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Mapping of coral reefs in the continental shelf of Brazilian Northeast through remote sensing*

Paulo Victor do Nascimento Araújo^{@, a, b}; Ricardo Farias do Amaral^b

ABSTRACT

The Continental Shelf has great importance in the study of coastal evolution, provided this area was affected by fluctuations in sea level during the Quaternary period. In the shallow continental shelf of the Northeastern Rio Grande do Norte, Brazil, submerged important geomorphological features can be found in the distance of 6 km from the coastline. Among these features, highlights the reef complex called *Parrachos* of Rio do Fogo. This study aims to characterize and analyze geomorphological features and benthic surface features found in this reef complex, from the analysis and interpretation of remote sensing products and *in situ* data collection. In this work, a digital model of bathymetry was created based on unpublished bathymetric data and compositions from images bands of satellite sensors OLI/Landsat-8, MS/GeoEye and PAN/WorldView-1, and then analyzed, interpreted and validated through field work. All obtained data and information were stored in a Geographic Information System (GIS). The following geoenvironmental units were mapped: intertidal reefs, submerged reefs, spurs and grooves, pools, sandy bank, sea grasses, bank of algae, submerged roads, Barreta Channel and the Rio do Fogo Channel. The use of the proposed methodology provided a detailed analysis of submerged geomorphology in the study area. This study may be used as a guide for future decision-making for environmental management in the region.

Keywords: Continental Shelf; Bathymetry; Geomorphology; Remote Sensing; Geoenvironmental Mapping.

RESUMO

Mapeamento de recifes de corais na plataforma continental rasa do nordeste brasileiro por sensoriamento remoto

A Plataforma Continental possui grande importância no estudo da evolução costeira, pois representa uma área afetada pelas oscilações do nível do mar no período Quaternário. Na plataforma continental rasa do Nordeste do Rio Grande do Norte, Brasil, importantes feições geomorfológicas submersas podem ser encontradas a cerca de 6km da linha de costa, dentre estas feições, se destaca o complexo recifal denominado *Parrachos* de Rio do Fogo. O presente estudo objetiva caracterizar e analisar as feições geomorfológicas e da superfície bentônica, encontradas neste complexo recifal, a partir da análise e interpretação de produtos de sensores remotos e coleta de dados *in situ*. Neste trabalho foi criado um modelo digital de batimetria

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com base em dados batimétricos inéditos e composições de bandas de imagens dos sensores orbitais OLI/Landsat-8, MS/GeoEye e PAN/WorldView-1, ambos analisados e interpretados de forma integrada e validados em trabalhos de campo. Todos os dados e informações obtidas foram armazenados em um Sistema de Informações Geográficas (SIG). Foram mapeadas as seguintes unidades geoambientais, os recifes intermareais, os recifes submersos, rastros e sulcos, piscinas, o banco arenoso interno, fanerógamas marinhas, o banco de algas, caminhos submersos, o Canal de Barreta e o Canal de Rio do Fogo. O emprego da metodologia proposta possibilitou uma análise detalhada sobre a geomorfologia submersa da área de estudo, podendo ser norteador, em futuras tomadas de decisão no manejo e gerenciamento ambiental da região.

Palavras-chave: Plataforma Continental; Batimetria; Geomorfologia; Sensoriamento Remoto; Mapeamento Geoambiental.

1. Introduction

Tropical coral reefs are the richest and most complex benthic communities in the oceans. These were formed over millions of years (about 500 million years ago) from the deposition of calcium carbonate from coral skeletons, and they are among the oldest known marine communities (Wilkinson, 2002). In Brazil, geological history of the current coral reefs indicates that they only began to grow 7,000 years ago, in the Quaternary period, when the sea level rose and completely flooded the current continental shelf (Prates, 2003).

Tropical coral reefs are considered the marine ecosystems that contain the highest levels of biodiversity, only exceeded by the tropical rainforests on land (Connell, 1978). Estimations point that at least 3,000 species of animals can be found in a single coral reef. Despite reefs occupy less than 1% of the total area of the oceans, 25% of all known species of fish are unique to these environments. According to Prates (2003), among the coral species in the world (350 species) at least 20 species (true and hydrocorals corals) were recorded in Brazil, and eight are endemic.

The high productivity associated with reef-building corals has a unique importance as a source of fisheries for coastal communities and corals are also important as (1) natural protective barriers to the coast of wave action, (2) sources of pharmacotherapy and (3) areas for tourism. Despite greater ecological and economic importance, coral reefs are subject to various factors that threaten their vitality and biodiversity (Hoegh-Guldberg, 1999; Moreira & Reuss-Strenz, 2009). Recent studies, coordinated by the World Resources Institute (WRI) which monitors coral reefs, warned that coral reefs are currently suffering from high temperatures and ocean acidification more than in any other time, in the course of the last 400,000 years (Burke *et al.*, 2011). If we continue down this path, all corals are likely to be threatened by 2050, as 75% are experiencing critical threat levels. The same report of WRI offers reason to hope: reefs around the world have demonstrated an ability to recover from damage, even in extreme cases, whereas it is the duty of environmental management to protect reefs and aid the recovery of some areas. These factors further confirm the importance of thorough studies concerning coral reefs, particularly when that environment

is suffering risk of environmental degradation – from the both biotic and abiotic points of view. This is the case of the area under research in this project.

In 2001, the Conservation Unit called "Environmental Protection Area of Coral Reefs" (*Área de Proteção Ambiental dos Recifes de Corais - APARC*) was created in the state of Rio Grande do Norte, in the Northeast region of the Brazilian coast (Figure 1). This area corresponds to the marine region covering the coastal strip of Maxaranguape, Rio do Fogo and Touros municipalities. In this area, we highlight coral reef complexes, which are shallow bodies, with intertidal stretches, mainly formed by bioconstructions of algae and corals on a mud bottom and carbonate sand beyond rhodolith.

These bodies, locally called "*Parrachos*", are costal reefs and are aligned parallel to the coastline. They grow over a hard bottom, probably lines of sandstone, related to the ancient coast lines (Branner, 1904; Vianna *et al.*, 1989; Amaral, 2002; Santos *et al.*, 2007). This area is composed of clear water during the major part of the year. Among its most important features, the *Parrachos* of Maracajaú, Rio do Fogo and Cioba are considered the most sensitive areas of APARC, given their environmental characteristics. Laborel (1967, 1969) describes the reef complex in the region under study as a group of oval-shaped reefs, located a few miles off the coast, constituted of simple structures, formed generally by numerous pinnacles in a shallow sandy bottom and a reduced number of species. Leão *et al.* (2003) comments that coral reefs belonging to the study area usually are oriented NW-SE, with a length from 8 to 12 km, parallel to the coastline and they are presented as a set of knolls and patch reefs. These bodies are described and related to the area known as "sublittoral turbid zone", by Testa & Bosence (1999).

APARC is currently suffering from intense pressure from use and occupation, which has led to a growth in environmental degradation. Overfishing, coastal occupation and disorderly tourist operation in a clear process of expansion are among the main reasons for the degradation in APARC and associated platform (Amaral, 2005). However, fishing activities – traditional or touristic – are the major method of gathering resources for the local population. The situation is aggravated by the lack of information needed for effective management,

although isolated studies already exist and discuss the sustainability of the region.

In Brazil, the mapping and studying of coral reef evolution, through the orbital sensing images employment, emerged at the same time the first environmental satellites were released in the 70s. In the 80s and 90s, some studies (Vianna & Solewicz 1988 ; Solewicz, 1989; Viana *et al.*, 1989; Viana *et al.*, 1991; Viana *et al.*, 1993; Testa *et al.*, 1997; Testa & Bosence, 1999) made the first utilization of satellite images for the understanding of regional structures, followed by field verification. Prates (2003) warns that there are few maps with location and complex coral coverage area due to the impossibility of using traditional techniques of drilling in the extensive shallow areas where the reefs occur. The exploration work carried out to date in the region of APARC and the determination of some physical parameters (Testa, 1997; Feitoza *et al.*, 2001; Lima, 2002; Amaral, 2005; Santos *et al.*, 2007; Henriques, 2008) underlie the need for more detailed mapping levels for the study area.

According to Hill & Wilkinson (2004), knowledge of the spatial characteristics of an area is a prerequisite for any study involving the environment and their rational and sustainable use.

In this sense, the availability of habitat maps is an excellent tool in land management, guiding strategies for sampling and identifying conservation areas (Hamel & Andréfouët, 2010). Habitat maps are great but geomorphic maps can be used as proxies and are easier to produce (*e.g.*, Hamylton *et al.*, 2012). The potential use of satellite sensor data for this type of research has been demonstrated in several studies worldwide (Luczkovich *et al.*, 1993; Green *et al.*, 1996; Mumby *et al.*, 1997; Andréfouët *et al.*, 2001; Andréfouët & Riegl, 2004; Scopéltis *et al.*, 2010).

Thus, this research aims to map the Geo-environmental features and the benthic surface of the *Parrachos* of Rio do Fogo and its surroundings, aiming for the acquisition and development of appropriate methodologies for its mapping, with the integrated utilization of several types of remote sensing products in orbital and underwater platforms. This will facilitate the determination of geographical and geological and biophysical indicators of threats to ecosystems.

2. Material and Methods

2.1. Study area

The studied area has approximately 90 km². It is located on the northeastern coast of Rio Grande do Norte State (Figure 1) and it is inserted in the Environmental Protection Area of Coral Reefs (APARC). APARC involves all marine regions with depths up to 25 meters, and their limit is the continental sector, the coastal areas

of the Maxaranguape municipalities, Rio do Fogo and Touros.

The climate regime of the continental region adjacent to the study area is of 'As' type, "hot and humid" according to the Köppen classification (Köppen, 1918). The main feature of this regime is a rainy season that includes the months from February to July, and a dry season, with more rigorous drought between October and December (Carneiro, 2011). The local weather pattern is largely influenced by air masses from the Atlantic Ocean and the winds from the SE (Silva, 2002). Current velocity between the east and northern coasts of Rio Grande do Norte varies between 1.39 cm/s and 24.92 cm/s, averaging 6.32 cm/s (Hazin *et al.*, 2008). The surface temperature of the sea water varies from 26.5°C during the winter at 28.5°C in the summer period (Servain *et al.*, 1990) and the salinity is between 36 and 37‰ (Testa, 1996). The predominant current direction during periods of peak intensity was to the NW. The wave climate for the sector covering the study area is defined by significant wave height of 1.0 m and 5 seconds to incident waves of ENE and 1.5 m and 6.5 seconds of SSE waves (Bittencourt *et al.*, 2002). The region has a semidiurnal tidal regime, with an average approximate range of 1.5 m, reaching 2.2 m in spring tides, and according to Hayes (1979), can be classified as a strand of meso-tide. Turbid water is generally high, especially in the rainy season, with high visibility during the spring and summer seasons (October to March). Turbidity is natural and consequent action of the winds and/or tidal currents that cause the particle suspension (Maida & Ferreira, 1997).

Fishing artisanal activities represent the main source of economic resources for the local population (Amaral, 2005). Bonilha (2003) reinforces that fishing communities in the region could be classified as small-scale merchants. And that the region also represents a great potential for the development of tourist, sport and recreational (such as scuba diving, boat rides and sport fishing) activities – provided they may be conducted inside a set of technical and social criteria (preferably the social inclusion of the local community) – what constitutes an opportunity for the eco-development of the region in a perspective of community wealth management of natural resources.

2.2. Coral mapping

The term geoenvironmental adopted by the International Union of Geological Sciences (IUGS), was created to adequately describe the work done by geoscience professionals on the environment. The aforementioned work contemplates the application of technical knowledge to the various instruments and mechanisms of environmental management. The geoenvironmental concept favors the integration of knowledge and

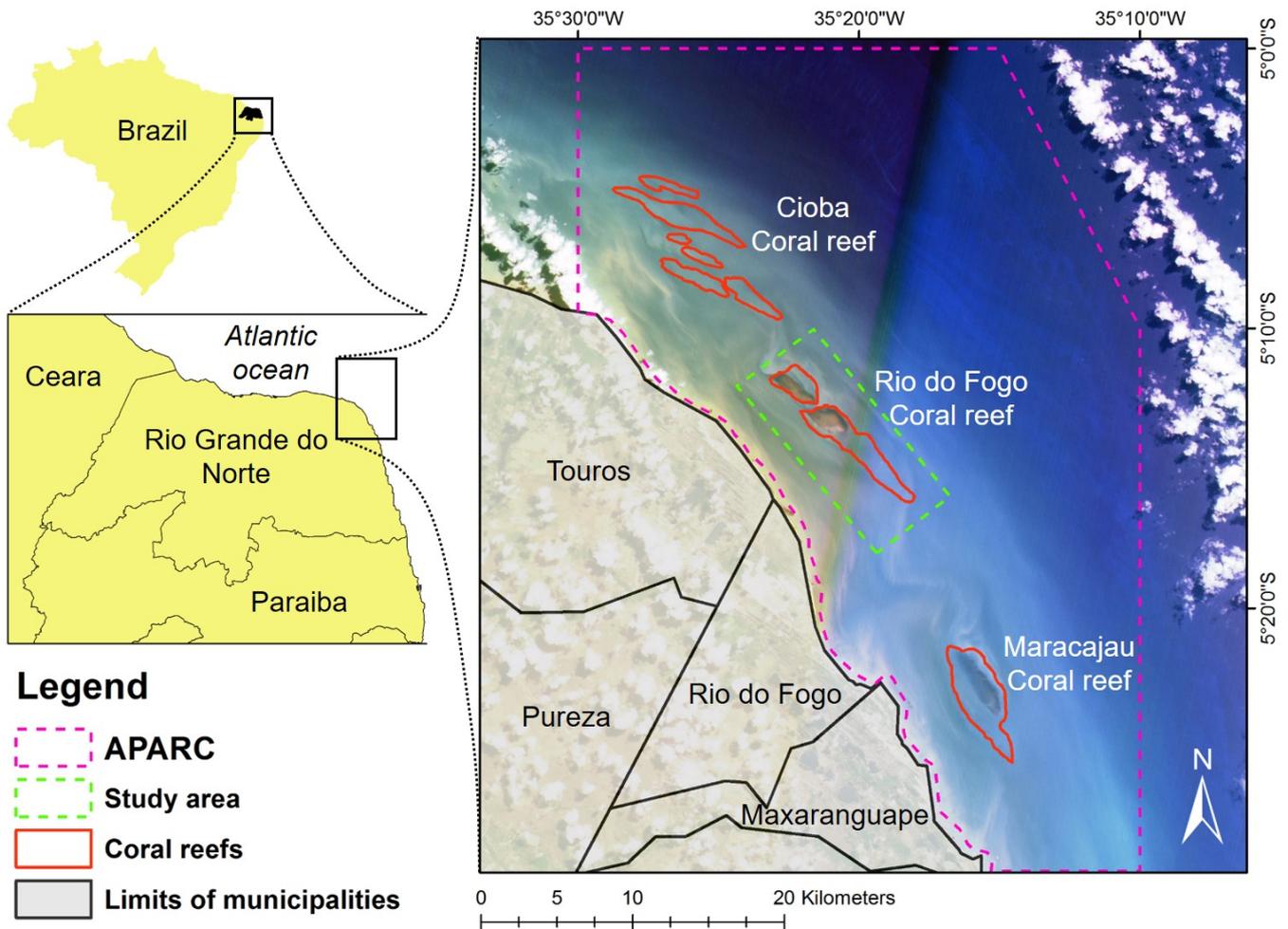


Figure 1 - Location of the studied area and delimitation of the APARC. In detail, the scene of CCD sensor/CBERS-2B in composition RGB-321 (scene date: 31/07/2008).

Figura 1 - Localização da área de estudo e delimitação da APARC. Em detalhe, cena do sensor CCD/CBERS-2B na composição RGB-321 (data da cena: 31/07/2008).

experiences when determining homologous areas. This mapping was conceived in this integrating perspective. In this study, the geoenvironmental mapping is mainly based in geomorphological criteria furthermore adding information pertaining to the type of sea floor, coral density and correlation between coral and height of tide.

2.2.1. Bathymetric analysis

Bathymetric surveys were conducted in April 2013, using a vessel equipped with Global Positioning System (GPS) and echo sounder (single-beam transducer, 200KHz). Details of the procedures that led to the establishment of the Digital Bathymetric Model (DBM) are described in Supporting Information I.

In the analysis of bathymetric profiles, the aim was to identify the main geomorphological areas of this reef complex. The following has been identified:

- *Back Reef*. Reef region facing the coast, which usually suffers less impact of the waves due to the protective effect by Reef Crest and Reef Front.

- *Reef Crest*. The highest portion of the reef at any stage of their growth, and in shallow water, the part of the top of the reef that receives most of the wind and waves.
- *Reef Front*. This zone extends from the surf zone (end of Reef Crest) to an indefinite depth (beginning of Fore Reef), where the topographic slope begins softening or changing pattern. This zone also absorbs much of the energy from the waves.
- *Fore Reef*. Located in the outer portion of the reef, after the Reef Front, and stand as far as the environmental topography stabilizes.

2.2.2. Orbital remote sensing products

The optical sensors used in this study were: MS (*Multispectral Sensor*) of the GeoEye-1 Satellite, PAN (*Panchromatic*) sensor of the WorldView-1 Satellite and OLI (*Operational Land Imager*) sensor of the Landsat-8 Satellite. Details of procedures are expressed in Supporting Information II.

2.2.3. Interpretation of remote sensing products

Initially, images were submitted to atmospheric and geometric correction (Drury, 1993; Richards, 1995; Walsh *et al.*, 1998). A cut was made around the study area in the collected images in order, so that the external features not to influence the variability of this information. After the corrections, a hybrid image was generated (RGBI-4328) with the OLI/Landsat-8, properly contrasted. Then, another hybrid image was generated (RGBI-RGBPAN) with high spatial resolution sensors, MS/GeoEye-1 and PAN/WorldView-1, properly contrasted. These two hybrid images were the basis for the visual interpretations of the objects. All image processing activities were carried out by the ERMAPPER v7.1 software (ERDAS, 2008).

Finally, there was the "ground truth". Three diving expeditions were conducted in the field, considering three occurrences of independent dives in each of the mapped homologous areas. At the dives the following parameters were observed and analyzed via georeferenced photography and filmography: types of sea floor; coral density and correlation between coral and height of tide. This allowed the interpretations validation of the data obtained with the processing of digital imagery. Data collection occurred in areas that were pre-selected during the processing of digital imagery according to procedures adopted by Amaral & Gonçalves (2004) and by Hill & Wilkinson (2004). The collected data were georeferenced through GPS receivers.

3. Results and discussion

Mapping of the study area allowed the assessment in greater detail, geomorphological features and the benthic surface, integrating the use of remote sensing and *in situ* data collection.

An elliptical shape is evident in the reef complex, with the semi-major axis oriented in the SE-NW direction. Has about 12 km long and 3 km wide, a ratio length x width of approximately 4:1.

3.1. Bathymetric analysis

Generation of *Digital Bathymetric Models* (DBM) from data interpolation is a highly widespread technique in coastal studies (e.g., Righton & Mills, 2006; Ryan *et al.*, 2007). In the working area previous studies (Nogueira & Amaral, 2009 and Araújo Filho, 2011) used DBM to outline their concerns about large-scale area of morphology. Santos (2006) already alerted to the need to work bathymetry so that it is utilized more precisely, in order to model the *Parrachos* in the region in order to position them properly. In this study the use of EBK interpolation method helped with the production of models of the stubby coral banks (typical of the region) in good regional scale. The same model

presented with a standard average error margin of 0.609 when subjected to the cross-validation process (Table 1).

Table 1 - Summary of cross-validation.

Tabela 1 - Resumo da validação cruzada.

Samples	1186
Mean	-0,004
Root-Mean-Square	0,601
Mean Standardized	0,004
Root-Mean-Square Standardized	0,944
Average Standard Error	0,609

By using the DBM, a map of the bathymetric contour, with 2m isobaths (Figure 2), a 3D model of bathymetry (Figure 3) and two-dimensional bathymetric profiles (Figure 4) were produced and examined.

The information drawn from these products complement each other and thus can have a more precise idea of the geomorphology of the study feature. The mapped area has a depth range of approximately 14m. The complex of the Rio do Fogo Reef is defined between the isobaths of 4 and 6 m, under which we see a rapid increase in the slope to a depth of approximately 10 meters. The DBM allowed the observation of a bank to SW from the *Parrachos*, an elevation between the reef complex and the mainland, limited by isobath 6m, with approximately 2 km wide. This bank has approximately the NS direction and is joined to the mainland near the Rio do Fogo community. His presence is not clear in the studied satellite images, so being called internal sand bank. It is also observed the presence of at least three transverse morphological discontinuity to the reef body (Figures 2 and 5):

- (I) The first, further north, clearly visible, is the morphological expression called Barreta Channel, separated into two bodies: Recife das Garças (further northwest) and Rio do Fogo reef. This channel will be described later.
- (II) Approximately in the center of the body other transversal discontinuity with direction SW-NE is clearly observed in both the bathymetric model as the satellite image. His evidence extends toward the platform until the isobath 10 meters in front reef.
- (III) Finally, a third discontinuity is observed just south, thus, more subtly evident, although clear, both in the DBM as in the images.

In the external sector of the reef body, positioned parallel to this, at a distance of 1000 meters, the isobath 12 meters shows an elongated depression with about 9km long. This channel limits the Front Reef and its presence is also seen in the satellite image. Its depth reaches 14 meters and the call of Rio do Fogo Channel.

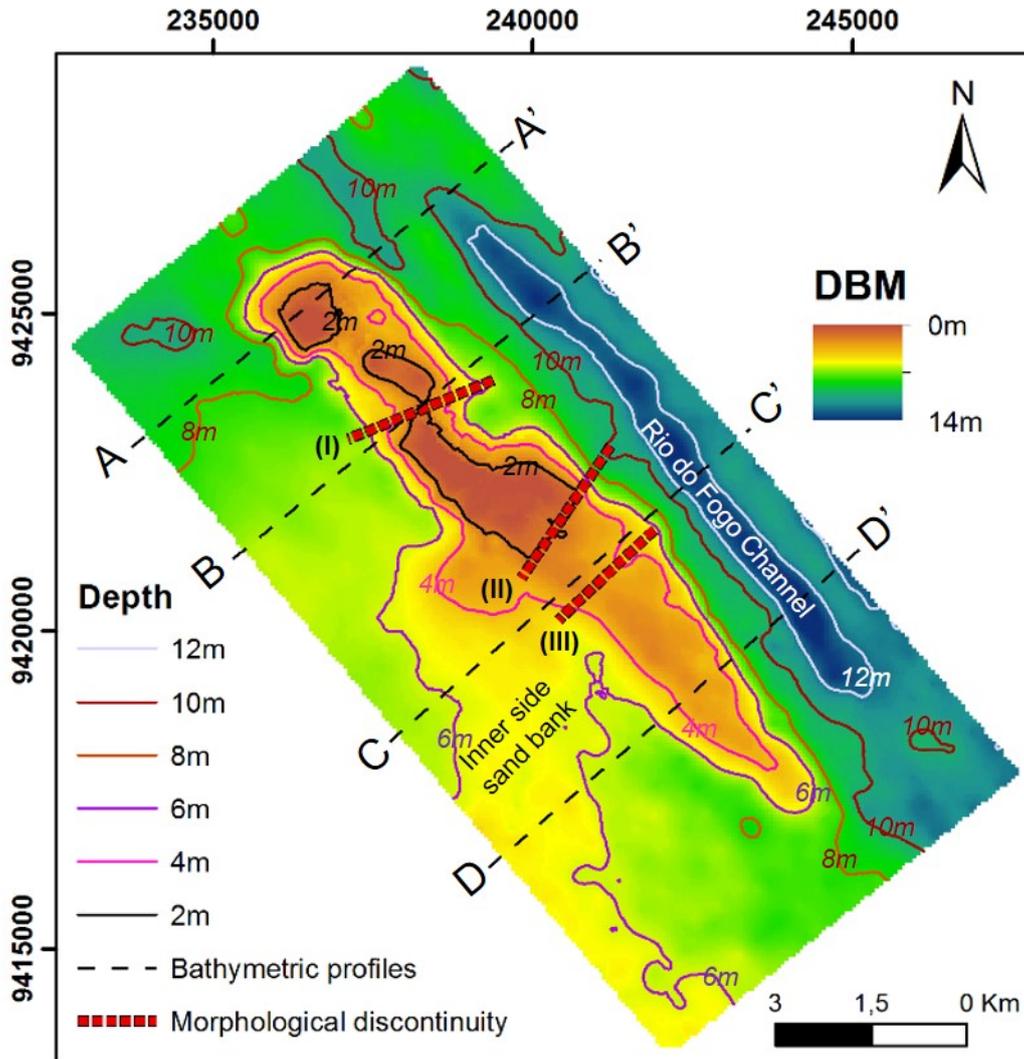


Figure 2 - Digital Bathymetric Models (DBM) interpolated from the Empirical Baeyesian Kriging (EBK). The positions of the selected bathymetric profiles are located in dash lines (see Figure 4). (I), (II) and (III) morphological discontinuities are observed.

Figura 2 - Modelo Digital de Batimetria (MDB) com interpolação a partir da Estimção Empírica Baeyiana (EBK). Em linhas tracejadas estão as posições dos perfis batimétricos selecionados (ver Figura 4). (I), (II) e (III) são as descontinuidades morfológicas observadas.

By analyzing bathymetric profiles (Figure 4), it was noticed that the back reef has a greater length in the CC' profile 3.5km, while the other sections, the back reef was approximately 1km. This is due to the presence of the internal sandbar previously mentioned. The area of the Reef Crest has a small variation in width throughout the complex, ranging from 0.5 to 1.2 km, being wider at the CC' profile, the central region of the study area. The width in the Reef Front region varied between 1.5 and 2 km in length, showing the greatest variation in the BB' profile. Finally the Fore Reef did not change, and in 4 sections, about 1km long. In profiles BB', CC' and DD', the outer limit of the Reef Front may be marked by the keel of the "Rio do Fogo Channel."

The outer edge of the reef front has sharp inclination, in general, owing to the fact that Rio do Fogo Channel, as

described above, is more than 12 meters deep, while the Back Reef maximum depth may be less than 6m, mainly due to internal sand bank. Leão *et al.* (2003) had already drawn attention to this morphology, pointing in the outside of *Parrachos* an almost vertical wall, with approximately 6m tall and indoors a height of about 4 m. This morphological difference is most likely associated with sediment thickness between *Parrachos* and the mainland, which can be reduced by the constant turbidity of water in this region due to the positioning of *Parrachos* that confines sediments moving towards the ocean. Ferreira (2013) detected the presence of a high concentration of suspended particulate matter in this region.

These reef bodies are associated with fluctuations in sea level during the Holocene by authors such as Vianna *et*

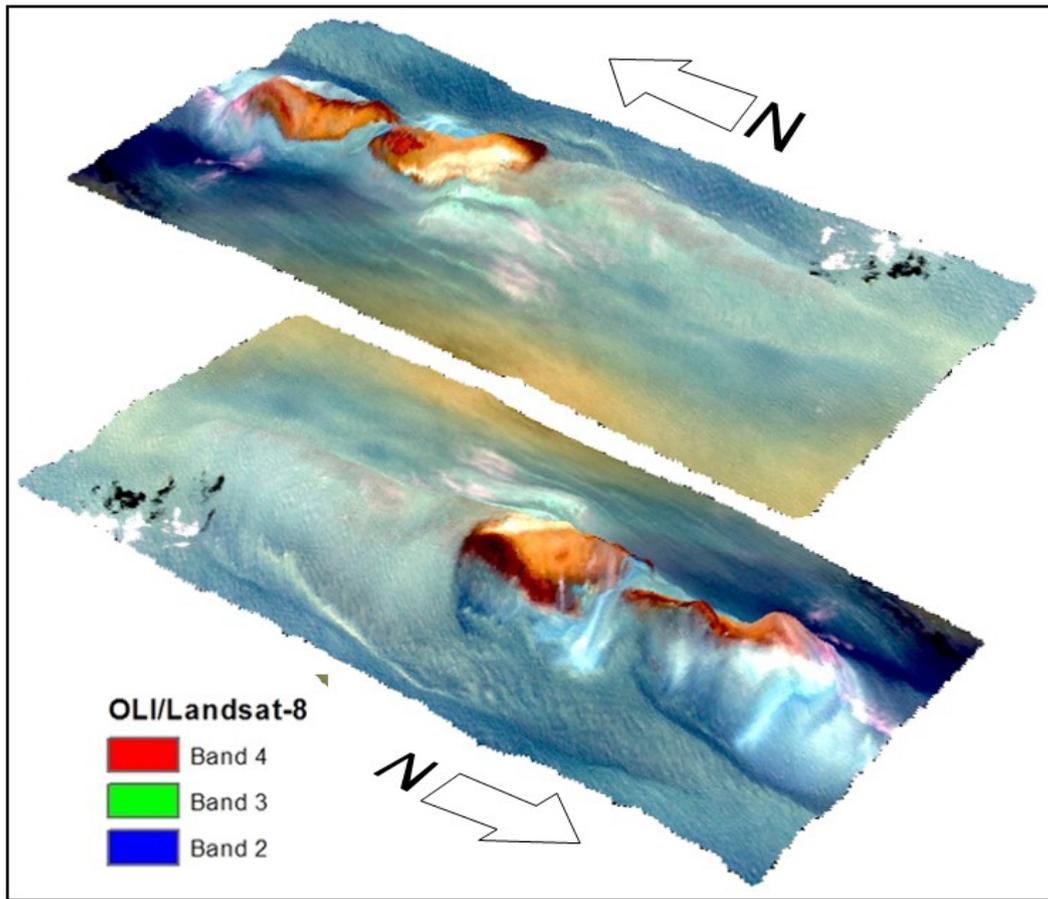


Figure 3 - 3D model of the study area in 2 viewing angles. Superposition of DBM with image of Sensor OLI/Landsat-8 (RGB-432).

Figure 3 - Modelo 3D da área de estudo em 2 ângulos de visualização. Superposição do MDB com imagem do Sensor OLI/Landsat-8 (RGB-432).

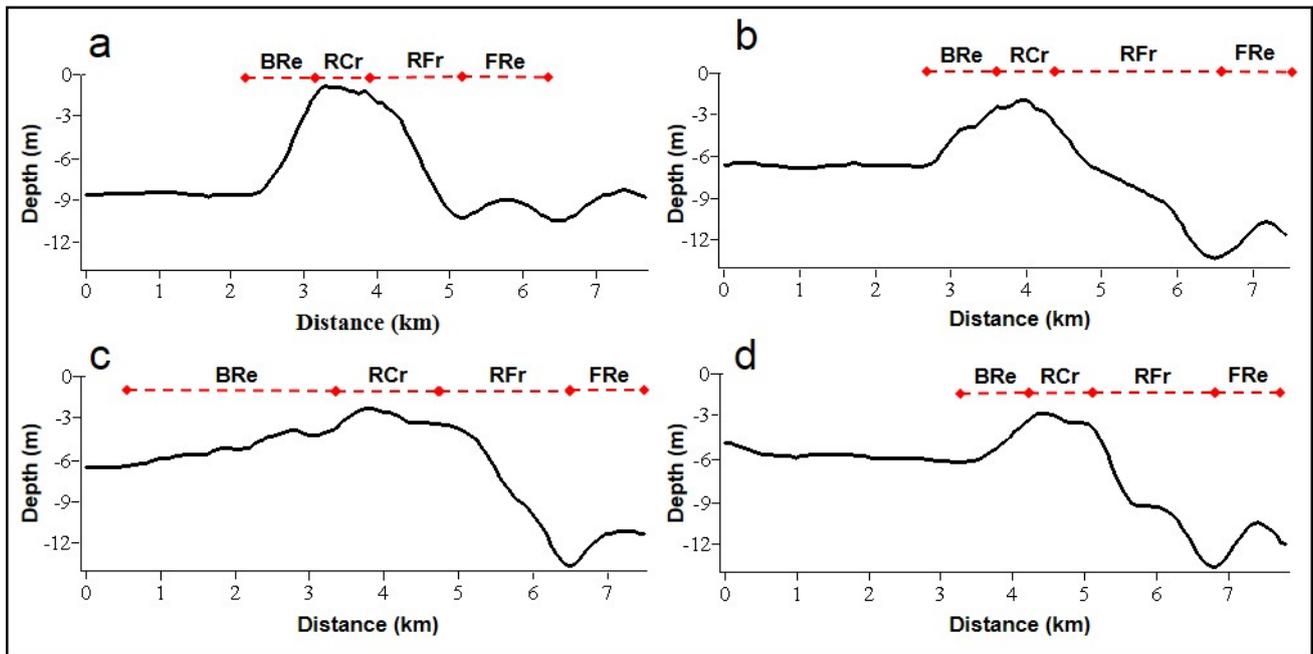


Figure 4 - Analysis of transversal bathymetric profiles to the Parrachos of Rio do Fogo Legend: BRe (Back Reef); RCr (Reef Crest); RFr (Reef Front); FRe (Fore Reef). CRF (Canal de Rio do Fogo – Rio do Fogo Channel).

Figura 4 - Análise dos perfis batimétricos transversais ao Parrachos de Rio do Fogo Legenda: BRe (Back Reef); RCr (Reef Crest); RFr (Reef Front); FRe (Fore Reef). CRF (Canal de Rio do Fogo).

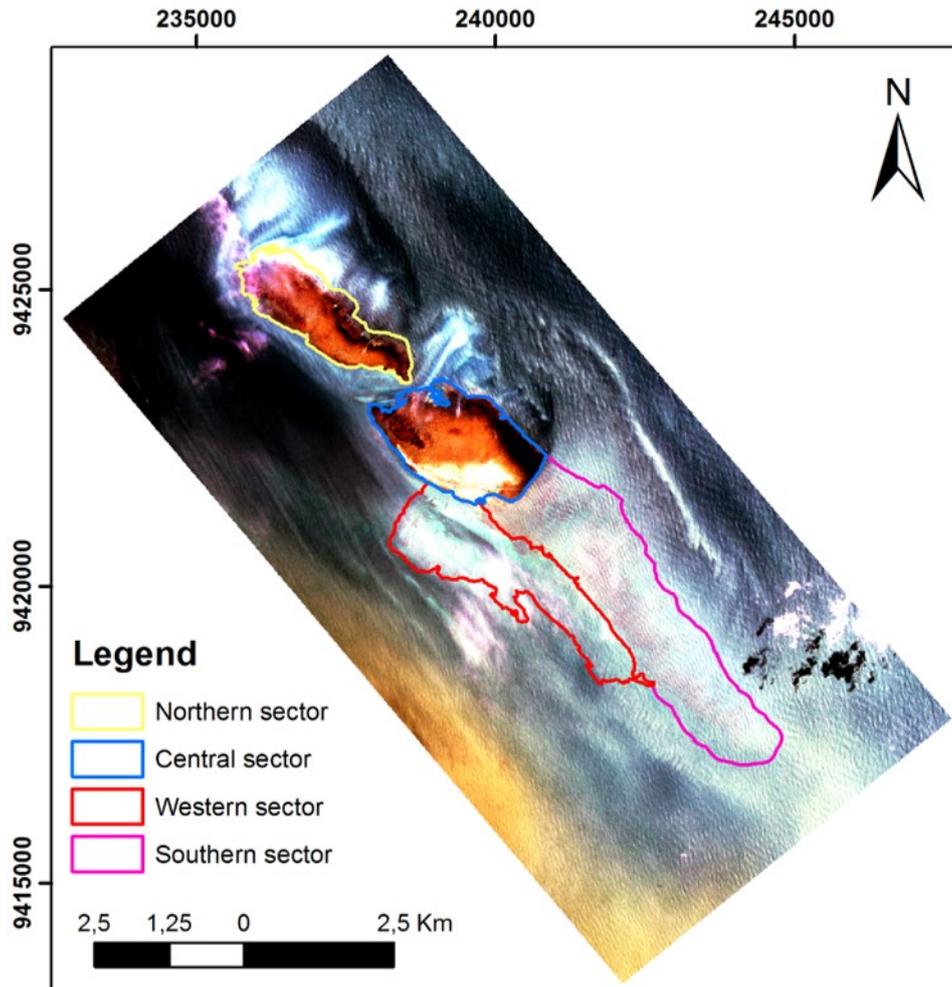


Figure 5 - Hybrid image from OLI/Landsat-8 sensor (RGBI-4328).

Figura 5 - Imagem híbrida do sensor OLI/Landsat-8 (RGBI-4328).

al. (1989), Testa (1997) and Testa & Bosence (1999). According to Amaral (2005), *Parrachos* in the region can be interpreted as evidence of ancient shorelines. The substrate necessary for fixation should possibly have been ferruginous sandstone beach or sandstone formation barriers, rocks abundantly present along the entire eastern coast of Rio Grande do Norte. About this bedrock would have settled the main reef colonies. As the sea level rose, under specific environmental conditions, these bodies have established their geometry (Amaral, 2005).

The history of sea level at the end of the Holocene shows that the Brazilian coast experienced considerable fluctuations in relative sea level (Martin *et al.*, 1979; 1985; 1996). These fluctuations have had profound effects on the morphological evolution of coral reefs, as the relative sea change exerts control on the geometry and architecture of these bodies (Wright & Burchette, 1996).

3.2. Interpretation of Remote Sensing Products

The mapping technique selected in this work was the classification of visual analysis, thus minimizing potential problems of "confusion" on automatic recommen-

dation rating of authors such as Morelli (2000) and Spalding *et al.* (2001).

The classification adopted takes into account primarily geomorphological aspects of submerged bodies and is based on that adopted by researchers in the field, as for Prates (2003), based on the discussion between various technical seminars in Brazil (Maida *et al.*, 1997; MMA, 1998).

Although the shallow and the channel has already been observed and mapped in hydrographic charts from 1886 and discussed by Branner (1903), description based on bathymetric specific measures and observation by satellite sensors is now preformed in accordance with their geometry in plan. This procedure adds a host of new information. Associated with fieldwork, facilitate the analysis of the overall behavior of the focus area, allowing, for example, the determination of "pilot areas" for a more detailed study.

Viana *et al.* (1988), Costa Neto (1997) Testa & Bosence (1999), Amaral (2002), Leão *et al.* (2003), Santos *et al.* (2007), present studies of the analysed area. Amaral (2002) classifies the shallows of Maracajau,

Rio do Fogo and Cioba in immersed and submerged reef bodies, marine phanerogam bottoms, clear bottoms and bottoms with clear rhodolith concentrations. Prates (2003), also uses similar classification setting the behavior of reef bodies with respect to the tides as one of the parameters and defining the intertidal and submerged reefs, in addition to describing the pools, island, sand on the reef and the slab/block. Here, as in previous classifications, the body's relation criterion with the tide level to sort the intertidal reefs and submerged reefs was kept. The type of background was also incorporated as a parameter. Accordingly, the following features were classified: pools, sandy bank, sea grasses and bank of algae. Finally, three other features were determined based on detailed morphological characteristics of the reef body: spurs and grooves and submerged roads, the latter already being the result of human action on reef bodies and Barreta Channel.

The shallows can be interpreted as evidence of ancient shorelines. The substrate necessary for its determination shall have been ferruginous sandstone beach or sandstone formation barriers, rocks abundantly present along the entire eastern coast of Rio Grande do Norte. The first reef colonies would have established over this bedrock and, as the sea level rose, under specific environmental conditions, these bodies have established their geometry.

The hypothesis above is based on samples collected in other nearby areas (e.g., Vianna *et al.*, 1988). Reports from anglers and from personal diving observations in deeper areas close to the reef body where development of corals covers the bedrock, was less efficient. Works that aim to clarify the evolutionary development of these bodies should try to collect sandstones with better spatial accuracy and its absolute dating methods. From this perspective the following descriptions of the features assigned to this work.

Supported by literature, fieldwork and bathymetric studies, a visual interpretation of satellite sensing images was performed, based on the hybrid composition of the OLI/Landsat-8 (RGBI-4328). In this interpretation was possible to distinguish, based on parameters such as texture, color and hue, 4 main sectors in *Parrachos*: (1) North, (2) Central, (3) South, (4) West (Figure 5).

The North Sector stands isolated from the others, separated by a transverse channel in the reef body, the Channel Barreta, as described above. Along with the central, comprises the area most clearly distinguished the compound, this composition arises in warm colors, as a result, possibly the highest reflectance of seaweed and coral cover the wavelength band 4 in the red channel. The West and South sectors are dominated by deeper areas, but clearly different. In the field, we associate the West sector benthic cover with the presence of

Marine Phanerogams as noted by Williams (2002) in *Parrachos* of Maracajau, south of the study area. Finally, the Southern sector is the one with less information, although the dives showed the presence of algae.

According to Santos (2006), *Siderastrea stellata* (Verrill, 1868) is the main coral reef formation in this region, with 80% prevalence, occurring on the plateau of these reefs. Maida & Ferreira (2004) further reported the presence of *Favia gravida* (Verrill, 1886) on the plateau of the reefs and *Monstastrea cavernosa* in greater depths. Arantes (2004) highlights that it was observed the occurrence of calcareous algae (*Lithothamnium sp.* and *Foslielia sp.*) covering areas between colonial species on the reef and sandy substrate by concretions. These algae were observed in this study, in the southern sector.

In addition to the demarcated areas in the outer region east of the reef complex, a tonal variation on the ocean surface is observed. Faced with the bathymetric study, this behavior is associated with Rio do Fogo Channel.

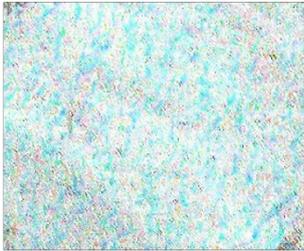
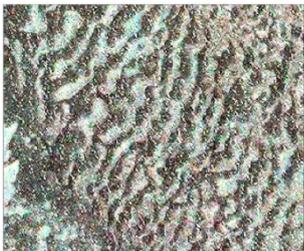
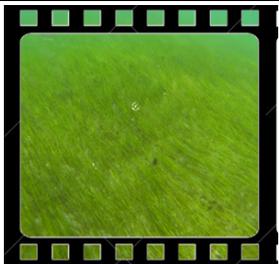
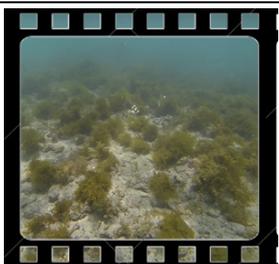
With the hybrid image MSPAN (RGBI-RGBPAN), high spatial resolution sensors, we could identify six well-defined units from the elements adopted in the visual interpretation, combined with validation of interpretations (Table 2). The following were used as attributes: ratio of bioconstructed bodies with the tide level (intertidal and submerged reefs); type of fund and the presence or absence of vegetation (pools, sandy bank, bank of algae, sea grasses) and more detailed morphological attributes such as bumps, holes and scars (spurs and grooves and submerged roads). Rio do Fogo and Barreta channels are major features.

These mapped Geoenvironmental units are described below:

- **Intertidal reefs.** Bioconstructed solid and porous bodies composed of calcareous algae, shells and other cnidarians invertebrates "welded" or next to each other and emerged in the lowest tide. They are locally known as *Cabeços* (bollards). They form an area of approximately 0.21 km² are observed in northern and central sector of the *Parrachos*.
- **Submerged reefs.** Emerged bodies are differentiated because they feel more apart from each other by the same remain submerged lower tides and by having the lower height. They occupy an area of approximately 3.75 km². They are positioned in lateral continuity to intertidal reefs.
- **Pools.** Pools are depressions in the flat reef (Pereira *et al.*, 2010) and are connected with the outside of the reef, focusing on the western central sector. In the study area, pools are approximately 0.73 km². The bottom is filled out with sandy sediments and in the larger pools are an isolated mushroom form of coral called "*chapeirões*."

Table 2 - Interpretation key with the main elements of visual interpretation for the hybrid image MSPAN (RGBI-RGBPAN).

Tabela 2 - Chave de interpretação com os principais elementos de interpretação visual para a imagem híbrida MSPAN (RGBI-RGBPAN).

Type Identification	Tonality / Color	Shape / Texture	Aspect of composition (Escale 1:1000)	Video frame field (filming 1m observer)
Intertidal reefs	Dark / Pink and black	Irregular / Rough		
Submerged reefs	Clear / Clear red	Irregular / Speckled		
Pools	Clear / Pink and white	Irregular / Rough		
Sandy bank	Clear / Light blue	Rolling with SE-NW direction / Smooth		
Sea grasses	Dark / Black and light blue	Rolling with SE-NW direction / Rolling		
Bank of algae	Dark / Blue brown	Irregular / Speckled		

- **Sandy bank.** This feature is concentrated in the western sector and has an area of 2.56 km².
- **Sea grasses.** Bank of phanerogam plants, tracheophytes, stem type rhizomes buried in the substrate. Concentrated on the western sector, having an area of approximately 1.90 km². According to Bonilha (2003) the internal portion of the APARC which is constituted by the region between the stubby coral banks and the coast line, includes a prairie community of shoalweed (of a yet unknown width) probably constituted by *Halodule wrightii*. It can be highlighted that this type of prairie community of shoalweed is commonly associated with coral reefs, developing thanks to the hydrodynamic protection offered by the barrier, usually growing in the internal, protected section of the reef. They are also scientifically known as marine nurseries aiding in the development of many fish and crustacean species of commercial importance: these species tend to spend their youth benefitting from the physical protection of the vegetation (Silva, 1995).
- **Bank of algae.** Banks of calcareous algae. Encompasses the entire southern sector and spreads it on an area of 7.60 km².
- **Spur and groove.** Recesses and small and repetitive bumps on the outer edge of the reef body. Common

area of Fore Reef, due to continued erosion effects caused by waves and currents. The morphology of these structures consists of small linear ridges separated by grooves (depressions) of sediments and debris (Figure 6b). The physical strength of wave energy acts as a controller in the morphology of these formations. They act as effective breakwaters and dissipate wave energy and intensity currents (Roberts *et al.*, 1992). These features are concentrated in the northern and central sectors of the complex, having a total area of 1.72 km².

- **Barreta Channel.** Araújo Filho (2011), based on water depth profiling studies, described that the width of this channel measures 100m at the central part and depth between 3 and 7 meters. In image analysis and bathymetric study of the geometry of this channel could be deepened so that it was found he has actually hourglass shape, approximately 120 feet wide in its most central section and edges measuring 1000 meters (Figure 6c).
- **Rio do Fogo Channel.** This feature is not included in Table 1, since it corresponds only to an elongated depression close to the oriental rim of the stubby coral reef that is typical in the area. The spatial distribution of Geoenvironmental units can be seen in Figure 7, already integrated all sector counterparts

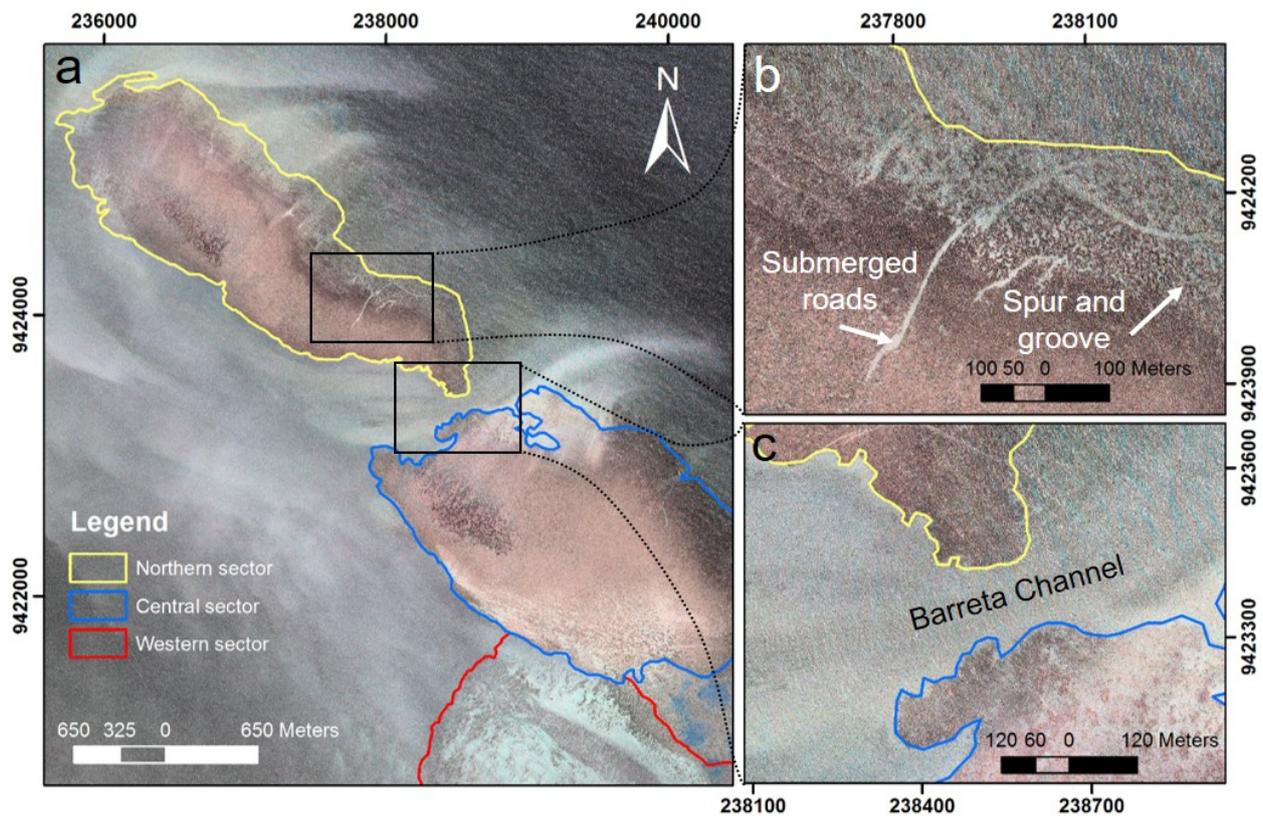


Figure 6 - Hybrid image MSPAN (RGBI-RGBPAN): (a) northwest region of the study area; (b) Cut illustrating the features "submerged roads" and "Spur and grooves"; (c) Highlight of the center channel Barreta channel region.

