark called the RBDS Geopark.

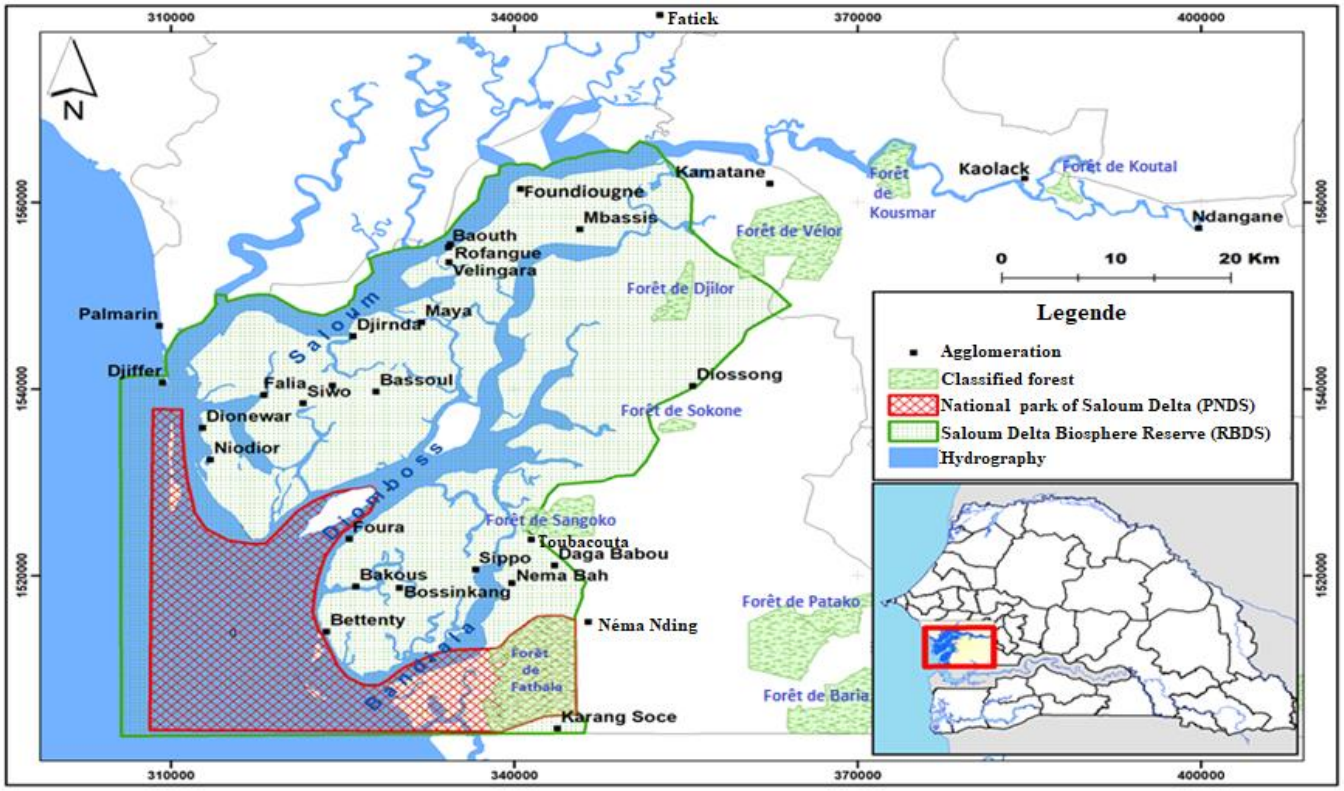

Fig. 1. Location map of the RBDS and the entities that accompany it (PNDS and classified forests)

According to [9] and [10], "*geosites are defined as portions of the geosphere that present a particular importance for the comprehension of Earth history, geological or geomorphological objects that have acquired a scientific, cultural/historical, aesthetic and/or social/economic value due to human perception or exploitation*". Geosites are then key elements from the perspective of the development of geotourism and education, while inventorying and evaluating them is the first step towards establishing a geopark [10]. Another key concept is geoheritage (geosites and geomorphosites), which needs to be evaluated [11], managed [12], subject to conservation [13], valorized through geoparks [14] and [15], and be the focus of geotourism [16], [17], geoscience museums [18]. Preserving geoheritage means safeguarding the natural diversity of the major geomorphological and geological elements, i.e. geoheritage sites, also known as geosites [19].

According to Lima et al. [20], most geosite evaluation methods use scientific value, which may be subdivided into four sub-criteria: representativeness, integrity, rarity, and also the degree of scientific knowledge about the geosite, attested by the number and quality of scientific publications focused on the geosite [21]. Representativeness concerns how exemplary a geosite is in terms of the geological processes that can be seen there. Rarity corresponds to the uncommonness of the geosite compared to geosites of the same typology at the global level, while integrity represents the degree of preservation of the

geosite [22]. In addition to the scientific one, other values, called "additional" values [23], can be identified and assessed: cultural, ecologic, economic, aesthetic and educational [24].