Figura 6 - Imagem híbrida MSPAN (RGBI-RGBPAN): (a) Região noroeste da área de estudo; (b) Recorte ilustrando as feições "Caminhos submersos" e "Spur and grooves"; (c) Destaque da região do canal central do canal da Barreta.

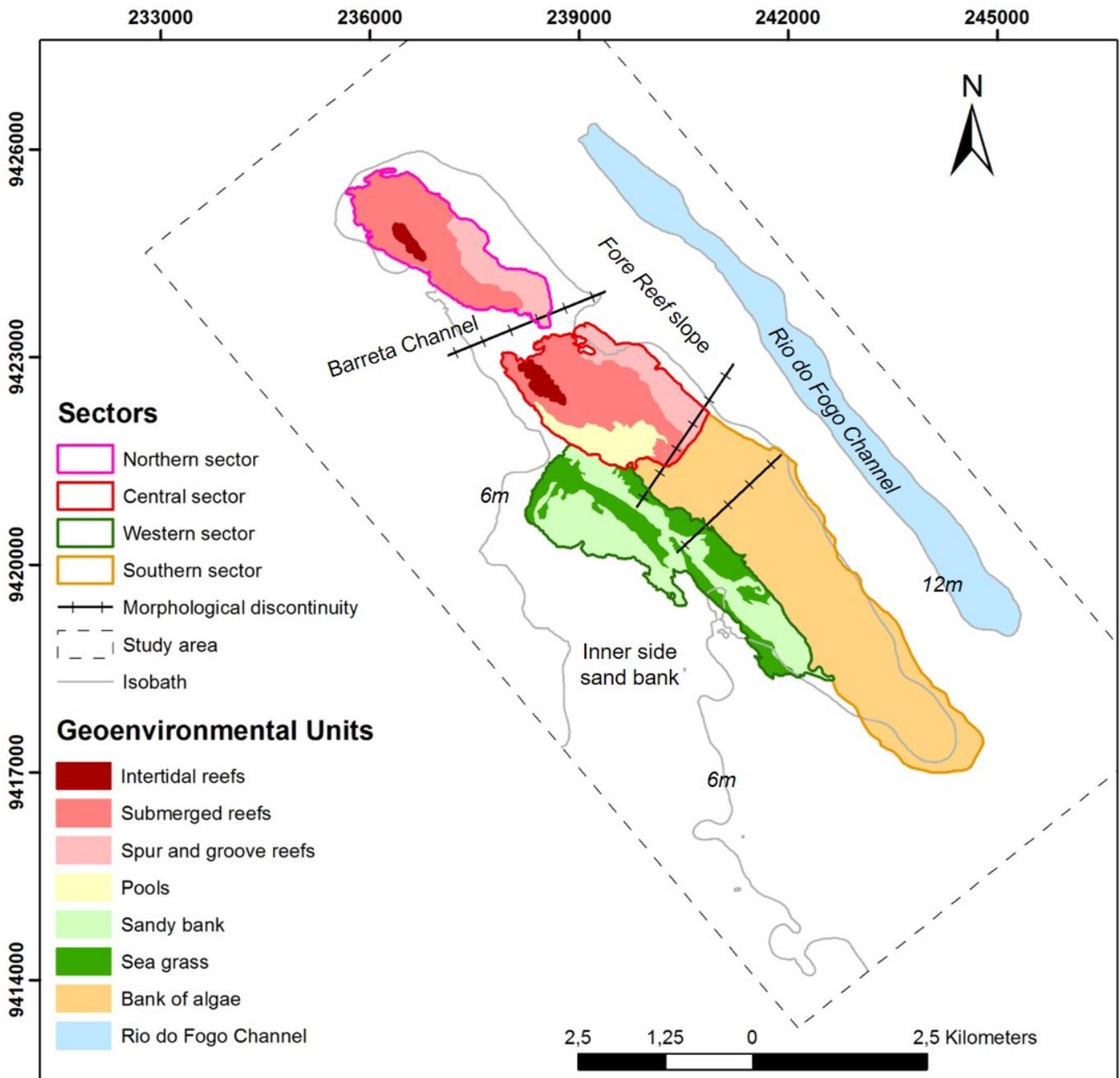


Figure 7 - Map of Geoenvironmental units of Parrachos of Rio do Fogo.

Figura 7 - Mapa das unidades geoambientais no Parrachos de Rio do Fogo.

and the Rio do Fogo channel, whose limits given based on the 12 m isobath. The space between the main reef complex body and this channel corresponds to the fore reef slope.

- **Submerged roads.** This feature was observed in the field. It wasn't mapped, however, for we found that further studies are still required in order to more clearly determine its characteristics. In the northern and central sectors, some linear features are observed. These features are locally called *estradas* (roads) (Figure 6b). Based on fishing reports and field observations, these paths were formed from ac-

cidental bumps boats on coral complex. Historically, coral reefs located in the region were stages of several shipwrecks. According to Medeiros (2014), through reports in the eight former newspaper sinkings occurred between 1840 and 1898. These were the vessels of different nationalities, carrying diverse merchandise.

It was estimated that the reef complex has approximately 46.75% (5.68 km²) environments dominated by bioclastic constructions (intertidal reefs, submerged reefs, spur and grooves), by calculating the total of each mapped area.

The full detail in the determination of homologous areas is suitable to be checked by comparing this mapping with previous mappings. This is due to a more detailed bathymetry and the use of higher spatial resolution remote sensing images and radiometric (this in the case of Landsat-8), and the use of more than one interpretation tool concatenated form.

4. Conclusions

The *Parrachos* of Rio do Fogo are characterized as a complex environment composed of corals and algae. Among the features that arise in this environment, we highlight the Barreta Channel, intertidal reefs, submerged reefs, spurs and grooves, pools, sandy bank, sea grasses, bank of algae, submerged roads beyond Rio do Fogo Channel and its internal sandy bank.

Some features, as seen, are clearly visible in all these approaches. Some are observed, for example, in water depth analysis; although they are not much clear in the analysis of satellite images. Even in the satellite image analysis, a mere difference of spatial resolution allows the mapping of sectors based on diverse criteria. All these approaches are complementary and might be enhanced based on knowledge of the area by the interpreter and though fieldwork for the elaboration of detailed maps of the bodies in shallow reef platforms.

The process of interpretation of satellite images, integrated to bathymetric analysis and field checks used as a method for mapping of Rio do Fogo reefs respond adequately to what was proposed. In light of the available data collected, the application of this methodology, allowed to obtain a product that brings both some quantitative information (areas, lengths, perimeters, depth of the analyzed features) as also qualitative (characteristics of Geoenvironmental units). The visual interpretations combined with the bathymetric data and validation in the field (dives), enabled the integration of knowledge of geomorphology in the region contributing to the definition of Geoenvironmental units of the coral reefs of Rio do Fogo. The results achieved are a real contribution to the technical and scientific knowledge highlighting the Geoenvironmental features of the shallow continental shelf, northeastern Brazil, mainly in relation to its morphological character.

The proposition of mapping through the integration of bathymetry and digital processing allows for the application of new subsidies to update the plan for how the Environmental Protection Area of Coral Reefs (*Área de Proteção Ambiental dos Recifes de Corais* - APARC) should be handled, especially as it pertains to the environmental zoning. Thus aiding in the promotion of social and economic activities while protecting the environment and the coral reef ecosystems and also serving as a north when it comes to zoning important regions of

the stubby coral reefs, such as: (i) Integral Protection Areas; (ii) Intensive Usage Areas (tourist activities); (iii) Extensive Usage Areas – Type I (fishing activities); and (iv) Extensive Usage Areas – Type II (autonomous diving activities).

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Appendix

Supporting Information associated with this article is available online at http://www.aprh.pt/rgci/pdf/rgci-629_Araujo_Supporting-Information.pdf

References

- Amaral, R.F. (2002) - *Mapeamento da Área de Proteção Ambiental dos Recifes de Corais – Fase Exploratória*. 50p, UFRN, Departamento de Geologia/IDEMA, SUGERCO. Relatório Interno, Natal, RN, Brazil. *Unpublished*.
- Amaral, R.F. (2005) - *Diagnóstico Ambiental da “Área de Uso Turístico Intensivo” no Parracho de Maracajaú*. 157p., UFRN, Departamento de Geologia/IDEMA, SUGERCO. Relatório Interno, Natal, RN, Brazil. *Unpublished*.
- Amaral, R.F.; Gonçalves, L.M.G. (2004) - Using Small Format Aerial Photographies (SFAP) to Map Coral Reefs in Rio Grande do Norte, Brazil. *Journal of Coastal Research* (ISSN: 0749-0208), SI 39 (Proceedings of the 8th International Coastal Symposium), Itajaí, SC, Brazil.
- Andréfouët, S.; Riegl, B. (2004) - Remote sensing: a key tool for interdisciplinary assessment of coral reef processes. *Coral Reefs*, 23(1):1-4. DOI: 10.1007/s00338-003-0360-z
- Andréfouët, S.; Muller-Karger, F.E.; Hochberg, E.J.; Hu, C.; Carder, K.L. (2001) - Change detection in shallow coral reef environments using Landsat 7 ETM+ data. *Remote Sensing of Environment*. 78(1-2):150-162. DOI: 10.1016/S0034-4257(01)00256-5
- Aranes, S.V. (2004) - *Descrição do recobrimento e ocorrência de macroinvertebrados bentônicos nos Parrachos de Maracajaú, município de Maxaranguape – RN*, 74p., Monografia de Bacharel em Ciências Biológicas, Programa de Graduação em Ciências Biológicas, Universidade Federal do Rio Grande do Norte (UFRN), Natal, RN, Brazil. *Unpublished*.
- Araujo Filho, L.P. (2011) - *Caracterização geomorfológica e modelagem de dados espaciais na plataforma*. 114p., Dissertação de Mestrado em Geodinâmica e Geofísica, Universidade Federal do Rio Grande do Norte (UFRN), Natal, RN, Brazil. Available on-line at <http://repositorio.ufrn.br:8080/jspui/handle/123456789/18818>
- Bonilha, L.E.C. (2003) - *Considerações quanto ao uso atual, conservação e situação socioambiental no ecossistema recifal/coralino dos “parrachos” do Rio Grande do Norte – (Município de Maxaranguape a Rio do Fogo)*. 19p., Relatório GEREX – IBAMA / RN, Natal, RN, Brazil. *Unpublished*.

- Bittencourt, A.C.S.P.; Martin, L.; Dominguez, J.M.L.; Silva, I.R.; Sousa, D.L.A. (2002) – A significant longshore transport divergence zone at the Northeastern Brazilian coast: implications on coastal Quaternary evolution. *Anais da Academia Brasileira de Ciências*, 74(3):505-518. DOI: 10.1590/S0001-37652002000300012
- Branner, J.C. (1904) - The stone reefs of Brazil, their geological and geographical relations, with a chapter on the coral reefs. 500p., *Bulletin of the Museum of Comparative Zoology*, 44 (Geol. Ser. 7):207-275, Cambridge, MS, U.S.A. Available on-line at https://openlibrary.org/books/OL24171492M/The_stone_reefs_of_Brazil
- Burke, L.; Reyntar, K.; Spalding, M.; Perry, A. (2011) - *Reefs at Risk Revisited*. 10p., World Resources Institute. Washington, DC. U.S.A. ISBN: 978-1569737620.
- Carneiro, M.C.S.M. (2011) - *Monitoramento das dunas utilizando o sistema de mapeamento a laser (lidar) aerotransportável: um estudo do campo de dunas do município de Rio do Fogo, RN, Brasil*. 132p., PhD thesis, Universidade Federal de Pernambuco (UFPE), Recife, PE, Brazil. Available on-line at <http://repositorio.ufpe.br/8080/handle/123456789/6122>
- Connell, J.H. (1978) - Diversity in Tropical Rain Forests and Coral Reefs. *Science*, 199(4335):1302-1310. DOI: 10.1126/science.199.4335.1302
- Costa Neto, L.X. (1997) - *Evolução Geológica-Geomorfológica Recente da Plataforma Continental Interna ao Largo do Delta do Rio Açu, Macau-RN*. 212p., Dissertação de Mestrado, Universidade Federal Fluminense, Rio de Janeiro, RJ, Brazil. *Unpublished*.
- Drury, S.A. (1993) - Image interpretation in Geology. 2nd ed. 283p., Chapman & Hall, London, U.K. ISBN: 041248809.
- English, S.; Wilkinson, C.; Baker, V. (1997) - *Survey Manual for Tropical Marine Resources*, 2nd ed., ASEAN - Australia Marine Science Project: Living Coastal Resources, Australian Institute of Marine Science, Townsville, Australia.
- ERDAS. (2008) - *ER Mapper - User's Guide*. 266p., Norcross-GA, U.S.A.
- Feitoza, B.M.; Sampaio, D.A.; Araújo, M.E. (2001) - Ictiofauna recifal dos Parrachos de Maracajaú (RN) na área dos flutuantes: inventário e estrutura da comunidade. *Arquivos de Ciências do Mar* (ISSN: 0374-5686), 35: 39–50, Fortaleza, CE, Brazil.
- Ferreira, A.T.S. (2013) - *Monitoramento Ambiental na Costa do Rio Grande do Norte com Base em Sensoriamento Remoto e Geodésia de Precisão*. PhD thesis, Universidade Federal do Rio Grande do Norte (UFRN), Programa de Pós-graduação em Geodinâmica e Geofísica, Natal, RN, Brazil. Available on-line at <http://repositorio.ufrn.br/handle/123456789/18367>.
- Ferreira, B.P.; Maida, M. (2006) - *Monitoramento dos recifes de coral do Brasil*. 250p., Ministério do Meio Ambiente, Brasília, DF, Brazil
- Green, E.P.; Mumby, P.J.; Edwards, A.J.; Clark, C.D. (1996) - A Review of Remote Sensing for the Assessment and Management of Tropical Coastal Resources. *Coastal Management*, 24(1):1-40. DOI: 10.1080/08920759609362279
- Hamel, M.A.; Andréfouët, S. (2010) - Using very high resolution remote sensing for the management of coral reef fisheries: Review and perspectives. *Marine Pollution Bulletin*, 60(9):1397–1405. DOI: 10.1016/j.marpolbul.2010.07.002
- Hamilton, S.; Andréfouët, S.; Spencer, T. (2012) - Comparing the information content of coral reef geomorphological and biological habitat maps, Amirantes Archipelago (Seychelles), Western Indian Ocean. *Estuarine, Coastal and Shelf Science*, 111:151-156. DOI: 10.1016/j.ecss.2012.06.001
- Hayes, M.O. (1979) - Barrier island morphology as a function of tidal and wave regime. In: S.P. Leatherman (ed.), *Barrier islands from the Gulf of St. Lawrence to the Gulf of Mexico*, pp.1-27. Academic Press, New York, U.S.A. ISBN: 978-0124402607.
- Hazin, F.H.V.; Wor, C.; Oliveira, J.E.L.; Hamilton, S.; Travassos, P.; Geber, F. (2008) - Resultados obtidos por meio do fundeio de um correntógrafo na plataforma continental do Estado do Rio Grande do Norte, Brasil. *Arquivos de Ciências do Mar* (ISSN: 0374-5686), 41(1):30–35, Fortaleza, CE, Brazil.
- Henriques, A.P.M. (2008) - *Classificação de imagens de ambientes coralíneos: uma abordagem empregando uma combinação de classificadores e máquina de vector de suporte*. 149p., PhD thesis, Universidade Federal do Rio Grande do Norte (UFRN), Natal, RN, Brazil. *Unpublished*.
- Hill, J.; Wilkinson, C. (2004) - Methods for ecological monitoring of coral reefs, Version 1, A Resource for Managers. 117p, *Australian Institute of Marine Science*, Townsville, Australia. Available on-line at <http://www3.aims.gov.au/bitstream/handle/11068/7495/HillMethodsforecological-monitoring2004.pdf?sequence=1>
- Hoegh-Guldberg, O. (1999) - Climate change, coral bleaching and the future of the world's coral reefs. *Marine and Freshwater Research*, 50(8):839-866. DOI: 10.1071/MF99078
- IDEMA (2002) - Atlas do Rio Grande do Norte. Instituto de Desenvolvimento Econômico e Meio Ambiente do Rio Grande do Norte (IDEMA), Natal, RN, Brazil.
- Köppen, W. (1918) - *Klassifikation der klimate nach temperatur, niederschlag und jahreslauf*. Petermanns Geographische Mitteilungen, 64:193-203, Gotha, Germany. Available on-line at http://koeppen-geiger.vu-wien.ac.at/pdf/Koppen_1918.pdf
- Laborel, J.L. (1967) - A revised list of Brazilian scleractinians corals and descriptions of a new species. *Postilla*, 107:1-14, Yale University, New Haven, CT, U.S.A. Available on-line at <http://biostor.org/reference/118495>
- Laborel, J. (1969) - *Les peuplements de madreporaires des côtes tropicales du Brésil*. 260p., Annales de l'Université d'Abidjan, Abidjan, Côte d'Ivoire.
- Leão, Z.M.A.N.; Kikuchi, R.K.P.; Testa, V. (2003) - Corals and corals reefs of Brazil. In: Jorge Cortés (ed.), *Latin American Coral Reefs*, pp.9-52, Elsevier Science B. V., Amsterdam, The Netherlands. ISBN: 0444513884. DOI: 10.1016/B978-044451388-5/50003-5.
- Lima, W.S.G. (2002) - *Geologia e Geomorfologia dos Recifes de Maracajaú – RN e Plataforma Rasa Adjacente*. 91p., PhD thesis, Universidade Federal do Rio Grande do Norte (UFRN), Programa de Pós-graduação em Geodinâmica e Geofísica, Natal, RN, Brazil. Available on-line at <http://repositorio.ufrn.br/jspui/handle/123456789/18777>.
- Luczkovich, J.J.; Wagner, T.W.; Michalek, J.L.; Stofflee, R.W. (1993) - Discrimination of Coral Reefs, Seagrass Meadows, and Sand Bottom Types from Space: A Dominican Republic Case Study. *Photogrammetric Engineering & Remote Sensing*, 59(3):385-389, American Society of Photogrammetry and Remote Sensing, Bethesda, MD, U.S.A.
- Maida, M.; Ferreira, B.P. (1997) - Coral Reefs of Brazil: an overview. *Proceedings of the 8th International Coral Reef Symposium*, 1:263-274.
- Maida, M.; Ferreira, B.P. (2004) - Recifes de coral brasileiros. In: E. Eskinazi-Leça, S.L. Neumann & M.F. Costa (orgs). *Oceanografia: um cenário tropical*, pp.617- 640, Bargaço, Recife, PE, Brazil. ISBN: 8574095826
- Maida, M.; Pontes, A.C.P.; Ferreira, B.P.; Castro, C.B.; Pires, D.O.; Rodrigues, M.C.M. (1997) - *Relatório do workshop sobre os recifes de coral brasileiros: pesquisa, manejo integrado e conservação*. 30p., Tamandaré, PE, Brazil.
- Martin, L.; Flexor, J.M.; Vilas-Boas, G.S.; Bittencourt, A.C.S.P.; Guimarães, M.M.M. (1979) - Courbe de variations du niveau

- relatif de la mer au cours des 7000 dernières années sur un secteur homogène du littoral brésilien (nord de Salvador-Bahia). In: K. Suguio, T. R. Fairchild, Martin Louis & J. M. Flexor (eds.), *Proceedings of the International Symposium on Coastal Evolution in the Quaternary*, pp.264-274, São Paulo, SP, Brazil. Available on-line at <http://www.documentation.ird.fr/hor/fdi:41921>
- Martin, L.; Flexor, J.M.; Blitzkow, D.; Suguio, K. (1985) - Geoid change indications along the Brazilian coast during the last 7000 years. *Proceedings of the Fifth International Coral Reef Congress*, 3: 85-90, Tahiti, French Polynesia. Available on-line at http://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_6/b_fdi_35-36/41896.pdf
- Martin, L.; Suguio, K.; Flexor, J.M.; Dominguez, J.M.L.; Bitencourt, A.C.S.P. (1996) - Quaternary sea-level history and variation in dynamics along the central Brazilian coast: consequences on coastal plain construction. *Anais da Academia Brasileira de Ciencias* (ISSN: 1678-2690), 68(3):303-354, Rio de Janeiro RJ, Brazil.
- Medeiros, R. (2014) - Maracajaú e Rio do Fogo – Antigos Cemitérios de Barcos da Costa Potiguar. Blog Tok de História, Available on-line at <http://tokdehistoria.wordpress.com/2014/01/07/maracajau-e-rio-do-fogo-antigos-cemiterios-de-barcos-da-costa-potiguar/>
- Moreira, P.P.; Reuss-Strenzel, G.M. (2009) - Mapeamento de habitats do recife de coral Pedra de Leste, Abrolhos, utilizando uma imagem multiespectral Landsat7 ETM+. *Anais XIV Simpósio Brasileiro de Sensoriamento Remoto*, pp.6595-6602, Instituto Nacional de Pesquisas Espaciais (INPE), Natal, RN, Brazil. Available on-line at <http://mar.te.sid.inpe.br/col/dpi.inpe.br/sbsr@80/2008/11.17.21.38/doc/6595-6602.pdf>
- Morelli, F.M. (2000) - *Mapeamento dos recifes costeiros de Paripueira, Barra de Santo Antônio e Passo do Camaragibe (AL), através da classificação de imagens Landsat-TM e HRV-SPOT*. Dissertação de Mestrado, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, Brazil. *Unpublished*.
- Mumby, P.J.; Green, E.P.; Edwards, A.J.; Clark, C.D. (1997) - Coral Reef Habitat-mapping: How Much Detail Can Remote Sensing Provide?. *Marine Biology*, 130(2):193-202. DOI: 10.1007/s002270050238
- Nimer, E. (1989) - *Climatologia do Brasil*. 2nd ed., 421p., Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, RJ, Brazil. ISBN: 978-8524002823.
- Nogueira, J.D.L.; Amaral, R.F. (2009) - Comparação entre os métodos de interpolação (Krigagem e Topo to Raster) na elaboração da batimetria na área da folha Touros – RN. *Anais XIV Simpósio Brasileiro de Sensoriamento Remoto*, pp.4117-4123, Instituto Nacional de Pesquisas Espaciais (INPE), Natal, RN, Brazil. Available on-line at <http://mar.te.sid.inpe.br/col/dpi.inpe.br/sbsr@80/2008/11.18.00.22/doc/4117-4123.pdf>
- Pereira N.S.; Manso V.A.V.; Silva A.M.C.; Silva M.B. (2010) - Mapeamento Geomorfológico e Morfodinâmica do Atol das Rocas, Atlântico Sul. *Journal of Integrated Coastal Zone Management / Revista de Gestão Costeira Integrada*, 10(3):331-345. DOI: 10.5894/rgci209.
- Prates, A.P.L. (2003) - *Atlas dos recifes de coral nas unidades de conservação brasileiras*. 180p., Ministério do Meio Ambiente. Secretaria de Biodiversidade e Florestas, Brasília, DF, Brazil.
- Richards, J.A. (1995) - Remote sensing digital image analysis: an introduction. 340p., Springer-Verlag, Berlin, Germany. DOI: 10.1007/978-3-642-30062-2. ISBN: 978-3-642-30061-5.
- Righton, D.; Mills, C. (2006) - Application of GIS to investigate the use of space in coral reef fish: a comparison of territorial behaviour in two Red Sea butterflyfishes. *International Journal of Geographical Information Science*. 20(2):215-235. DOI: 10.1080/13658810500399159
- Roberts, H.H.; Wilson, P.A.; Lugo-Fernandez, A. (1992) - Biologic and geologic responses to physical processes: examples from modern reef systems of the Caribbean-Atlantic. *Continental Shelf Research*, 12(7-8):809-834. DOI: 10.1016/0278-4343(92)90046-M
- Ryan, D.A.; Brooke, B.P.; Collins, L.B.; Kendrick, G.A.; Baxter, K.J.; Bickers, A.N.; Siwabessy, P.J.W.; Pattiaratchi, C.B. (2007) - The influence of geomorphology and sedimentary processes on shallowwater benthic habitat distribution: Esperance Bay, Western Australia. *Estuarine, Coastal and Shelf Science*. 72(1):379-386. DOI: 10.1016/j.ecss.2006.10.008
- Santos, C.L.A. (2006) - *Mapeamento de recifes no Rio Grande do Norte: Touros a Macau/RN*. 88p., Dissertação de Mestrado, Universidade Federal do Rio Grande do Norte (UFRN), Natal, Brazil. Available on-line at <http://repositorio.ufrn.br/jspui/handle/123456789/18736>
- Santos, C.L.A.; Vital, H.; Amaro, V.E.; Kikuchy, R.K.P. (2007) - Mapeamento de recifes submersos na costa do Rio Grande do Norte, NE Brasil: Macau a Maracajau. *Revista Brasileira de Geofísica*, 25(1):27-36. DOI: 10.1590/S0102-261X2007000500004.
- Scopéltis, J.; Andréfouët, S.; Phinn, S.; Arroyo, L.; Dalleau, M.; Cros, A.; Chabanet, P. (2010) - The next step in shallow coral reef monitoring: Combining remote sensing and in situ approaches. *Marine Pollution Bulletin*, 60(11):1956–1968. DOI: 10.1016/j.marpolbul.2010.07.033.
- Servain, J.; Sévea, M.; Rual, P. (1990) - Climatology comparison and long-term variations of sea surface temperature over the tropical Atlantic Ocean. *Journal of Geophysical Research: Oceans*, 95(C6):9421-9431. DOI: 10.1029/JC095iC06p09421
- Silva, E.A.J. (2002) - *As dunas eólicas de Natal/RN: datação e evolução*. 127p., Dissertação de Mestrado, Universidade Federal do Rio Grande do Norte (UFRN), Natal, RN, Brazil. Available on-line at <http://repositorio.ufrn.br:8080/jspui/handle/123456789/18750>
- Silva, E.T (1995) - Modelo Ecológico de Fundos Vegetados Dominados por *Ruppia maritima* L. (Potamogetonaceae) do Estuário da Lagoa dos Patos-RS. Tese de Mestrado, Universidade Federal do Rio Grande do Norte (UFRN), Natal, RN, Brazil. *Unpublished*.
- Solewicz, R. (1989) - *Feições fisiográficas submarinas da Plataforma Continental do Rio Grande do Norte visíveis por imagens de satélite*. 163p., Dissertação de Mestrado, Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, SP, Brazil. *Unpublished*.
- Spalding, M. D.; Ravilious, C.; Green, E.P. (2001) - *World atlas of coral reefs*. 424p., University of California Press / World Conservation Monitoring Centre (UNEP-WCMC), Berkeley Los Angeles London. ISBN: 0520232550. Available on-line at <http://fnad.org/Documentos/worldatlasofcora01spal.pdf>
- Testa, V. (1996) - *Quaternary Sediments of the Shallow Shelf, Rio Grande do Norte, NE Brazil*. 411p., PhD thesis, University of London, London, U.K.
- Testa, V. (1997) - Calcareous algae and corals in the inner shelf of Rio Grande do Norte, NE Brazil. *Proceedings of the 8th International Coral Reef Symposium*, 1:737-742, Smithsonian Tropical Research Institute, Panama.
- Testa, V.; Bosence, D.W.J. (1999) - Physical and Biological controls on the formation of carbonate and siliclastic bedforms on the north-east Brazilian shelf. *Sedimentology*, 46(2):279-302. DOI: 10.1046/j.1365-3091.1999.00213.x
- Testa, V.; Bosence, D.W.J.; Viana, M.L. (1997) - Submerged lithologies as indicators of relative sea-level oscillations in Rio Grande do Norte, NE Brazil. *Anais VI Congresso Brasileiro de Estudos do Quaternário*, pp.155-160.

- Vianna, M.L.; Solewicz, R.; Cabral, A.P.; Testa, V. (1991) - Sandstream on the northeast Brazilian shelf. *Continental Shelf Research*, 11(6):509–524. DOI: 10.1016/0278-4343(91)90008-T
- Vianna, M.L.; Solewicz, R. (1988) - Feições fisiográficas submarinas da plataforma continental do Rio Grande do Norte visíveis por imagens de satélite. *Simpósio de Sensoriamento Remoto (SBSR)*, pp.581-587, Natal, RN, Brazil. Available on-line at <http://mar.te.sid.inpe.br/col/dpi.inpe.br/marte@80/2008/07.25.13.26/doc/581-588>
- Vianna, M.L., Solewicz, R., Cabral, A.P. (1989) - Early Holocene stillstands in the Brazilian northeast mapped by satellite. *International Symposium on Global Changes in South America During the Quaternary: Past-Present-Future*, pp.250-254, São Paulo, SP, Brazil
- Vianna, M.L.; Cabral, A.P.; Gherardi, D.F.M. (1993) - TM-Landsat imagery to the study of the impact of global climate change on a tropical coastal environment during the last deglaciation. *International Journal of Remote Sensing*, 14(16):2971-2983. DOI: 10.1080/01431169308904413
- Walsh, S.J.; Butler, R.; Malanson, G.P. (1998) - An overview of scale, pattern, process relationships in geomorphology: A remote sensing and GIS perspective. *Geomorphology*, 21(3-4):183-205. DOI: 10.1016/S0169-555X(97)00057-3
- Wilkinson, C.R. (2002) - Status of coral reefs of the world. 363p., Australian Institute of Marine Science, Townsville, QLD, Australia. Available on-line at <http://www.icriforum.org/icri-documents/associated-publications/status-coral-reefs-world-2002>
- Wright, V.P.; Burchette, T.P. (1996) - Shallow-Water Carbonate Environments. In: Harold G. Reading (ed.), *Sedimentary Environments: Processes, Facies and Stratigraphy*, 3rd ed., pp.368-377, John Wiley & Sons. London, U.K. ISBN: 978-0632036271.

An attempt to assess horizontal and vertical integration of the Italian coastal governance at national and regional scales*

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ABSTRACT

This paper assesses the level of achievement of horizontal and vertical coordination needed to facilitate the governance of the Italian coast at national and regional scales. A questionnaire survey envisions a sectoral management of the coast and the lack of a uniform national strategy, even though a more integrated picture is found at regional scale. However, horizontal and vertical coordination is quite inhomogeneous between Regions, and different are the mechanisms put in place to accomplish it. Overall, it emerges a greater difficulty in coordinating policies and sectors at horizontal scale (i.e. same level of government) rather than at vertical level (different scales of government). To overcome the limited horizontal cooperation, some Regions have developed institutions based on an inter-sectoral coordination, committee or an advisory body. Others opted for an internal proactive collaboration that may resolve conflicting interests between General Directorates, without the mediation of any third party (advisory board). From the questionnaire survey emerges that several Regions have promoted pilot site projects to address specific sectoral issues, but only Emilia-Romagna has developed an integrated plan for the coastline to achieve integration across sectors. In addition, Emilia-Romagna and Toscana Regions have been promoting a bottom-up participatory vision for the coastal governance through forums or other discursive platforms to facilitate local participation. These Regions are also extending coastal management into the maritime spatial planning, a strategy recognised by the European Commission as the best compelling way to facilitate sectoral and institutional coordination and fully implement ICZM in Europe.

Keywords: horizontal and vertical integration; ICZM policy process assessment; national and regional coastal management; Italy.

RESUMO

Uma tentativa de avaliar a integração horizontal e vertical da governança costeira italiana em escalas nacionais e regionais
Este trabalho avalia o nível de realização de coordenação horizontal e vertical necessária para facilitar a governança da costa italiana em escalas nacionais e regionais. Através de um inquérito concluiu-se que existe uma gestão sectorial da costa e a ausência de uma estratégia nacional uniforme, apesar da existência de um quadro mais integrado à escala regional. No entanto, a coordenação horizontal e vertical não é homogénea entre as regiões, tendo sido criados diferentes mecanismos para a realizar. No geral, existe maior dificuldade na coordenação das

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Políticas e dos sectores à escala horizontal (ou seja, mesmo nível de governança), do que ao nível vertical (diferentes escalas de governança). Para superar a limitada coordenação horizontal, algumas regiões têm desenvolvido instituições baseadas num comité de coordenação inter-sectorial ou de um órgão consultivo. Outras optaram por uma colaboração pró-ativa interna que pode resolver conflitos de interesses entre Direcções-Gerais, sem a mediação de terceiros (conselho consultivo). O questionário permitiu verificar que diversas regiões promoveram projectos-piloto locais para tratar de questões sectoriais específicas, mas apenas Emilia-Romagna desenvolveu um plano integrado para o litoral como forma de alcançar a integração entre os setores. Além disso, as regiões de Emilia-Romagna e da Toscana têm vindo a promover uma visão participativa de baixo para cima na governança costeira através de fóruns ou outras plataformas discursivas para facilitar a participação local. Estas regiões também estão estendendo a gestão costeira para o ordenamento do espaço marítimo, estratégia esta reconhecida pela Comissão Europeia como a forma mais convincente de facilitar a coordenação setorial e institucional e implementar integralmente a gestão integrada das zonas costeiras da Europa.

Palavras-chave: a integração horizontal e vertical; avaliação do processo da política de ICZM; gestão costeira nacional e regional; Itália.

1. Introduction

This paper provides an overview of how significantly coordination is achieved at national and regional administrative scales in Italy, in order to identify those constraints limiting an Integrated Coastal Zone Management (hereafter ICZM) approach.

Nowadays in Italy, there is no overall coordinating policy for coastal management at national level. A review of the legal framework showed that territorial coordination is fragmented by a high number of sectoral laws and plans (Ministero dell'Ambiente, 2001a; MELS, 2011), even though a similar context is identifiable in other European countries (Humphrey & Burbridge, 1999). In order to counteract this model of governance, the EU launched since the middle of 90' several initiatives to reach a consensus on the necessary measures for ICZM in Europe, and to identify and implement concrete actions.

An important initiative was the EU ICZM demonstration programme of 35 pilot studies articulated around three key words: co-ordination, co-operation, and concertation (CEC, 1995; CEC, 1999).

In 2000, based on the experiences and outputs of the demonstration programme, the European Commission (EC) adopted a Communication to the Council and the European Parliament in which ICZM is considered the instrument "...to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics" (CEC, 2000).

In 2002, the Recommendation 2002/413/EC on the implementation of ICZM in Europe was adopted by the Council and Parliament (CEC, 2002), suggesting, among others, the "support and involvement of relevant administrative bodies at national, regional and local levels amongst which appropriate links should be established or maintained with the aim of improving coordination of the various existing policies". In other terms, this vision demands good communication among governing authorities (local, regional and national). However, thirteen years later, coordination of sectors re-

mains a critical issue in ICZM: the on-line consultation process held in 2011 on the impact of a Directive on Maritime Spatial Planning (MSP) showed that cooperation between the different competent bodies at different scales in the maritime governance remains a challenge (EC, 2011a). The incorrect use of the maritime space, caused by the lack of cross-sector coordination in granting sea spaces is considered one of the inefficiencies that could be compulsory addressed by the promulgation of a Directive on ICZM (EC, 2013) that was drawn in 2014.

Considering the importance of coordination and cooperation between competent bodies at different levels, this paper wants to show the state of the art of the coordinating strategies adopted at national and regional scales in Italy. In the literature, there are not many papers issuing this topic while the recent literature on Italian ICZM is more oriented to the formulation of decision support systems rather than analysing institutional processes (Pirrone *et al.*, 2005; Zanuttigh *et al.*, 2005; Marotta *et al.*, 2011; Giordano *et al.*, 2013). Some studies focused on the integration of several tools to support public administrations in limiting land use conflicts such as GIS, Emergency Analysis and Cost Benefit Analysis, mainly applied to coastal erosion and beach nourishment (Koutrakis *et al.*, 2008; Koutrakis *et al.*, 2010; Koutrakis *et al.*, 2011; Martino & Amos, 2015; Marzetti *et al.*, 2016).

Looking at the institutional aspects, Portman *et al.* (2012) assessed the performance in eight countries (Belgium, India, Israel, Italy, Portugal, Sweden, UK, and Vietnam), of five ICZM mechanisms (environmental impact assessment; planning hierarchy; setback lines; marine spatial planning, and regulatory commission) and their role in achieving integration. The authors found that environmental impact assessment enhances science-policy integration, planning hierarchy and regulatory commissions are effective mechanisms to integrate policies across government levels, and marine spatial planning is a multi-faceted mechanism with the potential to promote all types of

integration. Gusmerotti *et al.* (2013) pointed out the reciprocal benefits of integrating nature protection planning (marine protected areas) and ICZM policies, and suggested market-based approaches as self-financing mechanisms for marine and coastal zones. Finally, Rochette (2009) focusing on the Italian ICZM framework, proposed a regional scale approach to ICZM as a necessary step to correct the deficiency of the national legislation, even though this does not necessarily guarantee the implementation of a coherent coastal policy.

To the knowledge of the author, there is not any research on the quantitative valuation of horizontal and vertical integration for the Italian case and on the evaluation of the maturity of the ICZM policy by using the EU indicators for a good coastal governance (WGID, 2003). Although integration has a wide scope, in this paper it is considered the way to analyze the relationships between different levels of government (*vertical dimension*) and between institutions operating at the same administrative level (*horizontal dimension*). The main objectives of this research are:

1. Identifying the institutional arrangements for the management of the coastal zone in Italy;
2. Getting information on the perceived most suitable arrangements to achieve integration;
3. Assessing the vertical and horizontal integration of the Italian coastal management at national and regional levels, by a tailored questionnaire survey;
4. Evaluating the status or maturity of the ICZM policy process by using the EU indicators for coastal governance.

This paper describes initially the idea of ICZM adopted in this research, and then presents the methodology employed to assess coordination. Results are shown for the national and regional dimensions, and finally commented under the recent EU ICZM strategy based on a compulsory integrated maritime spatial planning approach.

2. ICZM as concerted action

The development of the ICZM model has facilitated the implementation of various initiatives both in developing and developed countries based on sharing “collective or concerted approach” as a key element to achieve sustainable coastal management (Steins, 1999). Of primary importance is the identification of those institutional arrangements able to “facilitate cooperative behaviour by which sustainability may be achieved” (Taussik, 2001).

Amending governance is a required condition and co-management strategy may offer an appropriate solution to cooperative behaviour as suggested for the fishery sector by Dubbink & van Vliet (1996). However, a unique solution for an integrated perspective of the

coast cannot be found, depending its implementation on the local conditions (social, economic, political, etc.) of each country. Assessing the governance process may provide insight on the need to improve coordination between and within different administrative levels. From a bibliographic review, it emerges that there are different methods for planning, implementing and assessing ICZM strategies. These are based mainly on the presence and the status of indicators describing the outputs of coastal governance. The methodology adopted by Knecht *et al.* (1996) is based on surveying different experts and stakeholders asking them to rate indicators of the coastal management process indicators along with an ordinal scale. Scores for each issue are summed up and then averaged. A similar framework is presented by Olsen *et al.* (1997), Olsen (2003) and Henoque (2003).

To facilitate effective ways of achieving conservation and sustainable use of marine and coastal biodiversity, the working group on indicator and data of the EC proposed two different sets of indicators to test the implementation of the eight ICZM principles proposed by the 2002 Recommendation (Table 1): the first set concerns the analysis of the progress of an integrated governance of the coast (WGID, 2003) (indicators used in this research are reported in the SI-I); the second one describes the level of sustainability of the coastal zone (WGID, 2003).

These principles can be used as a checklist for internal action to assess whether the governance of each country (at different scales) is leading to improved sustainability of the coastal resources. To assess the grade of implementation of these principles, pilot tests have been conducted in some countries (Ireland, Belgium and England), showing that the most challenging are those dealing with adaptive management, working with natural processes, participatory approaches stakeholders involvement of all stakeholders (Pickaver & Ferreira, 2008; Ballinger *et al.*, 2010).

However, no equivalent studies have been carried out for the Italian ICZM. Focusing our attention on principle 7 of the ICZM Recommendation (Table 1), concerning the relationships between administrative bodies at national, regional and local levels, the analysis of the partnership between and within different tiers of government can be assessed by the progress indicators 9, 18, 19, 25, 26 and 30 (shown in Table 2) proposed by Pickaver & Ferreira (2008). In this research, progress indicators of an integrated governance of the coast developed by the EU working group on indicators and data (WGID, 2003) are used. These partially overlap with the progress indicators suggested by Pickaver & Ferreira (2008). A recent application from Pickaver & Ferreira (2008) shows that principle 7 is not well attained in the EU member states ICZM policy, while some exceptions can be found where formal

Table 1 - The eight principles of good ICZM practice as contained in the EU ICZM Recommendation

<p>Principle 1: A broad overall perspective (thematic and geographic) which will take into account the interdependence and disparity of natural systems and human activities with an impact on coastal areas.</p> <p>Principle 2: A long-term perspective which will take into account the precautionary principle and the needs of present and future generations.</p> <p>Principle 3: Adaptive management during a gradual process which will facilitate adjustment as problems and knowledge develop. This implies the need for a sound scientific basis concerning the evolution of the coastal zone.</p> <p>Principle 4: Local specificity and the great diversity of European coastal zones, which will make it possible to respond to their practical needs with specific solutions and flexible measures.</p> <p>Principle 5: Working with natural processes and respecting the carrying capacity of ecosystems, which will make human activities more environmentally friendly, socially responsible and economically sound in the long run.</p> <p>Principle 6: Involving all the parties concerned (economic and social partners, the organisations representing coastal zone residents, non-governmental organisations and the business sector) in the management process, for example by means of agreements and based on shared responsibility.</p> <p>Principle 7: Support and involvement of relevant administrative bodies at national, regional and local level between which appropriate links should be established or maintained with the aim of improved coordination of the various existing policies. Partnership with and between regional and local authorities should apply, when appropriate.</p> <p>Principle 8: Use of a combination of instruments designed to facilitate coherence between sectoral policy objectives and coherence between planning and management.</p>
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Table 2 - A selection of ICZM indicators proposed by Pickaver *et al.* (2008) to assess the coordination between different policies and participatory approaches.

<p>Indicator 9: there is a formal mechanism by which coastal stakeholders meet regularly to discuss a range of coastal and marine issues</p> <p>Indicators 18: there are open channels of communication among those responsible for the coast at all levels of government</p> <p>Indicator 19: each administrative level has at least one member of staff whose sole responsibility is ICZM</p> <p>Indicator 25: there is a strong constant effective political support for the ICZM process</p> <p>Indicator 26: there is a routine cooperation across coastal and marine boundaries</p> <p>Indicator 30: mechanisms for reviewing and evaluating progress in implementing ICZM are embedded in governance</p>

mechanisms are enforced by regular stakeholders meetings.

As a whole, the questionnaire survey revealed that there were some promising results to achieve a better stakeholders' engagement at local scale, providing a useful contribution to the wider debate on the eight principles of the EU ICZM Recommendation and their evaluation (McKenna *et al.*, 2008).

3. Methodology

The ICZM "process" was evaluated by direct interview and questionnaire survey, and results were integrated with recent findings from the literature. An introductory letter, accompanying the questionnaire and explaining the aim of the research, was sent to the Environment and Territorial Planning Officers of the 15 coastal Regions. Regions that participated to the questionnaire survey are 6, a small selection of those that are implementing ICZM strategies (Figure 1). According to the non-statutory character of the EU ICZM Recommendation, no Region is obliged to adopt integrated measures for the coast. However, good practices developed by

these six Regions are making others awareness of the importance of the ICZM approach.

The questionnaire was answered only by one person for each Region, the responsible of the ICZM programme or the closest officer involved in decision and policy-making for the coastal zone. These answers reflect the subjective vision of the person interviewed rather than the official position of the Regions. Although this could reduce the robustness of results, findings reflect the authoritative vision of the staff responsible for the implementation of the ICZM policy. The questionnaire is divided in four sections and composed of 21 questions (see Supporting Information II). The first section is an introduction exploring a general idea on the meaning of ICZM, the motivations for starting an ICZM programme, and the reasons, if they exist, for the limited implementation of the programme. The second part investigates current policies and programmes enforced to deal with coastal problems. Thirdly, mechanisms that operate for achieving horizontal and vertical integration are surveyed. Finally, the last section evaluates the status of ICZM implementation using the indicators pro-



Figure 1 - Picture of the 20 administrative Regions and the six ones participating to the survey. 1. Calabria; 2. Emilia-Romagna; 3. Friuli Venezia-Giulia; 4. Lazio; 5. Sicily; 6. Toscana. Regions 2, 4 and 6 are implementing a regional ICZM approach, while Regions 1 and 5 are implementing pilot site ICZM schemes. The 15 coastal Regions host 44 million people, 72% of the total population of Italy (61 million). Those that have participated to this survey represent 50% of the coastal regions population (source: <http://www.comuni-italiani.it/regionip.html>).

posed by the EU working group on indicators and data (WGID, 2003).

In order to assess the preferences of ICZM institutional processes, several mechanisms, capable to provide coordination both at horizontal and vertical levels, have been proposed to officers that were asked to rank these mechanisms along an ordinal scale ranging from 1 to 4, where 1 is the highest value and 4 the lowest. In addition, the perceived level of integration achieved by each Region is assessed through the same ordinal scale to which respondents replied ticking only one level. Finally, the first version of the EU Working Group Indicators (WGID, 2003) is used to measure the evolution of the policy process towards the integrated “dimension” of the coastal governance. These indicators were originally proposed in 26 levels and grouped in 8 clusters (Pickaver *et al.*, 2004). Later they were revised in 31 levels and 4 clusters and adopted in 2005 to measure the progress of ICZM in some Member States (Pickaver & Ferreira, 2008). In this research, the first series of indicators was adopted, because of the unavailability of the final 2005 version when the questionnaire survey was carried out (see Supporting Information). The first

cluster does not comprise any activities achieving ICZM and no coastal planning is implemented; the second one indicates coastal planning is occurring, but it may not be of integrated nature. The third one indicates that non-systematic ICZM schemes are occurring. The fourth cluster is indicative of the presence of a framework for ICZM, while clusters 6 and 7 are indicative of vertical and horizontal integration, respectively. Cluster 8 indicates efficient participatory planning and, finally, cluster 9 the full implementation of all the ICZM levels.

Data analysis

Analysis of data is performed through descriptive statistics (means and frequencies of the answers provided). Responses ranked along an ordinal scale were averaged to produce a synthetic figure of the level of horizontal and vertical coordination (Veal, 2011). In addition, cluster analysis is used to reduce the information acquired and show common patterns (similarities) between Regions.

4. Results

4.1 The national dimension of coastal management

During a telephonic survey carried out in 2005 with the Ministry of Environment Land and Sea (MELS) emerged a clear uncertainty on the need to formulate a national integrated strategy for the coast. The aim of the national government was the acquisition of adequate knowledge on the likely environmental and geological risks for the coast (i.e., coastal erosion, pollution, eutrophication, etc.) (Ministero dell'Ambiente, 2001b). It is not in place any definition of the coast, and a uniform legal framework for coastal management is still lacking. However, although there is no specific law for ICZM, there are several legal provisions that are relevant to coastal management. Article 822 of Civil Code states that seashores, beaches, roads, ports and rivers belong to the State as part of the Public Domain. The same code introduces a 300 metres zone behind the public maritime domain in which the consent of maritime authority must be obtained for the implementation of civil engineering works. Italy claims the 12nm (Law 14 n° .359) and the continental shelf limits are agreed with the neighbouring countries, while there are no 200nm rights in the Mediterranean basin (Vallega, 1999; Scovazzi, 1994). In strictly legal terms, the Italian coastal zone has an extension ranging from 300m landwards to 12nm seawards.

Several central agencies are involved in coastal management: Supporting Information II reports a view of the main competencies in coastal management by national institutions. The foremost responsibility for the protection of the coastal zone rests with MELS, instituted by the law 349/86 and reorganized by the Decree of the Republic President 178/2001. The latter gives

MELS responsibilities on safety for navigation (to be operated by the Coast Guard), gazettement of marine protected areas, formulation of strategies against pollution, and conservation of marine biodiversity (art.7.3), among others. Other sectoral policies are provided by other Ministries (Supporting Information II), but conflicts between sectors and coastal policies are evident and slowly sorted out.

Supporting Information III presents a synthesis of the main laws affecting the governance of the coast both at national and regional scales, showing that for addressing the coastal governance, a re-distribution of administrative powers between State and Regions has been operated. The Law Decree 112/98 has transferred to the Regions accountability for nature protection, pollution control, waste management, planning in the coastal zone and defence against erosion. Moreover, Regions are responsible for the management of small harbours, monitoring and formulation of plans for water quality improvement. At lower tier, Provinces are empowered to produce water survey and prepare provincial territorial management plans, while Municipalities to carry out operative actions for maintaining coastal defence structures, managing aqueducts, wastewater treatment plants and collecting environmental charges and taxes (Caravita, 2000).

Notwithstanding the prominent position of the regional administrations in managing the coast, national ICZM activities have been promoting since 2008 when a dedicated group to ICZM was established. For example, MELS has recently reviewed the 2006-2010 evolution of ICZM, the legal framework and plans of the 15 coastal Region administrations to coordinate the incoming effort of an integrated sub-national coastal and marine strategy. In addition, MELS has recently defined the roadmap (topics, timelines and actors), in agreement with the Regions and local authorities, to elaborate the “National Strategy for Integrated Coastal Zone Management”, and has established a permanent technical table on ICZM. Parallel to this, MELS is working on the “National Biodiversity Strategy” that can be considered a positive input and a strong commitment to ICZM-related activities. In addition, Italy, among others, has ratified the 1992 International Convention on Maritime Rights (UNCLOS), and the Barcelona Convention for the Protection of the Marine Environment and the Mediterranean Coastal Region with its protocols, including the 2008 ICZM Protocol. However, difficulties in coordinating ICZM efforts persist. Several factors delay an effective integrated strategy at national scale: from the non-binding requirement of the EU ICZM Recommendation, the devolution of more powers to the regional administrations, that made less important the need for a national ICZM strategy, and the reduction of funds for environmental protection (MELS, 2011).

4.2 Coastal management at regional scale

The questionnaire survey showed the presence of local ICZM experiences in Calabria, Sicilia and Friuli Venezia Giulia (in this Region a local management of the integrated marine reserve of Miramare is enforced by means of a voluntary environmental management scheme), while the other Regions (Toscana, Lazio, Emilia-Romagna) have been coordinating ICZM efforts at regional scale. In this region of Giulia a local management of the integrated marine reserve of Miramare is enforced by means of a voluntary environmental management scheme-EMAS

Lazio Region has legally appointed a non-executive ICZM Commission, a technical board that coordinates and supports the development of the littoral and provides further assistance in organising campaigns for public education. Moreover, an overarching executive committee takes legal decisions, prioritising the needs raised by the ICZM commission. From the survey emerges that the relationships between different organisations at the same institutional level are considered very good and integration successfully-achieved by using ad-hoc round tables, while vertical coordination is considered critical, even though specific accords with local authorities and with the Ministry of the Environment are in force. In the **Toscana** Region, coastal planning is not specifically coordinated by an ICZM committee, but by the territorial planning office. This institution seems to provide only a moderate integration with central (national) government, but good relationships with Provinces and Municipalities, which set up agreements with the Regional government for the preparation of an integrated plan. **Emilia-Romagna** Region is the first and unique Italian Region to have an integrated plan for the coast at regional scale since 2003. There is not any specific institution dedicated to ICZM, but sectoral directorates and other operative services interact with some degrees of cooperation. However, this cooperation is not always successfully achieved, especially along the horizontal dimension, and informal mechanisms are recognized as a useful way to improve coordination.

At vertical level, the Conference between Regions and State (this institution is adopted to coordinate the themes that are of common interests and involve State and Regions negotiation; DPCM 19 October 1983) is considered a good consolidated mechanism, while other more informal consultations for vertical integration are not taken into account. This institution was adopted to coordinate the themes that are of common interests and involve State and Regions negotiation; DPCM 19 October 1983. The other Regions have not an integrated plan, but only sectoral schemes for arranging coastal erosion problems (**Sicilia**), and hydro-geological disasters (**Calabria**). It is clear that coordinating mecha-

nisms are not well consolidated as depicted by the responses provided by the interviewees.

For the Sicilia Region a negative opinion has been expressed about the suitability of inter- and intra-government relationships. Of greater interest appears the vertical coordination with ISPRA (the national agency for the protection of and research on the environment) that promotes a good exchange of scientific information, even though contacts with local communities remain limited. In analogue way, a regional officer of Calabria Region expressed a negative view about relations at horizontal level. A dedicated committee for integrated coastal management is not in place, even though the “Environmental Regional Board” leads coastal-related operations. Conversely, vertical cooperation is guaranteed by periodical meetings with the central (national) level through the monitoring activities carried out by ISPRA, as it happens for Sicilia. The **Friuli Venezia Giulia** Region has not a plan for the integration of coastal sectoral activities, but a strong policy concerning the protection of nature by the creation of a network of natural reserves, the majority of them located in the coastal zone. In particular, the Region had a primary role in institutionalizing the marine reserve of Miramare, managed by WWF, and in funding it. A common mechanism used for coordinating the numerous directorates is given by consultations, with the possibility to operate in a scenario of urgency under the procedures of the Conference of Service. This institution is adopted to simplify procedures and time of access to resources and obtain shortly authorizations from the public organizations. Law n.241 1990

A synthesis of the mechanisms coordinating the governance of the coast for each of the Regions that participated to the questionnaire survey is reported in Supporting Information IV.

In order to assess the maturity of the horizontal mechanisms for coordination, the respondents were requested to provide their opinion using an ordinal scale ranging from 1 to 4, where 1 stays for great success; 2 for moderate success; 3 for moderate failure; and 4 for great failure. Half sample responded that a moderate success is achieved (3 responses: Calabria, Sicilia and Friuli Venezia Giulia). Lazio interviewee considers horizontal coordination achieved with a great success, while Emilia-Romagna respondent declared horizontal coordination achieved with great failure. Finally, Toscana officer considers horizontal integration achieved with moderate failure. The average value of the ranking scores is higher than 2, highlighting that a little proportion of failures exists.

A similar consideration can be formulated for the vertical integration: the average score of 1.8 suggests that this dimension is easier to be achieved than horizontal one. The proportion of answers is oriented towards a

“moderate success”, as expressed by 80% of the sample (4 responses: Sicilia, Lazio, Friuli and Calabria interviewees). Only the Toscana Region, although has a reduced informal communication with the central level, considers vertical integration achieved with great success, in particular for the good relationships with Provinces and local Municipalities. The Emilia Romagna officer, that was very critic in valuing horizontal coordination, has not expressed any opinion, manifesting strong uncertainty.

4.3 Perception of the most effective horizontal and vertical mechanisms and level of implementation of ICZM at regional scale

A few common horizontal mechanisms have been proposed to investigate the most effective way of addressing an integrated strategy. The mechanisms proposed are an *inter-sectoral committee* (executive and non-executive), a *lead existing agency*, a *new lead agency*, a *consultative commission* and *regular forums*. In Figure 2, it is reported the final score obtained averaging the ranking provided by the respondents. The lowest number represents the preferred choice.

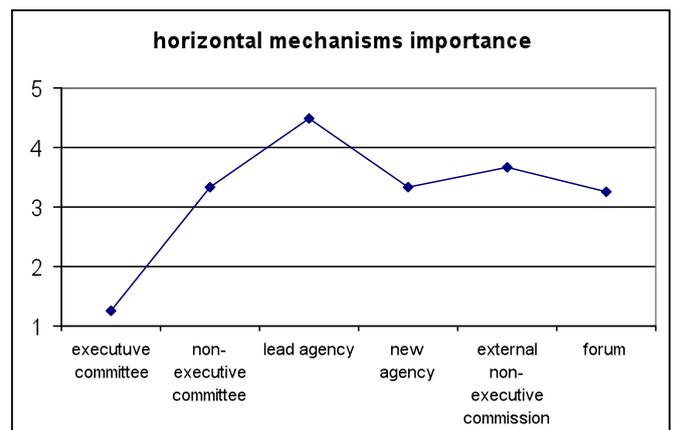


Figure 2 - Preference for horizontal mechanisms

It seems clear that an executive inter-sectoral committee is the best choice, as showed by Cicin Sain & Knecht (1998). A lead agency is not considered a good option probably because of the necessity of reducing the power of other agencies or directorates. Conversely, importance is given to a technical and advisory commission, as adopted by the Lazio Region, while Friuli Venezia Giulia and Emilia-Romagna Regions mainly advocate regular forums.

Vertical coordination seems to be more easily achieved by the well-consolidated State-Regions Conference. However, the other Regions use alternative mechanisms for obtaining formal and informal agreements with national agencies and local municipalities. Calabria and Sicilia Regions have facilitation in interacting with the Ministry of Environment by means of ISPRA, while Lazio Region has a direct dialogue with the same Min-

istry. Toscana Region, in particular way, shows good relationships with the Provincial administrations and local Municipalities, having agreed with them an integrated management strategy of the coast based on specific protocols. As regards the preferred choice, all Regions, apart from Emilia–Romagna and Friuli Venezia Giulia, consider the definition of a cascade of policies, from the strategic to operative level, fundamental to harmonise different tiers of government (Figure 3).

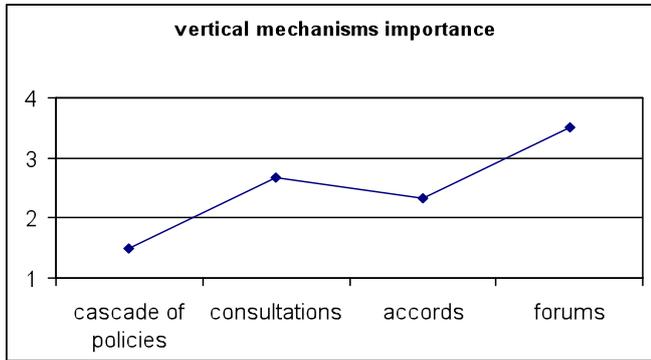


Figure 3 - Preference for vertical mechanisms

Emilia Romagna Region considers the cascade of policies the least important option among the mechanisms proposed and only the consequence of a previously adopted bottom-up strategy, involving consultations, accords and forums. This choice shows clearly that ICZM in Emilia Romagna has been achieving through a participative bottom-up process. Conversely, the analysis of the sample shows that, as for the horizontal integration, the least considered mechanism is forum and that coastal governance is far to be a participative process and still administered by a restricted number of policy makers, in line with a top-down approach. The best and worst options for each respondent on both horizontal and vertical coordinating mechanisms are proposed in Table 3.

A way of measuring the status of integration is employed here by adopting the UE indicators. Twenty-six questions test the presence (YES/NO answer) of five ICZM-related dimensions: 1) presence of general planning and management for the coast; 2) presence of local pilot projects on ICZM; 3) framework for, but not yet, an ICZM implemented programme; 4) vertical and horizontal scope; 5) sound participatory planning achievements. The result of this survey is proposed in Figure 4, by aggregating the levels of each dimension (cluster).

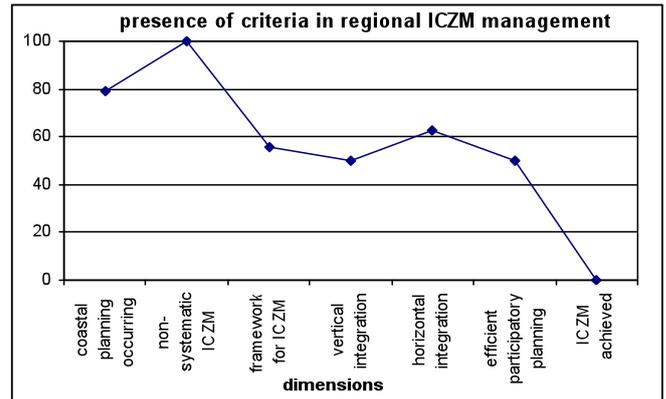


Figure 4 - Average value for each cluster of the EU ICZM indicators

From the Figure 4 emerges that while all the sampled Regions declare activities in coastal planning, positive answers on the presence of an ICZM framework drop to 50%, with integration perceived to be stronger at horizontal than vertical scale.

Finally, the cluster analysis is used to aggregate the Regions and to verify if there are some patterns of similarity, according to the responses given on the implementation of horizontal and vertical coordination mechanisms and the EU ICZM indicators. These similarities are assessed in terms of Euclidean distance

Table 3 – Most and least preferred horizontal and vertical coordinating mechanisms for each region.

	Calabria	Emilia-Romagna	Friuli	Lazio	Sicilia	Toscana
Horizontal coordination						
<i>More consideration:</i>	Intersectoral commission	Forums	Intersectoral commission	Intersectoral commission	Uncertainty	Uncertainty
<i>Less consideration</i>	Forums	Non executive external committee	Non executive external committee	Forums	Uncertainty	Uncertainty
Vertical coordination						
<i>More consideration</i>	Cascade of policies	Forums	Forums	Cascade of policies	Cascade of policies	Cascade of policies
<i>Less consideration</i>	Forums	Cascade of policies	Cascade of policies	Forums	Forums	Forums

between clusters (aggregations of Regions): the lower is Regions. From Figure 5 it is possible to individuate the presence of three clusters: one that contains only Emilia Romagna, the second encompassing Calabria and Sicilia, and the third Lazio, Friuli Venezia Giulia and Toscana. It is possible to note that there are no specific “regionalisms” (i.e., specific differentiations in the cluster aggregation due to different geographic positions): Regions with different geographical and socio-economic settings are in the same cluster and position in the cluster dendrogram, and it is likely that this result is given by the presence of a more mature activity in coastal management. Emilia Romagna is the unique Region that has in operation an integrated plan, and probably this has matured a new awareness of integrated coastal management. One of the most important features that differentiate Emilia Romagna from the other Regions is the consciousness of the importance of forums, public participation and informal exchange of information in tailoring an efficacious bottom-up ICZM programme.

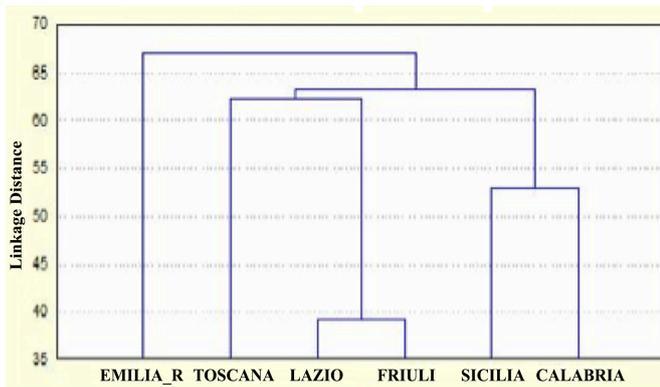


Figure 5 - Euclidean distance between Regions based on the EU policy process indicators

5. Discussion

As suggested by the primary survey (2005) and reaffirmed in the literature (Rupprecht Consult & International Ocean Institute, 2006; EC, 2011b), Italy lacks a “uniform” national ICZM strategy, and is not developing policies equivalent to ICZM, but only the implementation of fragmented initiatives. This sectoral approach to coastal management has determined fragmented competencies between State and Regions and a general overlap of laws and regulations, facilitated by the Law Decree 112/98, which has institutionalised the devolution of administrative procedures for coastal planning and management to the regional governments. In addition, this has limited the importance of the national role, as confirmed by the responses given by the Toscana Region officer. Finally, the last review on the ICZM state of art, conducted by the Ministry of Environment Land and Sea, has evidenced not only the lack of a specific national policy on ICZM, but also the

lack of ad-hoc planning and programming tools and the unavailability of adequate financial support (MELS, 2011).

Notwithstanding the aforementioned concerns, new cross-cutting institutions have recently been put in place to intensify dialogue with the peripheral administrations, such as specific policies and round tables, addressing and coordinating biodiversity issues. These are the national working group on the Integrated Maritime Policy; the Joint Committee for the National Strategy for Biodiversity (composed of representatives of the central Administrations, Regions and Autonomous Provinces); and the national Observatory for Biodiversity (coordinated by the Ministry for the Environment, and composed of representatives of the Regional Observatories on Biodiversity, Protected Areas, and the national main scientific institutions) (MELS, 2011). In addition, from the stock tacking provided by the Ministry of Environment Land and Sea, it emerges that a great effort was channelled to improve coordination between fisheries stakeholders through specific commissions (“tables”) within the Ministry of Agriculture Forestry and Fishery. In particular, the “Light-blue Table” was set up to guarantee coordination in fisheries management with the support of the Regions, while the central “Committee for fisheries and aquaculture” to guarantee exchange of information between administrators, researchers and entrepreneurs.

Notwithstanding the absence of any official positions from MELS on the ideal ICZM institution, we could expect, based on other European and international experiences (Sorensen, 1993; Cicin-Sain & Knecht, 1998), that an (executive) inter-agency commission might be appropriate to coordinate a national ICZM strategy, in conjunction with an act reducing conflicts and amending legal instruments governing sectoral interests.

Analogue perspective is found in the Mediterranean Action Plan (Pavasovic, 1996), where a networked approach (Born & Miller, 1988; Knecht *et al.*, 1996) is advocated. The latter is the most adopted approach in developed countries, where sectoral interests are unlikely harmonised by a lead-planning agency (Boelaert-Suominen & Cullinam, 1994; Cinin-Sain & Knecht, 1998). However, the UK approach based on building consensus from the bottom by integrating sectoral divisions inside forums and arenas (Kennedy, 1995; Inder, 1996; Jones, 1996; Scott, 1996; Taussik, 1997; Ballinger, 1999) seems to be exportable into the Italian context, especially after the devolution of many administrative functions to the regional governments. Recently, voluntary bottom-up strategies have been emerging at regional and local scales, facilitated by consolidated negotiated planning tools and pilot projects experimenting local ICZM strategies.

The results of the questionnaire survey, supported by the most recent institutional review (MELS, 2011), showed clearly the materialization of an integrated spatial plan for the implementation of ICZM in Emilia Romagna, while in other Regions coastal planning was addressed to specific issues (coastal erosion, landscape protection, etc.). Examples are given by the Lazio Region where specific programmes were oriented to the defence of the coast from erosion (Koutrakis *et al.*, 2008; 2010, Martino & Amos, 2015), and by the Toscana Region, that has developed a specific Plan for the National Park of the Tuscany Archipelago and for the Regional Park of Maremma. However, the possibility to improve coordination in Regions with only sectoral coastal planning in place seems to be related to the creation of new cross-fertilising institutions as already verified by Cicin-Sain & Knecht (1998).

Looking at the ICZM institutions in some European Countries, we can find three different main typologies: a national body serving mainly as an advisory board, such as the *Direcion General de Costas* in Spain; the UK national planning and marine policy guidelines addressing voluntary bottom-up coastal management strategies; and the planning approach adopted by Sweden (Taussik, 1997) to integrate terrestrial and maritime domain. While the Spanish choice is based on a central national top-down framework, the UK approach promotes voluntary local coastal partnerships, coordinated by the National Coastal Forum that brings together representatives of central and local governments, industry and commerce, recreation and conservation sectors (Humphrey & Burbridge, 1999). Amongst the EU Member States, the UK shows that informal links between different coastal stakeholders can provide interesting results in the achievement of major cooperation whereas other countries (Italy, Bulgaria, Cyprus, Ireland, Estonia, and Greece) have not shown any progress in the implementation of the principle 7 (see Table 1) of the EU ICZM Recommendation (Pickaver & Ferreira, 2008). Overall, a qualitative measure of ICZM implementation is about 50%. In other words, Europe is about halfway in implementing the ICZM principles (ECb, 2011).

The implementation of the subsidiarity principle in Italy makes high expectation for ICZM to be implemented by regional governments and local administrations. This caused different Regions to react in different ways to the formulation of an integrated strategy: from the new planning system of Emilia Romagna, to the centralised board of Lazio Region, and the enforcement of agreements between the Regional Government, Provinces and Municipalities adopted by the Toscana Region. In addition, some forms of voluntary participation in local isolated project have been experienced at municipal level, showing that local forums are a good way to hear

the dissent from public. Addressing this point, however, is not an easy task because coastal management was perceived in Italy as a public issue only in the early 1990s. Italy has a limited tradition in public discussion and stakeholders engagements during disputes and conflicts, as it generally occurs in the UK or USA. “Conflicts are numerous, but they are considered largely within the sanctuary of policy-makers and bureaucracy and are not topics of broad-ranging public debate” (Vallega, 2001). One of the rare moments of open debates was the gazettment of the important marine protected area of Portofino (Salmona & Verardi, 2001) that triggered an intense conflict between local authorities and users.

The third ICZM strategy is the integrated sea-land planning, adopted in Sweden. In 2013, the EU Commission opted for this approach to homogenise ICZM efforts in all members states, presenting a Directive (Directive 2014/89/EU) that establishes a framework for maritime spatial planning (MSP) as a tool to integrate sectoral activities at sea and land, to ensure the involvement of stakeholders, and to consider economic, social and environmental aspects in supporting sustainable development and growth (EC, 2007). A recent study revealed that a binding framework to implement MSP/ICZM would be the most effective way of achieving the operational objectives by the reduction of transaction costs for maritime businesses and coordination costs for public authorities (EC, 2013). The binding act will require Member States to establish coastal management strategies that build on the principles of the 2002 Recommendation and the Protocols of the Barcelona Convention on Integrated Coastal zone Management. This choice, for the first time in the European Union, will bring a set of obligations, including development of best practices, but a reduced emphasis for voluntary approaches, such as guidelines and recommendations that are not considered to produce the desired results in improving the sea-land interface planning. At the time of this script, no change in the governance of the Italian coastal zone, according to the Directive 2014/89/EU, is visible, whose maritime planning authority must be chosen by September 2016, and ICZM plans organised by 2021.

6. Concluding considerations

This paper is a first effort to evaluate approaches employed for coordinating levels of government for coastal management in Italy, and to assess the maturity of the ICZM policies at national and sub-national scales. As described in the literature and confirmed by the national survey, Italy lacks a uniform national ICZM strategy. An attempt of integrating initiatives for coastal management is evident at sub-national scale mainly in Emilia-Romagna, Toscana, Liguria, and

Lazio Regions, even though with different approaches and grades of maturity. Although since 2014 a binding act (Directive 2014/89/EU) requires Member States to establish coastal management strategies within a revised maritime spatial planning, no change to this direction in the governance of the Italian coastal zone is visible. However, results from the questionnaire survey show that some of the indicators suggested by the working group on ICZM indicators are achieved at regional scale, such as the presence of a framework for the evaluation of coastal activities; the promulgation of laws for planning protected areas; the promotion of isolated ICZM pilot projects; the integration of natural and social information; and the adoption of a monitoring programme.

The unfulfilled indicators refer to the absence of a national master plan for the coast, the lack of integrated legislation for coastal planning and management, and the limited communication between institutions at the same tiers of government. The latter point suggests that principle 7 of the EU Recommendation on ICZM is not yet fulfilled. Among the indicators reported in Table 2, only those numbered 9, 18 and 19, covering the presence of formal mechanisms, open channels of communication, and dedicated staff to ICZM implementation, respectively, are satisfied. However, it is not possible to say that an effective political support, routine cooperation across coastal and marine boundaries, and mechanisms for reviewing progress in implementing ICZM are achieved.

From the results of the direct survey, integrated by the recent national stocktaking and the literature review, it is possible to state that an inter-sectoral committee is emerging as the best solution for the horizontal coordination, while a cascade of policies from central to local governments and accords are considered a good way to reinforce dialogue between administrations at different scales. Conversely, forums both at national and regional levels were not well appreciated, probably for the lack of consensus-building approach in policy-making and the adoption of a top-down territorial planning strategy.

The low level of integration between ICZM policies is a common issue in many European countries, probably caused by the non-statutory requirements of the 2002 EU Recommendation. Considering the limited results achieved, integrating sectoral policies for the coast within maritime planning has been the choice of the EU. Beyond the recent decision of the EU to implement a directive on ICZM under a marine spatial planning strategy, and considering the pressures for organizational changes, the sectoral division may be unified through informal discursive platforms, especially at local scale where limited ICZM programme capacity exists, as promoted by the Toscana Region. The latter strategy would provide flexible decentralised arrange-

ments to local organisations and involve public interests in order to raise awareness of the importance of the coastal zone. This strategy seems a good solution to win the policy dictates of a top-down approach, typical of the Italian planning system, before achieving the new binding requisites of the maritime spatial planning Directive 2014/89/EU.

Appendix

Supporting Information associated with this article is available online at http://www.aprh.pt/rgci/pdf/rgci-616_Martino_Supporting-Information.pdf

References

- Ballinger, C.R. (1999) - The evolving organisational framework for integrated coastal management in England and Wales. *Marine Policy*, 23(4-5):501-523. DOI: 10.1016/S0308-597X(98)00054-2
- Ballinger, R.; Pickaver, A.; Lymbery, G.; Ferreria, M. (2010) - An evaluation of the implementation of the European ICZM principles. *Ocean & Coastal Management*, 53(12):738-749. DOI: 10.1016/j.ocecoaman.2010.10.013
- Boelaert-Suominen, S.; Cullinan, C. (1994) - *Legal and institutional aspect of integrated coastal area management in national legislation*, 124p., FAO.
- Born S.M.; Miller A.H. (1988) - Assessing networked coastal zone management programs, *Coastal Management*, 16: 229-243. DOI: 10.1080/08920758809362060
- Caravita, B. (2000) - *Diritto pubblico dell'ambiente*, seconda edizione, Il Mulino, Bologna.
- CEC (1995) - *Communication from the Commission to the Council and the European Parliament on the integrated management of the coastal zone*, COM 511/95, Bruxelles, Luxembourg. ISBN 92-828-6463-4.
- CEC (1999) - *Lessons from the European Commission's demonstration programme on integrated coastal zone management (ICZM)*, Bruxelles, Luxembourg.
- CEC (2000) - *Communication from the Commission to the Council and the European Parliament on integrated coastal zone management: a strategy for Europe*. COM (2000) 547 final. Brussels: CEC.
- CEC (2002) - *Recommendation of the European parliament and of the council of 30 May 2002 concerning the implementation of integrated coastal zone management in Europe*. 2202 413/EC
- Cicin-Sain, B.; Knecht, R. (1998) - *Integrated coastal and ocean management*, 543p., Island Press, Washington, U.S.A. ISBN: 9781559636049.
- Dubbink, W., van Vliet M. (1996) - Market regulation versus co-management? *Marine Policy*, 60(6):499-516. 10.1016/S0308-597X(96)00035-8
- EC (2007) - *An Integrated Maritime Policy for the European Union*. COM(2007) 574 final
- EC (2011a) - *Public hearing on integrated coastal zone management*, 30 May 2011 hearing report.
- EC (2011b) - *Support study for an impact assessment for a follow-up to the EU ICZM recommendation (2002/413/EC)*.
- EC (2013) - *Proposal for a Directive of the European Parliament and of the Council establishing a framework for maritime spatial planning and integrated coastal management*, COM(2013)133.
- Giordano, L.; Alberico, I.; Ferraro, L.; Marsella, E.; Lirer, F.; Di Fiore, V. (2013) - A new tool to promote sustainability of

- coastal zones. The case of Sele plain, southern Italy. *Rendiconti Lincei*, 24(2):113-126. DOI: 10.1007/s12210-013-0236-2
- Gusmerotti, N.M.; Marino, D.; Testa, F. (2013) - Environmental policy tools to improve the management of marine and coastal zones in Italy: the self-financing instruments. In: E. Creighton & P. Danovich, *Environmental Policy: Management, Legal Issues and Health Aspects*, Nova Science Publishers, New York, U.S.A. ISBN: 978-1628084979.
- Henoque, Y. (2003) - Development of process indicators for coastal zone management assessment in France. *Ocean & Coastal Management*, 46: 363-379. DOI: 10.1016/S0964-5691(03)00013-9
- Humphrey, S.; Burbridge, P. (1999) - *Planning and management process: sectoral and territorial cooperation*. Available at http://europa.eu.int/comm/environment/iczm/themd_rp.pdf.
- Inder, A. (1996) - Partnership in planning and management of the Solent. In: J. Taussik & Mitchell J., (org.), *Partnership in the coastal zone Management*. Cardigan Samara Publishing limited.
- Jones, S. (1996) - A comparative analysis of coastal zone management plans in England and The Netherlands- In: Jones, Healy & Williams (org.), *Studies in European coastal management*, pp. 143-154, Samara Publishing Limited, Cardigan, U.K. ISBN: 978-1873692073
- Kennedy, K.H. (1995) - Producing management plans for major estuaries - the need for a systematic approach: a case study of the Thames estuary. In: Healy and Doody (org.), *Directions in European coastal Management*, pp. 451-459, Samara publishing Limited, Cardigan, U.K. ISBN: 978-1873692066.
- Knecht, R.; Cicin-Sain, B.; Fisk, W.G. (1996) - Perception of the performance of state coastal zone management programs in the United States. *Coastal Management*, 24:141-163. DOI: 10.1080/08920759709362325
- Koutrakis, E.T.; Sapounidis, A.; Marzetti, S.; Giuliani, G.; Cerfolli, F.; Nascetti, G.; Martino, S.; Fabiano, M.; Marin, V.; Paoli, C.; Vassallo, P.; Roccatagliata, E.; Salmona, P.; Rey-Valette, H.; Roussel, S.; Carnus, F.; Bellet, F.; Povh, D.; Malvarez, C.G. (2008) - Le Sous-projet ICZM-MED - Actions concertées, outils et critères pour la mise en oeuvre de la Gestion Intégrée des Zones Côtières (GIZC) Méditerranéennes. In: BEACHMED-e (org.) - *La gestion stratégique de la défense des littoraux pour un développement soutenable des zones côtières de la Méditerranée*, 159p., GIER Graphic srl, Rome, Italy
- Koutrakis, E.T.; Sapounidis, A.; Marzetti, S.; Giuliani, V.; Martino, S.; Fabiano, M.; Marin, V.; Paoli, C.; Roccatagliata, E.; Salmona, P.; Rey-Valette, H.; Roussel, S.; Povh, D.; Malvarez, C.G. (2010) - Public Stakeholders' Perception of ICZM and Coastal Erosion in the Mediterranean. *Coastal Management*, 38(4):354-377. DOI: 10.1080/08920753.2010.487148
- Koutrakis, E.T.; Sapounidis, A.; Marzetti, S.; Marin, V.; Roussel, S.; Martino, S.; Fabiano, M.; Paoli, C.; Rey-Valette, H.; Povh, D.; Malvarez, C.G. (2011) - ICZM and coastal defence, perception by beach users: lessons from the Mediterranean coastal area. *Ocean & Coastal Management*, 54:821-830. DOI: 10.1016/j.ocecoaman.2011.09.004
- Marotta, L.; Ceccaroni, L.; Matteucci, G.; Rossini, P.; Guerzoni, S. (2011) - A decision-support system in ICZM for protecting the ecosystems: integration with the habitat directive. *Journal of Coastal Conservation*, 15(3):393-405. DOI: 10.1007/s11852-010-0106-3
- Martino, S.; Amos, C.L. (2015) - Valuation of the ecosystem services of beach nourishment in decision making: The case study of Tarquinia Lido, Italy. *Ocean & Coastal Management*, 111:82-91. DOI: 10.1016/j.ocecoaman.2015.03.012
- Marzetti S.; Disegna M.; Koutrakis E.; Saponidis A.; Marin, V.; Martino, S.; Roussel, S.; Rey-Valette, H.; Paoli, C. (2016) - Awareness of ICZM and WTP in European Mediterranean regions: a case study. *Marine Policy*, 63:100-108. DOI: 10.5367/te.2013.0360
- McKenna, A.J.; Cooper, A.; O'Haganm A.M. (2008) - Managing by principle: A critical analysis of the European principles of Integrated Coastal Zone Management (ICZM). *Marine Policy*, 32(6):941-955. DOI: 10.1016/j.marpol.2008.02.005
- Ministero dell'Ambiente (2001a) - *Relazione sullo stato dell'ambiente 2001*, Ministero dell'Ambiente, Rome, Italy.
- Ministero dell'Ambiente (2001b) - *Strategia d'azione ambientale per lo sviluppo sostenibile in Italia*, Ministero dell'Ambiente, Rome, Italy.
- MELS (2011) - *Italian National Report on the implementation of ICZM based on the EU ICZM Recommendation (2006-2010)*. Available on-line at http://www.minambiente.it/home_it/menu.html?mp=/menu/menu_attivita/&m=argomenti.html%7CMare.html%7CGestione_Integrata_delle_Zone_Costiere_.html.
- Olsen, B.S.; Tobey, J.; Kerr, M. (1997) - A common framework for learning from ICM experience, *Ocean & Coastal Management*, 37:155-174. DOI: 10.1016/S0964-5691(97)90105-8
- Olsen, S.B. (2003) - Frameworks and indicators for assessing progress in integrated coastal zone management initiatives, *Ocean & Coastal Management*, 46, 347-361. DOI: 10.1016/S0964-5691(03)00012-7
- Pavasovic, A. (1996) - The Mediterranean Action Plan Phase II and the revised Barcelona Convention: new prospective for integrated coastal management in the Mediterranean region, *Ocean & Coastal Management*, 31:133-182. DOI: 10.1016/S0964-5691(96)00036-1
- Pickaver, A.; Ferreira, M. (2008) - *Implementing ICZM at sub national/local level-recommendation on best practices*. EUCC The Coastal Union.
- Pickaver, A.H.; Gilbert, C.; Breton, F. (2004) - An indicator set to measure the progress in the implementation of integrated coastal zone management in Europe. *Ocean & Coastal Management*, 47: 449-462. DOI: 10.1016/j.ocecoaman.2004.06.001
- Pirrone, N.; Trombino, G.; Cinnirella, S.; Algieri, A.; Bendoricchio, G.; Palmeri, L. (2005) - The Driver-Pressure-State-Impact-Response (DPSIR) approach for integrated catchment-coastal zone management: preliminary application to the Po catchment-Adriatic Sea coastal zone system. *Regional Environmental Change*, 5:111-137. DOI: 10.1007/s10113-004-0092-9
- Portman, M.E.; Esteves, L.S.; Le, X.Q.; Khan, A.Z. (2012) - Improving integration for integrated coastal zone management: An eight country study. *Science of The Total Environment*, 439:194-201. DOI: 10.1016/j.scitotenv.2012.09.016.
- Rochette, J. (2009) - Challenge, dialogue, action... Recent developments in the protection of coastal zones in Italy. *Journal of Coastal Conservation*, 13(2-3):131-139. DOI: 10.1007/s11852-009-0051-1
- Rupprecht Consult & International Ocean Institute (2006) - *Evaluation of Integrated Coastal Zone Management in Europe* -Final Report, Cologne, Germany.
- Salmona, P.; Verardi, D. (2001) - The marine protected area of Portofino, Italy: a difficult balance. *Ocean & Coastal Management*, 44: 39-60. DOI: 10.1016/S0964-5691(00)00084-3
- Scott A. (1996) - The role of the coastal forum in coastal zone management: case study of Cardigan Bay forum. In: J. Taussik and Mitchell J., (org.), *Partnership in the coastal zone Management*, pp.557-564, Samara Publishing, Cardigan, U.K.

- Scovazzi, T. (1994) - International law of the sea as applied to the Mediterranean. *Ocean and Coastal Management*, 24(1):71-84. DOI: 10.1016/0964-5691(94)90053-1
- Sorensen, J. (1993) - The international proliferation of integrated coastal zone management efforts. *Ocean & Coastal Management*, 21:45-80. DOI: 10.1016/0964-5691(93)90020-Y
- N.A. (1999) - *All hands on deck. An interactive perspective on complex common-pool resource management based on case studies in the coastal waters of the Isle of Wight (UK), Connemara (Ireland) and the Dutch Wadden Sea*. Wageningen, ponsenand Looijen. ISBN: 90-5808-097-8
- Taussik, J. (1997) - The influence of the institutional system on planning the coastal zone: experiences from England and Sweden, *Planning Practice & Research*, 12(1):9-19. DOI: 10.1080/02697459716671
- Taussik, J. (2001) - *Collaborative planning in the coastal zone*. PhD thesis, University of Cardiff, U.K.
- Vallega, A. (1999) - *Fundamentals of integrated coastal management*. 267p., Kluwer Academic. ISBN: 978-0792358756. DOI: 10.1007/978-94-017-1640-6
- Vallega, A. (2001) - Focus on integrated coastal management- comparing perspectives. *Ocean & Coastal Management*, 44: 119-134. DOI: 10.1016/S0964-5691(00)00083-1
- Veal, A.J. (2011) - *Research methods for leisure and tourism, a practical guide*. 2nd ed., Pitman Publishing, London, U.K. ISBN: 978-0273717508
- WGID -Working Group on Indicators and Data (2003) - Measuring sustainable development on the coast. A report to the EU ICZM Expert Group by the working group on indicators and data under the lead of ETC TE. Available on-line at ec.europa.eu/.../iczm/pdf/report_dev_coast.pdf
- Zanuttigh, B.; Martinelli, L.; Lamberti, A.; Moschella, P.; Hawkins, S.; Marzetti, S.; Ceccherelli, V.U. (2005). Environmental design of coastal defence in Lido di Dante, Italy. *Coastal Engineering*, 52(10):1089-1125. DOI: 10.1016/j.coastaleng.2005.09.015

Legislation

- Civil Code approval, Royal Decree 16 March 1942, n. 262, GU, n°. 79, Suppl. Straord. 4th April 1942.
- Law n°.359/74, 14 August 1974, GU 218 21st August 1974.
- Law n°. 349/86, 8 July 1986, Institution of the Ministry of the Environment and legislation for environmental damage, GU 162 Suppl. Ord.59, 15th July 1986.
- Decree of the Republic President, n°. 178/2001, 27 March 2001, Organisation of the Minster of Environment, GU 114, 18th May 2001.
- Law Decree n°. 112/98, 31st March 1998, handing over administrative roles of the State to Regions and local administrations to enforce the law 15th March 1997, n. 59, GU 92, Suppl. Ord n. 77, 21st April 998.
- Barcelona Convention - Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. 16th February 1976. http://www.unep.org/NairobiConvention/docs/Barcelona_Convention_full_version.pdf
- Protocol on Integrated Coastal Zone Management in the Mediterranean. 21st January 2008. http://www.unep.org/NairobiConvention/docs/ICZM_Protocol_Mediterranean_eng.pdf

Environmental zoning and coastal zone conservation: the case of a protected area in Northeastern Brazil*

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ABSTRACT

Conservation of coastal zones is a matter of debate all around the world. In this context, marine protected areas can be counted as legal instruments to ensure proper use of natural resources and promote sustainable development. One of the main aspects for the management of protected areas is environmental zoning. Despite its importance, there are few studies focusing on environmental zoning in semiarid coastal environments. The purpose of this study was to present a case study on environmental zoning of a protected area located in the Environmental Protection Area of the Curú River estuary, which is located on the semiarid coast of the South Atlantic Ocean in Ceará-Brazil. The research was conducted in accordance with the classification criteria used in the Ecological-Economic Zoning (EEZ) of the Coastal Zone, a legal instrument that is important with regards to the Brazilian coast. The work was performed with a GIS technique and involved field activities. The results suggest the following environmental systems within the perimeter of the protected area: river plain, fluvial-marine plain with mangroves, fixed dunes, plain deflation/mobile dunes, plain deflation/fixed dunes, pre-coastal vegetation, and sandspit. The maps of the environmental systems zoning were developed on a 1:40,000 scale and were made to encourage the sustainable use of natural resources. As pressure on the environment by human activities increases, it is essential to update environmental zoning in protected areas, especially in the coastal areas of developing countries.

Keywords: Ecological-Economic Zoning, Coastal Ecosystems, Management, Mangroves.

RESUMO

Zoneamento ambiental e conservação de zonas costeiras: o caso de uma área protegida do Nordeste do Brasil

A conservação da zona costeira é questão de debate em todo o mundo. Neste contexto, as áreas marinhas protegidas na zona costeira estão inseridas como um instrumento legal para garantir o uso adequado dos recursos naturais e promover o desenvolvimento sustentável. Um dos principais aspectos para a gestão das áreas protegidas é o zoneamento ambiental. Apesar disso, existem poucos estudos com foco nos ambientes costeiros semiáridos; sistemas de reconhecida sensibilidade e importância ambiental. Neste trabalho foi realizada a descrição e o zoneamento de unidades geoambientais de uma área protegida na costa semiárida do Atlântico Sul Equatorial (Ceará, Nordeste do Brasil). A pesquisa foi realizada de acordo com critérios de classificação utilizados no Zoneamento Ecológico-Econômico da Zona Costeira; instrumento legal importante no contexto da costa brasileira. O trabalho foi desenvolvido por meio de geoprocessamento e trabalhos de campo que viabilizaram a detecção das seguintes unidades geoambientais dentro do perímetro da área protegida: Planície fluvial; Planície flúvio-marinha

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com manguezais; Dunas fixas; Planície de deflação/dunas móveis; Planície de Deflação/Dunas Fixas, Tabuleiro Pré-Litorâneo e Cordão Litorâneo. Os mapas das unidades geoambientais e do zoneamento ambiental foram desenvolvidos na escala de 1:40.000, sendo feito com o intuito de aconselhar a utilização correta dos recursos naturais, indicando áreas passíveis de uso e subsídios para a gestão ambiental. Considerando o incremento da pressão ambiental por atividades antrópicas, é imprescindível a atualização do zoneamento ambiental nas áreas protegidas, sobretudo nas zonas costeiras dos países em desenvolvimento.

Palavras-chave: Zoneamento Ecológico-Econômico, Ecossistemas Costeiros, Manejo, Manguezal.

1. Introduction

Coastal areas are on the continent/ocean interface and are subject to a number of natural and human-induced pressures (Samaras & Koutitas, 2014; Agostini *et al.*, 2015). The coastal zones that connect terrestrial and marine environments are important for the development of a country in terms of economy, energy, employment, and recreation. Unplanned development coupled with increasing population in coastal zones favors the degradation of these environments (Beeharry *et al.*, 2014).

In recent years, society has become more aware of the degradation levels of coastal and marine ecosystems, motivating studies and proposals for action to halt and reverse the causes, which lead to the environmental compromise of these regions. Although data show that land and ocean areas covered by protected areas have increased rapidly in the past few decades around the world, unfortunately, both terrestrial and marine biodiversity still have experienced rapid declines in that time frame (Mora & Sale, 2011). Protected areas are essential for the conservation of biodiversity and are one of the pillars of virtually all conservation strategies (Agostini *et al.*, 2015).

In this context, the management of coastal/marine protected areas represents one of the main mechanisms for the protection of areas with significant ecological importance, functioning as an essential tool for ensuring the conservation of nature and the promotion of sustainable development (Estima *et al.*, 2014). The zoning is used as a tool for the planning of coastal areas, combining the following characteristics: physical, biological, human, and institutional, along with terrestrial and marine components that can be interpreted and adjusted to the Protected Areas management goals. One of the main features of zoning in coastal areas is that their use must have a social perspective since they are public goods (Rodríguez *et al.*, 2012). There are several methods of zoning of protected areas, including environmental, geoenvironmental, and economic-ecological, but regardless of which one is used, all zoning methods aim for the same result: the delimitation of homogeneous areas (Mcwhinnie *et al.*, 2015). Zoning is undoubtedly the most important process in planning a protected area; it is a key regulatory instrument for the administration

and management of ecosystems (Sabatini *et al.*, 2007; Genelitte & Van Duren, 2008).

There is a growing number of studies on the importance and application of zoning for conservation and management of protected areas. As an example, we have the works of Bezaury & Creel (2005), Portman (2007), Grantham *et al.* (2013), and Li *et al.* (2014). In all these works, it was observed that there are still a low number of environmental zoning studies in countries with tropical coasts. The need to update local data to maintain the preservation of those ecosystems arises due to the ecological importance of protected areas in such regions. The purpose of this study was to develop a case study of the environmental zoning of a protected area located on the semiarid coast of the South Atlantic Ocean (Environmental Protection Area of the Curú River estuary). Furthermore, this information is expected to advance the knowledge of environmental zoning in protected areas and provide useful insights for the monitoring and conservation programs of tropical coastal ecosystems.

2. Materials and methods

2.1. Study site

The coastal zone of Brazil is home to 13 of the 27 state capitals and 16 of the 28 Brazilian metropolitan areas and has about 10,800 km of Atlantic coastline, of which 3480 km is in Northeastern Brazil (Schiavetti *et al.*, 2013). The coastal area of Northeastern Brazil extends from the Bay of St. Mark to the Bay of All Saints and has a wide variety of reef ecosystems and estuaries with mangroves (Leão *et al.*, 2010). Control land use and occupation within the Environmental Protection Areas (EPAs) due to inefficient management, either caused by poorly designed or outdated zoning and management plans, and conflicts in socioeconomic interests remain biggest challenges (Schiavetti *et al.*, 2013; Santos & Schiavetti, 2014; Vila-Nova *et al.*, 2014).

The semiarid coastal area is characterized by shallow estuaries, low freshwater inflow, concentrated rainfall in the first half of the year, long periods of drought, and strong salinization as well as by the presence of dunes, sandy beaches, and coastal reefs (Dias *et al.* 2013). The Curú River estuary is located on the semiarid coast of the state of Ceará in Northeastern Brazil (Figure 1). The protected area analyzed in this study is a Marine

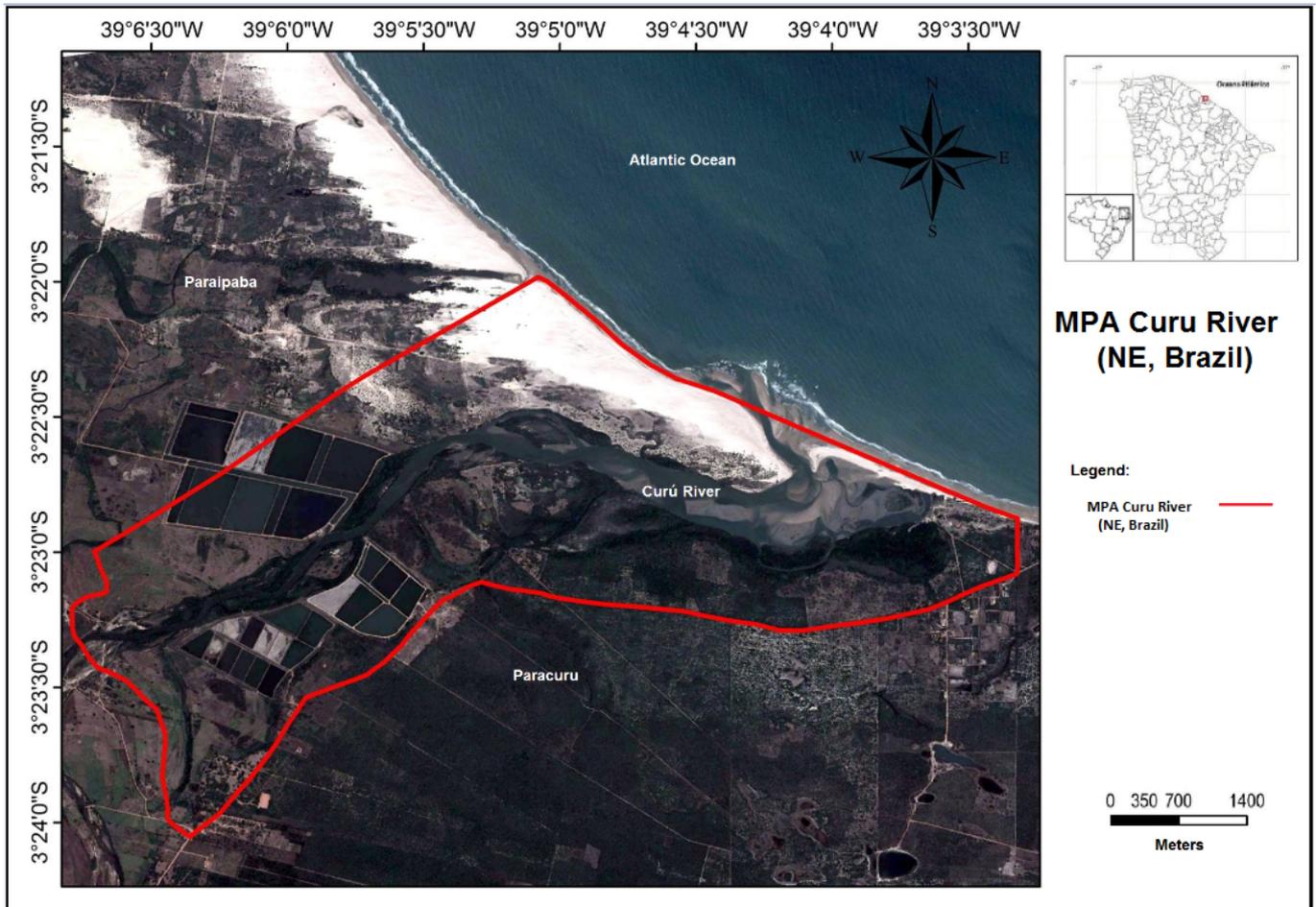


Figure 1 - Marine Protected Area (Environmental Protected Area Curú River).
 Figura 1 - Área Marinha Protegida (Área de Proteção Ambiental do Rio Curú).