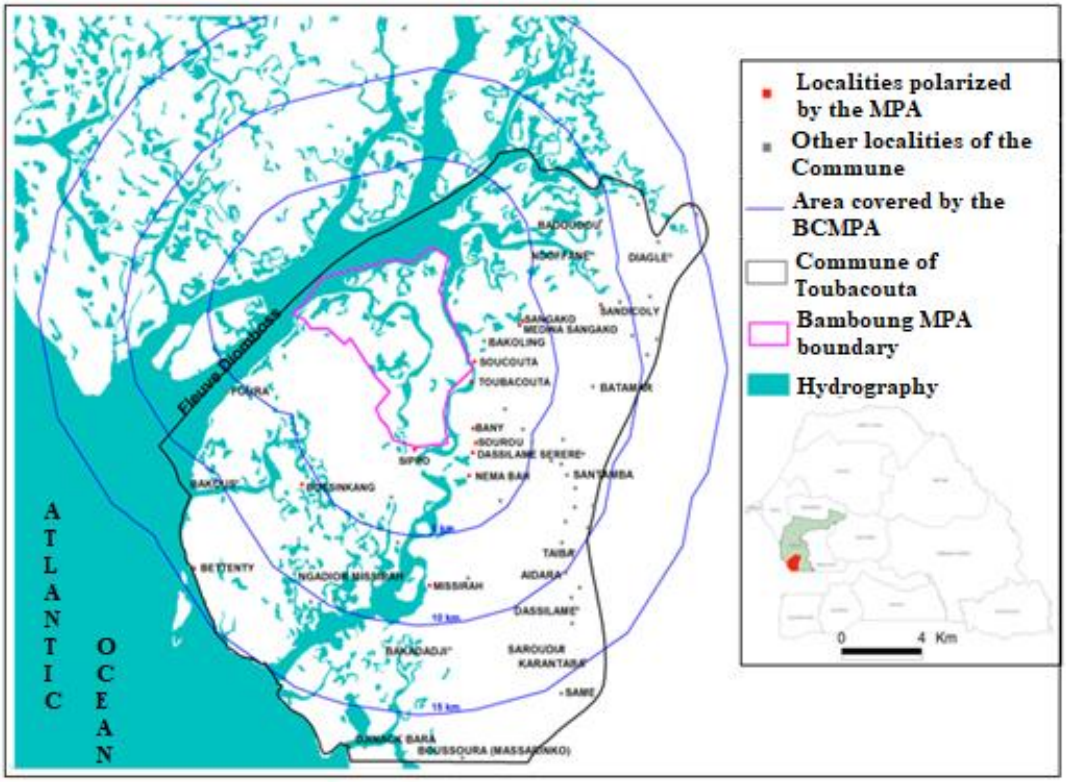

Fig. 2. Location map of the BCMPA and its area of influence (modified after [7])

This study is part of a wide multidisciplinary research program initiated in Senegal for the promotion of geodiversity. It follows the work carried out by [25] in the Dindéfélo Community Nature Reserve (DCNR) and that of [26] at Lac Rose located respectively 700 km and 30 km from Dakar. It aims to show the relevance of the BCPMA for the popularization and promotion of geosites. To be done, we conducted a qualitative assessment using the criteria proposed by [20] and [19]: scientific then ecologic, cultural, touristic, economic, and pedagogical, considered to be the most suitable for carrying out a preliminary examination, and by no means exhaustive [24]. Data come from our observations supplemented by the many works carried out in previous programs based mainly on biodiversity, archeology and tourism.

2 THE GEOGRAPHICAL, GEOMORPHOLOGICAL AND GEOLOGICAL FRAMEWORK OF THE RBDS

The RBDS is located on the coasts of West Africa, in the center west of Senegal, in the estuarine part of the Sine-Saloum watershed, on the Gambian border. Located between 13°35 and 14°15 North Latitude and 16°03 and 16°50 West Longitude [35], it is about 150 km south of Dakar, 50 km south-west of Kaolack and 20 km from Banjul, in The Gambia Republic (figure 1). It is located in the administrative region of Fatick and includes the districts of Djilor Diognick, Toubacouta, Fimela and Niodior; it occupies 340.000 ha there, which constitutes almost the entire estuary zone, i.e. more than 25% of its extent.

The RBDS is home of more than 200 islands and islets separated by narrow channels where the water is mainly saline to slightly brackish and 218 shell middens. The RBDS is made up of three main ecological domains [42], [51], [52]: (i) a continental domain limited in its lower part by the mangrove and the tannes (halomorph soils); (ii) an island domain made up of three sets of islands separated from each other by inlets surrounded by mangroves. The Diomboss separates the Gandoul islands to the north from Bétenty island, a large ovoid-shaped island 25 km long and 12 km wide, itself separated from the Fathala islands to the south by the Bandiala inlet (figure 1). Many channels called bolons separate the islands from each other. Among the most important, we will mention, for the islands of Gandoul: the Bolon Gokehor, the bolon Diogane, the bolon Sangako, the bolon Guilor... For the islands of Fathala; the bolon Ba, the bolon Missirah... The complex covers an area of 90.000 hectares; (iii) a maritime domain that opens onto the Atlantic Ocean.