Protected Area (MPA), known as the Environmental Protection Area of the Curú River estuary, and has a perimeter of 14,979 km and an area of approximately 8.82 km². Within its limits, there exist traditional communities that survive directly from the use of natural resources (fishing and subsistence agriculture). Some of the major environmental problems found in protected areas are the result of human action such as deforestation, agriculture, fishing, fires, and pollution (Gorayeb *et al.*, 2005). It is important to study this region to understand how to protect tropical semiarid coastal areas from the intense pressure of urbanization, tourism, and the growth of activities in the industrial complexes and main ports (Pecém and Mucuripe) in the nearby cities (Buruaem *et al.*, 2012).

2.2 Methodology

Materials used during this study included: bibliographies, maps, satellite images, articles, books, and government documents relevant to the study area and a geoprocessing tool. The research began with a compilation of data from previous studies of the area (Gorayeb *et al.*, 2005; Neto *et al.*, 2013). This was followed by the processing of data from geoprocessing

activities that were developed through remote sensing image processing (obtained from Google Earth images and Digital Globe 2013) and from the compilation and integration of cartographic material databases. The georeferencing of the satellite data occurred from images of the boundary of the protected area provided by the state entity that manages the protected area (CONPAM). The satellite images allowed the diagnosis of the environmental systems, which refers to the features included in the perimeter of the area.

Additionally, field activities throughout the month of October 2013 were performed and directed by the detailed knowledge of the ecosystems for the identification of the environmental systems. The ecosystems were confirmed and subsequently traced on an image previously georeferenced with a GIS tool, according to recommendations in Santos & Ranieri (2013). The outlines of the receiving units were stained for differentiation and identification only and the sum of the contours of all the environmental systems resulted in a map drawn on a 1:40,000 scale. From the environmental subdivision, zoning of the area for environmental stability/instability was carried out and was defined based on the criteria of environmental

elements proposed by the Ecological Economic Zoning (EEZ) of the Ceará Coast (legal instrument) and the methodological proposal of Bertrand (1969). The EEZ and instability/stability of environmental systems were used for determining the priority of the conservation zones.

3. Results and discussion

3.1 Environmental systems

The environmental systems were identified to develop the management plan within the perimeter of the EPA of the Curú River estuary. Seven environmental systems were identified, mapped, and distributed in three macro-areas marked in the EEZ (Figure 2). The order of predominance of the macro-areas, in ascending order, was highlands with 1.27 km²; followed by marine front with 2.09 km², and then fluvial corridor with 5.46 km² (14.40%, 23.70%, and 61.90%, respectively, of the total EPA area). This demonstrates that the estuary is the main element in the landscape of the protected area.

3.1.1 Fluvial corridor

a) Fluvial-marine plain

Predominantly unoccupied, the fluvial-marine plain has some deforestation points with bare soil stains. In this classification, the area devoted to shrimp farming was

included, given that the area was occupied previously by a plain tidal river (*Supporting Information I-A*).

The tidal river plain corresponds to the estuary itself. Thus, tidal influence over the river channels facilitates the maintenance of permanently flooded areas with organic rich sediments of continental origin and mangrove vegetation development (Giri *et al.*, 2015). Those areas are very unstable, with high vulnerability and sensitivity to occupation and human pressure on natural resources bringing about serious risks for the conservation of such ecosystems (Queiroz *et al.*, 2013; Albuquerque *et al.*, 2014).

Some factors contribute to the degradation and deforestation of mangrove ecosystems, including the diversion of freshwater flows, deterioration of water quality caused by pollutants and nutrients, aquaculture (Queiroz *et al.*, 2013), mining, and salt extraction. The ecological services of mangroves are extremely important for the ecological balance of coastal areas that were once engaged in protection against floods and hurricanes, reduction of shoreline erosion, and maintenance of biodiversity (Moberg & Ronnback, 2003; Tuan Vo *et al.*, 2012). Given the ecological importance and vulnerability of mangroves, there is a clear need for conservation measures for this type of ecosystem. Therefore, these ecosystems are now permanently protected under Brazilian law.

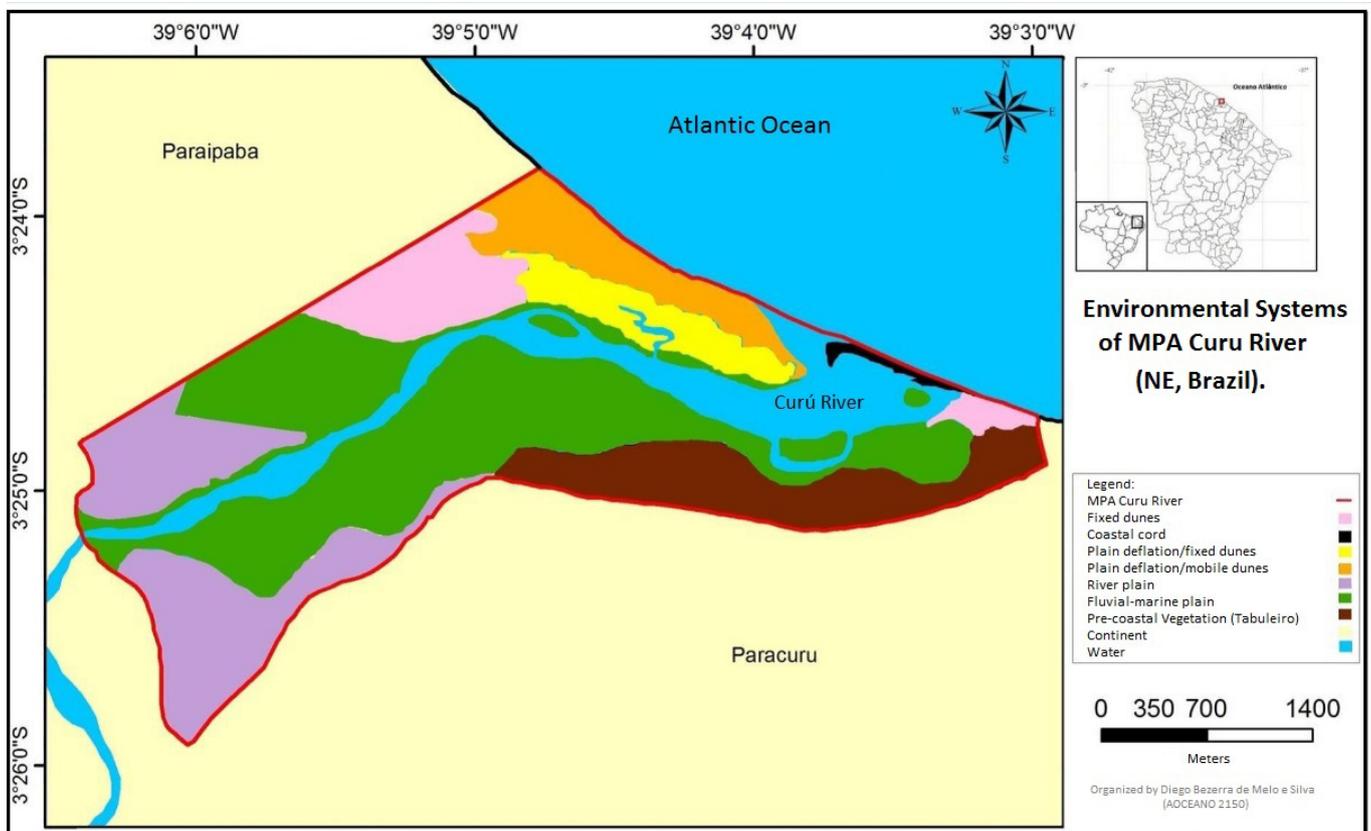


Figure 2 - Environmental Systems (Marine Protected Area Curú River).

Figura 2 - Sistemas Ambientais (Área de Proteção Ambiental do Rio Curú)

b) Fluvial plain

Based on satellite imagery analysis and the EEZ classification criteria, an area was ranked as a fluvial plain when it was not under marine influence. It was possible to identify evidence of a degraded forest with several points of exposed soil stains. Generally, fluvial plain areas have curves of meanders, oxbow lakes, shortcuts, and disruption deposit dikes. However, it was not possible to map those features at the chosen scale. Because the fluvial plain of the Curú River is narrow and extends up to 30 km from the mouth, it is prone to seasonal flooding (overflowing river channel) and is an unstable system with poor support for buildings. Such environmental systems provide relevant ecological contribution to coastal communities and provide surface water reserves for irrigated agriculture in periods of drought and water for livestock and human consumption. In addition, these types of systems present appropriate conditions for recreation and ecotourism. The disposal of contaminants, such as solid waste and other wastes, reinforces the need for protection and remediation measures for the conservation and proper use of these natural resources (Gorayeb *et al.*, 2005; Neto *et al.*, 2013).

3.1.2 Highlands - Pre-coastal vegetation

Even though the highlands were carved by waterways in the distant past, in recent times they do not get flooded, not even by major storm events. Within this classification, it was possible to identify the pre-coastal tray by bare soil regions, suggesting a forest degradation. There is also evidence of occupation in some areas of the board (livestock and subsistence agriculture, such as sugar cane plantations). Such environmental systems are formed by sediment barriers with vegetation represented by a semi-deciduous vegetation board which is a heavily degraded system (*Supporting Information I-B*).

In terms of human carrying capacity, the pre-coastal vegetation area is the most viable for use and occupation within the EPA, as long as the topography is planned with bands of coalescing alluvial fans, is quite bumpy, and has more stable ground because of a low potential for causing mass movements. Moreover, the pre-coastal vegetation area, cut by the Curú River, creates considerable possibilities for agricultural use, therefore enhancing and protecting the vegetation of the estuarine complex (mangrove and salt marsh ecosystems).

3.1.3 Marine front

a) Fixed coastal dunes

A small area of the EPA, approximately 0.78 km², is composed of only fixed dunes. The dunes, fixed by

vegetation, appear isolated from other environmental systems. In the fixed dune feature limit, evidence of marine influence (the appearance of a marine fluvial plain with salt flats of vegetation) at the dune foot was observed (*Supporting Information I-C*).

In Brazil, the dunes (whether mobile or fixed) are protected by law, because of their ecological importance and their special features in semiarid areas. Fixed coastal dunes contain vegetation on sandy quartz sediments with special adaptations to specific environmental conditions (salt water, temperature, and dynamic winds) and have been gaining worldwide recognition for their scientific importance (Tsoar *et al.*, 2009 ; Levin *et al.*, 2014).

b) Deflation plain/mobile dunes

The EPA contains two environmental systems (deflation plain and mobile dunes) with different spatial proportions that were not differentiated during the mapping due to scale and geomorphological identification limitations. Nevertheless, there was an advance in knowledge concerning this unit compared to existing literature, especially when compared to surveys of the environmental systems by Neto *et al.* (2013) for the region; this area was defined as a deflation plain, as it was in the EEZ.

Deflation plains are flat or gently sloped surfaces that are found between the maximum tide and the base of the dunes, which usually migrate toward the mainland system (*Supporting Information I-D*). The deflation plains are of great importance for the remobilization and removal of sediment, generating residual accumulation of sediment features and terraces carved by the wind (Farrell *et al.*, 2012; Yan & Baas, 2015). Brazil is covered by various ecosystems, including beaches, deflation plains, and dunes, which are a complex endowed with natural features, interdependent and interconnected. However, the current federal environmental legislation of Brazil does not distinguishing the different types of dunes. Federal Law N° 12.651-2012 (Código Florestal) states that any fixed dune is a feature separated from the others, thus recognizing fixed dunes as Permanent Preservation Areas (PPA). However, excluding the other already mentioned features (such the Deflation plain) of the dune ecosystem (Pinheiro *et al.*, 2013).

The dunes have significant ecological value because they contribute to the recharge of the groundwater aquifer and provide a substrate for vegetation and habitat for various animal species. Despite their ecological importance, coastal dune systems are among the most threatened ecosystems in the world, and thereby require conservation efforts and measures to preserve them (Muñoz Vallés & Cambrollé, 2014).

c) Deflation plain/fixed coastal dunes

Although a deflation plain is more likely to be found near the foreshore, specifically in the defined area described in the previous section, fieldwork showed that deflation plains were found near the fixed dunes.

The dunes evaluated in the study area had irregular shapes and were partially or totally obscured by short vegetation. This description suggests that they fall in the hammock classification. In addition, residual features of sediment accumulation were identified around the bushes, so-called rebdous that is characteristic of a deflation plain. In this section of the deflation plain, the presence of features related to wind-preferred corridors (blow-outs) (Farrell *et al.*, 2012) were confirmed as being common in vegetated dunes due to the possibility of the stable and unstable morphologies coexisting (*Supporting Information I-E*).

d) Spit

A sandspit (coastal cord) represents the smallest environmental system in the EPA of the Curú River estuary. The barrier spit was identified as a coastal cord because of its elongated sandy feature and the fact that it had been found parallel to the coastline and fused to the mainland at one end (*Supporting Information I-F*).

Concern regarding the interactions of fluvial-wind sediments at various temporal and spatial scales is growing (Han *et al.*, 2006). Analyzing satellite images of the study area revealed an increase in the EPA spit of the Curú River estuary over the last 10 years. The coastal cord had increased in length unidirectionally, causing a change in its shape and size.

Those spits are subject to constant morphological changes due to fluvial processes and strong coastal and marine dynamics. In most cases, these dynamics arise either from the inundation of the shoreline by the rising sea level or because of river dams and your consequences (reduction of river flow) (Diena *et al.* 2011). In general, they possess environmental instability, similar to dune environments, because of unconsolidated sandy sediments that can be easily reworked and removed by the action of river water, ocean tides and even the wind itself. However, spits are ecologically important as they act as a substrate for the fixation of mangrove vegetation and are connected to tidal river plains. Thus, they protect the integrity of fragile internal areas as well as provide potential scenic beauty (Otvos, 2000).

3.2 Environmental zoning

The environmental zoning of the protected area was possible after the identified environmental systems were established. The conservation priority areas were

distributed as the areas planned for eventual use according to the EEZ and such were described as the following : Special Protection Zone (PZ2); Priority Conservation Zone (CZ1); Special Conservation Zone (CZ2), and Permanent Preservation Area/Zone (PPA or PPZ) (Figure 3 and *Supporting Information II*).

A deflation plain is an area that is found easily in other regions; however, once intensive occupation occurs it may face severe impacts. Therefore, a deflation plain should be in the CZ1 because land occupation is discouraged and activities that are compatible with the capacity of the area are recommended in the CZ1. Nevertheless, there are strong environmental concerns regarding the use and occupation of deflation plains because they are usually associated with dunes, which are in Permanent Protection Areas/Zones (PPA/Z), and thus, protected by Brazilian law.

Both fixed and mobile dunes are protected by Brazilian law and fall under the PPA because of their environmental instability and high susceptibility to negative impacts (such as pollution of soil and water resources). This work was not able to differentiate the dune areas in relation to the deflation plain areas. Research on this in the future is important, especially for environmental licensing purposes within the EPA area. Since the sandspit has similar characteristics as the dunes, it also was classified as a PPA.

The tidal river plain containing mangroves was classified as a PPA as well, due to its particular characteristics that make environmental education and awareness so conveniently recommended. Those areas rich with high ecological potential, biodiversity and production of organic matter and are considerably endangered because of its own fragility, instability, and susceptibility. Moreover, current negative environmental impacts implying extra concerns over the following matters: management and environmental preservation, recovery of degraded parts, and controlled use of resources along those areas.

The fluvial plain is a rare area without much intensive occupation, but even so, it is subject to severe impacts when occupied inappropriately. Therefore, it should be put in the PZ2, which has high standards for the protection and regulation of the land use and occupation since fishing activities are recommended.

The pre-coastal board has the greatest relative environmental stability and, thereby the greatest ability to support human activities. It should be put in the CZ2, where the application of conservation and recovery measures and attempts to reduce the negative impacts are employed.

Day *et al.* (2008) presented a zoning model based on the importance of biodiversity maintenance, ecological health, and ecosystem productivity, which divided the

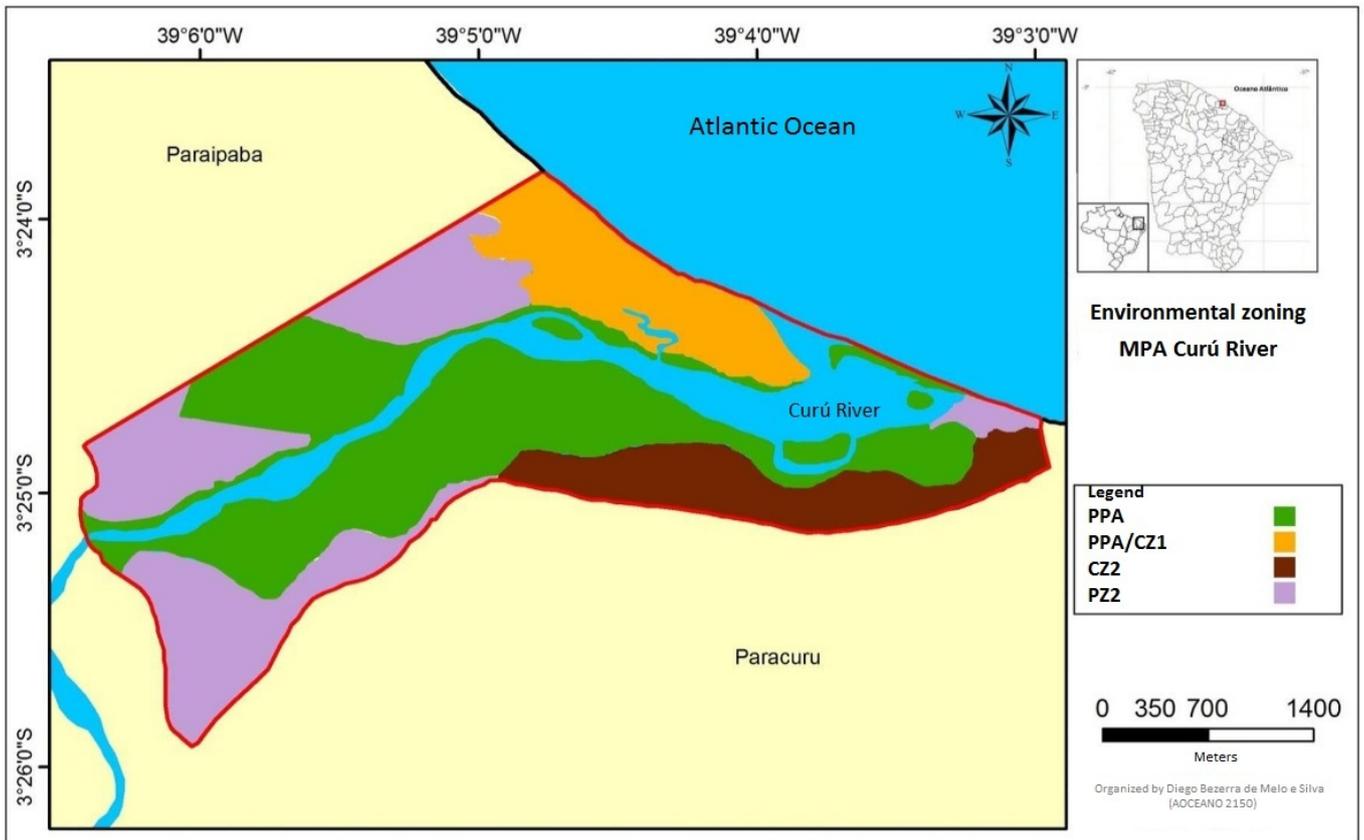


Figure 3 - Environmental Zoning (MPA Curú River).

Figura 3 - Zoneamento Ambiental (Área de Proteção Ambiental do Rio Curú).

areas into four zones. The first zone was ER1, which had the greatest habitat and marine species diversity for both coastal and estuarine environments. The second was the ER2, which had high diversity of habitat and coastal and estuarine marine species. The third was the ER3, which had moderate diversity of coastal and estuarine marine species. The last one was the ER4 zone, which did not have sufficient scientific data yet to classify it.

Genelitte & van Duren (2008) created protected area zones in the Paneveggio Pale di San Martino Natural Park (PPSM), located in the Trentino region of Italy. In their study, the park was divided into three zones. The first one was the A Zone (Integral Reserve), designed to ensure full protection of the environment and ecosystems and minimize the presence or disturbance caused by human activities.

The second one was the B Zone (Guided Reserve) where the cultural, historical, and scenic heritage was protected by restricting the land use to only traditional activities that are not considered harmful to the environment. The third, and last, zone was the C Zone (Controlled Reserve) which aimed to minimize disturbance to the environment as much as possible, but encouraged recreational use and the development of an infrastructure for tourists' facilities.

4. Conclusions

This paper describes the environmental systems of a protected area located on the semiarid coast of Northeastern Brazil and proposes zoning with technical and legal value for conservation purposes. Analysis of remote sensing data, together with fieldwork, seems to be the easiest and most economical way to develop management plans for protected areas on tropical coasts.

Suggested system implementation and periodic update every five years are recommended to, respectively, complete and refine the ecological zoning applied to the protected area analyzed in this article. It would be interesting to develop further the environmental assessment and the determination of vulnerability and support capacity, as well as the details of the dune areas (fixed and mobile) in order to distinguish the deflation plains in semiarid coasts.

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Appendix

Supporting Information associated with this article is available online at http://www.aprh.pt/rgci/pdf/rgci-603_Rego_Supporting-Information.pdf

References

- Agostini, V.N.; Margles, S.W.; Knowles, J.K.; Schill, S.R.; Bovino, R.J.; Blyther, R.J. (2015) – Marine zoning in St. Kitts and Nevis: A design for sustainable management in the Caribbean. *Ocean & Coastal Management*, 104:1-10. DOI: 10.1016/j.ocecoaman.2014.11.003.
- Albuquerque, A.G.B.M.; Ferreira, T.O.; Cabral, R.L.; Nobrega, G.N.; Romero, R.E.; Meireles, A.J.A.; Otero, X.L. (2014) - Hypersaline tidal flats (apicum ecosystems): the weak link in the tropical wetlands chain. *Environmental Research*, 22:99-109. DOI: 10.1139/er-2013-0026
- Beeharry, Y.; Makoondlall-Chadee, T.; Bokhoree, C. (2014) - Policy Analysis for Performance Assessment of Integrated Coastal Zone Management Initiatives for Coastal Sustainability. *APCBEE Procedia*, 9:30–35. DOI: 10.1016/j.apcbee.2014.01.006
- Bertrand, G. (1969) - Paisagem e Geografia Física global: esboço metodológico. *Caderno de Ciências da Terra*, 13:1-21.
- Bezaury-Creel, J.E. (2005) - Protected areas and coastal and ocean management in México. *Ocean & Coastal Management*, 48(11–12):1016–1046. DOI: 10.1016/j.ocecoaman.2005.03.004
- Buruaem, L.M.; Hortellani, M.A.; Sarkis, J.E.; Costa-Lotufo, L.V.; Abessa, D.M.S. (2012) - Contamination of port zone sediments by metals from Large Marine Ecosystems of Brazil. *Marine Pollution Bulletin*, 64:479-488. DOI: 10.1016/j.marpolbul.2012.01.017.
- Day, V.; Paxinos, R.; Emmett, J.; Wright, A.; Goecker, M. (2008) - The Marine Planning Framework for South Australia: A new ecosystem-based zoning policy for marine management. *Marine Policy*, 32(4):535–543. DOI: 10.1016/j.marpol.2007.10.009
- Dias, F.J.S.; Castro, B.M.; Lacerda, L.D. (2013) - Continental shelf water masses off the Jaguaribe River (4S), northeastern Brazil. *Continental Shelf Research*, 66:123-135. DOI: 10.1016/j.geomorph.2006.10.010
- Estima, D.C.; Ventura, M.A.M.; Rabinovici, A.; Martins, M.C.P.F. (2014) – Concession in tourism services and partnerships in the Marine National Park of Fernando de Noronha, Brazil. *Journal of Integrated Coastal Zone Management*, 14(2):215-232. DOI: <http://dx.doi.org/10.5894/rgci469>.
- Farrell, E.J.; Sherman, D.J.; Ellis, J.T.; Li, B. (2012) – Vertical distribution of grain size for wind blown sand. *Aeolian Research*, 7:51-61. DOI: 10.1016/j.aeolia.2012.03.003.
- Geneletti, D.; Van Duren, I. (2008) - Protected area zoning for conservation and use: A combination of spatial multicriteria and multiobjective evaluation. *Landscape and Urban Planning*, 85(2):97–110. DOI: 10.1016/j.landurbplan.2007.10.004.
- Giri, C.; Ochieng, E.; Tieszen, L.L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N. (2010) - Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology Biogeography*, 584:1-6. DOI: 10.1111/j.1466-8238.2010.00584.x. P1-6.
- Gorayeb, A.; Souza, M.J.N.; Figueiredo, M.C.B.; Araújo, L.F.P.; Rosa, M.F.; Silva, E.V. (2005) - Aspectos geoambientais, condições de uso e ocupação do solo e níveis de desmatamento na bacia hidrográfica do rio Curú, Ceará-Brasil. *Geografia*, 14(2):85-106. Available on-line at: <http://www.uel.br/revistas/uel/index.php/geografia/article/view/6688>
- Grantham, H.S.; Agostini, V.N.; Wilson, J.; Mangubha, S.; Hidayat, N.; Muljadi, A.; Muhajir; Rotinsulu, C.; Mongdong, M.; Beck, M.W.; Possingham, H.P. (2013) - A comparison of zoning analyses to inform the planning of a marine protected area network in Raja Ampat, Indonesia. *Marine Policy*, 38:184–194. DOI: 10.1016/j.marpol.2012.05.035
- Han, G.; Zhang, G.; Dong, Y. (2006) - A model for the active origin and development of source-bordering dunefields on a semiarid fluvial plain: A case study from the Xiliaohe Plain, Northeast China. *Geomorphology*, 86:512-524. DOI: 10.1016/j.geomorph.2006.10.010.
- Leão, Z.M.A.N.; Kikuchi, R.K.P.; Oliveira, M.D.M.; Soares, V.V. (2010) - Status of Eastern Brazilian Coral Reefs in Time of Climate Changes. *Pan-American Journal of Aquatic Sciences*, 5:52-63. Available on-line at: [http://www.panamjas.org/pdf_artigos/PANAMJAS_5\(2\)_224-235.pdf](http://www.panamjas.org/pdf_artigos/PANAMJAS_5(2)_224-235.pdf)
- Levin, N.; Neil, D.; Syktus, J. (2014) - Spatial variability of dune form on Moreton Island, Australia, and its correspondence with wind regime derived from observing stations and reanalyses. *Aeolian Research*, 15:289-300. DOI: 10.1016/j.aeolia.2014.06.006.
- Li, F.; Xu, M.; Liu, Q.; Wang, Z.; Xu, W. (2014) - Ecological restoration zoning for a marine protected area: A case study of Haizhouwan National Marine Park, China. *Ocean & Coastal Management*, 9:158–166. DOI: 10.1016/j.ocecoaman.2014.06.013.
- McWhinnie, L.; Briers, R.A.; Fernandes, T.F. (2015) – The development and testing of a multiple-use zoning scheme for Scottish waters. *Ocean & Coastal Management*, 103:34-41. DOI: 10.1016/j.ocecoaman.2014.11.004
- Moberg, F.; Rönnbäck, P. (2003) - Ecosystem services of the tropical seascape: interactions, substitutions and restoration. *Ocean & Coastal Management*, 46:27–46. DOI: 10.1016/S0964-5691(02)00119-9.
- Mora, C.; Sale, P.F. (2011) – Ongoing global biodiversity loss and need to move beyond protected areas: a review of the technical and practical shortcomings of protected areas on land and sea. *Marine Ecology Progress Series*, 434:251-266. DOI: 10.3354/meps09214.
- Muñoz-Vallés, S.; Cambrollé, J. (2014) - Successes and failures in the management of coastal dunes of SW Spain: Status analysis nine years after management decisions. *Ecological Engineering*, 71:415-425. DOI: 10.1016/j.ecoleng.2014.07.042.
- Neto, F.O.L.; Gorayeb, A.; Silva, E.V.; Rabelo, F.D.B. (2005) - Diagnóstico ambiental e zoneamento funcional do estuário do rio Curú: subsídios para a gestão local e regional. *Revista Eletrônica Geoaraguaia*, 3:97-113. Available on-line at: <https://www.google.com.br/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&ved=0CCoQFJA-A&url=http%3A%2F%2Fdiadnet.unirioja.es%2Fdescarga%2Farticulo%2F4340792.pdf&ei=2q-PUj6CAoy7kQemzIGQAg&usq=AFQjCNGpVVGAcamoH26A-X7WMBG7XgQ4mQ&sig2=1bQ-Vn9v7EaV22vG-cJlw&bvwm=bv.56988011.d.eW0>
- Otvos, E.G. (2000) - Beach ridges—definitions and significance. *Geomorphology*, 32:83-108. DOI: 10.1016/S0169-555X(99)00075-6.
- Pinheiro, M.V.A.; Moura-Fé, M.M.; Freitas, E.M.N. (2013) – The Dune Ecosystems and the Brazilian Environmental Legislation. *GeoUERJ*, 2(24):1-24. DOI: <http://dx.doi.org/10.12957/geouerj.2013.5546>.
- Portman, M.E (2007) - Zoning design for cross-border marine protected areas: The Red Sea Marine Peace Park case study. *Ocean & Coastal Management*, 50(7):499–522. DOI: 10.1016/j.ocecoaman.2007.02.008
- Queiroz, L.; Rossi, S.; Meireles, A.J.A.; Coelho, C. (2013) - Shrimp aquaculture in the federal state of Ceará, 1970–2012: Trends after mangrove forest privatization in Brazil. *Ocean & Coastal Management*, 73:54-62. DOI: 10.1016/j.ocecoaman.2012.11.009.
- Rodríguez, A.L.; Lozano-Rivera, L.; Sierra-Correa, P.C. (2012) - Criterios de zonificación ambiental usando técnicas participativas y de información: estudio de caso zona costera del departamento Del atlántico. *Boletín de Investigaciones Marinas y Costeras*,

- 41(1):61-83. Available on-line at <http://www.scielo.org.co/pdf/mar/v41n1/v41n1a04.pdf>
- Sabatini, M.C.; Verdiell, A.; Iglesias, R.M.R.; Vidal, M. (2007) - A quantitative method for zoning of protected areas and its spatial ecological implications. *Journal of Environmental Management*, 83(2):198–206. DOI: 10.1016/j.jenvman.2006.02.005
- Samaras, A.G.; Koutitas, C.G. (2014) - The impact of watershed management on coastal morphology: A case study using an integrated approach and numerical modeling. *Geomorphology*, 211:52-63. DOI: 10.1016/j.geomorph.2013.12.029
- Santos, M.R.R.; Ranieri, V.E.L. (2013) - Criteria for analyzing environmental zoning as an instrument in land use and spatial planning. *Ambiente & Sociedade*, 16(4):43-62. Available on-line at http://www.scielo.br/pdf/asoc/v16n4/en_04.pdf
- Santos, C.V., Schiavetti, A (2014) – Spatial analysis of Protected Areas of the coastal/marine environment of Brazil. *Journal of Nature Conservation*, 22(5):453-461. DOI: 10.1016/j.jnc.2014.05.001
- Schiavetti, A.; Manz, J.; Santos, C.Z.; Magro, T.C.; Pagani, M.I. (2013) – Marine Protected Areas in Brazil: An ecological approach regarding the large marine ecosystems. *Ocean & Coastal Management*, 76:96-104. DOI: 10.1016/j.ocecoaman.2013.02.003
- Tsoar, H.; Levin, N.; Porat, N.; Maia, L.P.; Herrmann, H.J.; Tatumi, S.H.; Claudino-Sales, V. (2009) - The effect of climate change on the mobility and stability of coastal sand dunes in Ceará State (NE Brazil). *Quaternary Research*, 71(2):217-226. DOI: 10.1016/j.yqres.2008.12.001
- Tuan Vo, Q.; Kuenzer, C.; Minh Vo, Q.; Moder, F.; Oppelt, N. (2012) – Review of valuation methods for mangrove ecosystem services. *Ecological Indicator*, 23:431-446. DOI: 10.1016/j.ecolind.2012.04.022
- Vila-Nova, D.A.; Ferreira, C.E.L.; Barbosa, F.B.; Floeter, S.R. (2014) - Reef fish hotspots as surrogates for marine conservation in the Brazilian coast. *Ocean & Coastal Management*, 102:88-93. DOI: 10.1016/j.ocecoaman.2014.09.005
- Yan, N.; Baas, A.C.W. (2015) – Parabolic dunes and their transformations under environmental and climatic changes: towards a conceptual framework for understanding and prediction. *Global and Planetary Change*, 124:123-148. DOI: 10.1016/j.gloplacha.2014.11.010.

Exploring the Challenges of Implementing Integrated Coastal Management and Achieving Sustainability within the Cameroon Coastline^{*}

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ABSTRACT

Integrated coastal management (ICM) has been accepted as a strategic management approach in achieving sustainable development in coastal areas. As such, many coastal nations, both from the developed and less developed countries have surmounted many challenges of the coastal milieu with a successful implementation of ICM and now enjoy a sound environment and a viable economy. However, a country like Cameroon with a coastline of about 402km still faces a lot of challenges in implementing ICM. According to Article 55 *et seq* of the Constitution, which lays down the general guidelines in matter of decentralization in Cameroon, the State is supposed to devolve upon regional and local authorities, under conditions laid down by law, powers over matters essential to their economic, social, health, educational, cultural and sports development. In reality, devolution of power still remains a nightmare, stifling sustainable coastal development. This paper, therefore, addresses the challenges faced by the State of Cameroon in implementing ICM. The work identifies predicaments/gaps in environmental planning and also makes relevant recommendations in bridging such gaps. In order to attend a desirable degree of sustainability within Cameroon's coastline, real implementation of ICM can only be achieved if sectoral lines are effectively minimized through the enforcement of the decentralization process.

Keywords: Integrated Coastal Management, Sustainable development, Decentralization, Capacity building

RESUMO[§]

Explorando os desafios da implementação de Gestão Costeira Integrada e alcançando a sustentabilidade no litoral dos Camarões

A gestão integrada do litoral (ICM) tem sido aceite como uma de gestão estratégica para alcançar o desenvolvimento sustentável nas zonas costeiras. Como tal, muitas nações ribeirinhas, tanto de países desenvolvidos como menos desenvolvidos, têm superado muitos desafios existentes nos ambientes costeiros através de uma implementação bem sucedida de ICM e desfrutando agora de um ambiente saudável e uma economia viável. No entanto, um país como a República dos Camarões com

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um litoral de cerca de 402 quilómetros, ainda enfrenta uma série de desafios na implementação do ICM. De acordo com o artigo 55 e seguintes da Constituição, que estabelece as directrizes gerais em matéria de descentralização nos Camarões, o Estado deve dotar as autoridades regionais e locais, nas condições estabelecidas por lei, de poderes sobre assuntos essenciais para o desenvolvimento económico, social, de saúde, educacional, cultural e desportivo. Na realidade, a atribuição destes poderes continua ainda a ser um pesadelo, asfixiando o desenvolvimento costeiro sustentável. Este artigo aborda os desafios enfrentados pelo Estado dos Camarões na execução ICM. O trabalho identifica impasses / lacunas no planeamento ambiental e faz também recomendações pertinentes no sentido de colmatar essas lacunas. Para atingir um grau desejável de sustentabilidade na costa dos Camarões, a implementação da ICM só pode ser alcançada se as linhas sectoriais forem efectivamente minimizadas através da aplicação de processos de descentralização.

Palavras-chave: *Gestão Costeira Integrada, Desenvolvimento Sustentável, Descentralização, Criação de Capacidades*

1. Introduction

The coastal zone of any nation is one of its most valued and contentious areas of real estate, commercial and expanse for industrial development (McKenna *et al.*, 2008). The coastal zone has the greatest aggregation of environmental resource and a physical system in comparison to any other types of bio-geographic units in the world (Sorensen, 2002). Approximately 50% of the world's population lives within 150 kilometers of a coastline (Ngoran, 2014; Ngoran *et al.*, 2015). In the face of mounting pressures, more is needed to build a truly sustainable way of life in the coastal zone. This requires the integration of action in three key areas: economic growth and equity; conserving natural resources and the environment; and social development. Therefore, sustainability interfaces with economics through the social and ecological consequences of economic activity. Sustainable development as defined in important international conferences and by numerous authors is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Ngoran & Xue, 2015; Mebratu, 1998; Van Marrewijk, 2003). It calls for the improvement of the quality of life for the world's population without increasing the use of natural resources beyond the earth's carrying capacity. Based on this definition and numerous studies around the world, the achievement of sustainable development still faces numerous challenges. This is either because of the difficulties inherent to applying sustainable development principles or the misunderstanding and/or misapplication, especially in developing countries.

The coast of Cameroon (figure 1) is of immense biogeochemical and socio-cultural and economic significance. However, unsustainable utilization, poor management and the negative impacts of climate change pose serious challenges to sustainable development. In particular, major resources (mangroves and fisheries) and major socioeconomic activity (Fishing) are directly threatened (Ngoran *et al.*, 2015). The latter is further complicated by the rapid rate of urbanization and a complex politico-administrative setup which is a major source of tension within the coastal milieu and a major

Challenge to sustainable development. As a direct result of these diverse pressures, the physical, chemical, biological and general health of the coastal ecosystem has been negatively affected and the integrity of the ecosystem is seriously endangered. Directly and indirectly, these pressures have significant negative social and economic impacts on the economy of Cameroon. This is due to the fact that Cameroon coastal cities serve as the economic power-house. With continuous degradation of the natural system on the Cameroon coastline, down-warping economy, poverty in all its facets is bound to increase and thus necessitating urgent attention and effective solutions.

In order to curtail the above raised coastal challenges as orchestrated by anthropogenic activities, a multiplicity of different management strategies has been advanced. These management lines include; ecosystem based management which lays more emphasis on transfrontier issues rather than administrative boundaries (Christie *et al.*, 2009; Boesch, 2006; Curtin, 2010), marine spatial planning that is geared at resolving sea use conflict by analyzing and assigning compatible human activities in geo-reference maritime locations (Curtin & Pallezo, 2010; Calado, 2010), marine protected areas; an approach which involves the restriction of human interference within demarcated portion(s) of the sea/ocean in order to protect such designated environments (Pollnac *et al.*, 2001; McClanahan *et al.*, 2006), and functional zoning among others. Despite the multiplicity of coastal management approaches, proponents of sustainable coastal management hold integrated coastal management (ICM) at a very high esteem; reason being that, it looks at the triangular relationship between the environment, the economy and the society (Chua *et al.*, 1992; Xue *et al.*, 2006). The core of this study is therefore to examine the challenges of implementing ICM and how this stifles the attainment of sustainable coastal development in Cameroon.

The rest of the paper is structured as follows; section 2 looks at the methodology and section 3 the study area. Section 4 addresses the coastal challenges, 5 section tallies on the discussion part whereas section 6 draws a logical conclusion.

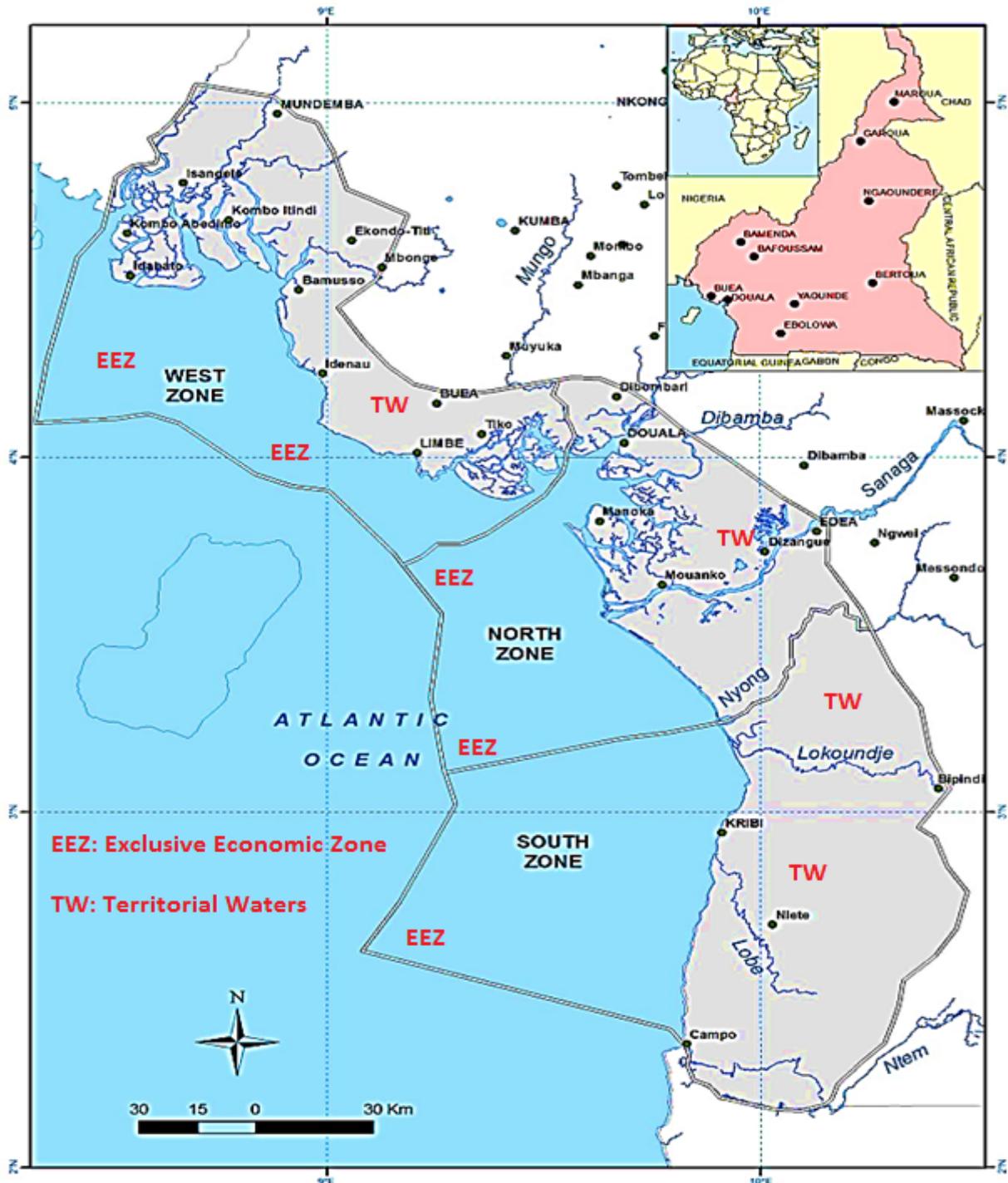


Figure 1 - Location of study area
 Figura 1 – Localização da área de estudo

2. Methodology

Existing literature was retrieved from various ministerial departments dealing directly or indirectly with the coastal stretch. The related texts handling concerns of decentralization were obtained from various government ministries.

Data on mangrove status were made available by Ministry of Environment and Nature Protection and Ministry of Forestry and Wildlife in Cameroon. Moreover,

monographs from different ministerial departments were carefully analyzed in order to establish the gaps in management as a result of the sectoral approach. Annuals from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Deutscher Entwicklungsdienst (DED), the Douala Rural and Urban councils and the Cameroon's Poverty Reduction Strategy Paper were other important sources of information. Existing scientific literature on ICM from the Xiamen University Library was also of paramount importance to this study.

3. Overview of Coastal Issues in Cameroon

3.1. Socioeconomic Setbacks

3.1.1. Urbanization and Industrialization challenges

The coastline of Cameroon being the industrial hub harbors more than 70 percent of the country's industry (Ndjama *et al.*, 2008). Additionally, the most fertile soils are located within the country's coastal milieu. The presence of industries and fertile soils along the coastal stretch serves as a pull factor not only to the hinterland population of Cameroon but also to the population from neighboring countries such as Nigeria, Chad, Gabon, Central Africa Republic, Equatorial Guinea and Congo. Unfortunately, the coastal cities of Cameroon (Douala, Kribi, Limbe and Tiko) face the challenge of accommodating this increasing population as well as catering for their employment needs. The result has been a surge in unemployment rates as well as sprawling habitats. Sprawl and weak socioeconomic status of the population has significant ramifications on coastal resources ranging from poor waste disposal to wanton cutting of mangrove (Figure 2 and 3).



Figure 2 - Poor waste disposal in Quartier Etage Bonaberi, Douala.

Figura 2 – Depósito de lixo em Quartier Etage Bonaberi, Douala.

The concentration of industries along the coast also presents a lot of challenges. Over 80 percent of Cameroon's industry is located in Douala, which is the economic capital of the country. Most of these industries are in their infancy and therefore discharge unwanted material to the immediate environment that ends up polluting the coastal milieu. The occasional occurrence of oil spills from the Société Nationale de Raffinage



Figure 3 - Wanton cutting of mangrove for commercial purposes.

Figura 3 - Corte não controlado de manguezal para fins comerciais.

(SoNaRa), Limbe petroleum plant (located in Cape Limbo) and the Chad – Cameroon pipeline in Kribi, severely impact marine life (Eyebe *et al.*, 2012). Added to oil spills, is the problem of unregulated ballast water discharge which is gradually gaining grounds. Ballast water has the potential of altering micro-ecological habitat in coastal settings, thereby giving room to the propagation of invasive species that can cause considerable economic and environmental impacts (Carlton & Geller, 1993). Fertilizers and chemicals leached from the plantations (cocoa, banana, tea, rubber and palm), have led to increasing eutrophication.

Moreover, the extraction of sand for the building of houses in the coastal zone is on a rise. This activity is mostly carried by the locals without taking into consideration the low topography of the coast. The resultant effect has been seawater intrusion, recurrence of landslides and flooding (Figure 4).

Urbanization and industrialization in reality do not present a potential threat to the implementation of ICM. However, urbanization and industrialization processes that are not well circumscribed by sustainable policies, well formulated and implementable laws are bound to bash ICM implementation into failure. Therefore, it is necessary that decision makers, scientists and other intervening stakeholders in Cameroon should endeavour to understand the multi-facet problems of unregulated urbanization and industrialization both in short and long term in order to ensure a successful ICM implementation.

3.1.2. Overfishing

Fishery resources contribute significantly to the development of many coastal nations. The fishery sector em-



Figure 4 - Sand Mining Boanassama Beach, Douala

Figura 4 – Exploração de areia em Boanassama Beach, Douala

employs over 41 million people worldwide, most of whom are from the developing states (Figure 5). Fish also constitutes an important source of protein, especially for the poor (Finegold, 2009). Unfortunately, the over-exploitation of fishery resources and the use of destructive fishing practices have resulted to a precarity in fish availability. A study conducted by Srinivasan *et al.* (2012) pointed out that Europe and North America are largely the cuprites of fallen fish stocks due to rapid industrialization and early over-exploitation. The latter coupled with population growth in Asia and fast technological change present a bleak future in the availability of fishery stocks. Concerns are also on declining stocks in the Atlantic coast of Cameroon due to foreign overfishing. Additionally, the challenges of fisheries management and poor coastal development in Cameroon are numerous and complex. However, the most common problems are largely attributed to a sectoral and centralized system of governance, little or no collaboration between the management sectors, gaps in the fisheries legislation, scientific research and insufficient expertise in the fisheries (Ndah, 2011)

Dwindling fish stocks on the coast of Cameroon further exacerbate poverty among the fishing communities most of whom are involved in artisanal fishing with very conservative ideas. Advocates of ICM will therefore need to address the challenges linked to the livelihood sustenance of these fishing communities, let alone the gaps in the system of governance.

3.1.3. Ethnic setbacks

The population in Cameroon is highly heterogeneous, comprising approximately 250 ethnic groups. Cameroon grass-fielders constitute the majority at 38 percent of the total population (the Bamoun and the Bamileke). The coastal tropical forest peoples, including the

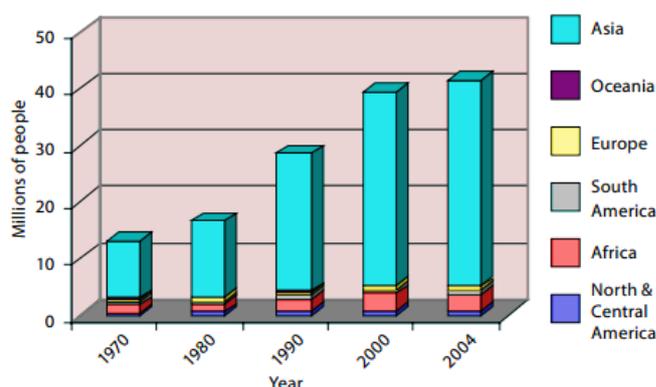


Figure 5 - Employment in fisheries and aquaculture. Source: Finegold, 2009

Figura 5 - Emprego na pesca e da aquicultura. Fonte: Finegold, 2009

Douala, Bassa, and many smaller entities account for about 12 percent of the population. In the southern rain-forest, ethnic groups include the Ewondo, Bulu, and Fang and the Maka and Pygmies and account about 18% of the population. The Fulani account for about 14% of the population and the Kirdi account for about 18 percent*. The country's ethnic and linguistic diversity is highly projected by politicians as developmental assets. Interviews granted at the ministry of culture indicated diverse ethnicity presents draw backs to development, especially in the domain of power sharing. Easterly & Levine (1997) point out that ethnic diversity can potentially breakdown the economy of a country when different fractions of country feel relegated to the background or largely dominated by a particular tribe. Abbot et al (2001) pinpoint that, attitude and behaviour are key pillars of ethnicity that act as a fridge to development. Therefore, for sustainable coastal management

* <http://www.encyclopedia.com/topic/Cameroon.aspx>

plan in Cameroon, there is need to address ethnic diversity.

3.1.4. Stakeholder participation

Achieving integrated management along the dimensions proposed by ICM is perhaps the most difficult challenge in managing oceans and coastal environment in Cameroon. Bringing together and harmonizing the perspectives of conflicting sectoral government agencies, of different levels of government (each with its own interests, mandates, and perspectives), and of different disciplines (each with different language, outlooks, and methodologies) characterizes the most challenging set of tasks. To achieve integrated management, it is very important to have incentives that promote continued collaboration among ICM entities (Cicin-Sain *et al.* 1998). Unfortunately, such incentives are nowhere near reality on the coast of Cameroon. Equally important is to offer training and education programs which underscore the interrelationships among coastal and ocean activities, uses, natural systems, and physical processes, and which develop the correct mindsets and skills that coastal managers/decision makers will need in their work (Cicin-Sain *et al.*, 1998). Again, the latter is effectuated on a negligible scale in Cameroon. As Hildebrand (2002) vividly puts it, Water-salty or fresh - is not glue that can join all the stakeholders that have a vested interest in coastal resources and environments. It will

always be a challenge to find common ground between stakeholders with vested interests in the non-sustainable development and exploitation sectors (*e.g.*, oil and gas, ports, intensive tourism, mariculture, large-scale commercial fisheries, and hazard-protection works) and pro-conservation stakeholders that promote sustainable development and protected areas.

3.2. Political challenges

3.2.1. Lengthy bureaucracy and corruption

Bureaucracy characterized by a clear division of work with boundaries of responsibilities is imperative for effective coastal management. Most African countries with fragmented institutions are setbacks to governance and management. According to Platteau (2009), the institutional legacy of African countries that was inherited from the colonial masters, still present a lot of loopholes to effective administration. In Cameroon, sustainable coastal management is stifled by lengthy, unclear/inexplicit working procedures. Moreover, the reluctance of most civil servants in exercising their duty further complicates and slows down development within the coastal span. The resultant effect has been rampant corrupt practices as the population tries to circumvent slow administrative modalities. This presents a big impediment in implementing ICM in Cameroon since most bureaucrats tally on their personal gains rather than of the entire nation (Figure 6).

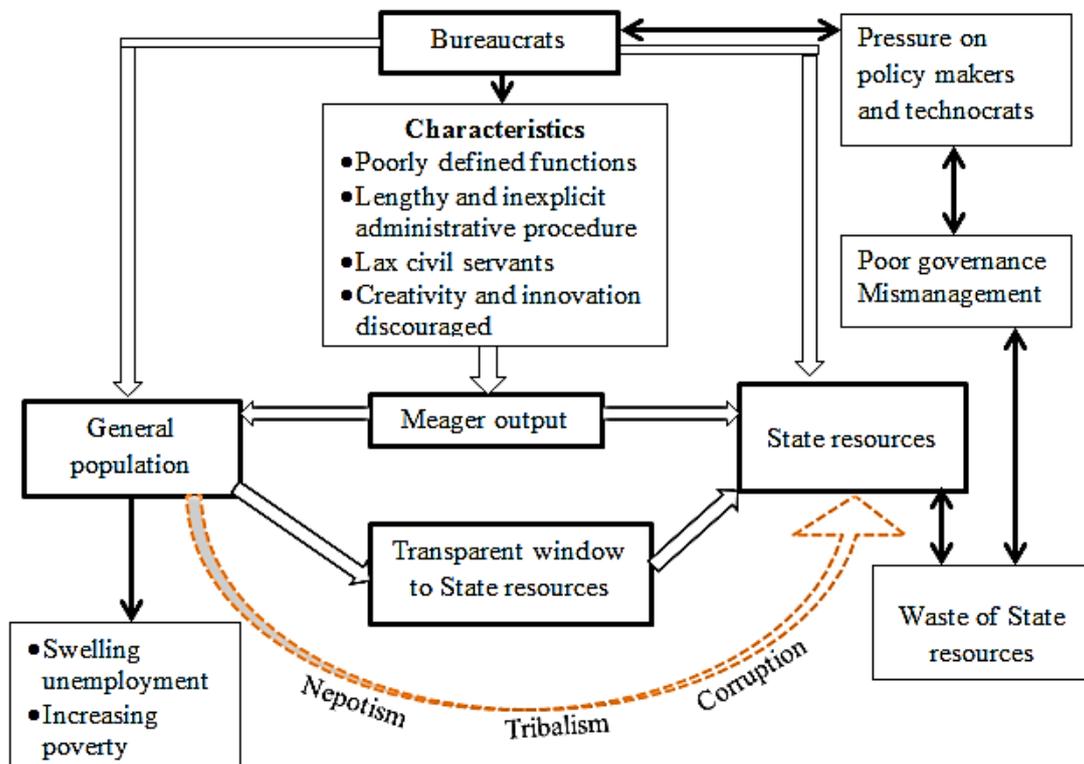


Figure 6 - Adverse effects of bureaucracy.
 Figura 6 – Efeitos adversos da burocracia.

Moreover, there is a huge difficulty in hiring and retaining competent program-managers and staff in Cameroon due of low pay and poor working conditions. Cameroonian with needed skills and education go abroad for education and experience and usually stay abroad (brain drain). Also, the over-reliance of Cameroonians on the skills and inputs of foreign consultants though many foreign assistance programs have not been able to instill capacity building that can sustain the ICM process. Additionally, implementation of ICM is often viewed as too expensive by the State of Cameroon.

3.2.2. Paper decentralization

The State embarks on the decentralization process because she wants to bring the government closer to the local population so that they can participate actively in orienting developmental issues of the country (Cheka, 2007). According to Article 55 *et seq* of the Constitu-

tion, that lays down the general guidelines in matters of decentralization in Cameroon, the State will devolve upon regional and local authorities, under conditions laid down by law, powers over matters essential to their economic, social, health, educational, cultural and sports development.

In reality, devolution of power still remains a nightmare. The exertion of power by the local authorities is still subject to rigid supervision by the hierarchy. Today, there is still a linear trickling down of power from the presidential level, ministerial level, regional level (governors) to the prefectural level and then, the local authorities (traditional rulers). Though the modalities of implementing effective decentralization are well circumscribed in the constitution, they remain largely on paper. Paper decentralization presents predicaments to the development of the entire country and more especially the densely populated coastal stretch (Figure 7).

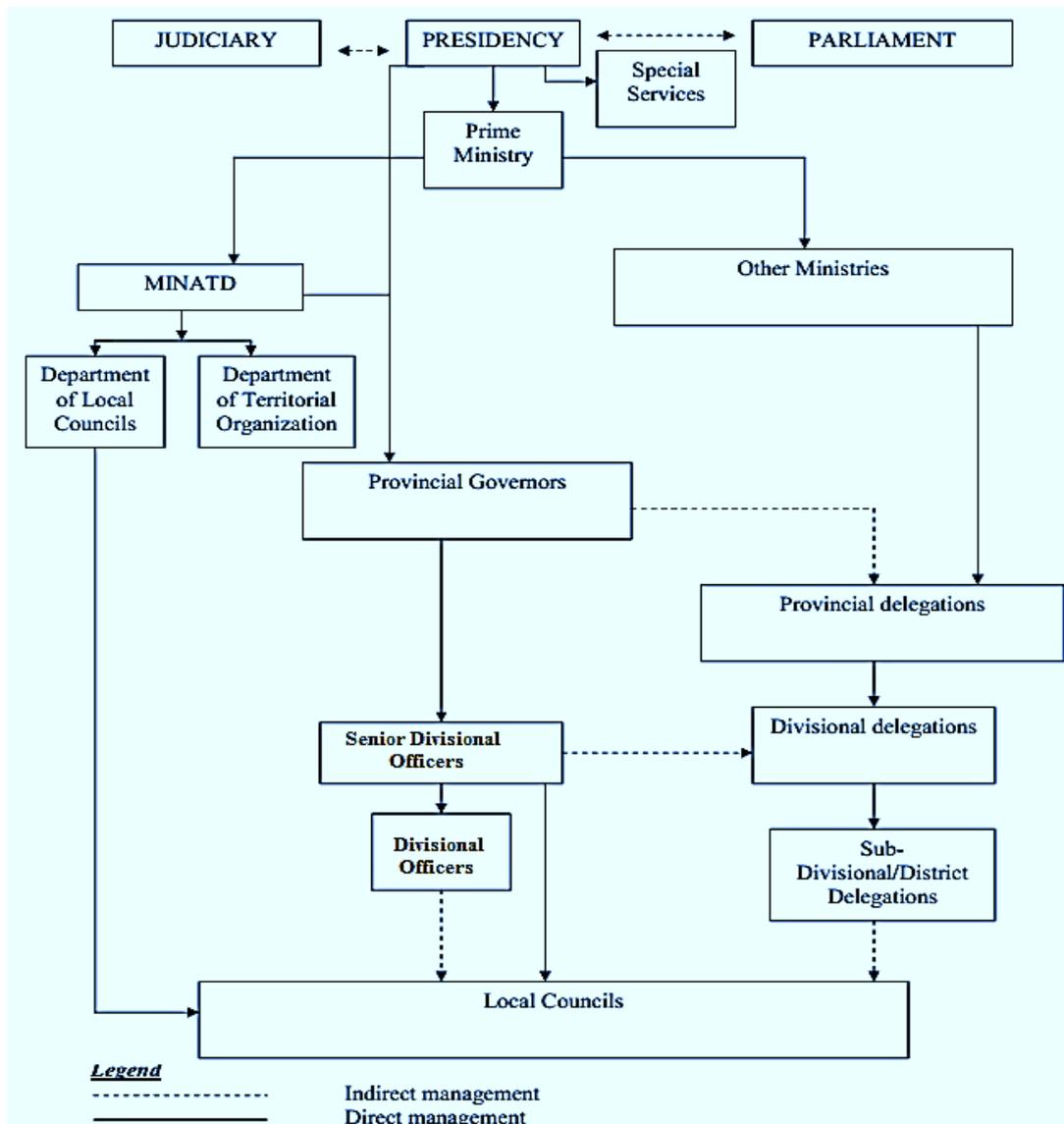


Figure 7 - Administrative setup in Cameroon
 Figura 7 - Configuração administrativa dos Camarões.

In other words, the sectoral fragmentation of the environment and resources therein, decision-making is the centred at the national level, with little or no ability actors at the decentralized administrative units to act without authorization from the central government. Thus, because each area has its local characteristics and problems known only by those living and/or working there, management of the Cameroon coast needs to be area-specific, and will be more efficient if decisions are taken at the local level, rather than being decided at the national level.

3.3. Geophysical challenges

3.3.1. Coastal erosion

The coast of Cameroon with increasing population concentration is witnessing rapid coastal habitats, sand and gravel mining, hotel and other infrastructure construction, human settlements, mangrove trees cutting and destruction of vegetal cover and also as a consequence of global warming (coastal erosion-accelerated sea level rise). There is poor planning and control of settlements along the sea front which lead to the loss of beach and landscape aesthetics and therefore reduction of tourism activities (Ajonina, 2008).

3.3.2. Siltation and sedimentation

Sedimentation and siltation are both naturally occurring erosive processes. However, anthropogenic activities have accentuated these processes resulting to excess accumulation of sediments (artificial sedimentation) that adversely affects coastal/marine organisms on the coastal esplanade of Cameroon. Artificial sedimentation is generally triggered by improper waste disposal from either domestic households or industrial wastes, uncontrolled logging and mining operations, and poorly built and maintained roads (Todd *et al.*, 2010). According to Otero *et al.*, (2006); Ngoran *et al.* (2015) mangrove forests worldwide retain a natural level of sedimentation at a rate of 0.5 to 1 cm per year on an average and anything above this threshold is considered to be an unnatural rate of sedimentation. Sedimentation becomes harmful to mangroves when portions of their roots become submerged. When this happens, there is less gaseous exchange between the roots and the water that surrounds them, thereby reducing the ability of the aquatic vegetation to respire and thus preventing an important physiological process. In addition, excess sediment inhibits adequate light from reaching the mangrove roots (Todd *et al.*, 2010). Sedimentation above the accepted threshold on the coast significantly disrupts the life cycle of aquatic organisms and more especially those that survive in brackish medium. Besides the biophysical impairment orchestrated by excess sediment deposition, heavy financial losses are also in-

curred annually by the Douala port authority in dredging the port area in order to easy anchoring by ships. Due to the bad geomorphological and hydrological situation of the Douala sea port, proponents of ICM will need to surmount the challenge of convincing decision makers that the Douala sea port should be relocated to Limbe with a natural deep harbours and calm waves.

4. Discussion

4.1. ICM and economic growth

Integrated coastal management is as recognized a management approach that addresses the problems plaguing the coastal and marine environmental in order to achieve sustainable use of coastal resources. Many works support the fact the ICM frame encompasses indicator of economic growth (Otero *et al.*, 2006). According to a study that seeks to evaluated the socioeconomic benefits without and with ICM implementation in Xiamen, China by Peng *et al.*, 2006, their study indicated that, implementation of the ICM program in Xiamen yielded significant increase of about 40 percent in annual socioeconomic benefit from the marine sectors. Additionally, Ngoran (2014) pointed out that the present value of ICM net benefits in Xiamen from 1995 to 2001 was more than RMB 27 billion. Likewise, Cullinan (2006) indicated that the European Union (EU) most valuable habitats were located in coastal zones, and that the total ecosystem benefits generated by EU coastal zones are worth more in economic terms than the national GDP of many of the smaller EU countries. The study also found out that the estimated gross annual socioeconomic benefits of implementing an integrated approach to coastal management were worth approximately to €4.2 billion

Viewed the economic benefits made with the successful implementation of ICM, it is therefore recommended that the government of Cameroon with other intervening stakeholders should draw valuable lessons from successful ICM cases like the Philippine and China

4.2. ICM and policy enhancement

According to Shi *et al.* (2001) ICM is an approach that provides strong legal and institutional framework to effectively address hot environmental issues such as pollution control, biodiversity protection and the management of multiple agencies' conflicts. Xue *et al.* (2011) points out that the implementation of ICM underscores the establishment of a unified mechanism that better coordinates government responsibility, re-orient the responsibilities of various government departments and gives them purposeful and sustainable vision in addressing coastal/marine problems, establishes a better licensing, charging and penalty systems to keep the activities of coastal users in checked. Chua & Scura

Table 1 - Summary of coastal challenges in Cameroon

Tabela 1 – Síntese dos desafios costeiras em Camarões

Attributes	Category	Events and Impacts
Socioeconomic Setbacks	Urbanization and industrialization challenges	<ul style="list-style-type: none"> - Harbours 70 percent of the country’s industry - Industries and fertile soils attract people from the hinterland and neighbouring countries. - Inadequate infrastructure and employ opportunities has resulted to trending pressure on coastal resources
	Over fishing	<ul style="list-style-type: none"> - Sectoral and centralized system of governance, little or no collaboration between the management sectors, gaps in the fisheries legislation, scientific research and insufficient expertise in the fisheries - Dwindling fish stocks exacerbate poverty among the fishing communities
	Ethnic setbacks	<ul style="list-style-type: none"> - The population in Cameroon is highly heterogeneous - ethnic diversity can potentially breakdown the economy of a country when different fractions of country feel relegated to the background or largely dominated by a particular tribe - Attitude and behaviour are key pillars of ethnicity that might act as a fridge to development (see main text)
	Stakeholder participation	<ul style="list-style-type: none"> - Bringing together and harmonizing sectoral government agencies and different disciplines is the most daunting characteristic for a successful ICM in Cameroon
Political challenges	Lengthy bureaucracy and corruption	<ul style="list-style-type: none"> - Fragmented institutions are setbacks to governance and management - The reluctance of civil servants in accessing their duty further complicates and slows down coastal development
	Paper decentralization	<ul style="list-style-type: none"> - Decision-making is the centred at the national level with little or no ability actors at the decentralized administrative units to act without authorization from the central government
Geophysical challenges	Coastal erosion	<ul style="list-style-type: none"> - Poor planning and control of settlements along the sea front has led to the loss of beach and landscape aesthetics - Increase Sand and gravel mining, hotel and other infrastructure construction, human settlements, mangrove trees cutting due to increasing population
	Siltation and sedimentation	<ul style="list-style-type: none"> - Sedimentation is harmful to mangroves when portions of their roots become submerged. Submerge roots reduces the ability of the aquatic vegetation to respire and thus prevent important physiological process.

(1992) supports Xue’s idea by stating that ICM implementation leads to improvement in coastal governance via strategic planning, policy and management integration and interagency coordination.

Contrary to the above authors, the successes in implementing integrated coastal management tallies on government’s effort. For instance in China, the entrusting of more powers by the central government to local governments to address environmental degradation, implement new environmental laws in the late 80s, paved the way for the Xiamen ICM program (Ngoran, 2014). Moreover, the opening up of the Chinese government to key stakeholders (Global Environment Facility (GEF), the United Nations Development Programme (UNDP), International Maritime Organization (IMO), Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas (MPP-EAS) and Programme on Partnerships in Envi-

ronmental Management for the Seas of East Asia (PEMSEA) can’t be left out. Likewise, the devolution of power by the Philippine government to local governments fostered increased stakeholders involvement in the management of coastal resources and hence, the success stories behind the Batangas Province ICM (Ngoran, 2014).

Lessons from the aforementioned examples could be adapter in order to bolster the uncoordinated and fragmented administrative system in Cameroon, especially along the coastal milieu.

4.3. ICM and environmental protection

The burgeoning world's population is exerting increasing pressure on coastal areas and there is need of a suitable management approach to arrest the ongoing situation. The integrated coastal management framework

therefore stands as one of the best management approaches to curtail nefarious human activity in coastal areas. What makes ICM an outstanding management program is the fact that it encompasses issues dealing with environmental protection, economic and pressing societal needs (Ngoran, 2014). For instance, Xiamen Island before the implementation of ICM was vicinity characterized with trending sewage disposal, the fecal coliform count exceeded maximum accepted standards in the Yuandang Lagoon and Maluan Bay; summarily, Xiamen Island was experiencing a severe environmental crisis (Peng *et al.*, 2011). Fortunately, there was a paradigm shift in Xiamen's environmental situation when it finally assimilated ICM implementation in 1994. Nowadays, Xiamen due to its environmental quality is a pivotal place not only for tourist from within China, but from other parts world (Ngoran & Xue, 2015). Due to the environmental standard in Xiamen, it has been designated by governmental officials and some renowned scholars as; National Sanctuary City, National Garden City, China's Outstanding Tourist City, and one of the Top 10 Liveable Cities in China. The achievements emblem in Xiamen ICM should serve as an eye opener to decisions makers and politicians in Cameroon to quickly embrace the ICM approach. With such a gear, the fast degrading coastal stretch of Cameroon stands a chance of recovering.

4.4. The need to strengthen municipal participation in environmental and resource management

The Douala city council and all subsidiary councils within the coastal stretch (Buea, Limbe, Tiko etc.) should be key players in integrated management of the Cameroon estuary, whose role is not only limited to improving the urban space and develop road networks. Thus, they must put environmental considerations at the fore, and integrate the principles of sustainable development into their planning process, which is done in concertation with other stakeholders, including communities and governmental and non-governmental agencies. Therefore, by balancing social, economic and environmental activities, the Douala municipality will pave the way to achieving environmentally sustainable urban development and a sustainable community.

4.5. The need to realize the full potential of the coastal ecosystem

From the foregone discussions, it is evident that the full potential of the Cameroon coastline is currently not realized, and has been compromised by poor management and the quest for short term financial benefits. Coastal ecosystems and their associated wetlands are important centres for ecotourism due to their attractive landforms and species diversity. Therefore, effective management of the Cameroon coast through ICM has the potential to

boost the tourism industry which is an important source of Government revenue and an important employer of the numerous unemployed or under-employed in Douala. However, despite the fact that Douala has the tourism potential, presently, the city is not on the list of cities local and international tourists consider visiting. Therefore, the Cameroonian authorities should evaluate what they are currently losing, and consider what they stand to gain by adopting integrated management.

Moreover, around the world, coastal areas have been identified as some of the most agriculturally productive systems. Much of the rice consumed around the World is cultivated in the estuaries in Southeast Asia, for example, in Vietnam, Cambodia, Thailand, Laos, China, etc. These estuaries have similar climatic and environmental characteristics as the Cameroon estuary, and in most cases, more than twice as much people. Therefore, rather than letting the uncontrolled colonization of wetlands for residential purposes go unabated, the municipal authorities and policy makers in Cameroon should consider utilizing some of these wetlands for rice cultivation by drawing from the experience of Asian nations. The adverse environmental impacts of agriculture in the fragile wetlands should however be taken into cognizance, and effective measures out in place to minimize such impacts while maximizing the benefits derived from the activity. In order to do this, numerous people must be displaced from what they currently consider their homes, in the wetlands. Therefore, in order not to create a social unrest, these wetland settlers should be resettled in further from the coast where there is abundant high ground covered with forest. In this sense, coastal managers should consider steering the growth and development of the city further inland in order to reduce anthropogenic pressures on the estuarine environment.

It should be noted that rice is the most consumed staple food and fish is the most consumed source of protein in Cameroon. Therefore, the importation of these are a major drain to the state treasury, further plunging Cameroon into poverty, with the already over-stretched citizens suffering from increasing costs of living. It is therefore not surprising that the February 2008 general unrest in the Country resulted from the skyrocketing costs of these basic products, notably rice and fish. Rice and fish rank high on the country's list of imports.

4.6. The need for capacity building integrated coastal management

"Capacity building" is a central concept in Agenda 21 and in other United Nations Conference on Environment and Development (UNCED) agreements. As defined by the UN Development Programme (UNDP) and the UN Division of Law of the Sea (UNDOALOS) in 1994, "capacity-building encompasses human resource

development, the development of organizations and endorsing the emergence of an overall policy environment favorable to the generation of suitable responses to emerging needs" (UNDP/UNDOALOS, 1993). A less formal delineation of capacity building in the context of integrated coastal management might be; the design and conduct of the range of activities essential to enhance the capacity of institutions and the individuals that comprise them to accept effective ICM programs. It could be argued that the objective of capacity building effort should be to create an environment wherein outside or external assistance is no longer needed, that is, to have educational and training facilities in place that will meet the needs for skilled ICM professionals in a specific nation.

Perceived in this way, the goal would be to create the capacity in-country (or on a regional basis) in universities and in training centers to produce people with the necessary skills. The challenge, then, is to select the range of skills required and to assist the in-country educational facility in gearing up to meet these newly identified needs. This usually means the design and design of new courses, the production of training materials (texts, notes, cases, etc.), and working with the faculty and/or instructors that will be involved in conducting the fresh programs (Cicin-Sain *et al.*, 1998).

Such capacity building however should be organized in such a way as to include already established policy-makers, scientists, and scholars, as well as young students, who should be trained at the very base on multi-disciplinary skills and the art of working successfully with multiple stakeholders a common sustainable development objective.

Cameroon can also draw inspiration from the major implementation actions inherent to ICM and their achievements, based on specific examples in South East Asia.

5. Conclusion

In this research article, we have expatiated on the factors constraining the implementation of ICM and hence the attainment of sustainable development in Cameroon. Moreover, relevant points have been advanced to buttress the gaps in coastal management as punctuated by sectoral management. There is a need for Cameroon to change from the current development approach. That is, a paradigm shift from the sectoral GDP-centred to an environmental/society-focused approach, while adopting integrated management for the sustainable management of coastal resources. In order to attend a desirable degree of sustainability within Cameroon's coastline, real implementation of ICM can only be achieved if sectoral lines are effectively minimized through the enforcement of the decentralization process as stipulated in to Article 55 *et seq* of the Constitution.

References

- Abbot, J.I.; Thomas, D.H.; Gardner, A.A.; Neba, S.E.; Khen, M.W. (2001) - Understanding the links between conservation and development in the Bamenda Highlands, Cameroon. *World Development*, 29(7):1115-1136. DOI: 10.1016/S0305-750X(01)00033-X
- Ajonina, G.N. (2008) - *Inventory and Modelling Mangrove Forest Stand Dynamics Following Different Levels of Wood Exploitation Pressures in the Douala-Edea Atlantic Coast of Cameroon, Central Africa*. Doctoral dissertation, Faculty of Forest and Environmental Sciences, Albert-Ludwigs-Universität Freiburg.
- Ayissi, I.; Ajonina, G.N.; Angoni, H. (2014) - Status of Large Marine Flagship Faunal Diversity Within Cameroon Estuaries of Central African Coast. In: Salif Diop, Jean-Paul Barousseau, Cyr Descamps (eds.), *The Land/Ocean Interactions in the Coastal Zone of West and Central Africa*, pp.97-107, Springer International Publishing. ISBN: 978-3319063874. DOI: 10.1007/978-3-319-06388-1_9
- Baird, R. (2005) - On sustainability, estuaries, and ecosystem restoration: the art of the practical. *Restoration ecology*, 13(1):154-158. DOI: 10.1111/j.1526-100X.2005.00019.x
- Boesch, D.F. (2006) - Scientific requirements for ecosystem-based management in the restoration of Chesapeake Bay and Coastal Louisiana. *Ecological Engineering*, 26(1):6-26. DOI: 10.1016/j.ecoleng.2005.09.004
- Calado, H.; Ng, K.; Johnson, D.; Sousa, L.; Phillips, M.; Alves, F. (2010) - Marine spatial planning: lessons learned from the Portuguese debate. *Marine Policy*, 34(6):1341-1349. DOI: 10.1016/j.marpol.2010.06.007
- Carlton, J.T.; Geller, J.B. (1993) - Ecological roulette: the global transport of non indigenous marine organisms. *Science*, 261(5117):78-82. DOI: 10.1126/science.261.5117.78
- Cheka, C. (2007) - The state of the process of decentralisation in Cameroon. *Africa Development*, 32(2):181-196. DOI: 10.4314/ad.v32i2.57187.
- Christie, P.; Pollnac, R.B.; Oracion, E.G.; Sabonsolin, A.; Diaz, R.; Pietri, D. (2009) - Back to basics: An empirical study demonstrating the importance of local-level dynamics for the success of tropical marine ecosystem-based management. *Coastal Management*, 37(3-4):349-373. DOI: 10.1080/08920750902851740
- Chua, T.E.; Scura, L.F. (eds.) (1992) - *Integrative Framework and Methods for Coastal Area Management*. Proceedings of the Regional Workshop on Coastal Zone Planning and Management in ASEAN: Lessons Learned, 169p., Bandar Seri Begawan, Brunei Darussalam, WorldFish. ISBN: 978-9718709320.
- Cicin-Sain, B.; Knecht, R.W.; Jang, D.; Fisk, G.W. (1998) - *Integrated coastal and ocean management: concepts and practices*. 517p., Island Press. ISBN: 978-1559636049.
- Cullinan, C. (2006) - *Integrated coastal management law: establishing and strengthening national legal frameworks for integrated coastal management*. Food and Agriculture Organization of the United Nations, Rome, Italy. Available on-line at <http://www.fao.org/docrep/012/a0863e/a0863e00.pdf>.
- Curtin, R.; Prellezo, R. (2010) - Understanding marine ecosystem based management: A literature review. *Marine Policy*, 34(5):821-830. DOI: 10.1016/j.marpol.2010.01.003
- Douvere, F. (2008) - The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy*, 32(5):762-771. DOI: 10.1016/j.marpol.2008.03.021
- Easterly, W.; Levine, R. (1997) - Africa's growth tragedy: policies and ethnic divisions. *The Quarterly Journal of Economics*, 112(4):1203-1250. DOI: 10.1162/003355300555466

- Eyebe, A.; Simeon, A.E.; Angu, K.A.; Endamana, D. (2012) - *Integrating Biodiversity Conservation into National Development Policy: A case study of Cameroon*. IIED Poverty and conservation learning group Discussion Paper, (09). Available on-line at <http://pubs.iied.org/pdfs/G03722.pdf>.
- Finegold, C. (2009) - The importance of fisheries and aquaculture to development. In: Wramner, P.; Cullberg, M.; Ackefors, H. (eds.), *Fisheries, sustainability and development*, pp.353-364, The Royal Swedish Academy of Agriculture and Forestry, Stockholm, Sweden. Available on-line at http://pubs.iclarm.net/resource_centre/WF_2546.pdf.
- Hildebrand, L. (2002) - *Integrated Coastal Management: Lessons Learned and Challenges Ahead*. Discussion document for Managing Shared Water/Coastal Zone Canada 2002. International Conference, Hamilton, Ontario, Canada.
- Leslie, H.M.; McLeod, K.L. (2007) - Confronting the challenges of implementing marine ecosystem-based management. *Frontiers in Ecology and the Environment*, 5(10):540-548. DOI: 10.1890/060093
- Liu, Z. (2003) - Sustainable tourism development: A critique. *Journal of sustainable tourism*, 11(6):459-475. DOI: 10.1080/09669580308667216
- Manga, V.E.; Agyingi, C.M.; Djieto-Lordon, A.E. (2013) - In-channel Sand Extraction in River Mungo, Cameroon: Nature Effects and Concerns. In: Water & Environmental Dynamics, 6th International Conference on Water Resources and Environment Research Proceedings, pp.11-28, Koblenz, Germany. DOI: 10.5675/ICWRER_2013.
- McClanahan, T.R.; Marnane, M.J.; Cinner, J.E.; Kiene, W.E. (2006) - A comparison of marine protected areas and alternative approaches to coral-reef management. *Current Biology*, 16(14):1408-1413. DOI: 10.1016/j.cub.2006.05.062
- McKenna, J.; Cooper, A.; O'Hagan, A.M. (2008) - Managing by principle: A critical analysis of the European principles of Integrated Coastal Zone Management (ICZM). *Marine Policy*, 32(6):941-955. DOI: 10.1016/j.marpol.2008.02.005
- Mebratu, D. (1998) - Sustainability and sustainable development: historical and conceptual review. *Environmental impact assessment review*, 18(6):493-520. DOI: 10.1016/S0195-9255(98)00019-5
- Ndah, A. B. (2011) - *Sustainable Development Challenges in Cameroon Estuarine complex and Opportunities for Integrated Management: Focus on the fisheries sector*. Masters Thesis, Xiamen University, China. *Unpublished*.
- Ndjama, J.; Kamgang, K.B.V.; Sigha, N.L.; Ekodeck, G.; Tita, M.A. (2008) - Water supply, sanitation and health risks in Douala, Cameroon. *African Journal of Environmental Science and Technology*, 2(12):422-429.
- Ngoran, S.D. (2014) - *Socio-environmental Impacts of Sprawl on the Coastline of Douala: Options for Integrated Coastal Management*. 172p., Anchor Academic Publishing. ISBN: 978-3954892464
- Ngoran, S.D.; Xue, X. (2015) - Addressing urban sprawl in Douala, Cameroon: Lessons from Xiamen integrated coastal management. *Journal of Urban Management*, 4(1):53-72. DOI: 10.1016/j.jum.2015.05.001
- Ngoran, S.D.; Xue, X.; Ngoran, B.S. (2015) - The Dynamism between Urbanization, Coastal Water Resources and Human Health: A Case Study of Douala, Cameroon. *Journal of Economics and Sustainable Development*, 6(3):167-181.
- Otero, X.L.; Ferreira, T.O.; Vidal-Torrado, P.; Macías, F. (2006) - Spatial variation in pore water geochemistry in a mangrove system (Pai Matos island, Cananeia-Brazil). *Applied Geochemistry*, 21(12):2171-2186. DOI: 10.1016/j.apgeochem.2006.07.012
- Peng, B., Chen, W.; Hong, H. (2011) - Integrating ecological damages into the user charge for land reclamation: a case study of Xiamen, China. *Stochastic Environmental Research and Risk Assessment*, 25(3):341-351. DOI: 10.1007/s00477-010-0372-5
- Peng, B.; Hong, H.; Xue, X.; Jin, D. (2006) - On the measurement of socioeconomic benefits of integrated coastal management (ICM): Application to Xiamen, China. *Ocean & coastal management*, 49(3), 93-109. DOI: 10.1016/j.ocecoaman.2006.02.002
- Platteau, J.P. (2009) - Institutional obstacles to African economic development: State, ethnicity, and custom. *Journal of Economic Behavior & Organization*, 71(3):669-689. DOI: 10.1016/j.jebo.2009.03.006
- Pollnac, R.B.; Crawford, B.R.; Gorospe, M.L. (2001) - Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. *Ocean & Coastal Management*, 44(11):683-710. DOI: 10.1016/S0964-5691(01)00075-8
- Pomeroy, R.; Douvère, F. (2008) - The engagement of stakeholders in the marine spatial planning process. *Marine Policy*, 32(5):816-822. DOI: 10.1016/j.marpol.2008.03.017
- Shi, C.; Hutchinson, S.M.; Yu, L.; Xu, S. (2001) - Towards a sustainable coast: an integrated coastal zone management framework for Shanghai, People's Republic of China. *Ocean & coastal management*, 44(5):411-427. DOI: 10.1016/S0964-5691(01)00058-8
- Xue, X.; Hong, H.; Charles, A.T. (2004) - Cumulative environmental impacts and integrated coastal management: the case of Xiamen, China. *Journal of Environmental Management*, 71(3):271-283.

Governance and the promotion of sustainable and healthy territories: the experience of Bocaina, Brazil*

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ABSTRACT

This paper describes and evaluates the governance of sustainable development applied to the territory within the strategic, integrated, participatory management of the Bocaina Project (the Observatory of Sustainable and Healthy Territories — OSHT), highlighting the mechanisms and tools that allowed the Agenda of Sustainable and Healthy Territories to be implemented territorially. The paper discusses and further develops governance strategies and practices implemented in the territory through the characterization, analysis, monitoring and evaluation of sustainable and healthy experiences — based on the Bocaina Project / OSHT, an actual experience currently being implemented at the Mosaico Bocaina (in the municipalities of Angra dos Reis, Paraty and Ubatuba, the latter at the state of São Paulo and the previous two at the state of Rio de Janeiro, Brazil – in a coastal zone providing coastal area ecosystem services), where traditional communities of three ethnic groups (Indigenous, Quilombola and Caiçara) live. The Evaluation of the Effectiveness of Territorialized Strategies for Sustainable Development showed that the implementation of the Project brought about more integration and the adoption of values (equity, sustainability and autonomy) and parameters (diversity, vulnerability, integrality, ecology of knowledge, territorialization, intersectorality, participation and empowerment) which, in turn, raised the standard of environmental governance and local sustainability.

Keywords: Mosaico Bocaina, Traditional Communities, Governance, Sustainable and Healthy Territories, Effectiveness Evaluation.

RESUMO

Governança para a promoção de territórios sustentáveis e saudáveis: a experiência da Bocaina, Brasil

Este artigo descreve e analisa o processo de governança em desenvolvimento sustentável aplicado ao território, no contexto da gestão estratégica, integrada e participativa, do Projeto Bocaina / Observatório de Territórios Sustentáveis e Saudáveis da Bocaina (OTSS), destacando os mecanismos e ferramentas para implementar territorialmente a Agenda Territórios Sus-

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tentáveis e Saudáveis, por meio da caracterização, análise, monitoramento e avaliação desta experiência, em andamento nos municípios de Angra dos Reis e Paraty, no litoral do Estado do Rio de Janeiro, e município de Ubatuba, no litoral do Estado de São Paulo, Brasil, onde vivem comunidades tradicionais de três etnias: indígena, quilombola e caçara. Da aplicação da Matriz de Análise de Efetividade de Estratégias Territorializadas de Desenvolvimento Sustentável constatou-se que há evidências de integração e apropriação das dimensões (equidade, sustentabilidade e autonomia) e dos parâmetros (diversidade, vulnerabilidade, integralidade, ecologia de saberes, territorialização, intersectorialidade, participação e empoderamento), com impacto positivo para a governança ambiental e sustentabilidade local.

Palavras-Chave: *Mosaico Bocaina, Comunidades Tradicionais, Governança, Territórios Sustentáveis e Saudáveis, Avaliação de Efetividade*

1. Introduction

1.1 Governance and Sustainable Development

In the last 50 years, ecosystems suffered quicker and more intense changes than in any other period in human history. This has led to considerable loss of biodiversity and, consequently, ecological imbalance. Losing biodiversity may affect the dynamics of and how ecosystems work, as well as cause diseases to emerge (Keesing *et al.*, 2010) and interfere with the provision of ecosystem services (Cardinale *et al.*, 2012). The relationship between human beings and the environment has, throughout time, determined the impact of diseases on humanity, as well as the health of the environment. If the eradication of poverty and hunger is not only a global challenge, but also an indispensable prerequisite for sustainable development, strategies for addressing socioenvironmental determinants are, therefore, necessary for all social groups to be economically productive, healthy and sustainable. This implies a model of governance that sees society and the environment non dualistically, which can be achieved by including various agents (governmental and non-governmental) in the planning process, thus broadening the scope of social participation in the decision-making process (Gallo and Setti, 2012).

The idea of "governance" has been developed through a continuous and complex process that produced an array of approaches that vary depending on ideology or the scope in question (see SI-I).

Governance for sustainable development understands the deliberative practice, in the perspective of what is fair, and development as processes through which freedoms and both individual and collective capacities are expanded, which means that it should be structured and operate to promote autonomy, equity and socioenvironmental justice. For that, governance should mobilize the intersectoral government policies that include shared goals and joint planning, in the national and global spheres, via negotiations within governments and the participation of different segments of the civil society (Buss *et al.*, 2014). Participation must stimulate pluralism and promote people's autonomy, which can make choices free from embarrassment and in conditions of respect and equality (Habermas, 1997).

The challenge of intersectorality has to be overcome at the level of State institutions (whether these are central, state or municipal), which not only have been created and developed with a sectoral rationale, but also are unprepared to share decision-making power and are dominated by the urgencies of short political cycles (Bógus & Westphal, 2007; Fernandez & Mendes, 2007; Schmidt & Guerra, 2010).

For better results, the structure and operation of the global and national governance of sustainable development — as well as the internal and specific governances of the health and environment sectors and of segments of the civil society that relate primarily with each of these government segments — must be evaluated in the light of sustainable development, of the environment and of health (Buss *et al.*, 2012).

1.2 Local Governance and Traditional Communities / Social Movement

Territorial development assumes the organized participation of social actors in the decision-making process. In the context of traditional communities, the goal is to contribute to an equitable model of development that includes the protection of the environment and natural resources, the promotion of economic growth and the improvement of the quality of life of the populations.

The protagonism of social movements opens more space for participation, changes norms, rules and habits with their organization and struggle, but, when evaluated at the light of their contribution for localized processes of productive transformation, of their capacity to lead the development of new conditions in the realms of the economy, education, culture and health, results are not as uplifting (Bebbington *et al.*, 2008). Therefore, it is fundamental to train social movements to carry out institutional actions at the level of the territory by strengthening their governance capacity (see SI-II).

1.3 Sustainable and Healthy Territories

The complexity of problems affecting and determining the health of the population is a challenge for public health, given that health is not limited to biology (that is, the absence of disease) and includes social and political aspects, life styles, culture, the environment and

the economy. The goal is a type of development that is environmentally sustainable as to the access and use of natural resources and the preservation of biodiversity; socially sustainable concerning the reduction of poverty and social inequalities, promoting justice and equity; culturally sustainable as to the conservation of its system of values, practices and symbols of identity; and politically sustainable for strengthening democracy and assuring the access and the participation of all in decisions regarding the public order (Guimarães, 2001).

Sustainable development and health promotion programs seek to respond, in the field of public health, to the global trend of integrating sectors and knowledge areas, promoting social participation applied to specific territories, as well as building autonomy, equity and sustainability. This assumes not only opening the issue for discussion and negotiating the convergence of interests, but also all sectors sharing planning and evaluation. This way, an active conversation between different forms of knowledge, disciplines and practices needs to be assured, a model of participatory governance capable of developing not only a hierarchy of priorities based on the needs of the territory, but also technopolitical solutions based on the ecology of knowledge, in a strategic/situational and communicative management process (Gallo & Setti, 2014). Because of their complexity, strategies like that are applicable to social settings, demanding approaches that triangulate methodologies, that implement situational and strategic analyses, that design actions for social transformation and incorporate participatory evaluation as an effort that always feeds back into action (Matus, 1993; Ribeiro *et al.*, 2002; Gallo & Setti, 2012).

This study aims to evaluate the effectiveness of Bocaina Project / OSHT, which is being implemented at the Mosaico Bocaina, an area in the municipalities of Angra dos Reis and Paraty (in the state of Rio de Janeiro) and the municipality of Ubatuba (in the State of São Paulo), Brazil, in the context of traditional communities living in this coastal zone and in most cases interacting with this coastal area ecosystem services in a governance for sustainable development perspective and integration.

2. Study area

2.1 South America

The governance of environmental health in South America has been pointing at human rights and environmental justice as ethical values and pillars, linking them to global public goods and human security.

2.2 Brazil - Southeast Region - Rio de Janeiro and São Paulo

Currently, the Southeast of Brazil has been going through a water crisis caused by factors such as: a large population; a growing demand for water, especially in

industries; environmental degradation of water sources; disorderly urban expansion; waste during distribution; a lack of involvement of the population and a lack of political will, which shows it is not simply a problem of low levels of rainfall, but, essentially, a lack of adequate governance to face its determinants (Machado, 2014). Water governance includes a theory and practice that seek to establish a dialogue between different social actors toward solutions that respond to the needs of the territory.

2.3 The Mosaico Bocaina Region

The studied area — the Mosaico Bocaina — is protected and located in the coast of Rio de Janeiro and São Paulo states, in the Southeast region of Brazil (Figure 1 in SI-III).

The Mosaico Bocaina is composed of a set of conservation units in the federal, state and municipal levels and their respective buffer, with around 216 thousand acres of forests under special conditions of management and legal protection, it includes 59 traditional communities in three segments, 44 of them Caiçara (most are traditional artisanal fishermen), 7 Indigenous and 8 Quilombola, as well as their buffer zones.

Large construction projects caused social and economic changes in the region, among which: the construction of the Rio-Santos Highway (BR-101), port terminal and of the Angra dos Reis nuclear power plants, which intensified the urbanization of the coast and caused tourism to be the main economic activity of the region rather than artisanal fishing (Mattoso & Moraes, 2006).

The use and occupation of the territory occurred both via disorderly growth with a large environmental impact — like the clearing and landfilling of mangrove areas for the construction of homes — and the preservation of areas in which occupation is restricted and monitored by environmental agencies. Real estate speculation and predatory tourism, among other factors, threaten the way of life and the permanence of traditional communities in their territories.

In this context, the Oswaldo Cruz Foundation (Fiocruz) has been developing, since 2009, a set of strategies through the Bocaina Project (see SI-IV Bocaina Project / Observatory of Sustainable and Healthy Territories of Bocaina – OSHT), in partnership with the Forum of Traditional Communities (FTC). This is an action research project whose goal is contributing to the promotion of a better quality of life, focusing on reducing inequalities and promoting autonomy and sustainability through collective development and the implementation of a local strategic agenda — Healthy Community —, that is integrated to the agenda of traditional communities, focused on community-based tourism and the promotion of solidarity economy (Gallo & Setti, 2012).

3. Traditional communities

In Brazil, the idea of traditional communities emerged in the context of the creation of protected areas referring to communities that originally lived in these areas, since they maintained centuries-old aspects of their culture and still practiced subsistence agriculture or fishing (Santos, 2003) (see SI-V).

Indigenous peoples are traditional populations that settled in Brazil around eleven or twelve thousand years ago, with an estimated population of between two and five million individuals when the European colonizers arrived, in 1,400 ethnic groups, suffering a strong reduction in numbers: around 600,000 individuals in 225 ethnic groups today (Kayser, 2010).

The Quilombolas are black slave descendants that settled in public land and conserved their cultural traces until today. They originated mainly by runaway slaves occupying free — generally isolated — land, but also obtained via conquest, inheritance, donation or in payment for services provided to the State or by the simple permanence on the land (Giddens, 2010).

The Caiçara are non Indigenous traditional peoples, the product of intense miscegenation between colonizers, the native Indigenous populations and slaves, who developed specific life styles that depend on natural cycles, the knowledge of biological cycles and natural resources, technologies, symbols and myths (Diegues, 1999). Most are traditional artisanal fishermen.

4. Methods

Action research (Thiollent, 2006; Toledo *et al.*, 2014) was used to generate contextualized understandings on the phenomena studied and implement structural and structuring actions in the fields of health promotion and socioenvironmental sustainability with the goal of strengthening the life styles of traditional communities, stimulating the sustainable use of the territory and expanding the access of these communities to goods and services.

Accordingly to Thiollent (2006), action research involves participation and planned action by interveners (people and social groups) within the problem under observation.

In the processes should be valorised the acquired knowledge by the intervenient being able to produce new knowledge and to participate in the decision making (empowerment).

Both an ecosystemic (Freitas, 2005; OPAS, 2009; Gallo & Setti, 2012) and a communicative approach of the strategic/situational planning (Matus, 1993; Gallo, 2009) were adopted to facilitate the permanent agreement between the various agents involved, to create opportunities for dialogue, participation, learning and

networking, with the goals of creating solutions that promote autonomy and socioenvironmental justice.

The literature was searched, documents were analyzed, and methods such as participant observation and focal groups with a previously-structured script were applied to representatives of traditional communities. Thus, a conversation was established through methodologies and tools that facilitate the collective development of the project, focusing on collective register and visualization and consensus building techniques.

The participant observation emerges from the need of the researcher to become an integrated member of the social group under research and being able to understand practices, attributed means, beliefs and values. The observational data was register in a field book diary.

The focal group methodological technique was realized in the “Quilombo do Campinho da Independência”, Paraty, Rio de Janeiro, on the 27th April 2015. It takes 90 minutes and the moderator managed the questions and discussion dynamics and focus. The group integrated the representatives from the traditional communities (same age interval and social valorisation within the group from traditional communities representatives was tried). The meeting was recorded.

The focal group was carried out with the goal of identifying ideas and collecting beliefs, perceptions, expectations, motivations and needs of traditional communities regarding the Bocaina Project / OSHT and included the participation of 06 (six) people — 02 (two) of them Caiçara, 04 (four) of them Quilombola and no Indigenous persons. The interviews with the focal group were transcribed literally and the transcription was analyzed concerning sustainability, equity, autonomy, evaluational parameters and a few indexes/variables established at the Matrix for the Analysis of the Effectiveness of Territorialized Sustainable Development Strategies (Table 1 in SI-VI).

The chosen conceptual framework includes, as structuring elements of sustainable development, the promotion of equity, autonomy and sustainability, which, in turn, are split into parameters that allow the analysis of the consistency and the coherence of projects as to their development, implementation and generation of evidence of effectiveness (Gallo & Setti, 2012). The theoretical/methodological process that led to the development of an approach that integrated the principles and categories of sustainable development and health promotion produced a tool to evaluate the effectiveness of territorialized agendas.