The RBDS offers great geological diversity. The marine transgression of Nouakchottian (5500 years BP) caused sandy deposits which formed terraces on the edge of the continental shelf sometimes high enough to form islands, mudflats with mangroves which are more or less sandy deposits and tidal channels. During this period, the sedimentary series presents the same characteristics throughout the estuary: abundance of sand, poverty or absence of diatoms [27], [28], [29], [30]. The inlets of the Saloum (very winding and ramified) are occupied by the sea to the upstream of Kaolack (more than 110 km from the mouth). Due to a rainfall deficit, former exposed mudflats have turned into tannes devoid of vegetation. This development has continued until the present day. There is a greater extension of the tannes in the islands of Gandoul in the north than in the Bétenty islands in the south [31]. In addition, the entire right bank of the Saloum River is made up of tannes, the mangroves constituting only a thin curtain along the tributaries of this bank. The tide, essentially semi-diurnal, is the main factor in estuarine hydrodynamics [32]. The drop in rainfall has increased the salt concentration of the Saloum estuarine waters, which contributes to the degradation of the mangroves. This degradation is explained, among others, by the excessive salinity of the waters, their high pH almost always between 7 and 8, the presence of acid sulphate soils, sunshine, etc... [31], [33], [34], [35], [36]. The whole is bordered by intertidal mudflats which constitute the most important geomorphological and sedimentological unit because of their role in the ecosystem. The relief of the area is practically flat, with altitudes ranging from 0 to 5 m. On the other hand, shell middens can exceed sea level by more than 10 m. Because of this weakness of its relief, the important hydrographic network, the islands and its vegetation, the Saloum shelters a very rich biodiversity which makes it an important natural heritage.

3 GEOSITE OF THE BAMBOUNG COMMUNITY MARINE PROTECTED AREA (BCMPA)

3.1 GEODIVERSITY VALUES

In the BCMPA, five geological and geomorphological units can be distinguished [37], [38], [39], [40]: (i) the hydrographic space is essentially made up of the Bolon of Bamboung and its very dense ramifications, with an area of about 850 ha and 15 kilometers long from the confluence with the Diomboss to the mudflats of the Kolé forest. Its width varies from 50 to 500 meters and its depth fluctuates between 0 and 15 meters. The salinity of the bolon is reduced thanks to the resurgence of fresh water from underground sources. Compared to other bolons in the Saloum Delta, the water visibility of the Bamboung bolon is estimated at 3.7 meters against 1.8 meters in the rest of the estuary [41]. In addition to the Bamboung bolon, the BCMPA includes around twenty small and medium-sized bolons (Bolon with crocodiles, with manatees, Bandialé, Balando, Niokolong, Diogane, Kabaye, etc.) and ponds. The Bamboung bolon longitudinally divides the BCMPA into two nearly equal parts. The diversity of tributaries and the quality of the water make the BCMPA a site of tranquility, calm and rest for the fish; (ii) the insular domain made up of islands separated from each other by bolons surrounded by mangroves. It occupies 15 to 20% of the BCMPA surface and is mainly represented by Coco Island [42]; (iii) the mudflats which are located on the immediate border of the bolons and the main inlets, their sandy fraction, generally higher at the base of the sedimentary series, would have a marine origin [35], their clay fraction dominated by kaolinite and their carbonated fraction is generally scarce.; (iv) tannes subdivided into bare tannes with saline efflorescence, grassy tannes and floodable tannes separating the mangrove mudflat from the bare tannes. The set formed by the mudflat and tanne areas covers an area estimated at 1.238 ha. They result from the degradation of mangrove ecosystems caused by the invasion of salt water from the ocean; (v) sand bars, sediments of the bottom of the channels essentially sandy and the shell mounds.

These units began to set up in Chadian (13,000 to 8,000 B.P.); however, the most important phase of their formation is located in the Nouakchottian (6800 to 4200 B.P.) [35], [43], [44], [45]. The oldest ages on the sedimentary bedrock are around 6130 and 6070 obtained at Bandiala by [46]. During this period, the Nouakchottian marine transgression caused sand deposits which formed terraces on the edge of the continental shelf, sometimes high enough to form islands, mangrove mudflats and bolons. In the Tafolian, the formation of islands, initiated in the Nouakchottian, is accentuated by the addition of successive coastal bars and the formation of lagoons between them. The lagoons thus formed are filled with clay mud under the control of the flow of the Gambia River and allow the development of diatoms [30]. Between 460 B.P. and 1090 A.D., [47] showed, by studying the oxygen isotopes of molluscs, that the precipitation-evaporation budget was positive in the Saloum delta whose waters were brackish; causing a proliferation of euryhaline diatoms [30]. To this general context of humidity, we must add the Bandiala's supply of fresh water from the Néma River [48] and the water table of Coco Island. Around ca. AD 1800, a period of rapid aridification sets in and the recent emergence of Sahel drought [49].

3.2 BIODIVERSITY POTENTIAL

Fresh water from a large groundwater table on Coco Island (east shore) and underground springs flow into the bolons of the BCMPA, thus locally reducing salinity and creating a favorable climate for the development of marine flora and fauna. This makes BCMPA one of the richest bolons in the RBDS.