Issues and categories were triangulated/collated with secondary information. Data collected in the focal group are in line with the theoretical/methodological framework and will be introduced below.

5. Results and discussion

The results here introduced and discussed follow an analytic structure stemming from the established methodology (see Table 1 in the SI-VI) and portray the data obtained via literature search, participant observation and focal groups with representatives of traditional communities.

5.1 Equity

5.1.1 Diversity

Cultural diversity is a striking aspect of the territory at hand, the result of a historic/social process. Multiculturalism is observed in material and immaterial goods, including cultural events, modes of creating, doing and living, as well as artistic and technological creations of traditional communities.

Representativeness of ethnic groups

One of the challenges and a central pivot of the interests and needs pointed out by participants has to do with the representativeness of the three ethnic groups (Indigenous, Quilombola and Caiçara) in the implementation of the project.

(...) the project has the very encompassing goal of supporting the forum of traditional communities, which is not that easy, as you can imagine, since there are various groups (Extracted from the Focal Group on Traditional Communities, in 2015).

The low level of participation of the Indigenous group in the implementation of the Bocaina Project / OSHT — when compared to the Quilombolas and Caiçaras — was diagnosed through participant observation which evinces the need to consider the specificities of this group in the intercultural context. A difficulty in communicating and understanding Portuguese was identified among Indigenous groups whose main language is Guarani. The transportation to where the meetings was also identified as a problem spot for the participation of Indigenous groups. However, these hypotheses are sufficient to understand the phenomenon and assure the active participation of Indigenous groups in the implementation of the project. They should be further investigated in a specific research project.

Valorization of the culture of different ethnic groups

Throughout history, culture — understood as the dynamic means of living, creating and doing of a group — was marked by the struggle between different ethnic groups, by the determination of their goals and values, which suggests a rupture of social and cultural reproduction via alternative practices and resistance (Giroux, 1995). Cultural diversity was identified as a legacy in the speech of a representative of traditional communities in the focal group.

(...) we are the heirs to a story, a legacy, so continuing that legacy is a great honor for us (Extracted from the Focal Group on Traditional Communities, in 2015).

Representativeness and valorization of their culture are structural for the resilience of traditional communities and for ensuring their space in society, which is crucial for any participatory process of governance that seeks to promote autonomy, equity and socioenvironmental justice.

5.1.2 Vulnerability

Vulnerability is also an issue in the territory, a product of a historic/social process and of the dimension of equity as a collective effort toward facing avoidable, unjust and unnecessary inequalities. Inequities produce a negative impact in the health of traditional communities through increased exposure to generational risk, the non recognition of their fundamental rights, and restricted access to social goods and services.

Conquering and preserving territory

One of most important issues regarding the interests and needs identified by the participants of this study has to do with maintaining their ways of life and preserving their culture.

(...) considering that this is a conservation area, that mass tourism has been arriving at our communities, and that we continue there with our culture and leading our ways of life, for me, it's resistance (Extracted from the Focal Group on Traditional Communities, in 2015).

The argument is that, in order for Bocaina to have sustainable and healthy territories, the implementation of a project for the valorization of multicultural and participatory citizenry, ensuring the access to land as a prerequisite for the survival of traditional communities, is necessary.

(...) this project goes way beyond what is written there (...) regarding the ways of life because it was created with that goal in mind, the goal of, first of all, ensuring our territory and increasingly valorizing our culture (Extracted from the Focal Group on Traditional Communities, in 2015).

Social exclusion and the impact on self esteem

Inequality generates poverty and social exclusion, causing a negative impact on the living and health conditions of the population and expanding inequities related to social determinants: violence, precarious access to health services and education (Buss *et al.*, 2014), ethnic discrimination, among others. Such relationship can be observed in the focal group, in the speech of representatives of traditional communities, who mentioned the negative impact generated on collective health.

(...) *no one can take knowledge away from you, but they are able to undermine that, so there are several generations of people with a series of problems that, then, affect their health, lower their self-esteem, which brings insecurity, stress, depression. All of that is the product of a person that is not healthy, of the insecurities that they planted in their minds: "you are no one, you are stupid" (...), to a point that even they repeat it: "I am stupid, I can't learn anything and there's no way around that"* (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) *prejudiced people may look at Indigenous communities and say: "that people is horrible, their houses are horrible, that people is nothing," but that people is everything, it is more than any other people* (Extracted from the Focal Group on Traditional Communities, in 2015).

In this context, the vulnerability that traditional communities are usually assumed to have — understood as the exposure to different risks (economic, cultural, social) — poses challenges that are caused by exclusion and social inequality. This has a negative impact in the living and health conditions of traditional communities, which indicates the need to establish a model of governance that addresses the social determinants of health.

5.1.3. Integrality

Integrality has become essential for healthcare practices that consider the multidimensionality of subjects. The goal is to meet the needs of individuals and population groups in an expanded perspective. In this context, healthcare actions include dialogue, listening, sheltering, generating bonds, providing access, and being accountable with a formal and political quality (González & Almeida, 2010).

Generational integrality

Generational integrality, in the context of the Bocaina Project / OSHT, is understood both in terms of assuring human rights and promoting intergenerational equity. This implies assuring social, cultural, collective and diffuse rights, but also rights related to communication, the development of peoples, freedom, democracy, information and pluralism (Lafer, 1998). It also implies a commitment to future generations regarding the quality of the environment, the valorization and preservation of ethnocultural diversity and the equitable access to resources, goods and services (Weiss, 1992). In that sense, the idea of integrality was observed in the speeches of representatives of traditional communities, in the focal group.

(...) *as human beings, we are always fighting a battle. A battle to grow, to change, and then to aggregate all these values (...) so, at the right moment, we can pass*

it them on (Extracted from the Focal Group on Traditional Communities, in 2015).

The project, in sum, needs to aim at the future of the children. The tourism that we have; is that what we want? Is that the education that we want, that only trains youths for the job market? (Extracted from the Focal Group on Traditional Communities, in 2015).

Establishing a bond with the territory and between actors

The bond and identification with the land increase the efficacy of actions and stimulates autonomy and citizenry, promoting participation in the identification of the needs of the territory (Campos, 1997). Voluntary social participation, in turn, strengthens minorities in conflicts of interest and in the power relations that are inherent to society (Tavares, 2014). Therefore, the Bocaina Project / OSHT established that strengthening traditional communities was identified in the speech of their representatives in the focal group.

Strengthening not only the local communities, but the surrounding communities. Not only the surrounding ones, but all of them in the region, which used to happen in the past. With this project, we also brought back sociability, which happened in the past (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) *we are very happy to be part of a traditional community and to have you as partners, you know? I say it from the heart. They are our friends. So if we get it wrong, everybody gets it wrong. If we get it right, we will all get it right, because it is something we can get right or wrong* (Extracted from the Focal Group on Traditional Communities, in 2015).

The knowledge and the acceptance of their culture and the opportunity to learn about other cultures are requisites for people to feel capable of voluntarily participating in processes of social interaction (Tavares, 2014). The feeling of belonging to a traditional community and their valorization was pointed out in the speech of one of its representatives in the focal group.

(...) *a strong people, a happy people (...) belonging to this ethnic group that not only built this region, but the whole country* (Extracted from the Focal Group on Traditional Communities, in 2015)

In this context, the specific needs of certain groups (regarding ethnicity, gender, age, etc.) concerning their exposure to additional risks should be considered according to their level of social vulnerability (Tavares, 2014).

Equity is one of the pillars of territorialized agendas of sustainable development and health and very important for the promotion of a fairer society that is more equitable in the distribution of income, of the access to goods

and services, in the use of resources and in fulfilling human rights, intervening in its parameters of vulnerability, integrality and cultural diversity.

5.2 Sustainability

5.2.1. Ecology of knowledge

The ecology of knowledge recognizes the plurality of heterogeneous knowledges (modern science being one of them), which interact with one another sustainably and dynamically without compromising their autonomy. There are various different forms of knowing about matter, society, the life and the spirit, etc., but also many other ideas and criteria about what counts as knowledge (Santos, 2007).

Mechanisms of producing knowledge

Knowledge is historical and socially produced. With knowledge, the world can be understood and transformed. Actions are always intentional and aim either to liberation or oppression. Knowledge is liberational when it includes the needs and desires of all people involved in the process (Freire, 2004; Luckesi, 2012). Therefore, the Bocaina Project / OSHT sought to involve the different social actors in the territory, especially traditional communities so that, based on a dialogue between different forms of knowledge and different practices and on the relationships they develop among themselves and with the environment in which they live, their needs can be understood and their actions can acquire meaning. This mechanism of knowledge generation was identified in the speech of representatives of traditional communities, in the focal group.

(...) it is a big community. Actually, it even sustains our counter hegemony, (...) it sustains our ideal of society, it helps us think and reflect on how we debate, how we should debate and where we want to get (...) it will leave a legacy, even the things we were not able to accomplish (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) a project of ecological sanitation. It is a new way of thinking on a new model of society; a new model that speaks of health when talking about ecological sanitation. (Extracted from the Focal Group on Traditional Communities, in 2015).

Although it recognizes the positive results of empowering the social movement, this study observed the non involvement of the local government in the beginning of the implementation of the project.

In this context, the strategies of the agenda of sustainable and healthy territories aim at promoting the health of the population and stimulating the local government to develop a new form of governing based on intersectoral actions and the assurance of equity and social participation, introduced in the Intersectorality section.

Valorization of popular / traditional / native knowledge

Traditional knowledge is a relevant, contemporary issue, addressed, at the international level, by multilateral organization which have different perspectives on the protection of traditional knowledge, which makes it hard for an international norm that meets different interests to be implemented (Zanirato & Ribeiro, 2007). However, the Convention on Biological Diversity (CBD) recognized that many biological resources depend on local communities and populations with a traditional lifestyle (ONU, 2000), which was highlighted by a representative of traditional communities in the focal group.

(...) traditional communities have this defense, this thing with nature, this sensibility (Extracted from the Focal Group on Traditional Communities, in 2015).

Traditional knowledge — understood as traditions, beliefs, practices and customs transmitted from parents to their children in traditional communities that live in direct contact with nature — is a cumulative, informal, long-term process that constitutes a shared heritage of that social group (Zanirato & Ribeiro, 2007). The traditional knowledge and practices regarding healthcare were mentioned, in the focal group by a representative of traditional communities, who highlighted the interference of conventional medicine in their traditional lifestyles.

(...) it is a lot of work to bring back natural medicine today. It is a big problem; it isn't easy. Even though we talk to the people, they stop using the herbs and go to the doctor, to a point that the doctor tells them that they didn't have to go there for that (Extracted from the Focal Group on Traditional Communities, in 2015).

The Ecology of Knowledge integrates technical, scientific and traditional knowledge — consequently, both universities and social movements — in search of innovative solutions that promote a fairer and more egalitarian society. In this sense, the methodological design of the partnership of the project (see the Methodology section) makes the exchange of experiences and the transfer of technology and knowledge possible, as well as promotes greater political and institutional support.

5.2.2. Territorialization

Territorialization is a social product with economic, political and cultural aspects. Therefore, territorialization assumes different configurations depending on the needs and the model of management of the territory.

Needs and priorities of the territory

Regarding the access to goods produced by the society, the understanding of the territory includes prioritizing

the valorization of the local culture, which will keep future generations in activities that are inherent to each community. In this context, representatives of the traditional communities mentioned issues regarding their life styles, a question that is being developed at the Bocaina Project / OSHT.

(...) community-based tourism is stimulating the people in communities to continue living and working in their own communities (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) strengthening culture (...) as a cross-cutting issue (...) agroecology (...) a differentiated education (Extracted from the Focal Group on Traditional Communities, in 2015).

Despite recognizing the cultural diversity in the region, the local educational system does not incentivize traditional practices, as highlighted by a representative of traditional communities, in the focal group.

(...) the issue of education (...) we have to do something about it because we had a meeting with students and things are impossible and sad. All they talk about is their cell phones, their TVs. They never speak about their rows, their canoes, the fish (...) canoeing (...) it has potential (...) we want to implement in the community (Extracted from the Focal Group on Traditional Communities, in 2015).

Shared management, co-management

The coordination of institutional and social actors to establish priorities and collectively decide on solutions was observed by traditional communities, in the focal group.

(...) when the project got here (...) it had nothing (...) it took some time to get to practice, from the meetings to the execution (...) This is what is cool about the project: it has been listening a lot to the community and even redesigning what we thought was wrong (Extracted from the Focal Group on Traditional Communities, in 2015).

Moreover, the shared responsibility as to the planning, the programming, the coordination and the execution of actions were also pointed out.

(...) the forum has a series of projects, and all of them are embraced. This is very interesting to see, because they could say something like: "no, now we are only talking about sanitation," which would be reductionist (...) and we would accept it because we know that it is big, but that is not the case, their attitude is always very receptive. That was the case with differentiated education. We made suggestions, we understood the process, and there it is (Extracted from the Focal Group on Traditional Communities, in 2015).

In this context, to promote sustainable and healthy territories, it is necessary to incentivize a model of govern-

ance that addresses the social determinants related to ethnicity, promote social cohesion, strengthen traditional communities and valorizes culture.

5.2.3. Intersectorality

Through intersectorality, different forms of knowledge are coordinated and common goals are shared, which facilitates the implementation of public policies. Meanwhile, new problems and challenges linked to the fragmentation and the coordination of public policies emerge, especially when considering the sectoral culture that still prevails in the public administration (Gallo & Setti, 2014).

Converging agendas

Representatives of traditional communities understand intersectorality as related to the integration, of sectors and agendas not only among themselves, but with society, although the implementation of intersectorality had not been noticed in practice, as highlighted by a representative of the traditional communities in the focal group.

(...) one project will have to dialogue with the other, and with the other, and with the other (...) There are different proposals and activities for differentiated education, for agroecology, for community-based tourism, for the project itself (...) How do we converge all that? (Extracted from the Focal Group on Traditional Communities, in 2015).

Inter-scale integration

They also referred to intersectorality as a good strategy toward strengthening traditional communities to solve their own problems and facilitating the implementation of public policies, which makes it possible for inter-scale actions to be promoted (Gallo & Setti, 2014).

I think we are very experienced as to that. Through this project, we can keep progressing; until, one day, this policy is discussed at someone's office in Brasília (Extracted from the Focal Group on Traditional Communities, in 2015).

Integrating stakeholders

Regarding that experience, they pointed out the challenge to involve the public sector so that intersectoral actions that promote equity could be implemented.

The public sphere has to be stimulated, and that is what we are doing when we launch a campaign. The goal is to stimulate them; we want this or that, but we also want you to do your duty, to incentivize the implementation of policies (Extracted from the Focal Group on Traditional Communities, in 2015).

The low levels of participation of traditional communities in the decision-making process regarding issues that

affect them and have to do with the future of the municipality should be highlighted.

Therefore, the coordination between the Forum of Traditional Communities and the municipal governments of Angra dos Reis, Paraty and Ubatuba was promoted toward the development of a Regional Solidarity Economy Plan. The Angra, Paraty and Ubatuba Regional Integration Center (RIC) was then created to carry out coordinated actions related to solidarity economy and sustainable development in the region. The process was benefited from the political alignment between the three municipal governments and the federal government, although it still has problems in its administration, which makes its implementation still a challenge.

Idea / Holistic approach

Under the perspective of sustainable and health territories, health was understood by the participants of the focal group as a multidimensional phenomenon that involves physical, mental, social and spiritual aspects that are constantly affected by biogenetic, environmental, socioeconomic, political and cultural aspects, all of which are interdependent.

(...) health is a very wide field. There's mental health, spiritual health, all of them converging for human beings and communities to be well. It is not just a matter of giving someone medication for them to be fine. That is not the case. I believe that giving medication is a last resort, when there is nothing else to do. That's what medication is for. Before that, there are things that we can do to make that community healthy and not need the medication in the first place. (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) society teaches us that we need to have a doctor (...) to give us medicine, but we have prevention, we have health promotion, and it is not just about health, it is leisure too, which means things work together (Extracted from the Focal Group on Traditional Communities, in 2015).

Intersectorality was observed by traditional communities in the coordination of different forms of knowledge and experiences for the planning, execution and evaluation of actions carried out to promote sustainable and healthy development.

(...) when I joined the project, I thought it was just for sanitation and that it would be over afterwards (...) but that was not the case. I was able to get deeper into it and realize that sanitation has to do with tourism, with community-based tourism, with education, that education has to do with sanitation, (...) and that the community is empowered by that. Today, I can see we progressed a lot (Extracted from the Focal Group on Traditional Communities, 2015).

Tackling challenges in an integrated manner implies promoting horizontal power relations in the decision-making. In this context, in order to implement healthy and sustainable public policies, intersectorality is necessary for governance (Gallo & Setti, 2014).

Sustainability seeks to assure that processes last long and remain strong. Therefore, participation in the planning and management is a prerequisite for local governance; a process guided by intersectoral action, which coordinates different forms of knowledge and shares common goals.

5.3 Autonomy

5.3.1 Social Participation

The active participation of communities is crucial for the governance for sustainable development. It develops their ability to meet their immediate needs, identifies and incentivizes their local vocations and systematically evaluates the promotion of sustainable and healthy territories.

Capacity for intervention

Management models that consider the implementation of healthy public policies strengthen community actions and the development of personal abilities (Westphal *et al.*, 2013; Gallo & Setti, 2012). The effective participation of traditional communities in the development of the Project was observed in the speech of their representatives, in the focal group.

(...) have been giving us the privilege of contributing to this development. The project has great respect for this population. In the past, there were actions, but they were imposed. Now we have the perspective of strengthening our identities even further in this process (Extracted from the Focal Group on Traditional Communities, in 2015).

The challenge of overcoming the culture of non participation in Brazil — which makes it harder for the civil society to participate in the discussion of local problems and in the search for possible solutions (Gohn, 2004) — was identified by the representatives of traditional communities.

(...) we still have trouble bringing people in the communities to the forum. Therefore, activities are often concentrated in the people that are here every day (Extracted from the Focal Group on Traditional Communities, in 2015).

The effectiveness participation of traditional communities was seen in the performance of the protagonist role. The use of methodologies that are guided by participation seems to instill a need to change the reality of communities day by day, which is observed in the need to involve youths in the process.

(...) increasingly protagonists of the process, and not merely a target public, and that is nice because it reveals our identity more and more (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) the forum has great work to do in that matter. How to bring more people in and how to involve (...) youths? (Extracted from the Focal Group on Traditional Communities, in 2015).

In this context, social participation and new management structures are pivotal for local governance processes that promote sustainable development, that are based on cultural and social diversity, that consider social movements in advancing citizenry, that expand the political space, that change dominant practices and include new social actors.

5.3.2 Empowerment

Empowerment strategies stimulate effective participation, ensuring autonomy in the decision-making process and strengthening social movements through a problem-based approach.

Ability to formulate

Empowerment allows people to take control over their lives. At the level of the individual, it relates to the development of personal abilities, like the ability to develop critical thinking on problems and of implementing self-care and autonomy (Setti & Bógus, 2010), which were highlighted by representatives of traditional communities in the focal group.

(...) now we have the conditions to rethink and recreate ourselves (after all, that what human life is about) (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) I have learned a lot and become more autonomous (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) the project has been listening to these populations. It is great to know that we have the privilege of being able to develop this model in Brazil, and even in the world (Extracted from the Focal Group on Traditional Communities, in 2015).

Protagonism of the social movement

Practices developed within the Bocaina Project / OSHT contributed for the individual and collective empowerment of the community and the social movement. Issues regarding the valorization of cultures and local potentials — as well as the mobilization for change and for solving problems — were observed in the speech of representatives of traditional communities in the focal group.

(...) we are currently very fortunate to be able to continue with our struggle, because we are movement

(Extracted from the Focal Group on Traditional Communities, in 2015).

(...) the forum has been giving the project a direction. The project has a partnership with the forum, in the region, through their leaders (Extracted from the Focal Group on Traditional Communities, in 2015).

(...) the forum is autonomous to make suggestions. That's one thing, since it follows a new (Extracted from the Focal Group on Traditional Communities, in 2015).

At the level of autonomy, empowerment strategies and the effective participation of traditional communities — in a process of local governance that prioritizes the coordination of actors in the decision-making process, strengthens community action and the development of the organizational capacity of the Forum of Traditional Communities of Angra, Paraty and Ubatuba — were considered.

6. Conclusions

Local socioenvironmental governance and territorialized agendas of sustainable development and health — in its aspects related to the participation of, the sense of belonging to and the valorization of traditional communities, to territorial and cultural preservation and to multicultural and participatory citizenry — are guidelines for actions aimed at strengthening traditional communities promoted by the Bocaina Project / OSHT.

The local governance has been promoting equity-based sustainable development, considering vulnerability, integrality and cultural diversity.

As to sustainability, the Bocaina Project / OSHT sought to involve different actors in the territory, understand their socioenvironmental dynamics and provide meaning to their actions and perspectives regarding sustainability. The Ecology of Knowledge, in the methodological design of a partnership, made it possible for a large number of organization cultures, methods, objectives and practices to come together, facilitating the exchange of experiences and the transfer of technology and knowledge, an expression of greater political and institutional support.

Intersectorality and inter scale integration demonstrated to be the most relevant requisites for governance and implementation of healthy and sustainable public policies. Communities perceived and integrated although there is a need for more engagement of the local public entities (e.g., municipalities) in this projects/processes.

Regarding equity and citizenship the implementation of a territorialized agenda that supports a better integration of this excluded territories (and communities) positively interfered in the local governance within this traditional communities. Ecological, Traditional and Cultural knowledge are to be recognized and valued in the defi-

nition of sustainable strategies and practices (eg agroecology, traditional and artisanal fisheries, and social technologies).

Autonomy is fundamental for the promotion of sustainable and healthy territories and depends on how governance is structured — ensuring the intervention of many different social actors on socioenvironmental determinants by strengthening the protagonism of traditional communities and valorizing their culture. In this project, a relative level of success was achieved regarding the Quilombola and Caiçara communities. Specific, differentiated strategies are necessary to involve Indigenous communities. Intersectoral and inter-scale approaches — prerequisites of any model of governance dedicated to the implementation of healthy and sustainable public policies — were perceived by traditional communities in the coordination of different forms of knowledge and experiences in the planning, execution and evaluation of the actions of the project. The participation of the public administrators that work on the territory was also noticed, although it is still necessary to engage the local public sphere (municipal governments) in the actions.

It should also be mentioned that, in this project, the type of governance employed was able to implement empowerment strategies that promoted the participation of traditional communities, especially the Quilombola and Caiçara communities, which contributed to greater autonomy for them and produced an impact in the management capacity and governability of the social movement, as represented by the Forum of Traditional Communities.

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Appendix

Supporting Information associated with this article is available online at http://www.aprh.pt/rgci/pdf/rgci-612_Setti_Supporting-Information.pdf

References

- Bebbington, A.; Abramovay, R.; Chiriboga, M. (2008) - Social Movements and the Dynamics of Rural Territorial Development in Latin America. *World Development*, 36(12):2874-2887. DOI: 10.1016/j.worlddev.2007.11.017
- Bógus, C.M.; Westphal, M.F. (2007) - Participação social e cidadania em movimentos por cidades saudáveis. In: Fernandez, J.C.A.; Mendes, R. (org.), *Promoção da saúde e gestão local*, pp. 61-83. Hucitec, Cepedoc Cidades Saudáveis, São Paulo. ISBN: 978-85-60438-43-3.
- Buss, P.M.; Machado, J.M.H.; Gallo, E.; Magalhães, D.P.; Setti, A.F.F.; Netto, F.A.F.; Buss, D.F. (2012) - Governança em saúde e ambiente para o desenvolvimento sustentável. *Ciência e Saúde Coletiva*, 17:1479-1491. DOI: 10.1590/S1413-81232012000600012
- Buss, P.M.; Magalhães, D.P.; Setti, A.F.F.; Gallo, E.; Netto, F.A.F.; Machado, J.M.H.; Buss, D.F. (2014) - Saúde na Agenda de Desenvolvimento pós-2015 das Nações Unidas. *Caderno de Saúde Pública*, 30(12):2555-2570. DOI: 10.1590/0102-311XAT011214
- Cadman, T. (2012) - Evaluating the quality and legitimacy of global governance: a theoretical and analytical approach. *International Journal of Social Quality*, 2(1):4. DOI: 10.3167/IJSQ.2012.020102
- Campos, G.W.S. (1997) - Considerações sobre a arte e a ciência da mudança: revolução das coisas e reforma das pessoas. O caso da saúde. In: Cecilio, L.C.O. (org.), *Inventando a mudança na saúde*, pp.29-88, Editora Hucitec, São Paulo.
- Cardinale, B.J.; Duffy, J.E.; Gonzalez, A.; Hooper, D.U.; Perrings, C.; Venail, P.; Narwani, A.; Mace, G.M.; Tilman, D.; Wardle, D.A.; Kinzig, A.P.; Daily, G.C.; Loreau, M.; Grace, J.B.; Larigauderie, A.; Srivastava, D.S.; Naeem, S. (2012) - Biodiversity loss and its impact on humanity. *Nature*, 486:59-67. DOI: 10.1038/nature11148
- Creado, E.S.J.; Mendes, A.B.V.; Ferreira, L.C.; Campos, S.V. (2008) - Entre "tradicionais" e "modernos": negociações de direitos em duas unidades de conservação da Amazônia brasileira. *Ambiente e Sociedade*, (11):255-271. DOI: 10.1590/S1414-753X2008000200004
- Diegues, A.C. (1999) - *A educação ambiental e a questão das áreas naturais protegidas*. Núcleo de Apoio à Pesquisa sobre Populações Humanas em Áreas Úmidas Brasileiras, Universidade de São Paulo, SP, Brasil. Available on-line at <http://nupaub.fflch.usp.br/sites/nupaub.fflch.usp.br/files/color/educamb.pdf>
- Fernandez, J.C.A.; Mendes, R. (2007) - Gestão local e políticas públicas para qualidade de vida. In: Fernandez, J.C.A.; Mendes, R. (org.), *Promoção da saúde e gestão local*, pp.41-60, Hucitec, São Paulo. ISBN: 978-85-60438-43-3
- Fonseca, I.F.; Bursztyn, M. (2009) - A banalização da sustentabilidade: reflexões sobre governança ambiental em escala local. *Sociedade e Estado*, (24):17-46. DOI: 10.1590/S0102-69922009000100003
- Foucault, M. (2012) - *Microfísica do poder*. Graal, Rio de Janeiro. ISBN: 9788570380883
- Freire, P. (2004) - *Pedagogia da autonomia: saberes necessários à prática educativa*. Paz e Terra, São Paulo. ISBN: 85-219-0243-3
- Freitas, C.M. (2005) - As Ciências Sociais e o Enfoque Ecológico em Saúde. In: Minayo, M.C.S.; Coimbra, J.R. CEA, *Críticas e atuantes: ciências sociais e humanas em saúde na América Latina*, pp. 47-59, Fiocruz, Rio de Janeiro. ISBN: 978-85-7541-392-0
- Gallo, E. (2009) - Alienação, Inovação e Cotidiano Organizacional: Teses e Hipóteses. In: Mandarino, A.C.S.; Gomberg, E. (org.) *Leituras de Novas Tecnologias e Saúde*. EDUFBA, Salvador. ISBN: 9788523206222
- Gallo, E.; Setti, A.F.F. (2012) - Abordagem ecossistêmica e comunicativa na implantação de agendas territorializadas de desenvolvimento sustentável e promoção da saúde. *Ciência e Saúde Coletiva*, (17):1433-1446. DOI: 10.1590/S1413-81232012000600008

- Gallo, E.; Setti A.F.F. (2014) - Território, intersectorialidade e escalas: requisitos para a efetividade dos Objetivos de Desenvolvimento Sustentável. *Ciência e Saúde Coletiva*, 19(11):4383-4396. DOI: 10.1590/1413-812320141911.08752014
- Gallo, E.; Setti, A.F.F.; Ruprecht, T.; Sobrinho, F.X.; Finamore, P.; Shubo, T.; Machado, G. (2015) - Territory, needs and ecology of knowledge: ecological sanitation solution in the Praia do Sono, Paraty, Rio de Janeiro, Brazil. In: Leal Filho, W.; Azeiteiro, U.M.; Alves, F. (eds) *Climate Change and Health: improving resilience and reducing risks*. Springer (no prelo).
- Giddens, A. (2010) - *The politics of climate change*. Polity Press, Cambridge. ISBN: 9780745654645
- Giroux, H.A. (1995) - Praticando Estudos Culturais nas faculdades de educação. In: Silva, T.T. (org.), *Alienígenas na sala de aula: uma introdução aos Estudos Culturais*, pp.85-103, Vozes, Rio de Janeiro. ISBN: 8532614973, 9788532614971
- Gohn, M.G.M. (2004) - Empoderamento e participação da comunidade em políticas sociais. *Saúde e Sociedade*, 13(2):20-31. DOI: 10.1590/S0104-12902004000200003
- González, A.D.; Almeida, M.J. (2010) - Integralidade da saúde – norteando mudanças na graduação dos novos profissionais. *Ciência and Saúde Coletiva*, 15(3):757-762. DOI: 10.1590/S1413-81232010000300018
- Grindle, M. (2007) - Good enough governance revisited. *Development Policy Review*, 25(5):553-574. DOI: 10.1111/j.1467-7679.2007.00385.x
- Guimarães, R.P. (2001) - A ética da sustentabilidade e a formulação de políticas de desenvolvimento. In: Viana, G.; Silva, M. (org.). *O desafio da sustentabilidade*, Fundação Perseu Abramo, São Paulo. ISBN: 2147483647
- Habermas, J. (1997) - *Direito e democracia: entre facticidade e validade*. 354p. Tradução: Siebeneichler, FB. Tempo Brasileiro, Rio de Janeiro. ISBN: 85-282-0091-4
- Keesing, F.; Belden, L.K.; Daszak, P.; Dobson, A.; Harvell, D.C.; Holt, R.D.; Hudson, P.; Jolles, A.; Jones, K.E.; Mitchell, C.E.; Myers, S.S.; Bogich, T.; Ostfeld, R.S. (2010) - Impacts of biodiversity on the emergence and transmission of infectious diseases. *Nature*, 468(7324):647-652. DOI: 10.1038/nature09575
- Lafer, C. (1988) - *A reconstrução dos direitos humanos. Um diálogo com o pensamento de Hannah Arendt*. 416p. Companhia das Letras, São Paulo. ISBN: 9788571640115
- Luckesi, C.C. (2012) - *Fazer universidade: uma proposta metodológica*. Cortez, São Paulo. ISBN: 8524901608
- Machado, M.K. (2014) - *Águas do Cantareira: Governança e diálogo de saberes*. 175p. Universidade de São Paulo, Piracicaba, Brasil. Available on-line <http://www.teses.usp.br/teses/disponiveis/91/91131/tde-07112014-150736/pt-br.php>
- Mattoso, A.; Moraes, G. (2006) - *Dossiê Mosaico Bocaina. Projeto Mosaicos do Corredor da Serra do Mar*. 12p. Reserva da Biosfera da Mata Atlântica, São Paulo. Available on-line http://www.rbma.org.br/programas/docs_programas/mosaicos_corredores_ecologicos/01_06_06.pdf
- Matus, C. (1993) - *Política, planejamento e governo*. 591p. IPEA, Brasília, Distrito Federal. ISBN: 361-0509180915
- Merhy, E.E. (2002) - *Saúde: a cartografia do trabalho vivo*. 189p. Hucitec, São Paulo. ISBN: 978-8527105804
- Oakley, P.; Clauton, A. (2003) - *Monitoramento e avaliação do empoderamento*. 97p. Intrac, São Paulo, SP, Brazil.
- ONU (2000) - *Convenção sobre Diversidade Biológica. Cópia do Decreto Legislativo no. 2, de 5 de junho de 1992*. 30p., Ministério do Meio Ambiente, Brasília, DF, Brazil. Available on-line at: http://www.mma.gov.br/estruturas/sbf_chm_rbbio/_arquivos/cdbport_72.pdf
- OPAS (2009) - *Enfoques ecossistêmicos em saúde – perspectivas para sua adoção no Brasil e países da América Latina*. 48p. Organização Pan-Americana da Saúde, Brasília. ISBN: 978-8587943958. Available on-line http://www.paho.org/bra/index.php?option=com_docman&task=doc_view&gid=158&Itemid=614
- Ribeiro, H.; Günther, W.M.R.; Araújo, J.M. (2002) - Avaliação qualitativa e participativa de projetos: uma experiência a partir de pesquisa em educação ambiental e saneamento do meio. *Saúde e Sociedade* (ISSN: 0104-1290), (11):23-37, São Paulo, SP, Brazil. Available on-line <http://www.scielo.br/pdf/sausoc/v11n2/08.pdf>
- Santos, B.S. (2000) - *A crítica da razão indolente: contra o desperdício da experiência*. 376p., Edições Afrontamento, Porto, Portugal. ISBN: 9789723605242
- Santos, M. (2003) - *Por uma outra globalização: do pensamento único à consciência universal*. 174p. 10ª ed. Record, Rio de Janeiro. ISBN: 978-8501058782
- Santos, B.S. (2007) - Para além do pensamento abissal: das linhas globais a uma ecologia de saberes. *Novos estudos CEBRAP*, (79):71-94. DOI: 10.1590/S0101-33002007000300004
- Schmidt, L.; Guerra, J. (2010) - Da Governança Global à Sustentabilidade Local - Portugal e o Brasil em Perspectiva Comparada. *Revista de Ciências Sociais* (ISSN: 0041-8862), 41 (2):106-124, Ceará, Brasil. Available on-line at: http://www.ces.uc.pt/cesfct/pp/criatividade_urbana.pdf
- Setti, A.F.F.; Bógus, C.M. (2010) - Participação comunitária em um programa de intervenção em área de proteção ambiental. *Saúde e Sociedade*, 19(4):946-960. DOI: 10.1590/S0104-12902010000400020
- Setti, A.F.F.; Gallo, E. (2013) - Educação e Meio Ambiente: princípios e desafios para produção da autonomia. In: Mandarino, A.C.S.; Gallo, E.; Gomberg, E. (org.), *Informar e Educar em Saúde: análises e experiências*. 267p. Edufba, Salvador, Brasil. ISBN: 978-8523210427
- Setti, A.F.F.; Ribeiro, H.; Gallo, E.; Alves, F.; Azeiteiro, U.M. (2015) - Climate Change and Health: governance mechanisms in traditional communities of Mosaico Bocaina/Brazil. In: Leal Filho, W.; Azeiteiro, U.M.; Alves, F. (eds), *Climate Change and Health: improving resilience and reducing risks*, Springer (no prelo)
- Tavares, R.C. (2014) - O sentimento de pertencimento social como um direito universal. *Caderno Pesquisa Interdisciplinar em Ciências Humanas, Florianópolis, Santa Catarina*, 15(106):179-201. DOI: 10.5007/1984-8951.2014v15n106p179
- Thiollent, M. (2006) - *Metodologia da pesquisa-ação*. 112p. Cortez, São Paulo. ISBN: 9788524911705
- Toledo, R.F.; Giatti, L.L.; Jacobi, P.R. (2014) - A pesquisa-ação em estudos interdisciplinares: análise de critérios que só a prática pode revelar. *Interface* (ISSN: 1807-5762), 18(51):633-46, Botucatu, SP, Brazil. DOI: 10.1590/1807-57622014.0026
- Weiss, E.B. (1992) - In Fairness To Future Generations and Sustainable Development. *American University International Law Review*, 8(1):19-26. Available on-line at <http://digitalcommons.wcl.american.edu/cgi/viewcontent.cgi?article=1498&context=auilr>
- Westphal, M.F.; Fernandes, J.C.A.; Nascimento, P.R.; Zioni, F.; André, L.M.; Mendes, R.; Noronha, G.P.; Moreira, R.S. (2013) - Práticas democráticas participativas na construção de agendas sociais de desenvolvimento em municípios do sudeste brasileiro. *Ambiente and Sociedade*, 16:103-128. DOI: 10.1590/S1414-753X2013000200007
- Zanirato, S.H.; Ribeiro, W.C. (2007) - Conhecimento tradicional e propriedade intelectual nas organizações multilaterais. *Ambiente & Sociedade*, 10(1):39-55. DOI: 10.1590/S1414-753X2007000100004

Legislation

- DOU (2000) - *Lei no 9.985, de 18 de julho de 2000. Institui o Sistema Nacional de Unidades de Conservação da Natureza e dá outras providências. Diário Oficial da União*, Seção 1, 19/07/2000, p.1. Available on-line at: http://www.planalto.gov.br/ccivil_03/leis/19985.htm
- DOU (2006) Portaria MMA nº 349, de 11 de dezembro de 2006 - Reconhece como mosaico de unidades de conservação da região da Serra da Bocaina. *Diário Oficial da União*, Seção 1, 12/12/2006, p.71. Available on-line at: <http://www.mma.gov.br/legislacao/areas-protegidas>
- DOU (2007) Decreto Lei nº 6040, de 07 de fevereiro de 2007 – Institui a Política Nacional de Desenvolvimento Sustentável dos Povos e Comunidades Tradicionais. *Diário Oficial da União*, Seção 1, 8/2/2007, p.316. Available on-line at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/decreto/d6040.htm

Evaluation of Coastal Scenery in Urban Beaches: Torres, Rio Grande do Sul, Brazil*

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ABSTRACT

The Brazilian coastal zone (CZ) is recognized as a National Heritage by the Federal Constitution and the lack of adequate planning results in inappropriate soil occupation, which threatens the integrity of the coastal and marine environments. In this context, the recognition of coastal and adjacent marine zone characteristics is essential for adequate CZ planning. This research evaluated coastal scenery of Torres municipal district, located on the north coast of Rio Grande do Sul State, south of Brazil, which receives a large number of visitors during the summer season, i.e. from December to March. In January 2014, a landscape quality evaluation of the beaches was realized. The method evaluates 26 natural and human parameters in order to classify beaches into 5 classes' class 1 being the one with the highest landscape attractiveness and class 5 the less attractive one. In order to apply the checklist, the Torres coastline was divided into 12 sectors. These are all urban beaches, so human related characteristics had considerable weight on the analysis results indicated that the assessed sectors are distributed between classes 3, 4 and 5. The Guarita Park beach stands out from the others, being the only one classified as a class 3. Cal and Molhes beaches were classified as class 4, and the other sectors were classified as class 5. Results highlighted poor coastal zone management with much litter being found on the beaches, tourist support facilities located in inappropriate places together with discharge of waste waters from effluents. Most sites have physical parameters for which coastal zone managers can do little or nothing to alleviate scenic impact, so emphasis should be given to assessing ways of improvement/upgrading the different human usage parameters, amongst them special attention must be devoted to litter and waste water management.

Keywords: coastal management; coastal landscape; landscape quality.

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RESUMO**Avaliação da paisagem costeira em Praias Urbanas: Torres, Rio Grande do Sul, Brasil**

A Zona Costeira (ZC) brasileira é reconhecida como Patrimônio Nacional pela Constituição Federal, devido a sua biodiversidade e beleza paisagística. A falta de planejamento resulta na ocupação inadequada do solo ameaçando à integridade dos ambientes costeiros e marinhos. Neste contexto, o reconhecimento das características da região costeira e marinha adjacente é fundamental para o planejamento adequado da ZC. A presente pesquisa objetivou avaliar o cenário costeiro do município de Torres, Litoral Norte do Estado do Rio Grande do Sul, sul do Brasil. As praias de Torres recebem um grande público na temporada de verão (dezembro a março) e devido a isso foi realizada, em janeiro de 2014, a avaliação da qualidade paisagística das mesmas. O método utilizado foi o Sistema de Avaliação de Cenário Costeiro proposto por Ergin *et al.* (2004, 2006, 2011), que consiste na avaliação de 26 parâmetros, tanto naturais quanto antrópicos, com resultados incorporados em 5 classes, sendo a classe 1 a de maior atratividade paisagística e a 5 de menor atratividade. Para a aplicação do checklist, dividiu-se o litoral de Torres em 12 setores. Os resultados demonstram que os setores avaliados distribuíram-se entre as classes de paisagem 3, 4 e 5. O Sistema de Avaliação de Cenário Costeiro empregado evidenciou a gestão deficitária da orla, com ocorrência de resíduos na faixa de praia, colocação de equipamentos de apoio ao turista em locais inapropriados e a descarga de efluentes. Por se tratarem de praias urbanas, as características antrópicas tiveram um peso considerável na análise. A praia do Parque da Guarita se destacou das demais, sendo a única enquadrada na classe 3. As praias da Cal e dos Molhes se enquadraram na classe 4 de qualidade paisagística e os demais setores foram enquadrados na classe 5. A baixa atratividade da paisagem é resultante de fatores naturais e antrópicos, destacando-se o acúmulo de resíduos sólidos na faixa de praia – problema que pode ser manejado. No cenário das praias do Rio Grande do Sul, Torres é detentor de uma paisagem singular, com elevado potencial turístico, mas com problemas de planejamento e gestão. O município tem uma economia consistente e com infraestrutura para atender a demanda turística e, neste contexto, a avaliação da qualidade dos cenários costeiros do município pode ser uma ferramenta importante para subsidiar uma melhor gestão de sua paisagem.

Palavras-chave: gestão costeira; paisagem litorânea; qualidade paisagística.

1. Introduction

The Brazilian Coastal Zone (CZ) is recognized as a National Heritage by the Federal Constitution due to its scenic beauty and inherent biodiversity. The marine and coastal zones represent more than 50% of the Brazilian territory, covering a large diversity of ecosystems, such as coral reefs, mangroves, marshes, dunes, beaches, rocky shores, cliffs and estuaries (MMA, 2010).

Brazil consists of 26 states, of which 17 have an interface with the sea. Among the seven most populated metropolitan regions of the country, four are situated in the Coastal Zone: Rio de Janeiro (RJ), Recife (PE), Salvador (BA) and Fortaleza (CE) (IBGE, 2010). The urbanization rate of the country went from 36% in 1950 to 84.4% in 2010 (IBGE, 2010). Currently, the Brazilian Coastal Zone has 44 million inhabitants, with a population density six times higher than the national average (135 inhabitants/km²) (Oliveira & Nicolodi, 2012).

Lack of planning associated with the proliferation of areas for second residences, hotel projects and bathing areas has created inadequate land occupation, with landscape alteration and destruction of coastal and marine ecosystems. Recognition of the physiographic characteristics of the coastal and adjacent marine zone is fundamental for sound CZ planning. This must be carried out through observation of coastal geology/geomorphology and the interaction between the marine and coastal systems, all working as a basis for management, use, and occupation of the coast planning programs (Gruber *et al.*, 2003).

The current research consists of a coastal scenery evaluation of Torres, a municipal district located on the north coast of Rio Grande do Sul, Brazil, using the Evaluation of Coastal Scenery System proposed by Ergin *et al.* (2004, 2006, 2011). This method consists of a checklist application with natural and human related parameters, considered essential for an attractive coastal landscape. The Torres' coastal region, having approximately 16 km of coast (SI-I Figure 1), is limited at the north by the Mampituba river and at the south by the municipality of Arroio do Sal. It is the only coastal municipality of the State with cliffs which are being eroded. Torres has a large biodiversity of coastal landscapes, with the mouth of the Mampituba river, Violão Lagoon, cliffs, sandy beaches, an island, and dune fields. More information regarding the geological, ecological and social economic contexts of Torres is presented in SI-I text.

2. Material and methods

Evaluation of the Torres coastal scenery landscape quality was carried out through application of the Coastal Scenery Evaluation System proposed by Ergin *et al.* (2004, 2006, 2011). This methodology utilizes fuzzy logic to estimate weights for 26 parameters (18 relative to physical parameters – P - and 8 human related parameters – H) considered essential for an attractive coastal landscape. The main parameters which denote landscape quality were classified in a scale from 1 (absence/bad quality) to 5 (presence/excellent quality). A mathematical model based on fuzzy logic was utilized to integrate the parameters' weights in a special

system for the scenarios' classifications. The value "D" is the indicator of attractiveness of the evaluated place. The system has five classes according to the following "D" value (Ergin *et al.*, 2008, 2011):

- Class 1** (D value > 0.85): extremely attractive natural site;
- Class 2** (D value 0.85 – 0.65): natural, attractive areas with high landscape value;
- Class 3** (D value 0.64 – 0.4): mostly natural areas with low landscape value;
- Class 4** (D value 0.39 – 0): urban areas, mainly unattractive, with low landscape value;
- Class 5** (D value < 0): unattractive urban areas, with intense development and low landscape value.

The municipality coast was divided into sectors according to its landscape diversity. Some sectors coincidentally agreed with sections of well-defined beaches, others are subdivided, as deemed convenient for a better assessment of the coastal scenery. Figure 1 presents the municipality coast division in the 12 sectors. The checklist was applied during the summer season of 2013/2014 (January 2014), i.e. the period with the highest tourist

activity and each coastal sector was evaluated by means of field observations. The field team was formed by professionals of different disciplines, such as, geography, oceanology, and biology.

The method utilized in this study has already been tested in many–other places, such as, New Zealand, Australia, Japan, United States, Pakistan, Colombia, Cuba and Spain (*i.e.* Williams *et al.*, 2012; Rangel-Buitrago *et al.*, 2013; Anfuso *et al.*, 2014). The results can be used to open new perspectives not only in relation to the potential development of coastal tourism in natural areas, but also in relation to policies for improving landscapes in current tourist areas (Rangel-Buitrago *et al.*, 2013).

3. Results and discussion

Results from this study showed that the 12 assessed sectors of Torres coastline were distributed amongst landscape quality classes 3, 4 and 5 (Figure 2). Since the investigated areas are essentially urban, the human related attributes acquired a considerable weight, especially regarding human occupation (presence of litter and sewage evidences), and social economic activities.

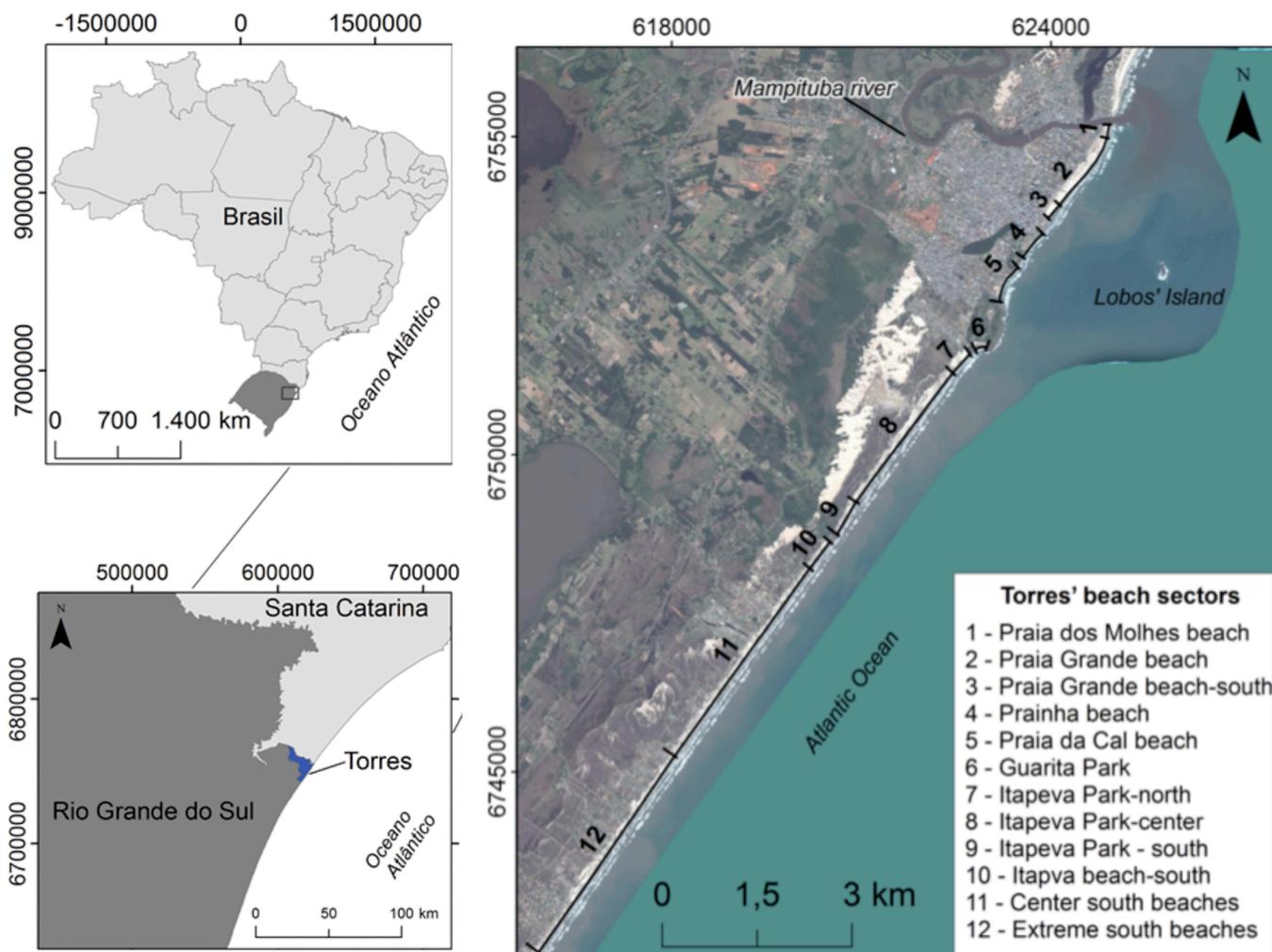


Figure 1 – Torres beach sectors evaluated to determine their landscape quality (base map ESRI, UTM-WGS84, 22J).

Figura 1 - Divisão dos setores praias de Torres avaliados quanto a sua paisagem (mapa base ESRI, UTM-WGS84, 22J).



Figure 2 – Distribution of evaluated beach sectors and their respective classes (base map ESRI –WGS84, 22J).

Figura 2 - Distribuição dos setores praias avaliados e respectivas classes (mapa base ESRI, UTM-WGS84, 22J).

Guarita Park beach stood out from the others, being the only one in class 3, with a D value of 0.52. This sector presented intermediate and low values for the physical and human related parameters, respectively (Figure 3A). Such scoring was influenced due to the vehicle access control in this section of the Guarita Park, as well as the presence of few seaside bars and restaurants. Undoubtedly Guarita Park constitutes an outstanding landscape site, with active cliffs of pink sandstone, which stand out of the sandy landscape; it has a high weighted average of physical parameters. The anthropogenic pressure is evident due to the presence of few litter items along the beach. In the membership degree curve, the graph inclination reflects the value of the evaluated attributes (Williams *et al.*, 2012). In the Guarita Park, the steepening (between 3 and 5) reflected the higher scenic values.

Praia da Cal beach ($D=0.05$) and Praia dos Molhes beach ($D=0.04$) were classified as class 4. The beaches present several natural scenic attractions, however they are highly influenced by humans parameters. Praia da

Cal beach presents a long stretch of rocky coast; however, there is evidence of contaminated effluents (two spillways) and the presence of urbanization on the frontal dunes and the backshore. This beach presents a high concentration of beachgoers during summer months, culminating in a negative impact caused by the accumulation of litter. The weighted averages of this sector are balanced in their respective values for the physical and human related parameters (Figure 3B). When comparing the membership degrees of Praia da Cal beach and Praia dos Molhes beach with Guarita Park's, it is possible to note that there is a greater score in averages in lower attributes' values (1 and 2), which reflect the negative impact of physical or human parameters (Figures 3B and 3C).

Praia dos Molhes beach, located close to the mouth of the Mampituba river, has several attractions, i.e. the presence of sea lions close to breakwaters and dolphins at the river mouth. Behind the beach there is a well-developed dune system, covered by native vegetation. The urbanized area along the margins of the Mampituba

river is responsible for pollution due to domestic sewage, which can be seen at the river mouth which is very close to the beach. As a consequence, at this beach portion, bathing is not allowed during a few months of the year, a factor that increased the weighted averages of the evaluated human related parameters (Figure 3C). The highest concentration of vegetation debris occurs next to the Praia dos Molhes beach sector, where aquatic macrophytes and other residues reach the sea through the Mampituba river's mouth. These are deposited on the beach by wave action, conferring an unpleasant effect on the landscape during some periods, especially when river discharges increase because of heavy rainfall in the basin. This aspect, a result of natural processes associated with anthropogenic impacts, reduces the landscape value of some beaches, particularly those located near mangroves (Anfuso *et al.*, 2014). Investment of resources for the removal of vegetation accumulated on this beach portion is often required.

The majority of Torres beaches obtained scores corresponding to class 5 on the landscape quality evaluation.

In a few cases, give names this classification was linked to the low attractiveness of the natural landscape associated with poor management, which does not take into account basic parameters of health and environmental well being. In other cases, -give names the attractiveness of the natural landscape was favorable, but human related factors contributed negatively on the assessment. The beaches ranking class 5 were: Praia Grande beach - south (D=-0.46) (Figure 4A), Itapeva Park - north (D=-0.42) (Figure 4B), Praia Grande beach, Extreme south beaches (D=-0.25); Centre south beaches (D=-0.22) and Itapeva Park - center (D=-0.14). Stand-out sectors of beaches ranked class 5, however with values very close to class 4 were: Prainha beach (D=-0.06), Itapeva Park - south (D=-0.02) and Itapeva beach - south (D=-0.03), caused by the anthropogenic influence. The presence of litter on these three sectors, and evidence of sewage discharge, made some beaches unsuitable for bathing purposes.

The membership degree curves reflect the attributes value, and, in the case of Torres, some beaches in the same Class (5) show peculiar curves (Figure 4). In the

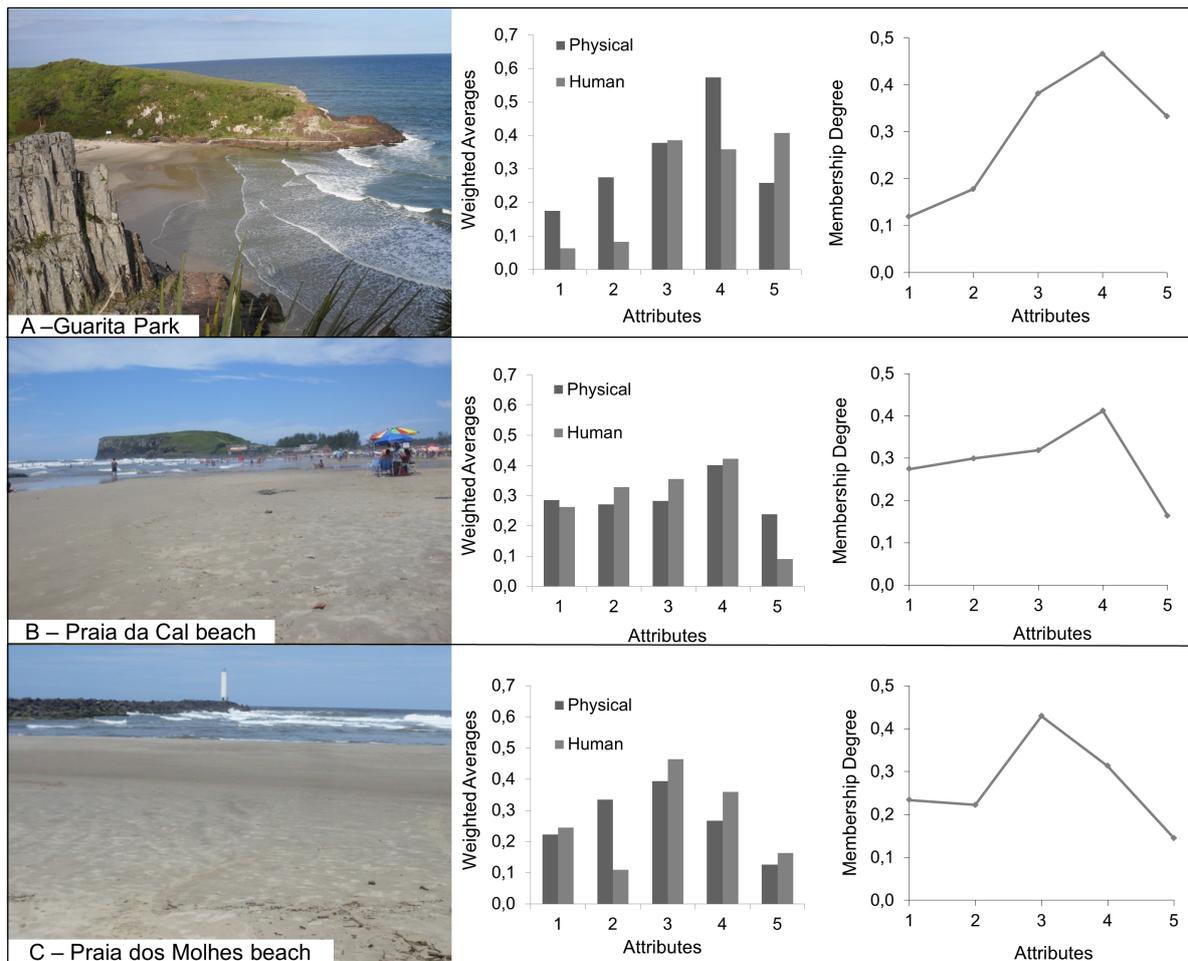


Figure 3 – Photography, weighted average for physical and anthropic parameters and membership degree for the beaches: A) Guarita Park; B) Praia da Cal beach; and C) Praia dos Molhes beach.

Figura 3 – Fotografias, médias ponderadas dos parâmetros físicos e antrópicos e grau de pertinência das praias: A) Guarita Park; B) Praia da Cal; e C) Praia dos Molhes.

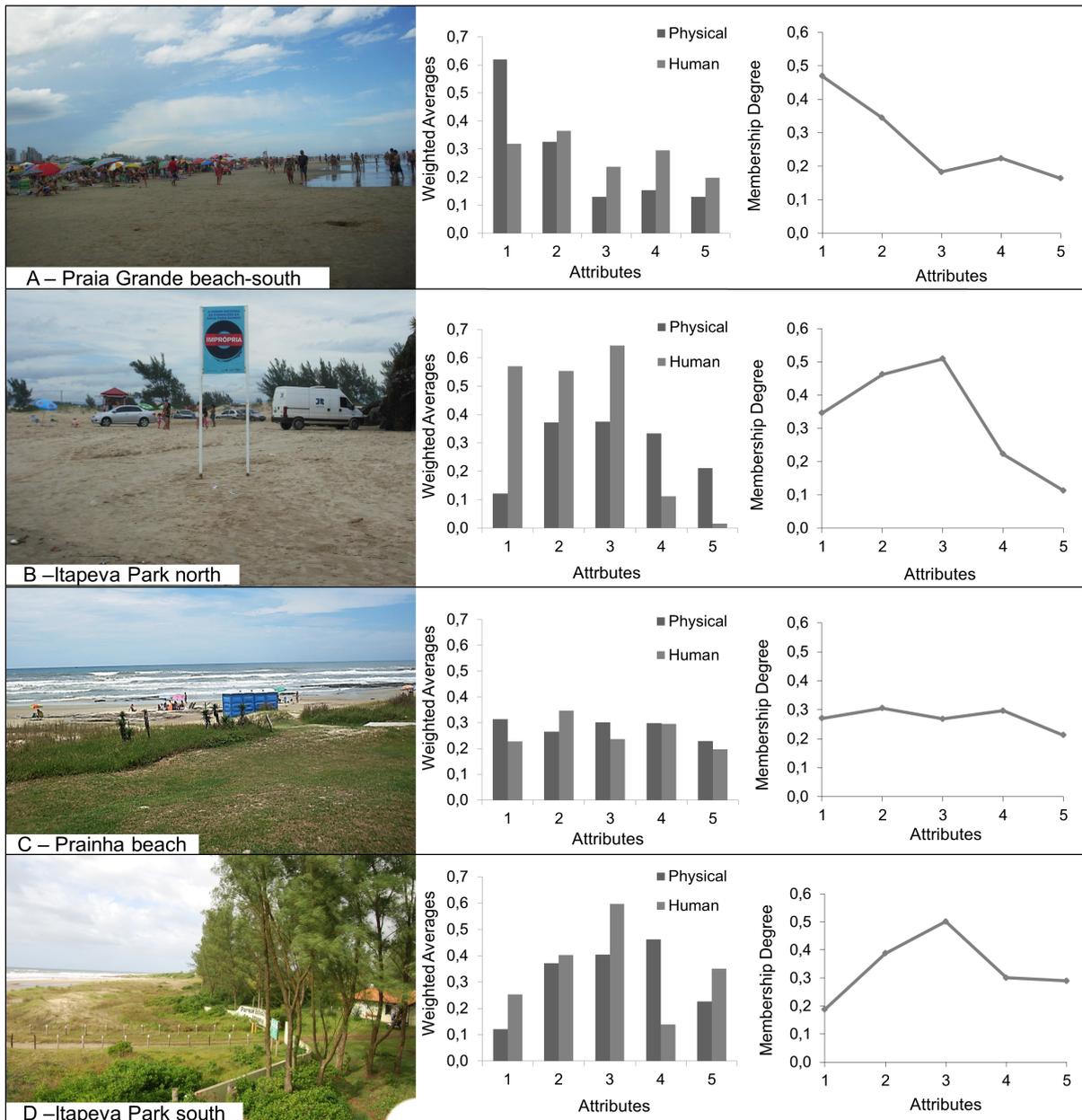


Figure 4 – Photography, weighted average for physical and anthropic parameters and membership degree for beaches: A) Praia Grande beach - south; B) Itapeva Park - north; C) Prainha beach; and D) Itapeva Park - south.

Figura 4 – Fotografias, médias ponderadas dos parâmetros físicos e antrópicos e graus de pertinência das praias: A) Praia Grande sul; B) Itapeva Park norte; C) Itapeva Park; e D) Itapeva Park sul.

Praia Grande beach there are low attributes' values, between 1 and 2; for the sector Itapeva Park-north, there is a greater curve steepening between values from 1 to 3 (value 3 due to the most attractive landscape); for Prainha beach, the graph shows a more straight line with constant attributes' values – results of a great quality landscape, impoverished by the installation of public facilities in unsuitable areas; for Itapeva Park-south, the graph shows steepening in attribute 3, but considerable values for attributes 2, 4 and 5 – the last ones emphasizes the positive landscape aspects in the conservation unit beach.

The sectors of Prainha beach (Figure 4C), Itapeva Park - south (Figure 4D) and Itapeva beach – south, may upgrade from class 5 to class 4 if management measures are taken. These sectors present high values for the physical parameters, but equally high values for the human related parameters. They are beaches of relevant natural characteristics, with occurrence of rocky shores outcrops contrasting in beaches with clear sand. Inadequate management on these beaches damages the landscape quality. It is possible to observe for example, the installation of chemical toilets on the beach area of Prainha beach sector that, in addition to disfiguring the

landscape, give an unpleasant odour and possible contamination resulting from poor handling, vandalism, tides and wind. These factors give high attribute (negative) values to the human related parameters.

In the sector of Itapeva Park - south and Itapeva beach - south, the landscape was also damaged due to the public accessing the beach by vehicles, which generates noise and degrades the environment. However, in May 2015, the Federal Public Ministry associated with Itapeva Park, whose land use plan is currently under review decided to prohibit-all vehicle access to Torres beaches. Accordingly there is a trial period for the regulated use of vehicles in the Itapeva Park area; which the Municipal government did not attend. I do not follow this Is the sentence now correct The Federal Public Ministry founded its decision on the fact that the high circulation of vehicles causes segmentation of the dune environment, pollutes beaches with residues and noise, and creates insecurity to beach users. The decision brings benefits to the Torres coastal landscape, but the importance of management actions, such as the establishment of parking lots and instruments to support tourism that meets environmental conditions, as well as effective supervision, should be noticed.

Evaluation of Torres coastal scenery resulted in the distribution of its beaches between the classes 3, 4 and 5, i.e. they ranged from mainly natural areas with a few valuable scenery parameters to urban unattractive beaches, with intensive development and low landscape features. More discussions about Torres coastal landscape conservation and management are provided in SI-III.

4. Conclusion

The method utilized for the classification of Torres coastal scenery was extremely effective. It is evident that, among the landscape degradation factors, there are several ones linked to poor and insufficient management practices. Practices that stood out in some sectors include: (i) the disposal of litter on the coast, due to the lack of appropriate bins and environmental awareness actions; (ii) the placement of tourist support facilities in inappropriate places, such as chemical toilets and a large number of kiosks and restaurants on the coast; and (iii) sewage discharge, which gives rise to unsuitable conditions for bathing.

In general, the obtained D values (classes 3 to 5) reflect the urban characteristics of almost all investigated beaches. Only the natural beach of Guarita Park belonged to class 3. The beach reached this status because it is situated in a natural park, combining an attractive natural landscape with low anthropogenic impact. The beaches with lower landscape attractiveness are intensively used, being located in large urban areas with poor natural scenery parameters.

Within Rio Grande do Sul State, Torres municipality has a unique landscape characterized by sandy sectors and well developed cliffed sectors, which give high scenery values and a huge tourist potential. Loose or poor management was-observed at many places. The results of this study can contribute to improvement of the management of the Torres beaches favouring coastal development in accordance with the preservation of an attractive landscape, that is only possible through adequate management and supervision measures.

Acknowledgments

The authors thank the *Secretaria de Meio Ambiente* (Department of Environment) of the *Prefeitura Municipal de Torres* (Torres' City Hall) for providing the Coastal Dunes Management Plan of the municipality for scientific purposes. We also thank the Graduate Program in Geosciences/UFRGS, by narrowing the Brazil-Spain link, enabling scientific and experiential exchange between professionals within the scope of coastal areas management.

Appendix

Supporting Information associated with this article is available online at http://www.aprh.pt/rgci/pdf/rgci-661_Cristiano_Supporting-Information.pdf

References

- Anfuso, G.; Williams, A.T.; Cabrera-Hernández; Pranzini, E. (2014) - Coastal scenic assessment and tourism management in western Cuba. *Tourism Management*, 42:307-320. DOI: 10.1016/j.tourman.2013.12.001
- Ergin, A.; Karaesmen, E.; Micallef, A.; Williams, A. T. (2004) - A new methodology for evaluating coastal scenery: fuzzy logic systems. *Area*, 36:367-386. DOI: 10.1111/j.0004-0894.2004.00238.x
- Ergin, A.; Williams, A.T.; Micallef, A. (2006) - Coastal scenery: appreciation and evaluation. *Journal of Coastal Research*, 22(4):958-964. DOI: 10.2112/04-0351.1
- Ergin, A.; Karaesme, E., Uçar, B. (2011) - A quantitative study for evaluation of coastal scenery. *Journal of Coastal Research*, 27(6):1065-1075. DOI: 10.2112/JCOASTRES-D-09-00093.1
- Gruber, N. L. S.; Barboza, E. G.; Nicolodi, J. L. (2003) - Geografia dos Sistemas Costeiros e Oceanográficos: Subsídios para Gestão Integrada da Zona Costeira. *Gravel* (ISSN 1678-5975), 1: 81-89, Porto Alegre, RS, Brasil. Available on-line at http://www.ufrgs.br/gravel/1/Gravel_1_07.pdf
- IBGE - Instituto Brasileiro de Geografia e Estatística (2010) - *Censo Demográfico 2010*. Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, RJ, Brasil. Available on-line at <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/default.shtm>.
- MMA, Ministério do Meio Ambiente (2010) - *Panorama da conservação dos ecossistemas costeiros e marinhos no Brasil*. Brasília: MMA, 2010. Available on-line at http://www.mma.gov.br/estruturas/205/_publicacao/205_publicacao03022011100749.pdf
- Oliveira, M.R.L.; Nicolodi, J.L. (2012) - A gestão costeira no Brasil e os dez anos do Projeto Orla – Uma análise sob a ótica do poder público. *Revista de Gestão Costeira Integrada*, 12(1):89-98. DOI: 10.5894/rgci308.
- Rangel-Buitrago, N.; Correa, I.D.; Anfuso, G.; Ergin, A.; Williams, A.T. (2013) - Assessing and managing scenery of the Caribbean Coast of Colombia. *Tourism Management*. 35:41-58. DOI: 10.1016/j.tourman.2012.05.008.

Williams, A.T; Micallef, A.; Anfuso, G.; Gallego-Fernandez, J.B.
(2012) - Andalusia, Spain: An Assessment of Coastal Scenery.
Landscape Research, 37(3): 327-349. DOI:
10.1080/01426397.2011.590586

Gender Specific Vulnerability in Climate Change and Possible Sustainable Livelihoods of Coastal People. A Case from Bangladesh*

Joydeb Garai^{@, a}

ABSTRACT

The paper addresses the gender specific vulnerability of coastal people in climatic hazards in Bangladesh. This study has been conducted by qualitative methods with some qualitative tools i.e. Key Informants Interview (KII) and Focus Group Discussion (FGD) to get the vivid and comprehensive views about gender specific susceptibility of climate induced hazards from social, gender, cultural and behavioral perspectives. The paper explores the gender specific vulnerability of climate change and possible sustainable livelihoods of coastal people in Bangladesh. This paper finds that climate change is not gender neutral. It affects men and women differently for their roles and responsibilities in the society. Women's roles are often confined to household labor such as looking after children and ailing people, as well as disaster specific roles such as saving properties from obliteration. These roles make women particularly vulnerable in natural hazards. By contrast, men's roles often include working outside and so are more likely to escape natural hazards. The paper also finds that woman's dependency on natural resources is severely affected by climate change variability which causes vulnerability to women in natural hazards. This paper outlines key considerations of gender and climate change that can help policy makers improve policy and implementation for the diminution of vulnerability of women in Bangladesh as well as developing countries of the world.

Keywords: Climate Change; Climate Change Impacts; Gender Division of Labor; Gender Specific Vulnerability; Coastal People.

RESUMO[§]

Vulnerabilidade específica de género na mudança climática e possíveis modos de vida sustentável de populações costeiras. Um caso do Bangladesh.

O artigo aborda a vulnerabilidade específica de género de populações costeiras no que se refere a riscos climáticos no Bangladesh. Este estudo foi realizado através de métodos qualitativos com algumas ferramentas qualitativas, isto é, entrevistas a informadores chave (KII) e Grupos Foco de Discussão (FGD), por forma a obter pontos de vista vivos vívidos e abrangentes sobre a susceptibilidade específica relativa ao género relativamente a riscos climáticos decorrentes de perspectivas sociais, de género, culturais e comportamentais. O artigo explora a vulnerabilidade específica de género às alterações climáticas e possíveis modos de vida sustentáveis de populações costeiras no Bangladesh. Conclui-se que a mudança climática não é neutra no que se refere ao género. Afecta de forma diferente os homens e as mulheres no que se refere aos papéis que desem-

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§ Portuguese versions of title, abstract and captions by Maria Beleza on behalf of the Editorial Board



penham e às responsabilidades que têm na sociedade. O papel das mulheres limita-se, muitas vezes, ao trabalho doméstico, tal como cuidar das crianças e de pessoas com dificuldade, bem como desempenham funções específicas em situações de desastre, como proteger bens da destruição. Essas funções tornam as mulheres particularmente vulneráveis em caso de ocorrerem desastres naturais. Por outro lado, os papéis dos homens muitas vezes incluem trabalhar fora e por isso são mais propensos a escapar riscos naturais. Conclui-se, também, que a dependência da mulher relativamente aos recursos naturais é gravemente afectado pela variabilidade da mudança climática, o que induz maior vulnerabilidade das mulheres aos riscos naturais. O artigo tece considerações sobre o género e a mudança climática, que podem auxiliar os decisores políticos a melhorar a implementação de políticas tendentes a diminuir a vulnerabilidade das mulheres do Bangladesh e de outros países em desenvolvimento.

Palavras-chave: Alterações Climáticas; Impactos das Mudanças Climáticas; Divisão Sexual do Trabalho; Vulnerabilidade Específica de Género; Populações Costeiras.

1. Introduction

There is a growing international consensus that climate change is one of the most serious challenges to current and future sustainable development. Adverse impacts of climate change have already been observed on the environment, natural resources, food security, human health, economic activities, and physical infrastructures (Garai, 2014). The recent global assessment report on climate change inducing natural disasters of the United Nations shows that the number of natural hazards, economic losses and number of people affected are increasing at a rapid rate, faster than risk reduction can be achieved (UN-ISDR, 2009). Considering this issue, scientists and environmentalists express apprehension and propose different models for mitigating natural disasters and making sustainable development in the planet.

To many, Bangladesh is almost synonymous with disaster (Cannon, 2002). The UNDP has identified Bangladesh to be the most vulnerable country in terms of cyclone and the 6th most vulnerable country in terms of floods (Siddiqui, 2010). Reports published by German watch⁷ and climate vulnerability monitors 2010: The states of climate crisis have also found Bangladesh as one of the most vulnerable countries (Ahmed 2012). Floods and cyclones in Bangladesh are also predicted to increase in frequency, severity, and duration and extent (Cannon, 2002). Climate change variability is expected to increase the severity of cyclones and the tidal surges by 2050, combined with an expected rise in sea level. Climate change inducing tidal surges are projected to inundate an additional 15% of the coastal area. Bangladesh has been incurring significant damages in terms of crops losses, destruction of roads and other infrastructure, disruption of industry and small scale entrepreneurs, and injures and losses in human every three to five years (Ahmed 2012).

Recently to address the challenges of climate change significant attention has been given to gender perspectives and the inclusion of women in disaster management and mitigation. It is widely understood that climate change shape men and women in diverse way due to the existing inequalities such as their role and responsibility in the society, and access to resources and

power relations that may affect severely to the ability to cope with the hazards of climate change (WEDO 2007, Canvajal *et al.*, 2008, BRIDGE 2008, IPCC 2007).

Gender differences in vulnerability to climate change related disaster is severe in Bangladesh. Like many other developing countries of the world, Bangladeshi women have limited access to resources and decision making power. They carry the major responsibility for household water supply, as well as, energy gathering for cooking and food security. As a result, women face multiple challenges in coastal area because their gendered labor roles are severely affected by climate change. This paper will shed light on the gender specific vulnerability of climatic hazards and possible sustainable livelihoods of coastal people in Bangladesh.

2. Climate Change, Hazards and Gendered Vulnerability

Climate change is one of the most important development challenges in recent time. Climate change requires immediate attention as it has discernable and indeed worsening effects on human communities (IPCC, 2007). The worsening effects of climate change affect women severely for gender differentiated attitudes of the people in the society. The gender differentiation is detected in every stratum of social institutions ranging from family to religious groups to caste systems, political and legal structures, economic and educational institutions and the mass media and so on. Gender differentiated attitudes creates gender inequality between men and women and constraints women to own her rights in the society. Moreover, socially constructed role and responsibility leads women to be much more susceptible than men to poverty. Furthermore, along with poverty, climate change intensified the existing vulnerability in terms of accessing natural resources, further constraints women's ability to adapt to climate variability and change.

Gender also intersects with other social categories. For example, women in developing countries rural areas depend on natural resources, such as water, and agricultural and forest products, for their livelihood, making them particularly vulnerable to changes in availability

and access. Climate change is widely anticipated to affect all these areas of women's life adversely (Terry, 2009). Along with rurality, poverty and social and cultural norms are also responsible for women's greater vulnerability. For example, religious taboos often restrict women from going outside. If women live in housing unable to withstand environmental hazards, their restricted movement would make them more vulnerable. For instance, following the cyclone and flood of 1991 in Bangladesh the death rate was almost five times as high for women as for men. Because like many other Asian countries women have never learned swim due to religious orthodoxy and cultural norms, consequently reduce their survival chances in natural hazards (Rohr, 2005). According to a recent report from the World Conservation Union / Women's Environment and Development Organization (IUCN/WEDO,) women and children are fourteen times more likely to die than men during disaster ((IUCN/WEDO, Broady *et al.*, 2008). One example is the Asian Tsunami of 2004 where the largest numbers of fatalities were said to be women and children under the age of 15 (Arora-Jonsson, 2011).

The absence of women in decision making power often magnify women's vulnerability during pre and post disaster periods since their needs and concerns are not represented and are often inadequately addressed (Garai 2014). Arora-Jonsson (2011), in reference to the Indian Government National Action Plan on Climate Change (NAPCC), states, "The impacts of climate change could prove particularly severe for women. With climate change there would be increasing scarcity of water, reduction of yields of forests biomass and increased risks to human health with children, women and elderly in a household becoming the most vulnerable" (Arora-Jonsson, 2011).

Terry Cannon (2002) in a study claimed that poverty accelerates women's susceptibility in climate induced natural hazards and gender plays a significant role in determining poverty. According to Asian Development Bank, over 95% of female headed household in Bangladesh live below poverty line and their number is 20-30% (Asian Development Bank 2001). Women headed households, as a result of divorce or death, face acute vulnerability during natural hazards (Cannon, 2002). According to a study 70% of the 1.3 billion people in the developing world living below the threshold of poverty is woman (Denton 2002, Rohr 2006). Another study of World Bank asserts that gender differences are greatest among the poorest families. Moreover, due to cultural norms, women of this poorest family eat last and least especially in Bangladesh like many other developing countries (Hemmati *et al.*, 2007).

Climate induced natural hazards have severe impacts on children, women and elderly people and people liv-

ing with disabilities (Chambers,1989; Alenander,1997; Dulal *et al.*, 2010; Garai, 2014). Climate change impacts are expected to have a disproportionate effect on women's economic activities such as countenancing barriers to do domestic activities, collecting foods, fodders and fibers that may also fall them vulnerability in their locality (Garai, 2014). Along with this, small community especially in coastal wetland area who depends on natural resources for their livelihoods i.e., fishing and hunting and collecting natural resources are in risk (Shah *et al.*, 2013).

Many of the regions of third world countries, women's literacy rate are very low due to their extensive domestic responsibility, ignorance of parents for education and financial inadequacy. For example, according to Bangladesh Bureau of Statistics (BBS) the literacy rate of Shymnagare upazila (sub district) of Satkhira district (study area) is 28% where male and female literacy rate are 38% and 17.4% respectively (BBS, 2006). The low literacy rate of women constraints their ability to adapt for and cope with the hazards that intensify their vulnerability (Ahsan *et al.*, 2014). Due to low literacy / illiteracy women find difficulty to understand how to manage disaster during emergency periods. For example, they cannot understand the meaning of warning message of upcoming hazard, so they cannot take initiative to minimize loss.

3. Theoretical Framework

The concept of vulnerability may be defined as the proportion of human lives, assets, and economic activity that could be affected in a given place should a given disaster occur. The calculation of different levels of vulnerability is made by combining the probability of a destructive event with the level of exposure of lives and assets to that hazard' (Trujillo *et al.*, 2000).

Vulnerability is applied as a core concept in disaster risk in the study of livelihoods and poverty, food security and climate change (Miller *et al.*, 2010). Adger (2006), and Gallopin (2006) identify, amidst the diverse interpretations of vulnerability, the key concepts of exposure, sensitivity, coping and adaptive capacity as underpinning many dominant approaches. Moreover, Downing *et al.* (2005) identify the following common elements of most approaches to vulnerability: the threat, e.g., climate change; a place or sector, e.g., health outcomes; a socioeconomic group, e.g., the poor, and the consequences of outcomes of vulnerability, e.g., loss of livelihoods (Miller *et al.*, 2010). In this study, vulnerability means the way of economic activities, assets, and lives of women and men are affected due to climate change induced natural hazards in coastal area of Bangladesh.

Blaikie (1994) has developed a model named pressure and release model by which human vulnerability to

natural hazards are revealed. The Pressure and Release (PAR) model indicates that a disaster is the junction of two opposing forces' that are the process generating vulnerability and physical exposure to hazard. Increasing pressure may come from either side, but to relieve the pressure, vulnerability has to be reduced.

Blaikie presents three main levels of progression of vulnerability: (i) root causes, (ii) dynamic pressures and (iii) unsafe conditions. Root causes have indirect influences on vulnerability. These are economic, demographic and political processes within society that reflect the distribution of power in a society and its limitation bring vulnerability to the people during hazards. Dynamic pressures related to the root causes can form insecurity of resources and bring vulnerability to the affected people. For example, lack of local institutions, and skills, local markets causes vulnerability to hazards affected people of a particular locality. About unsafe conditions, Blaikie asserted that it is a specific form in which people's vulnerability is expressed in time and space in conjunction with hazard (Blaikie, 1994).

4. Methodology

The present study is qualitative in nature. The data were collected from primary and secondary sources. Primary data were collected from eight villages of two unions namely Burigoalini and Gabura of Shymnagar upazila under Satkhira district in Bangladesh (Figure 1).

The logic behind choosing this area as study area is that it is one of the most vulnerable zones of natural disasters. The type, intensity and frequency of natural disasters such as cyclone, tidal surge, soil salinity, and flood are common phenomena in this area. Moreover, being located adjacent to the Bay of Bengal and Sundarbans (Mangrove forest), people's vulnerability also increased to a great extent. Therefore, considering all the above traits, Shymnagar upazila was selected for this study. In addition to this, simple random sampling was adopted for selecting unions and villages of this study.

Each man and woman (age 15-70) who lives in the selected area is the unit of the study. Some qualitative tools i.e., Key Informants Interview (KII) and Focus

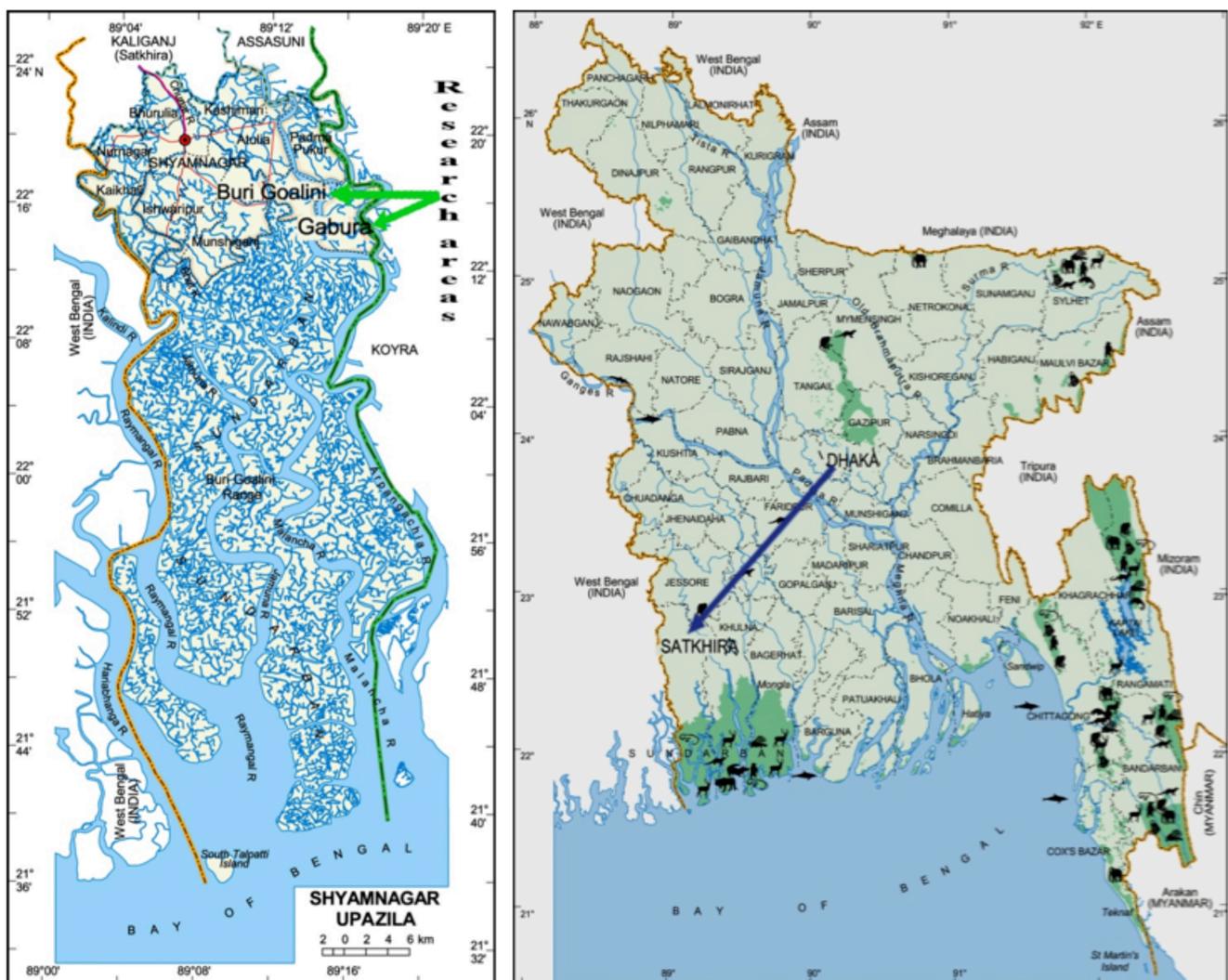


Figure 1 - Maps of Shymnagar upazila in Satkhira districts of Bangladesh

Group Discussion (FGD) were adopted to get the astute and inclusive views about vulnerability of women in climatic hazards and possible sustainable livelihoods of coastal people. By using KIIs, this study was able to discover the challenging conditions of the most vulnerable disadvantaged people i.e. women from social, gender, cultural and behavioral perspectives.

At the same time, FGDs were adopted to get an in-depth and insightful view about the nature of vulnerability and coping strategies of coastal people during, pre, and post disaster periods. To fulfill this purpose, two FGDs, and two KIIs in each eight villages of two unions (total 16 FGDs and 16 KIIs) were adopted of which men and women respondents were equal. Total 12 respondents of heterogeneous occupations were selected by using purposive sampling for each FGD groups. Along with chief researcher, a research assistant was present in the FGD meeting who wrote down the information which was come out from the discussions. To conduct KIIs, especially knowledgeable persons such as teachers, union parishad chairman, members, NGO workers, were given priority. After conducting this study, data were processed and analyzed manually. This field work was conducted between August and September in 2012. The study therefore aims at to assess the gender specific vulnerability and possible sustainable livelihoods of coastal people in climate change variability by applying qualitative method.

Secondary data were collected from several Bengali and western literatures, research papers, newspapers, magazines and so on to enrich the study.

5. Results

5.1. Decision Making Power

We found that women face difficulty to take decision independently in household level. The inherent causes of this are the cultural norms of our society and women's economic dependency in the family. For this why, many times in disaster period women cannot take decisions, what she should do. For example, she may wait for her husband to do something to combat disaster. Consequently, residing in flimsy housing structure many times women face vulnerability in hazards. In addition to this, traditionally being income earner men always take decision in the family, so women's decision making power cannot flourish in the society.

5.2. Dynamic Pressure

Our study revealed that the people of the affected area face dynamic pressure during the climatic hazards. Due to poor communication and management system they cannot co-ordinate with local institution and local market and face severe scarcity in term of foods, pure drinking water, raw materials and other emergency needs of their family in hazards periods.

The female-headed households become more vulnerable in this situation because they have to manage both inside and outside tasks of their family. For example, beside managing household chores, women have to manage daily commodity (i.e., foods, drinking water, etc.) which become difficult for them to do in hazards periods. Moreover, they face difficulty to shift their family members in safer place due to religious orthodoxy. However, male can do this task in the hazard periods properly (Table 1).

5.3. Women in Risky Situation

The study findings indicate that women living in the coastal belt area face very risky situation, because many of them cannot get information, being confined to house. Moreover, many of them cannot know how to swim and are incapable to cope with the hazards. The majorities of people in the coastal area are poor, so the housing structures of this locality are mostly made with mud/soil in the wall and thatched or tin on the roof. These building materials may collapse during storms and floods, trapping and potentially killing people inside. The role of women often confines them to indoor spaces, leading to increased vulnerability to this type of danger (Table 1).

5.4. Education, Information and Decision Making Power

Majority of the respondents of the case study villages agreed that a greater proportion of women in the study area are illiterate than men and their educational opportunities are often limited due to their cultural expectations and their extensive domestic role and responsibility. Moreover, religious regulation leads to girls being restricted from attending school. For this why, they are deprived of education in their locality. Being illiterate, women fail to develop skill and awareness to face disaster in their everyday life. Moreover, they find difficulty to attend different disaster management training and implement it during hazards due to their illiteracy. They also often fail to acquire certain skills that would help increase their resilience to this impact. As a result, women easily fall to vulnerability during natural disaster.

5.5 Poor Disaster Management System

The findings of the study indicate that embankment of the coastal belt is not effective enough to protect the flow of water. Moreover, there is not enough forest around the coastal belt that protects the flowing wind and water during the natural hazards. Many a time the weather forecasting and warning system of the affected area is not working well, so many people unable know about the hazards in proper time. For example, in remote area, due to poor communication system the an-

Table 1 - Key social indicators of gender vulnerability in climate induced natural hazards
 Tabela 1 - Principais indicadores sociais de vulnerabilidade de gênero em riscos naturais induzidos climaticamente

Gender specific vulnerability during and post-disaster periods		
Social indicators	Men	Women
Decision making power	Core decision maker in household affair for being sole income earner.	Hardly take decision due to possessing limited property.
Nutritional status	Affliction from malnutrition.	The affliction of malnutrition rate among women is higher than men because they eat less than men due to deficit of foods in the family.
Security status	Worried about female members in family.	Feel insecure during and post disaster period in terms of eve teasing / sexual violence etc.
Diseases/injures	Suffering from different diseases such as diarrhea, cold fever, skin diseases, along with injures due to natural hazards.	Skin diseases, dysentery, diarrhea, injuries are common among women.
Unhygienic environment	Man stay less time in Unhygienic environment inside the house due to working outside.	Women have to stay in this unhygienic environment to look after children, elderly people and domestic properties.
Drinking water	Think collecting water is a female's duty.	Women have to go to distance places to collect water and often face vulnerability during disaster
Interactive activities	Have outer exposure to other people.	No scope to interaction to outer members during and post-disaster periods.
Religious restrictions/burden	Have no restriction to go outside.	Face restriction to go outside even for earning money for livelihoods.
Biological activities	Have to do this on open place, especially road side in post disaster periods.	Women face insecure and shame to do biological activities outside the fragile home ground in disaster periods.
Risky environment	Male can move to this environment carefully.	Females face problems to move in risky environment, i.e., in slippery and muddy road, strong current of water.
Coping capability	Can cope/adapt in hazardous situation easily.	Cannot cope/adapt with hazardous situation easily.
Sexual harassment	Do not face this problem.	Frequently face this problem during hazardous periods.
Flimsy housing structure	Are less vulnerable as they are outside during disaster for earning.	Have to stay all the time in house to look after baby and doing other activities.
Warning message	Get easily the message about the upcoming hazards.	Have less scope to get outer information especially warnings message and other forecast due to their confinement in household chores.
Belief in fate	Go to cyclone center.	During disaster do not want to go to cyclone center believing that God will save them in house.
Secure place	Easily go cyclone center during disaster.	Feel embarrass to go cyclone center (in mass people) during disaster periods due to religious orthodoxy.
Medical facilities	Have to go far distance to receive medical treatment. Feel comfortable to take treatment from faith healer.	Face difficulty to take treatment going far distance / city. Females also go faith healer for treatment due to their availability and low cost.
Educational facilities	Being far distance to educational institutions male go school/college by riding bicycle.	Parents refuse to send their daughter to school due to being far distance. Thus due to illiteracy girls remain less skillful to combat disaster.

Source: FGDs and KIIs

nouncement of upcoming disaster is not done well. Moreover, cyclone center of the belt area is not sufficient to accommodate comparing all the affected population. However, some of the cyclone centers are far distance from the affected area, so many of the people cannot take shelter in the cyclone center during the emergency periods.

About the disaster management system, the study indicates that compared to males, females are more aware about this. They know how to save the household properties and reduce the losses during hazards but sometimes to save this they fall at risk in disasters.

5.6. Nature of Challenges of Women, Children, Disabled and Elderly People

A large proportion of the respondents agreed that those who were injured or died in the natural disaster are mostly women, children and disabled people. The study indicates that pregnant women are the most vulnerable in disaster because in this time they cannot move from the house as the environments around them are risky. Moreover, the slippery and the muddy roads are risky for them to move swiftly for safe place (Table 1). In the same way, children, disabled and elderly people also face great difficulty during natural hazards. The findings indicate that during tidal surges or flash floods, they cannot cope with it easily and become vulnerable during the natural hazards.

5.7. Income and Occupational Challenges after Natural Hazards

The findings of the study indicate that climate change greatly hampers the economic activities of women. They are confined to house as the economic sources have reduced and become jobless. Different natural hazards contribute to demolish natural resources, i.e., forest creepers, roofs, tubes from the forest, roots, honey, fuel woods and mineral water that are the gathering resources for women in the coastal belt. Moreover, women in the coastal area who depend on collecting fishes and prawns in the river cannot collect that sufficiently as natural hazards contribute to massively obliterate their reproductive capacity. The findings also indicate that women failed to do agro-based processing activities such as harvesting crops, boiling paddy, drying cereals etc. during the disaster periods (Table 2). Women also face problems moving to the flooding kitchen garden for preparing foods, cleaning utensils, and other household activities. All of these challenges contribute to make woman vulnerable.

Men also lose their income and occupation sources due to climate change and migrate to adjacent districts for income (Table 2). Many of the people bound to change their occupational sources and try to find out other sources and lead a very miserable life in the locality.

5.8. Livelihoods at Risk

The study findings indicate that the natural resources that women are more dependent on are at greater risk from climate change. Due to the severity of salinity in river water increased, the reproductive capacity of fish species decreased to a great extent. As a result, fishermen cannot get fishes in their expected level. In the same way, women who collect prawns (pona) and larvae in the river cannot get that sufficiently (Table 2).

Moreover, frequent tidal surges and flash floods disrupt the embankment and enter saline water to their community and create scarcity of pure drinking and irrigation water. This saline water inundates crops land and threatens food security of the locality. Women also struggle to get their traditional food sources in this situation. Women as well as men are forced to change their occupations and searching for new income sources for maintaining their livelihoods.

6. Discussion

The people of coastal area in Bangladesh frequently face with natural hazards. In the hazards, some of the affected people can get resilience easily but many of them cannot adapt because of their scarcity in material and non-material resources. Material resources may be land, livestock, crops, reserved foods, cash money, household security, raw material and so on. On the other hand, non-material resources include coping strategies, skillfulness, disaster management techniques, personal relationship, flow of information, social network etc. The access of these resources is based on social and economic relation particularly the social relations of production, gender, ethnicity, social status and age (Denton, 2002). Moreover, proper access of this resources influence affected people to overcome the hazards quickly. The affected people can borrow/collect money, foods and other material from their relatives, neighbor or other groups and cope with the hazards. They can also get it as relief from Government and NGOs as coping mechanisms for resilience in natural hazards. Women also can cope with this hazard by being members of the NGOs and lending money and taking training about disaster management.

In the coastal zone of Bangladesh, women are vulnerable group in the hazards period for gendered division of labor, unequal access of natural resources, lack of decision making power and patriarchal domination upon women. Moreover, women are gradually separated to the nature as natural resources are severely affected and diminished by climate change as well as hazards. So government should take necessary steps to protect the existing resources. Women should be given the freedom to access the existing natural resources in the coastal belt. Also, government should ensure the augment/growth of resources in coastal area along with

Table 2 - Key economic indicators of gender vulnerability in climate induced natural hazards in the study area

Tabela 2 - Principais indicadores económicos de vulnerabilidade de género em riscos naturais induzidos pelo clima.

Gender specific vulnerability during and post- disaster periods		
Economic indicators	Men	Women
Productive activities	Face problems to crop productions in salinity farms.	Find difficulty to do agro based activities in home-stead garden.
Food preparation	Take no responsibility.	Fall vulnerability for preparing food during hazards due to scarcity of resources.
Employment opportunities	Limited scope to find job during and post disaster periods.	No scope to get job in disrupted situation.
Domestic chores	Feel no interest to do domestic chores thinking it women's works.	Like other time, women perform all domestic works in disaster periods including cleaning houses, collecting water, managing fuel woods, preparing foods etc. that make them easily vulnerable in hazards.
Wages	Men get wages according to their works.	Women are paid less for the same work.
Availability of work	Can go distance place in search of work after disaster periods.	Cannot go distance place in search of work due to their physical constraints and religious taboos.
Fish production	Due to severity of salinity in water, people largely depend on aquaculture instead of fishing in rivers.	Women cannot get enough prawn (pona) from the river.
Salinity intrusion	Face vulnerability in agricultural activities by growing paddy, wheat, jute and so on, because salinity hamper the productions.	Face problems to do horticultural activities in home-stead garden.
Livestock rearing	Face problems for rearing cows, goats, buffalo and so on, due to scarcity of animal fodders.	Fall in distress position by producing hens, ducks, and so on for lack of fodder and living place.
Cleaning and washing	Take no responsibility.	Face problems to clean clothe in saline water. Muddy wall of housing structure is also damaged due to salinity in soil of the house.
Homestead foods	Men depends on women for this.	No scope to collect homestead foods such as forest creepers, roofs, tubes and related forests products.
Saving domestic materials	Males remain outside in disaster periods for breadwinning.	Face vulnerability in disaster periods for saving livestock, children and other domestic products.