It has an important mangrove ecosystem covering a total area of 3,506 ha (nearly half of its area) (Figure 3) and the wooded savannahs, most of which are surrounded by mudflats [7]. The mangrove vegetation, developed all along the bolon and its channels, is made up of different species of mangrove trees: *Rhyzophora racemosa* and *Rhyzophora harrisonii* are found along the edges of channels; to the rear, *Rhizophora mangle* is much more abundant and occupies high ground likely to be submerged during high tides. This species forms the most important population of the bolon, while *Avicennia africana* develops in the upper part of the mudflats [51]. Mangroves, being both a source of organic matter and a support for a high production of periphyton, constitute a breeding ground for estuarine fauna, mainly juveniles. They constitute the habitat of halieutic resources (fish, molluscs, crustaceans, sea turtles, dolphins, manatees, Nile crocodiles, etc.) (figure 4a) [7], [51]. The manatee, a marine mammal threatened with extinction, comes to drink from the freshwater resurgences on the shores of Coco Island.

Fig. 3. Mangrove vegetation in submersible areas of BCMPA. a: Soucouta; b: Missirah; c: Toubacouta; d: Sipo

The areas of terrestrial savannas (433 ha), gallery forests (38 ha), mudflats and tannes are favorite places for many bird species (Goliath heron, gray pelicans, flamingos, kingfishers, etc.) [53] (Figure 5). Many species of land mammals such as bushbuck, spotted hyena, monkeys, baboon, jackal, warthog, monitor lizard, snakes, etc., frequent the wooded savannah areas. The regeneration of these forests and savannahs results from the absence of bush fires and the reforestation of the

forest. These terrestrial habitats are also home to significant forest resources composed of *Proposis africana, Eleais guineensis, Detarium senegalense, Dialium guinensis, Tamarindus indica, Adansonia digitata, Anacardium occidentale, Eucalyptus globulus,...*) (figure 4b).

Fig. 4. Mangrove oyster in Bétenty (a) and vegetation of the non-submersible zone in the BCMPA (b)

Since the establishment of this CMPA and the measures that have been taken for its protection, it would seem that the species encountered are more and more numerous and that the average size of individuals is increasing [50]. A biological recovery (51 species of fish in 2003, 74 in 2006, 85 in 2012 and 130 in 2018) has been noted, linked to experimentation with tools and sustainable financing mechanisms. It should also be noted that this CMPA is a place where many fish come to breed and grow up in the tangle of mangroves bordering the bolons, for example the "THIOF" (*Epinephelus aeneus*) and the manatee [54]. Special monitoring and ecological monitoring of molluscs and birds are also developed.

Fig. 5. Some images of Bird Island

3.3 CULTURAL POTENTIALS

The BCMPA has a rich cultural heritage based on archaeological potential, the existence of places of worship and traditional ceremonies.

The BCMPA is home to about twenty shell middens accumulated mainly on former sandbanks, including Diorom Boumack [52], one of the largest shell middens which contains 125 tumulus (Figure 6). These accumulations consist essentially of shells of *Senilia senilis* (arches) and rarely of shells of *Crassostrea gasar* (mangrove oysters) or a succession of strata of these species [55]. These shells are mixed with pottery debris (figure 7a), kitchen remains, plants, hearths, ceramics, stone and metals. The deads were buried under these shell heaps arranged in layers on top of each other; thus over the millennia, large mounds of shell deposits have formed in the old cemeteries.

Fig. 6. Shell middens of Dioron Boumak surmounted by a baobab forest (modified after [49])

The age of the shell middens is still the subject of discussion. According to [55], the oldest dates in the RBDS are 5800 years BP obtained at the Sipo site. According to these authors, these traces, rare between 6000 and 2000 years BP, reached their maximum around 1700 years BP before experiencing a decline from the beginning of the 15th century. However, [56], from ongoing work on the shell middens of Oudierin-Boumak, announce that the exploitation of shells began at the beginning of the Holocene, some 10.000 years ago. The author adds that the long-term models of their exploitation reveal a punctuated use with short periods of relatively intensive collection/processing followed by long periods of abandonment and distinguishes four periods of different durations: early Holocene, middle l 'Holocene, end of the Holocene and beginning of the second millennium AD. Throughout the Saloum delta, 17 shell middens surmounted by tumulus have been registered on the list of historical monuments of Senegal (decree n°10787 of December 11, 2000) including Diorom Boumack and Diorom Boundaw. Moreover, these sites constitute a natural heritage with shell middens that have become niches, refuges for fauna, in particular birds and flora; a cultural landscape with a thousand-year-old tradition that is still alive, favoring a way of life based on shellfish gathering and fishing, in a fragile natural environment of great biodiversity and one of the few places in the world where shell collecting practices survive [57]. Since 2013, the monitoring of molluscs has started at the level of the BCMPA and its periphery and has focused on 6 species: *Senilia senilis, Crassostrea gasar, Pugilina morio, Murex duplex, Cymbium glans* and *Cymbium pepo* [7]. Concerning shell middens, it is advisable to regulate their exploitation to prevent their depletion, as happened on the sites of Faboura [58], and Bangaler [59].

Fig. 7. Dioron Boumak shell midden: pottery extracted from archaeological excavations (a) and path running through the midden (b) (modified from [53])

There are places of worship and sacred “trees” in almost every village [7] which encompasses the BCMPA where people usually come to pray during circumcision, approaching wintering, wrestling galas... These are: the giant cheese maker of Missirah (figure 8a), the Baobab of the griots (figure 8b), the sacred "taba" of Sourou, the Batakoung or large rice field which is a place full of mysteries and important for the inhabitants of Bossinkang, of the Wouliniama of Bétenty symbolized by a baobab whose fruits are eaten on the spot, of the Ngoumbo Taba of Missirah (blinding tree which stunned those who wanted to attack the village), of the sacred wood of the places of circumcision, the forest of Diouanwoula whose access is regulated or even forbidden, a place of prayer in Missirah represented by a plot of land with a tree incursion inside the arm of the sea, a socio-religious meeting place (Keur mouride) in Nema Ba.

Fig. 8. “Millennial” cheese maker from Missirah (a) and Baobab des griots (b) at the BCMPA level [7]

Traditional wrestling is also a cultural heritage in the area in accordance with the departmental calendar and the sessions are organized in each village with various activities including dancing and singing. It is a safe bet that supports the cultural heritage of the BCMPA so far.

Nowadays with the Islamization of its villages, some of these beliefs are increasingly losing their value because the majority of the population does not even mention them, although certain rituals continue to be practiced in the confidentiality of the guardian families of the cults and exceptionally during events affecting the whole community (drought, epidemic, etc.).

3.4 TOURISM POTENTIAL

Long before the creation of the BCMPA, tourism and ecotourism were already featured in local development strategies [60]. Ecotourism is a form focused on environmental education, awareness, protection and conservation of nature [61]. It is a tourist activity promoting the natural, historical and cultural heritage that is carried out in all the villages of the area. On the other hand, the camp project is one of the by-products of the CMPA intended to offset the loss of income from the absence of fishing and to offer a new economic opportunity.

In Bamboung, community ecotourism is the only alternative activity created as part of the sustainability of the CMPA [3]. The main receptives are hotels, hostels and camps. The spatial distribution of tourist accommodation is uneven. In the Municipality of Toubacouta, area where the BCMPA is located, there are two hotels (Palétuviers and Keur-Saloum) and several camps. Currently almost all the villages in the area have tourist camps. Thus, each village has an ecotourism circuit (figure 7b). Due to their proximity to the BCMPA, the activities of these establishments and tourist sites depend more or less on this MPA. The Keur Bamboung camp is the most visible achievement of the MPA; it is more than a camp, it is a management and local development tool for this site with exceptional ecosystems. It was built inside the MPA in 2004, with funding from the French Global Environment Facility (FFEM). Thus, by paying for their stays, tourists contribute to the development of the BCMPA and the municipality, which receives a share of the revenue, the other going to the management committee. Seven huts have been built in the cottage and can accommodate 26 visitors (2 double huts with a capacity of 6 beds, 4 single huts with a capacity of 3 beds and 1 single hut with a capacity of 2 beds) [3]. They are built with terracotta and straw, lit by the use of renewable energy which also ensures the delivery of water from the borehole to these huts. At the foot of the huts, boarding by canoe kayak is offered for visits to the environment. The vocation of limiting the number of visitors in the lodging reflects the fact that the camp does not intend to increase its reception capacity in order to preserve the comfort of visitors and not to increase the pressure of visits on the preserved environment of the CMPA. Tourist attendance is annual. It is more intense from October to April and relatively weak from May to September.

The activities offered to visitors to the ecotourism camp of Keur Bamboung range from sea kayaking trips to discover the bolons and the mangrove, walking trails to discover the mangrove, the gallery forest and the wooded savannah or ecological heart of the mangrove, then in the bolons and on the lively and grassy tannes of the MPA. Canoe trips, an introduction to ornithology or even a visit to the village of Sipo to discover the craft market are also offered [3].

The Dioron Boumack ecomuseum is currently in a poor state of conservation; however, it allows the discovery of the most impressive shell midden in the Bamboung MPA. A circular path running through the various shell mounds allows you to discover the extent of the site punctuated by impressive baobabs (figure 7b). A rehabilitation project is planned for this large shell pile. This eco-museum should become a place for displaying old cooking methods, used agricultural equipment, fishing equipment and a wrestling arena [3].

The management of the camp as well as the receipts fall under the prerogatives of the management committee, which is responsible for setting the principles of management and redistribution (figure 9). The distribution key put in place provides for (i) a third of the revenue for the operation of Keur Bamboung, (ii) another intended for the financing of surveillance and the development of the BCMPA, which makes it possible to finance surveillance and to remunerate the eco-guards up to 2000 FCFA/day in addition to the purchase of gasoline and (iii) finally, the third part is intended for the municipality. For the town hall, these financial resources are used to develop socio-economic projects in the villages bordering the BCMPA. It has thus promoted the creation of direct jobs (15) and indirect jobs that could benefit nearly 10.000 inhabitants [3] and [62].

Fig. 9. Restitution workshop - validation of the BCMPA Development and Management Plan (modified from [53])

3.5 SOCIO-ECONOMIC POTENTIAL

The population living in the localities polarized by the BCMPA is mainly composed of Mandingos and Serers. It is marked by its youth with 44% who are under 17, including 18% girls and 26% boys [52] (Table 1). On the BCMPA site, the exploitation of fishery resources is totally prohibited, but remains open in the Bolon of Sangako and in the Diomboss [63]. Thus activities such as fishing and shellfish harvesting are practiced there regularly. The women of the area are involved in the processing of fishery products and the collection of molluscs (figure 10). The latter is an activity of great importance that is carried out in very difficult conditions with little security. They put in place a certain number of informal rules that make it possible to regulate the use of spaces, in particular the outskirts of the area during the collection of shellfish. These rules allow each village to use the spaces in turn according to a flexible and mutually accepted "rotation" [3].

Table 1. Distribution of households according to age groups and gender in Toubacouta according to [52]

0 to 5 years (%)		6 to 16 years (%)		17 to 59 years (%)		60 years and over (%)	
Boys	**Girls**	**Boys**	**Girls**	**Men**	**Women**	**Men**	**Women**
14	6	12	12	23	25	3	4

In terrestrial savannah areas, gallery forests and areas polarized by BCMPA, people practice other activities. Agriculture is practiced by most of the population. Arboriculture is well developed and quite diversified in the area; cashew trees, coconut trees, oil palms, etc... can be listed. Added to this is livestock (poultry, sheep, goats, etc.); craftsmanship, which is essentially limited to the sculpture of works of art and Djembe because of the availability of illegally exploited wood and the development of tourism in the area; trade which is very developed in Toubacouta even if there is only one weekly market based in Némanding; the exploitation of salt which is more developed in Sangako than in the other villages because it has adequate equipment and infrastructure; money transfers from migrants [52] and [63].

Fig. 10. Women preparing shellfish meat for sale (modified from [53])

Fig. 11. Views of the BCMPA Environmental Education Center (modified from [7])

3.6 Scientific And Educational Potential

The Saloum estuary has been the subject of several studies. They are based on the mangrove, its evolution and its deterioration [34], [64]; sedimentology [43], [44], [65], [66]; geomorphology, grain size, exoscopy and mineralogy [67], [68]; microfauna and macrofauna [69]; salinity, rainfall and precipitation-evaporation [48], [70], [71], [72],; the biology of fish community [73] and archeology [45], [56]. However, nowadays, the attention of the international community is mainly focused on biology (fisheries and mangrove resources) and tourism. Historical and cultural sites receive little attention.

The BCMPA is also committed to promoting the ecological, cultural and marine heritage of this site and its surroundings through its Environmental Education Center (CEE) built in 2008 under the dome of the OCEANIUM (figure 11). In fact, because of its ecological richness, this MPA lends itself to educational visits and practical work, particularly on themes such as ornithology, botany, ichthyology, the discovery of historical heritage and cultural and even the organization of seminars and workshops related to these themes. Through this center, exhibitions, conferences, awareness-raising and education actions on the marine environment for the general public but also for schoolchildren (educational workshops) could be envisaged [7] (figure 9 and 11).

3.7 Development Potential

This CMPA offers significant development opportunities. The natural richness of the site is not only explained by the importance of the diversity of its ecosystems and its landscapes (mangrove, banks of the bolons, forests, pedestrian and ecological paths) but also by a rich cultural heritage.

The Saloum Delta region offers favorable coastal climatic conditions, with the presence of many waterways bordered by mangroves, beaches with fine, clear sand, a string of islands and islets sheltering forests dotted with baobab and meandering, making it an attractive tourist destination. From a cultural point of view, the shell middens and the remains they contain constitute a specific resource for the BCMPA. In addition, there are places of worship and traditional ceremonies.

The richness of the site is accompanied by a national and regional policy supported by international conventions that have enabled the acquisition of a certain number of collective infrastructures: health posts, educational establishments, equipment for supplying water, etc., which constitute levers for the sustainable development of the BCMPA [52] (table 2).

Communication infrastructures (roads, internet, etc.), although insufficient, exist. In order to support people's means of subsistence, microfinance institutions offer several financial services, including: "campaign credits" intended for seasonal agricultural activities (winter farming, fattening, fishing, etc.); "trade credits" intended for individuals and groups as a goodwill; "investment credits" for agricultural activities and handicrafts [52]. However, the funds that are granted relate to short periods (one production cycle or two years maximum) and many households have never used these loans. For example in Toubacouta, 90% of households have no access to credit at all and only 39.66% are members of local credit associations [52].

Table 2. Some indicators describing the facilities in the localities polarized by the BCMPA according to [52]

Localities	Indicators						
	Number of health posts	Number of colleges	Number of fuel sales stations for speedboats	Number of ice factories	Number of drilling	Number of fishery product processing units	Number of honey houses
Bétenty	1	2			1	1	
Bossinkang						1	
Dassilamé	1	1			1		1
Missirah			2	1		1	
Sandicoly						1	
Sangako						1	
Sokone (Mboul Diamé)	1	1	1		Connected to Sokone drilling		
Soukouta	1	2			1	1	
Total	4	6	3	1	3	6	1

4 DISCUSSION

The Bamboung Community Marine Protected Area is the first of a series of three MPAs created in the Saloum Delta. The other two are the Gandoul (March 31, 2014) and Sangomar (March 25, 2014) CMPAs. Sangomar has the largest area (87,437 ha) with a maritime part and Bamboung the smallest (6,800 ha). In the Sangomar CMPA, the zones of mudflats and tannes, gallery forests and terrestrial savannah are less extensive, as is the number of islands (Table 3). The BCMPA has the least salty and clearest waters (3.7 m against 1.8 m for the other two). The mangrove ecosystem widespread on the shores of the bolons is well developed in the three CMPAs, as is the estuarine fauna (fish, molluscs and crustaceans), marine mammals (manatee, dolphin) and reptiles (turtles, crocodiles, etc.). As for terrestrial mammals and forest resources, they are more abundant in the BCMPA. The avifauna is more diversified in the GCMPA which shelters the bird island with both sedentary and migratory species [74]. Cultural heritage is rich in all CMPAs although the archaeological sites of Bamboung are better known. Tourism is less developed in the GCMPA which does not have tourist receptives. On the socio-economic level, the exploitation of fishery resources (fish, molluscs and crustaceans) remains the main activity in all the MPAs, even if fishing is totally prohibited on the BCMPA site and their transformation is ensured everywhere by the women. Agriculture, arboriculture, market gardening, animal husbandry, crafts and trade are more developed in the area polarized by the BCMPA than in the other MPAs.

Table 3. Potential of the three Marine Protected Areas of the Saloum Delta

Potentialities		CMPA		
		Bamboung	Gandoul	Sangomar
	Total area	6 800 ha	15 732 ha	87 437 ha
Geodiversity Potential	Area of bolons and inlets.	3 506 ha	The 4 main pits exceed 5 ha	8 bolons + 4 fish breeding area
	Water salinity	Reduced	Variable	Saline to supersaline
	Water visibility	≈3,7 meters	≈1,8 meter	≈1,8 meter
	Areas of mudflats abd tannes.	1 238 ha	Few	Very few
	Number of islands	The largest is Coco Island	14 of which 10 are inhabited	8 villages
	Terrestrial savannah zones	433 ha	35 %	Very few in polarized areas
	Gallery forest areas	38 ha		
Biodiversity Potential	Mangrove ecosystem	Nearly 50% of the area	Fairly widespread on the banks of the bolons	Well developed in the estuary part
	Estuarine fauna	Abundant and diverse	Abundant and diverse with pools (fish nursery)	Very diverse
	Seafood	Molluscs and crustaceans		

	Marine mammals and reptiles	Manatee, dolphin, turtles, crocodiles, etc		
	Terrestrial mammals	Numerous and diversified	Little diversified	Very little diversified
	Avifauna	Abundant and diversified	Sedentary and migratory with Bird Island	Migratory birds
	Forest resources	Substantial	Undiversified in the process of regression	Undiversified
Cultural Potential	Archaeological sites (Shell middens)	Abundant (20)	Fairly abundant	Fairly abundant
	Places of worship	In almost all villages	Well supplied	Numerous and diversified
	Myths	Developed	Highly developed	Developed
	Traditional ceremonies	In each village		
	Islamization	Galloping	Strong establishment	Some localities
Touristic Potential	Hotels	02	Not in the area	03
	Hostels	Several	Not in the area	Small receptives in Palmarin
	Tourist camps	In each village	Not in the area	14 + 22 residences
	Ecotourism circuit	Each village	2 in Fambine	Mainly at sea
	Existence of management committees	Yes	Not well structured	Good organization
Socio-economic Potential	Young population (under 17)	44% including 18% girls in Toubacouta	44% including 21% girls in Gandoul	44% including 21% girls in Dionewar
	Exploitation of fishery resources in the MPA	Totally prohibited	Authorized with nets and lines	Fishing practiced all year round
	Shellfish harvesting	By women in nearby areas	Authorized	Practiced all year round
	Processing of fish products	By women		
	Exploitation regulations	Yes	Access to bolons	Seafood
	Agriculture, arboriculture, market gardening	Yes	Moderate	Poorly developed
	Breeding	Poultry, sheep, goats, etc.	Moderate	Poorly developed
	Arts and crafts	Artwork and Djembé	Very poorly developed	Poorly developed
	Trade	Developed in Toubacouta	Poorly developed	Local products
	Weekly market	Only one in Némanding	Poorly developed	None
	Salt exploitation	Developed in Sangako	Poorly developed	Highly developed
	Transferts d'argent	Provenant des migrants		
Development potentials	Climatic conditions	Favorables		
	National and regional policy	Stimulator		
	International conventions	Stimulator		
	Basic collective infrastructures	Existing	Very poorly developed	
	Microfinance institutions	Existing	Few	

In 2004, Senegal set up four other MPAs: Abéné MPA in Casamance (900 ha), Joal-Fadiouth MPA (17,400 ha), Saint-Louis MPA (49,600 ha), Kayar MPA (100 ha) [75] (figure 12) all intended for the restoration and conservation of biodiversity. In the West African sub-region there is a network of MPAs (Regional Network of Marine Protected Areas in West Africa: RAMPAO). The ranking of these countries in terms of protected area is as follows in descending order: Mauritania (1,317,780 ha), Guinea Bissau (495,601 ha), Senegal (171,075 ha), Guinea Bissau (111,556 ha), Cape Verde (59,335 ha) and Gambia (41,800 ha) [63].

As a geosite, the BCMPA has different potentialities from other sites described as potential geosites in Senegal. In relation to geodiversity, the ecosystems are almost all continental in Dindéfélo [25] while in Lac Rose [26] they are partly aquatic but less diversified than in Bamboung. This difference conditions all the other potentialities (Table 4).

Fig. 12. Location and contours of the seven MPAs in Senegal (modified from [75])

Table 4. Comparison of the BCMPA geosite to those previously described in Senegal

POTENTIALITIES	GEOSITES		
	AMPCB	**Lac Rose (Youm et al., 2022)**	**Dindéfelo (Youm et al., 2018)**
Geodiversity potential	Presence of channels, mudflats, tannes and islands	Low salt ponds, resurgences of fresh water	Sandstone/lutite hills and alluvial deposits
	Clear and slightly salty water	High concentration of salt	Fresh water
	Gallery forests and terrestrial savannas	Dunes	gallery forests and open forests
Biodiversity potential	Mangrove* and forest ecosystems	Azoic except for some halophilic green algae; herbaceous and casuarina trees around	Woody and herbaceous vegetation + diatoms
	Estuarine, marine and seafood fauna	Fish, foraminifera, ostracods and diatoms in the ponds	No aquatic fauna
	Reptiles, birds*, marine* and terrestrial mammals	Birds	Amphibians, Reptiles, birds* and mammals*
Cultural potential	Archaeological sites (Shell middens with burials)	Shell middens with burials	No archaeological sites reported
	Places of worship in almost all villages	Unmarked places of worship	Ritual bathing for locals and visitors
	Well-developed myths	Unreported myths	Myths and legends
	Existence of traditional ceremonies	Traditional ceremonies not reported	Existence of traditional ceremonies

Touristic potential	Hotels, hostels, tourist camps	Hotels, hostels	reception centers and tourist camps
	Existence of management committees and several ecotourism circuits	Existence of management committees and ecotourism circuits	Management committees and ecotourism circuit hardly passable
Socio-economic potential	Exploitation of fishery resources prohibited in the CMPA and authorized around	No fishery resources	No fishery resources
	Processing of fish products by women	Exploitation of salt by women	Existence of a center for the self-promotion of women
	Breeding, agriculture, arboriculture, market gardening	Market gardening, arboriculture	Breeding, agriculture, market gardening gathering, gold panning
	Salt mining, handicrafts, trade	Sand mining, shellfish extraction, handicrafts and small trade	Packaging and marketing of water
	Only one weekly market in Némanding	No weekly market	One weekly market in Dindéfélo
	Favorable climate	Maritime freshness	Sudano-Guinean climate
	Favorable national and regional policy		
	Existence of international conventions		
	Existence of basic collective infrastructures		
	Existing microfinance institutions		

**Species threatened with extinction.*

5 CONCLUSION

The analyzed area has a sufficiently high geodiversity potential that can serve as a basis for the creation of a geosite. In terms of representativeness, it is home to very diverse biotopes: bolons and passes with clear, low-salt water and plenty of fish; resurgences of fresh water; mangrove mudflats; bare tannes; numerous islands and islets sheltering forests dotted with baobabs; beaches with fine, clear sand; shell middens containing remains. The rarity sub-criterion is evidenced by comparison with other potential geosites described in the country. Integrity is ensured by the different statuses attributed to the area: Saloum Delta National Park (PNDS) in 1976, Saloum Delta Biosphere Reserve (RBDS) in 1981 in the Man and Biosphere (MAB) program, wetland of international importance in 1984 within the framework of the Ramsar Convention and Marine Protected Area in 2004. The last sub-criterion which evaluates the scientific value, the degree of scientific knowledge on the geosite, is attested by the number and quality of scientific publications focused on the geosite.

In terms of biodiversity, the BCMPA is home to a mangrove ecosystem that covers nearly 50% of its area; an abundant and diversified estuarine fauna made up of fish, molluscs and crustaceans; reptiles (turtles, crocodiles, etc.) and marine mammals, some of which are threatened with extinction (manatee, dolphin, etc.); numerous and diverse terrestrial mammals; abundant forest resources; abundant and diverse birdlife.

The AMPC has a rich cultural heritage based on archaeological potential with around twenty shell middens containing burial mounds, the existence of numerous places of worship and traditional ceremonies practiced in all the villages. It is clear that most of these beliefs lose their values with Islamization.

Tourism and ecotourism are well anchored in the local development strategies of the BCMPA. The main receptives are hotels, hostels and camps. Each village in the area has tourist camps and an ecotourism circuit. The management is ensured by a committee and the receipts benefit the municipality and the populations.

The young population is mainly made up of Mandingos and Serers. Apart from tourism, fishing and shellfish harvesting are practiced regularly in the bolons outside the BCMPA site and the processing of fish products is carried out by women. In terrestrial savannah areas and gallery forests, people practice other activities such as agriculture, arboriculture, market gardening, livestock, handicrafts, trade, etc.

This natural, cultural and socio-economic wealth of the site is accompanied by a national and regional policy supported by international conventions which has enabled the acquisition of a certain number of collective infrastructures which constitute levers for the sustainable development of the BCMPA.

However, it is necessary to modernize, expand and improve tourist infrastructure, mainly accommodation and catering structures and geotourism trails; assess the impact of certain conflicts related to the use of resources in the area polarized by the BCMPA and promote effective mechanisms for their management. These include the cutting of mangrove wood for smoking fish and the use of small-mesh nets at the entrance to the bolons. Particular attention should also be paid to cultural potential by regulating the exploitation of shell middens to prevent their depletion.

In addition, the educational value of the site remains insufficiently exploited. The establishment of a secure educational circuit for student visits would make them more aware of environmental education. The site could also accommodate field camps for students in history, geography, but also in marine geology.

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