Source: FGDs and KIIs

the equal access of the existing material and non materials resources for both men and women to bring sustainable livelihoods in the coastal area of Bangladesh.

For effective disaster management, people should be undergone intensive training especially women to reduce losses in term of live saving, and other resources. Due to cultural norm, women are unable to acquire certain skills to resilience in hazards. For example, women are much less likely than men to have learned to swim that can have extreme effect, after the flood and cyclone of 1991 in Bangladesh. The death rate for woman was nearly five times more comparing for man in that hazards (Brody, 2008).

The coast of Bangladesh constantly faces different natural hazards, so the main priority should be to heighten and broaden the embankment adjacent to the river/sea.

According to most of the respondents, the height of this embankment must be at least 10 feet and in broad 6 feet from the sea level to protect the entrance of saline water into the locality.

Different types of trees should be planted surrounding the embankment/dam, then it can reduce soil erosion and prevent the tidal surges during the hazards. In addition to this, a committee should be formed for the purpose of monitoring the status of embankment especially in rainy season, so they can inform the authority to patch up it when they find any fault/leakage through the embankment.

7. Conclusion

Bangladesh is one of the worst victims of climate change in the world (Islam, 2011). The people of the

coastal area face many natural hazards all the year rounds. However, women, due to their gender specific roles in society, are often more vulnerable to natural disasters related to climate change. As women constitute half of the world population, so neglecting them real development cannot be gained. Women's participation in climate change decision, the enhancement of institutional capacity to mainstream gender issues in global and national climate change, the development of gender policies, gender awareness, internal and external gender capacity and expertise therefore should be assured. Moreover, the traditional assumption towards women as unworthy and incapable of engaging in environmental management and climate change should be avoided, because historically women are the natural resources managers and effective agents for disaster management. Greenbelt movement in Kenya and Chipko movement in India may be best example for this. So government as well as policy makers should formulate policy and implement it to ensure gender issues to reduce vulnerability in climate induced natural hazards and bring sustainability in the coastal area of Bangladesh.

References

- Adger, N.W. (2006) - Vulnerability, *Global Environmental Change*, 16(3):268-281. DOI: 10.1016/j.gloenvcha.2006.02.006
- Ahmed F.R.S., (2012) - Climate change issues in Bangladesh & need for adaptation to climate change [Presentation]. Palli Karma Sahayak Foundation (PKSF), Dhaka, Bangladesh. Available on-line at http://www.ilo.org/wcmsp5/groups/public/@asia/@ro-bangkok/@ilo-dhaka/documents/presentation/wcms_181127.pdf
- Ahsan, M.N.; Warner J. (2014) - The socioeconomic vulnerability index: A pragmatic approach for assessing climate change led risks - A case study in the south-western coastal Bangladesh. *International Journal of Disaster Risk Reduction*, 8:32-49. DOI: 10.1016/j.ijdr.2013.12.009
- Alexander, D. (1997) - The Study of Natural Disasters, 1977-97: Some Reflections on a Changing Field of Knowledge. *Disaster*, 21(4):284-304. DOI: 10.1111/1467-7717.00064.
- Arora- Jonsson, S. (2011) - Virtue and vulnerability: Discourses on women, gender and climate change. *Global Environmental Change*, 21(2):744-751. DOI: 10.1080/13552070215903
- BBS (2006) - *Population Census Wing, Bangladesh*. Bangladesh Bureau of Statistics (BBS). Available on-line at http://web.archive.org/web/20050327072826/http://www.bangladeshgov.org/mop/ndb/arpc91_v1/tables04.htm
- Blaikie, P.; Cannon, T.; Davis, I.; Wisner, B. (1994) - *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. 284p., Rutledge, London. ISBN: 9780415084772.
- BRIDGE (2008) - *Gender and Climate Change: Mapping the Linkage*. BRIDGE (development - gender), Institute of Development Studies, University of Sussex, Brighton, UK. Available on-line at http://siteresources.worldbank.org/EXTSOCIALDEVELOPMENT/Resources/DFI_D_Gender_Climate_Change.pdf
- Brody, A.; Demetriade, J.; Esplen, E. (2008) - *Gender and Climate Change: Mapping the Linkages; A Scoping Study on Knowledge and Gaps*. 25p., BRIDGE (development - gender), Institute of Development Studies, University of Sussex, Brighton, UK. http://www.bridge.ids.ac.uk/sites/bridge.ids.ac.uk/files/reports/Climate_Change_D_FID.pdf
- Cannon T. (2002) - Gender and Climate Hazards in Bangladesh- *Gender and Development*, Special Issue: *Climate Change*, 10(2):45-50. DOI: 10.1080/13552070215906.
- CARE (2010) - *Adaptation, Gender and Women's Empowerment*, 6p., CARE International Climate Change Brief, Atlanta, GA, U.S.A. Available on-line at http://www.care.org/sites/default/files/documents/CC-2010-CARE_Gender_Brief.pdf
- Carvajal-Escobar, Y.; Quinero, M.; Garcia, M. (2008) - Women's role in adapting to climate change and variability. *Advances in Geosciences*, 14:277-280, European Geosciences Union, Munich, Germany. DOI: 10.5194/adgeo-14-277-2008.
- Chambers, R. (1989) - Vulnerability, Coping and Policy (Editorial Introduction). *IDS Bulletin*, 20(2):1-7, Institute of Development Studies, Brighton, UK. Available on-line at http://ipcc-wg2.gov/njlite_download.php?id=5783
- Denton, F. (2002) - Climate Change Vulnerability, Impacts, and Adaptation: Why does Gender Matter? *Gender and Development*, Special Issue: *Climate Change*, 10(2):10-20. DOI: 10.1080/13552070215903
- Downing, T.E.; Aerts, J.; Soussan, J.; Barthelemy, O.; Bharwani, S.; Hinkel, J.; Ionescu, C.; Klein, R.J.T.; Mata, L.J.; Martin, N.; Moss, S.; Purkey, D.; Ziervogel, G. (2005) - *Integrating Social Vulnerability into Water Management*. 32p., SEI Working Paper and Newater Working Paper No. 4. Oxford / Stockholm Environment Institute. ISBN: 9197523860. Available on-line at https://www.pik-potsdam.de/research/projects/projects-archive/favaia/pubs/downing_et_al_2005.pdf
- Dulal, H.B.; Brodnig, G.; Thakur, H.K.; Green-Onoriose, C. (2010) - Do the poor have what they need to adapt to climate change? A case study of Nepal. *Local Environment*, 15(7):621-344. DOI: 10.1080/13549839.2010.498814
- Gallopín, G.C. (2006) - Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, 16(3):293-303. DOI: 10.1016/j.gloenvcha.2006.02.004
- Garai, J. (2014) - The impact of climate change on the livelihoods of coastal people in Bangladesh: A sociological study. In: W. Leal Filho, F. Alves, S. Caeiro & U.M. Azeiteiro (eds.), *International Perspectives on Climate Change: Latin America and Beyond*, pp 151- 163, Springer International Publishing, Switzerland; ISBN: 978-3319044880. DOI: 10.1007/978-3-319-04489-7_11
- Hemmati, M.; Rohr, U.(2007) - A Huge Challenge and a Narrow Discourse: Ain't No Space For Gender in Climate Change Policy? *Women & Environments International Magazine* (ISSN: 1499-1993), Issue #74-75, Institute for Women's Studies and Gender Studies, Columbia University, New York, N.Y., U.S.A.
- IPCC (2007) - *Climate Change, 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Switzerland. Available on-line at https://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm
- Islam, R. (2011) - Vulnerability and Coping Strategies of Women in Disaster: A Study on Coastal areas of Bangladesh. *The Arts Faculty Journal 2010-2011*, pp.147-169, Dhaka University, Dhaka, Bangladesh. Available on-line at <http://www.eldis.org/go/home&id=64076&type=Document#.VseewjZpp4>
- Miller F.; Osbahr., H.; Boyd, E.; Thomalla, F.; Bharwani, S.; Ziervogel, G.; Walker, B.; Birkmann J.; van der Leeuw, S.; Rockstorm. J.; Hinkel, J.; Downing, T.; Folke, C.; Nelson, D. (2010) - Resilience and Vulnerability: Complementary or Conflicting Concepts? *Ecology and Society*, 15(3):11. Available on-line at <http://www.ecologyandsociety.org/vol15/iss3/art11/>
- Rohr, U. (2005) - *Gender and Climate Change – a Forgotten Issue?* Tiempo Climate Newswatch, UEA, SEI and IIED. Available on-line at <http://tiempo.sei-international.org/newswatch/comment050711.htm>

- Rohr, U. (2006) - *Gender and Climate Change*. *Tiempo*, 59:3-7, University of East Anglia (UEA), Stockholm Environment Institute (SEI) and International Institute for environment and Development (IIED). Available on-line at http://www.preventionweb.net/files/9739_tiempo59low.pdf
- Satterfield, T.A.; Mertz, C.K.; Slovic, P. (2004) - Discrimination, Vulnerability and Justice in the Face of Risk. *Risk Analysis*, 24(1):115-129. DOI: 10.1111/j.0272-4332.2004.00416.x
- Shah, K.U.; Dulal, H.B.; Johnson C.; Baptiste A. (2013) - Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago. *Geoforum*, 47:125-137. DOI: 10.1016/j.geoforum.2013.04.004
- Siddiqui, I. (2010) - community based adaptation to climate change: the Bangladesh Case. In: *Developing Proactive Policy and Practice for Land and Water Management Responsive to Climate Change*, Proceedings (Abstracts), Monash University, Melbourne, VIC, Australia. Available on-line at https://www.monash.edu/_data/assets/pdf_file/0004/293998/alaf-proceedings-v1.pdf
- Terry, G. (2009) - No climate justice without gender justice: An overview of the issues. *Gender and Development*, 17(1):5-18. DOI: 10.1080/13552070802696839
- Trujillo, M.; Ordonez, A.; Hernandez, C. (2000) - *Risk Mapping and Local Capacities: Lessons from Mexico and Central America*. 80p., Oxfam Publishing, Oxford, U.K. ISBN: 978-0855984205.
- UN-ISDR, (2009) - *Risk and Poverty in a Changing Climate: Invest Today for a Safer Tomorrow*. Summary and Recommendations: 2009 Global Assessment Report on Disaster Risk Reduction. 20p., United Nations International Strategy for Natural Disaster Reduction Global Assessment Report on Disaster Risk Reduction. Available on-line at http://www.preventionweb.net/files/9414_GARsummary.pdf
- WEDO (2007) - *Changing the Climate: Why Women's Perspectives Matter?* 4p., Women's Environment & Development Organization (WEDO), New York, NY, U.S.A. Available on-line at <http://www.wedo.org/wp-content/uploads/changing-the-climate-why-womens-perspectives-matter-2008.pdf>

Holocene invertebrates from the Rocas Atoll: A contribution for the ecological history of South Atlantic islands*

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ABSTRACT

The South Atlantic Ocean is the youngest of the world's oceans and one of the most important biodiversity hotspots; however, there is a lack of scientific knowledge about its ecological history. Here, we present the first results of a fossil invertebrate survey from the Rocas Atoll. By using radiometric dating (¹⁴C) and a survey of fossilized benthic invertebrates on this atoll, we provide new paleobiogeographic and paleoceanographic information. The results suggest eight taxa (five mollusks, two corals, and one decapod). Dates ranged from 3449 ± 790 y BP to 3033 ± 620 y BP. The data represent new invertebrate records for the middle Holocene in this atoll, and evidence of sea-level changes in this period. Considering that the Rocas Atoll is one of the newest marine atolls in the world, these results suggest recent colonization by species from the Southwestern Atlantic Coast and Fernando de Noronha Archipelago.

Keywords: Paleoceanography, Benthic communities, Paleobiogeography

RESUMO

Invertebrados holocénicos do Atol das Rocas: contribuição para a história ecológica das ilhas do Atlântico Sul

O Atlântico Sul é o oceano mais recente e um dos mais importantes hotspots de biodiversidade; entretanto, há uma lacuna no conhecimento científico sobre sua história ecológica. Aqui, são apresentados os primeiros resultados de um estudo sobre invertebrados fósseis do Atol das Rocas. Utilizando datação radiométrica (¹⁴C) e levantamento de invertebrados bentônicos fossilizados desse atol, são fornecidas novas informações paleobiogeográficas e paleoceanográficas. Os resultados mostram a ocorrência de oito táxons (cinco moluscos, dois corais e um crustáceo decápoda), com datas variando de 3449 ± 790 a 3033 ± 620 anos antes do presente. Os dados revelam novos registros de invertebrados para o Holoceno Médio nesse atol e novas

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evidências de mudanças no nível do mar durante esse período. Considerando que o Atol das Rocas é um dos mais recentes atóis do mundo, esses resultados sugerem uma colonização recente por espécies advindas da costa do Atlântico Sul Ocidental e do Arquipélago de Fernando de Noronha.

Palavras-chave: *Paleoceanografia, Comunidades bentônicas, Biogeografia*

1. Introduction

The South Atlantic Ocean is the youngest of all oceans and one of most important biodiversity hotspots in the world (Neraudeau & Mathey, 2000; Roberts *et al.*, 2002; Miloslavich *et al.*, 2011). This ocean has some important and particular biogeographic and ecological characteristics such as isolation, biogeographic barriers, geomorphology, reef types, and oceanic islands (Hachich *et al.*, 2015). St. Helena is one of the most isolated oceanic islands. Other islands located far from the Brazilian coast are Ascension, Trindade, and St. Paul's Rocks. Closer to the continental shores, but still far enough to demonstrate the effects of isolation are Fernando de Noronha Archipelago and Rocas Atoll (Joyeux *et al.*, 2001). The paleobiogeography and paleoecology of the Indian and Pacific Ocean islands have been more frequently studied than those of the South Atlantic Ocean (McDowall, 2005; Hickerson & Meyer, 2008). The South American marine biodiversity is the least well known among tropical sub-regions (with the exception of Costa Rica and Panama) (Miloslavich *et al.*, 2011).

Beach rocks are common inorganic deposits in tropical areas (Irion *et al.*, 2012) and form in the oceans and along the coast, such as the calcarenites in atolls (Pereira *et al.*, 2007, Woodroffe, 2008). Beach sandstone banks are structures that provide evidence for coastline dislocation in relation to the continent (Davies & Kinsey, 1973, Mauz *et al.*, 2015), provide paleobiogeographic data (Shen *et al.*, 2013), and cause vertical variations in the sea level (Spurgeon *et al.*, 2003; Morais *et al.*, 2009, Erginal *et al.*, 2013). Studies on tropical Atlantic reefs, particularly of the barrier reefs and atolls in the Caribbean region (Stoddart *et al.*, 1982, Beier, 1985, Gischler & Lomando, 1997) have shown that beach rocks can be used as indicators of sea-level oscillations and ecological history of atolls during the Holocene.

Atolls are ring-shaped oceanic reefs that commonly include an internal lagoon and islands formed by sandy Holocene deposits (Barry *et al.*, 2007). Calcarenites have been reported on islands from Atolls (Stoddart & Cann, 1965; Woodroffe, 2008), although few studies have been conducted on the paleobiogeographic and paleoceanographic features of the tropical South Atlantic (Leão & Kikuchi, 2005, Irion *et al.*, 2012, Angulo *et al.*, 2013).

The Rocas Atoll is a unique atoll formation and potentially one of the most "pristine" reefs in South Atlantic

(Longo *et al.*, 2015). Several studies have been recently conducted on the atoll (for example, Gherardi & Bosence, 1999, 2001, 2005; Soares *et al.*, 2011; Pereira *et al.*, 2010, 2013, 2015; and Longo *et al.*, 2015).

These studies involved the collection of geomorphological and biological data, but to our knowledge, no studies have been conducted on fossilized benthic invertebrates that could provide information about the recent ecological history. The Rocas Atoll is the only atoll in the tropical southwestern Atlantic and is one of the smallest in the world (Gherardi & Bosence, 2005). This makes the reef a significant source of information about the ecology and history of the South Atlantic Ocean (Longo *et al.*, 2015). This study has two objectives: 1) to identify the fossilized benthic invertebrates in calcarenites on the Rocas Atoll, and 2) to determine, by radiometric dating (^{14}C), the age of these records.

2. Material and Methods

2.1. Study site

The Rocas Atoll is located 267 km to the northeast of Brazil (mainland) and 148 km west of the Fernando de Noronha Archipelago (Supporting Information I). The tectonic setting and substrate character of the atoll were reviewed by Kikuchi & Leão (1997), who states that the Rocas Atoll and Fernando de Noronha Archipelago belonged to an alignment of seamounts, which is a branch of the meso-oceanic chain. In the Rocas Atoll, seawater temperature averages 27°C, but can reach 42°C in pools, and surface salinity varies between 36‰ and 37‰. The tide regime is semidiurnal and mesotidal, with the maximum variation of 2.7 m, leaving the reef flat and the calcarenites exposed at low tide (Gherardi & Bosence, 1999, 2001, Soares *et al.*, 2011). According to the review by Kikuchi & Leão (1997), 80% of the waves come from E and 15% from NE, at a range of 4 to 7 s and heights of 1 to 2 m.

The atoll reef rim has a slightly elliptical shape, 3.5 km long (E-W) and 2.5 km wide. There are two sand cays on the atoll, Farol and Cemitério Islands, located on the leeward side and oriented SW-NE and SE-NW, respectively. They are accumulations of bioclastic calcareous sediments, mainly coralline algal fragments, generated by mechanical and biological breakdown (Gherardi & Bosence, 2001). Farol Island is the largest, with a length of 850 m and width of 250 m. Cemitério Island is 350 m long and 170 m wide. The maximum elevation of Farol Island is 3.7 m, and of Cemitério Island, 2.8 m (Kikuchi & Leão, 1997).

2.2. Methods

The field survey included identification of the calcarenite facies (Bioclastic / Peloidal Grainstones) in Cemitério Island in order to understand the geological context of the collected taxa. Samples (gastropod shells) for radiometric dating (^{14}C) were collected from calcarenites 2.0 m above mean sea level (MSL). ^{14}C datings were performed in the Physics Laboratory of Federal University of Ceará (UFC). Detailed methods are available in the Supporting Information II.

3. Results

Qualitative analysis revealed an assembly constituted by marine invertebrates such as mollusks (gastropods and bivalves), corals, and crustaceans (Table I). Gastropods were the most prevalent animal group including four species.

Table 1 - Data from the survey of benthic invertebrates (middle Holocene) on the Rocas Atoll (Equatorial South Atlantic)

Tabela 1 - Invertebrados bentônicos (Holoceno Médio) no Atol das Rocas (Atlântico Sul Equatorial)

Taxa	Species
Mollusca, Gastropoda	<i>Tonna pennata</i>
	<i>Malea noronhensis</i>
	<i>Lithopoma tectum</i>
	<i>Hipponix incurvus</i>
Mollusca, Bivalvia	<i>Codakia orbicularis</i>
Cnidaria, Anthozoa	<i>Siderastrea stellata</i>
	<i>Favia gravida</i>
Arthropoda, Crustacea	<i>Johngarthia lagostoma</i>

Gastropods showed the greatest diversity, represented by *Lithopoma tectum* (Lightfoot, 1786), *Hipponix incurvus* (Gmelin, 1791), *Malea noronhensis* (Kempf and Matthews, 1969), and *Tonna pennata* (Morch, 1853). The only bivalve observed was *Codakia orbicularis* (Linnaeus, 1758), which is representative of the infauna of unconsolidated sediments. The scleractinian corals, *Favia gravida* (Verrill, 1868) and *Siderastrea stellata* (Verrill, 1868), are represented by fossilized components identified in this survey. The decapod *Johngarthia lagostoma* (Milne-Edwards, 1835) was also recorded.

Radiometric dating of the calcarenite ranged from 3449 ± 790 y BP to 3033 ± 620 y BP, situating the samples in the middle Holocene (Quaternary). Considering this data, a theoretical model of these benthic communities can be proposed. This invertebrate assembly is probably representative of a low-energy subtidal environment;

most likely, a back-reef lagoon ecosystem with a benthic community represented by two assemblies (I and II). Assembly I is indicative of an unconsolidated bottom assembly (*T. pennata*, *M. noronhensis*, *C. orbicularis*, and *J. lagostoma*). On the other hand, Assembly II indicates consolidated bottom community of coralline patch-reefs distributed on the bottom of the lagoon (*H. incurvus*, *L. tectum*, *S. stellata*, *F. gravida*).

4. Discussion

The gastropods *T. pennata* and *M. noronhensis*, belonging to the family Tonnidae, inhabit unconsolidated substrates (sand) in shallow water from the intertidal zone to a depth of 15 m (Kempf & Matthews, 1969, Rios, 1994, 2009). *T. pennata* is an anfiatlantic species widely distributed in the western Atlantic (records ranging from Bermuda, Florida, Caribbean Sea, Colombia, Venezuela, and Brazil) and the archipelagos of Madeira, Canary, and Cape Verde in the eastern Atlantic (Rios, 1994, 2009).

In Brazil, *T. pennata* occurs in the Brazilian northeast coastal zone (from Ceará to Bahia), in the Fernando de Noronha Archipelago, and on the Rocas Atoll (Rios, 2009). The wide geographic distribution of *T. pennata* is likely due to its planktonic larval stage (planktotrophic veliger larvae), which increases its ability to disperse (Leal, 1991). On the other hand, *M. noronhensis* is endemic to the southwestern tropical Atlantic Islands (Fernando de Noronha Archipelago and Rocas Atoll). This species was described by Kempf & Matthews (1969) from empty shells, and no live specimens (with soft parts) have been collected so far. Kempf & Matthews (1969) also mention that this is the first recent record of the genus *Malea* from the Atlantic Ocean. Previous records were only of Tertiary fauna from Jamaica and Florida (Woodring, 1928).

The species *H. incurvus* (Gastropoda: Hipponicidae) inhabits consolidated substrates (mainly corals) in shallow waters (Rios, 1994, 2009; Simone, 2002). Restricted to the western Atlantic, *H. incurvus* shows a wide latitudinal distribution, occurring from North Carolina (USA) to Santa Catarina (Brazil), including the Fernando de Noronha Archipelago, Rocas Atoll, Abrolhos Archipelago, and the chain Vitoria-Trindade (Trindade Islands, Martin Vaz Archipelago, and some submarine mountains) (Leal, 1991; Rios, 1994, 2009; Simone, 2002). Similar to *T. pennata*, *H. incurvus* has a larval planktonic stage (lecithotrophic veliger larvae) that increases its ability to disperse.

L. tectum (Gastropoda: Turbinidae) is a species that inhabits consolidated substrate from the intertidal zone to a depth of 10 m (Rios, 1994, 2009). This species has only been recorded in the western Atlantic (Bahamas, Mexico, Caribe, Venezuela, and Brazil). In Brazil, *L. tectum* occurs in the costal zones of Rio Grande do

Norte to Santa Catarina, Fernando de Noronha Archipelago, Rocas Atoll, and Trindade Island (Leal, 1991, Rios, 1994, 2009). Similar to *H. incurvus*, *L. tectum* has a lecithotrophic veliger larva.

The species *C. orbicularis* (Bivalvia: Lucinidae) inhabits unconsolidated substrates (sandy and muddy) in shallow water (depth, 2–55 m) (Rios, 1994, 2009). This species has a restricted geographical distribution - the western Atlantic, with records from North Carolina to Brazil (from Ceará to São Paulo) (Rios, 1994, 2009). According to Gomes *et al.* (2006), *C. orbicularis* also occurs in Saint Paul's Rocks and Fernando de Noronha Archipelago. To our knowledge, this is the first record of this species on the Rocas Atoll.

Corals are indicators of environmental variables in the ecosystems of the middle Holocene. *S. stellata* is known to exhibit tolerance for wide temperature variation, high rates of sedimentation and turbidity, and resistance to hydrodynamics (Leão *et al.*, 2003). *F. grävada* is highly resistant to environmental variation, particularly variations in temperature, salinity, and turbidity. *S. stellata* and *F. grävada* are very common modern reef coral in the tropical southeast Atlantic coast and on the Rocas Atoll (Longo *et al.*, 2015). *J. lagostoma* is a species of crab that lives on Ascension Island and on three other islands in the South Atlantic (Trindade Island, Fernando de Noronha, and Rocas Atoll) (Hartnoll *et al.*, 2009). The biogeography of this species across a small number of islands in the southern Atlantic Ocean is very unusual and difficult to explain by planktonic dispersal. Hartnoll *et al.* (2009) suggested the existence of former islands, now submerged, which could have acted as "stepping stones" for the colonization of Ascension Island.

Gischler & Lomando (1997) reported that the main invertebrates found in the calcarenites of the barrier reefs and atolls of Belize were mollusks and corals. Kikuchi & Leão (1997) and Gherardi & Bosence (2005) noted the presence of coral and mollusks fragments on the Rocas Atoll; however, the benthic invertebrates were not identified. For the first time, to our knowledge, we identify eight invertebrate (mainly mollusks) fossilized species on the Rocas Atoll. Nevertheless, high levels of endemic species restricted to the northeast coast of Brazil or to the South Atlantic Islands were observed. Thus, islands present a diversity and stability paradox. They are often extremely poor in the number of species, but have considerable biological interest in terms of extraordinary endemic genera and taxonomically isolated groups (Cronk, 1997). The answer to this paradox is isolation from the continent and location in the ocean. The Rocas Atoll is located approximately 300 km from the South American continent. However, the data show species commonly found in the coastal zone (*S. stellata*

and *F. grävada* are abundantly found corals on the coast of Brazil). The data also indicate invertebrate species such as *M. noronhensis* restricted to the South Atlantic Ocean Islands (*J. lagostoma*) and endemic to the insular Rocas Atoll / Fernando de Noronha complex.

Because of the extreme isolation of the shallow water, the tropical biota of the southwestern Atlantic region has stimulated much interest in terms of its taxonomic composition, origin, and evolution (Hachich *et al.*, 2015). Large areas of biogeographic interest in the southern Atlantic are not well known; among these environments are oceanic islands with a reef fauna of low species diversity, presenting isolation effects (Floeter & Gasparini, 2000). Considering that the islands may vary in their age of formation, size, and distance from the coast, comparative studies among their paleofauna may reveal considerable information on the evolution patterns and distribution of sea species (Joyeux *et al.*, 2001).

Centers of endemism predominate in areas isolated by distance or oceanography. For example, isolated islands rich in endemic species include St. Helena and Ascension Islands in the Atlantic Ocean. These endemism centers also occur where no reversing currents move water from the tropical to temperate latitudes (Roberts *et al.*, 2002). The islands of the Rocas Atoll and Fernando de Noronha are situated in the Caribbean Province, in the Antillean sub-region, by virtue of their malacofauna. Faunal invasion probably occurs from St. Helena and the Ascension islands. The South Equatorial Current from the Gulf of Guinea, which flows into Cape São Roque, may be the main avenue for species introduction. The South Equatorial Current flows in the direction of Fernando de Noronha, crosses the region of the Rocas Atoll, with a constant westward drift at a speed of 0.8–1.0 knot (Kikuchi & Leão, 1997), and then to the southeastern tropical coast.

Radiometric datings of the calcarenite situate the samples in the middle Holocene (Quaternary). Gherardi & Bosence (2005) suggests that the development of beach rock can occur when a sufficiently large amount of detrital biogenic material is allowed to accumulate. Conditions necessary to ensure detrital material for beach rock formation includes constant, strong wind direction and absence of devastating storms. The same authors suggest that the present day Rocas Atoll topography may be the result of late Holocene SW Atlantic sea-level changes. The geologic history of the Rocas Atoll finishes at a short geological period with the oldest date only 4860 y BP ¹⁴C (Kikuchi & Leão, 1997). The data of Kikuchi & Leão (1997) and Gherardi & Bosence (2005) and the new biogeographic data from this study suggest a hypothesis of recent colonization on the Rocas Atoll, probably only in the Holocene, from the

Tropical Southwestern Atlantic coast and Fernando de Noronha Archipelago.

5. Conclusions

Benthic invertebrates (mollusks, corals, and crustaceans) discovered on the Rocas Atoll constitute new records of species with radiometric dates ranging from 3449 ± 790 y BP to 3033 ± 620 y BP. These oceanic reef fossils provide important paleoceanographic (evidence of sea-level changes) and paleobiogeographic (new invertebrate records) data for the middle Holocene in the South Atlantic. Knowledge of the main fossilized benthic species in this scarcely known region in the Equatorial South Atlantic is important for understanding the paleobiogeography of marine islands. Therefore, future studies on quantitative benthic assemblages in the Rocas Atoll should use paleoecology and sea level history to understand the geological history of this island. This information can promote effective management of tropical oceanic reefs in the face of rising sea levels in the Anthropocene. In particular, stratigraphic changes in the distribution of benthic organisms can be used as indicators of sea level changes. To understand the recent ecological history of South Atlantic Islands, comprehensive surveys over a range of islands in the tropical Atlantic Ocean are required.

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Appendix

Supporting Information associated with this article is available online at http://www.aprh.pt/rgci/pdf/rgci-651_Soares_Supporting-Information.pdf

References

- Angulo, R.J.; Souza, M.C.; Fernandes, L.A.; Disaró, S.T. (2013) - Quaternary sea-level changes and aeolianites in the Fernando de Noronha archipelago, northeastern Brazil. *Quaternary International*, 305:15-30. DOI: 10.1016/j.quaint.2012.12.029
- Barry, S.J.; Cowell, P.J.; Woodroffe, C.D. (2007) - A morphodynamic model of reef-island development on atolls. *Sedimentary Geology*, 197(1-2):47-63. DOI: 10.1016/j.sedgeo.2006.08.006
- Beier, J.A. (1985) - Diagenesis of Quaternary Bahamian beachrock: petrographic and diagenetic evidence. *Journal of Sedimentary Petrology*, 55(5):755-761. DOI: 10.1306/212F87DD-2B24-11D7-8648000102C1865D
- Cronk, Q.C.B. (1997) - Islands: stability, diversity, conservation. *Biodiversity Conservation*, 6(3):477-493. DOI: 10.1023/A:1018372910025

- Davies, P.J.; Kinsey, D.W. (1973) - Organic and inorganic factors in recent beach rock formation, Heron Island, Great Barrier Reef. *Journal of Sedimentary Petrology*, 43(1):59-81. DOI: 10.1306/74D726E4-2B21-11D7-8648000102C1865D
- Erginal, A.E.; Ekinci, Y.L.; Demirci, A.; Bozcu, M.; Ozturk, M.Z.; Avcioglu, M.; Oztura, E. (2013) - First record of beachrock on Black Sea coast of Turkey: Implications for Late Holocene sea-level fluctuations. *Sedimentary Geology*, 294:294-302. DOI: 10.1016/j.sedgeo.2013.06.003
- Floeter, S.R.; Gasparini, J.L. (2000) - The southwestern Atlantic reef fish fauna: composition and zoogeographic patterns. *Journal of Fish Biology*, 56(5):1099-1114. DOI: 10.1006/jfbi.2000.1231
- Gherardi, D.F.M.; Bosence, D.W.J. (1999) - Modeling of the ecological succession of encrusting organisms in recent coralline-algal frameworks from Atol das Rocas, Brazil. *Palaios*, 14(2):145-158. DOI: 10.2307/3515370
- Gherardi, D.F.M.; Bosence, D.W.J. (2001) - Composition and community structure of the coralline-algal reefs from Atol das Rocas, South Atlantic, Brazil. *Coral Reefs*, 19(3):205-219. DOI: 10.1007/s003380000100
- Gherardi, D.F.M.; Bosence, D.W.J. (2005) - Late Holocene reef growth and relative sea-level changes in Atol das Rocas, equatorial South Atlantic. *Coral Reefs*, 24(2):264-272. DOI: 10.1007/s00338-005-0475-5
- Gischler, E.; Lomando, A.J. (1997) - Holocene cemented beach deposits in Belize. *Sedimentary Geology*, 110(3-4):277-297. DOI: 10.1016/S0037-0738(96)00088-7
- Gomes, R.S.; Costa, P.M.S.; Monteiro, J.C.; Coelho, A.C.S.; Salgado, N.C. (2006) - Moluscos das Ilhas Oceânicas brasileiras. In: R. J. V. Alves & J.W.A. Castro (eds), *Ilhas Oceânicas brasileiras da pesquisa ao manejo*, pp. 179-198, Ministério do Meio Ambiente, Secretaria de Biodiversidade e Florestas, Brasília, DF, Brazil. ISBN: 8587166913.
- Hachich, N.F.; Bonsall, M.B.; Arraut, E.M.; Barneche, D.R.; Lewinsohn, T.M.; Floeter, S.R. (2015) - Island biogeography: patterns of marine shallow-water organisms in the Atlantic Ocean. *Journal of Biogeography*, 42(10):1871-1882. DOI: 10.1111/jbi.12560
- Hartnoll, R.G.; Broderick, A.C.; Godley, B.J.; Saunders, K.E. (2009) - Population Structure of the land crab *Johngarthia lagostoma* on Ascension Island. *Journal of Crustacean Biology*, 29(1):57-61. DOI: 10.1651/08-2992.1
- Hickerson, M.J.; Meyer, C.P. (2008) - Testing comparative phylogeographic models of marine vicariance and dispersal using a hierarchical Bayesian approach. *BMC Evolutionary Biology*, 8:322. DOI: 10.1186/1471-2148-8-322
- Irion, G.; Morais, J.O.; Bungenstock, F. (2012) - Holocene and Pleistocene sea-level indicators at the coast of Jericoacoara, Ceará, NE Brazil. *Quaternary Research*, 77(2):251-257. DOI: 10.1016/j.yqres.2011.10.007
- Joyeux, J.C.; Floeter, S.R.; Ferreira, C.E.L.; Gasparini, J.L. (2001) - Biogeography of tropical reef fish: the South Atlantic puzzle. *Journal of Biogeography*, 28(7):831-841. DOI: 10.1046/j.1365-2699.2001.00602.x
- Kempf, M.; Matthews, H.R. (1969) - Occurrence of the genus *Malea* Valenciennes, 1832 in Atlantic waters, with the description of a new species (Mollusca: Gastropoda). *Arquivos de Ciências do Mar* (ISSN 0374-5686), 9(1):57-62, Fortaleza, CE, Brazil. Available on-line at http://www.labomar.ufc.br/images/stories/arquivos/ArqCienMar/V09_1_1969/acm_1969_9_1_12.pdf
- Kikuchi, R.K.P.; Leão, Z.M.A.N. (1997) - Rocas (Southwestern Equatorial Atlantic, Brazil): an atoll built primarily by coralline algae. In: H. A. Lessios & I. G. Macintyre (eds.), *Proceedings of*

- the 8TH International Coral Reef Symposium, pp.731-736, Smithsonian Tropical Research Institute, Panama City. Available on-line at [http://www.researchgate.net/publication/221965459_Rocas_\(Southwestern_Equatorial_Atlantic_Brazil\)_an_atoll_built_primarily_by_coralline_algae](http://www.researchgate.net/publication/221965459_Rocas_(Southwestern_Equatorial_Atlantic_Brazil)_an_atoll_built_primarily_by_coralline_algae)
- Leal, J.H. (1991) - *Marine prosobranch gastropods from Oceanic Islands off Brazil, species composition and biogeography*. 418p., Dr. W. Backhuys Publishers / U.B.S. Oegstgeest, Amsterdam, The Netherlands. ISBN: 978-9073348110
- Leão, Z.M.A.N.; Kikuchi, R.K.P.; Testa, V. (2003) - Corals and coral reefs of Brazil. *Latin American Coral Reefs*, 2003:9-52. DOI: 10.1016/B978-044451388-5/50003-5
- Leão, Z.M.A.N.; Kikuchi, R.K.P. (2005) - A relic coral fauna threatened by global changes and human activities, Eastern Brazil. *Marine Pollution Bulletin*, 51(5-7):599-611. DOI: 10.1016/j.marpolbul.2005.04.024
- Longo, G.O.; Morais, R.A.; Martins, C.D.L.; Mendes, T.C.; Aued, A.W.; Cândido, D.; Oliveira, J.; Nunes, L.T.; Fontoura, L.; Sissini, M.N.; Teschima, M.M.; Silva, M.B.; Ramlov, F.; Gouveia, L.; Ferreira, C.E.L.; Segal, B.; Horta, P.A.; Floeter, S.R. (2015) - Between-habitat variation of benthic cover, reef fish assemblage and feeding pressure at the only atoll in South Atlantic: Rocas Atoll, NE Brazil. *PLoS ONE*, 10(6):e0127176. DOI: 10.1371/journal.pone.0127176
- Mauz, B.; Vacchi, M.; Green, A.; Hoffman, G.; Cooper, A. (2015) - Beachrock: A tool for reconstructing relative sea level in the far field. *Marine Geology*, 362(1):1-16. DOI: 10.1016/j.margeo.2015.01.009
- Mcdowall, R.M. (2005) - Falkland Islands biogeography: converging trajectories in the South Atlantic Ocean. *Journal of Biogeography*, 32(1):49-52. DOI: 10.1111/j.1365-2699.2004.01167.x
- Miloslavich, P.; Klein, E.; Díaz, J.M.; Hernández, C.E.; Bigatti, G.; Campos, L. (2011) - Marine Biodiversity in the Atlantic and Pacific Coasts of South America: Knowledge and Gaps. *PLoS ONE*, 6(1):e14631. DOI: 10.1371/journal.pone.0014631
- Morais, J.O.; Irion, G.F.; Pinheiro, L.S.; Kasbohm, J. (2009) - Preliminary results on Holocene sea-level changes on Ceará coast/Brazil. *Journal of Coastal Research* (ISSN 0749-0258), SI56:646-649, Lisboa, Portugal. Available on-line at http://e-geo.fch.unl.pt/ICS2009/_docs/ICS2009_Volume_1/646.649_J.O.Morais_ICS2009.pdf
- Neraudeau, D.; Mathey, B. (2000) - Biogeography and diversity of South Atlantic Cretaceous echinoids: implications for circulation patterns. *Paleogeography, Paleoclimatology, Palaeocology*, 156(1-2):71-88. DOI: 10.1016/S0031-0182(99)00132-7
- Pereira, M.M.V.; Ros, L.F.; Bezerra, F.H.R. (2007) - Lithofaciology and palaeoenvironmental analysis of Holocene beachrocks in northeastern Brazil. *Journal of Coastal Research*, 23(6):1535-1548. DOI: 10.2112/05-0562.1
- Pereira, N.S.; Manso, V.A.V.; Silva, A.M.C.; Silva, M.B. (2010) - Mapeamento Geomorfológico e Morfodinâmica do Atol das Rocas, Atlântico Sul. *Journal of Integrated Coastal Management / Revista da Gestão Costeira Integrada*, 10(3):331-345. DOI: 10.5894/rgci209
- Pereira, N.S.; Manso, V.A.V.; Macedo, R.J.A.; Dias, J.M.A.; Silva, A.M.C. (2013) - Detrital carbonate sedimentation of the Rocas Atoll, South Atlantic. *Anais da Academia Brasileira de Ciências*, 85(1):57-72. DOI: 10.1590/S0001-37622013000100005
- Pereira, N.S.; Voegelin, A.R.; Paulukat, C.; Sial, A.N.; Ferreira, V.P.; Frei, R. (2015) - Chromium-isotope signatures in scleractinian corals from the Rocas Atoll, Tropical South Atlantic. *Geobiology*, 14(1):1-14. DOI: 10.1111/gbi.12155
- Rios, E. C. (1994) - *Seashells of Brazil*. 481p., Fundação da Universidade do Rio Grande, Rio Grande, RS, Brazil. ISBN: 8585042362.
- Rios, E. C. (2009) - *Compendium of Brazilian Sea Shells*. 668p., Editora Evangraf, Rio Grande, RS, Brazil. ISBN: 8577271730
- Roberts, C.M.; McClean, C.J.; Veron, J.E.N.; Hawkins, J.P.; Allen, G.R.; McAllister, D.E.; Mittermeier, C.G.; Schueler, F.W.; Spalding, M.; Wells, F.; Vynne, C.; Werner, T.B. (2002) - Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science*, 295(5558):1280-1284. DOI: 10.1126/science.1067728
- Shen, J.W.; Long, J.O.; Pedroja, K.; Yang, H.Q.; Xu, H.L.; Sun, J.L. (2013) - Holocene coquina beachrock from Haishan Island, east coast of Guangdong Province, China. *Quaternary International*, 310:199-212. DOI: 10.1016/j.quaint.2013.05.011.
- Simone, L. R. L. (2002) - Comparative morphological study and phylogeny of representatives of the Superfamily Calyptraeoidae (including Hipponicoidea) (Mollusca, Caenogastropoda). *Biota Neotropica*, 2(2):1-37. DOI: 10.1590/S1676-06032002000200013.
- Soares, M. O.; Meirelles, C. A.O.; Lemos, V.B. (2011) - Reef bioconstructors of Rocas Atoll, Equatorial South Atlantic. *Biotemas* (ISSN 2175-7925), 24:37-46, Florianópolis, Santa Catarina. Available on-line at <https://periodicos.ufsc.br/index.php/biotemas/article/download/2175-7925.2011v24n2p37/17820>
- Spurgeon, D.; Davis Jr., R.A.; Shinnu, E.A. (2003) - Formation of 'Beach Rock' at Siesta Key, Florida and its influence on barrier island development. *Marine Geology*, 200(1-4):19-29. DOI: 10.1590/S1676-06032002000200013
- Stoddart, D.R.; Cann, J.R. (1965) - Nature and origin of beach rock. *Journal of Sedimentary Petrology*, 35(1):243-247. DOI: 10.1306/74D7122B-2B21-11D7-8648000102C1865D.
- Stoddart, D.R.; Fosberg, E.R.; Spellman, D.L. (1982) - Cays of the Belize Barrier Reef and lagoon. *Atoll Research Bulletin* (ISSN 0077-5630), 256:1-76, New York, United States of America. Available on-line at <http://www.sil.si.edu/digitalcollections/atollresearchbulletin/issues/00256.pdf>
- Woodroffe, C.D. (2008) - Reef-island topography and the vulnerability of atolls to sea-level rise. *Global Planet Change*, 62(1-2):77-96. DOI: 10.1016/j.gloplacha.2007.11.001.
- Woodring, W.P. (1928) - Miocene Mollusks from Bowden, Jamaica. Part 2, Gastropods and Discussion of Results. In: W. P. Woodring (ed.), *Contributions to the Geology and Palaeontology of the West Indies*, 564p., Carnegie Institution, Washington, D.C., U.S.A.

Geohistorical analysis of uses and activities on the waterfront of the “Parque Atlântico Mar Chiquito” Reserve, Argentina*

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ABSTRACT

Mar Chiquita is a small seaside town located in the province of Buenos Aires, Argentina. The everyday life of its residents has been considerably affected since the area was declared a biosphere reserve in 1996. The harmonization of its preservation along with the human activities has become the main challenge for the community. A geo-historical analysis of the different human activities carried through the waterfront of the natural reserve was conducted in order to identify conflict of interests, incompatibilities between the various activities and other issues of preservation. That being said, the main aim was to determine key elements in order to improve the area management. The results obtained allows us to identify the main problems of the waterfront and to establish a set of measures so as to ensure a proper management of the area. Moreover, strategic units were identified in order to ensure land-management policies and to redesign the protected area.

Keywords: incompatibilities, conflict of interests, management and sustainable development

RESUMO

Análise geohistórica de usos e atividades na beira-mar da Reserva de “Parque Atlântico Mar Chiquito, Argentina

Mar Chiquita é uma pequena cidade costeira na província de Buenos Aires, Argentina, que viu transformada suas vidas diárias, ao ser declarada reserva da biosfera, em 1996. Desde então, das atividades econômicas com a conservação ambiental tornou-se o principal desafio para a comunidade. Através de uma análise geohistórica diferentes usos e atividades que se desenvolvem na orla costeira da reserva, foi feita a identificação de incompatibilidades dos usos, conflitos de interesse e de problemas decorrentes do conflito entre os objetivos de conservação e de uso. Como objectivo derivado, foram analisados os elementos críticos para melhorar a gestão. Os resultados permitem identificar os principais problemas da orla marítima e estabelecer recomendações para a adopção de uma gestão adequada. Por sua vez, são identificadas unidades estratégicas, para estabelecer políticas de uso da terra e redesenhar a área protegida.

Palavras-chave: incompatibilidades, conflitos de uso, gestão and desenvolvimento sustentável.

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1. Introduction

Coastal areas have the highest population density in the world. Historically, these regions have been the focus of major development in countries with access to the sea, and are often rich in natural resources. These two factors have led to a wide range of human activities in order to benefit from these territories. The variety and the intensity with which each of these activities are implemented has an impact, not only on the physical, environmental and ecological conditions of the area but they also generate major conflict of interests. The multiple land-use causes incompatibilities that bring about conflicts between the activities and the land users or even among certain sectors of society that intend to benefit from a specific activity. In this case, most common conflicts are related to the conservation of the area, recreational activities and economic growth. One of the main challenges in strategic and coastal management is to solve these conflicts and propose the most suitable organization of the territory in terms of sustainability, avoiding any land-use incompatibilities and meeting the needs and interests of the sectors involved.

Muñoz (2003) establishes a general classification of the various land-use types and economic activities that can be developed in the coastal areas. In regards to the land-use types he suggests the following:

- As a natural space
- As human settlement
- As facilities and infrastructure support
- As space transmitter/receiver discharges
- As a coastal defense

Economic activities include:

- Extractive or Primary
- Basic
- Industrial or Manufacturing
- Commercial linked to Maritime Transportation
- Leisure and Tourism

The practice of the previously mentioned land-use types depends not only on the physical environment characteristics but also on other factors such as the urban area size and population, level of economic development, political conditions, social perception and legal framework, among others.

In South America, along the Atlantic coast, the physical conditions allow the practice and development of all types of land-use and economic activities listed above, typically combined with large urban areas. One example would be the coastline of the Buenos Aires province, the most populated one in the country.

The truth is that both natural processes and human actions, generate territorial transformations, those of which can be either permanent and visible or dynamic and untraceable. Consequently, two types of analysis

emerge: the historical or geo-historical analysis that reflects the evolution of the territorial changes over time and the present analysis, which reflects the results, implications and consequences of this evolution.

Mar Chiquita is a small town in the province of Buenos Aires, Argentina, which has always lived off agriculture and livestock. Tourism contributes to the local economy during the summer season, but it has never been the focus of orderly development and planning.

All locations along the Atlantic coastline of Buenos Aires are considered to be “sun and sand” destinations sharing the same tourism model with a marked seasonality in supply and demand. The reserve lagoon, its fishing, open-air camping and distinctive tranquility have always been its main attractions, still Mar Chiquita has never been known as a popular destination.

The city plan was approved in 1949 (Venancio, 1951) but it was with the biosphere reserve declaration in 1996, within the *Man and Biosphere* program (MAB), that the still existing dichotomy between a mass development activity and a low impact activity arises.

The first one is carried through with the “sun and sand” model around the lagoon area, considering the immoderate number of visitors which is not advisable and even detrimental to the ecosystem size and fragility. The low impact alternative takes place entirely in the core area of the biosphere reserve which has a limit of 50 visitors per day.

Even though the appropriation and certain uses of coastal resources may be common to different time periods in history, it is also true that many of those have changed. In this regard, the declaration of the biosphere reserve represented a turning point which involved the design of new development strategies.

From that moment onwards, the implicated sectors’ interests were to be oriented towards the development and use of resources in agreement with the objectives of the reserve. These specifications might imply certain adjustments and modifications in some of the uses and activities that are regularly developed in the area.

Based on the above, the following objectives are being raised:

- Analyze the different uses and activities that have been developed in the Mar Chiquita waterfront since 1949 until today.
- Describe any conflicts and incompatibilities between all current uses and other resulting issues.

2. Study Area

The study area corresponds to the Mar Chiquita MAB reserve. Mar Chiquita is the only long canal semi-enclosed coastal lagoon within Argentina and the southernmost one of its category in South America. It is

located between 37° 33' - 37° 43' S and 57° 15' - 57° 30' W in the Atlantic coast of the Buenos Aires Province. It has an elongated shape, with a general NNW-SSE direction, a length of 25 km. and a variable width between 100 and 4500 m.

According to Cousseau (2003), the Mar Chiquita reserve has a total area of 46 km² with a drainage basin of 10,000 km². It is separated from the ocean by a large chain of dunes developed during the Pleistocene Epoch and its connection with the open ocean is performed by a canal which is approximately 6 km long, 200 m wide and a depth ranging between 3 and 0.5 m. In addition to the surface area of the lagoon, the nearly 260 km² of adjoining territories should be also considered as part of the Biosphere Reserve "Parque Atlántico Mar Chiquito".

The Argentine coastline extends over 4725 km long (IGM, 2001) and can be divided into two main areas: the Pampeano and Patagónico Fueguino (Dadón & Matteucci, 2006). Mar Chiquita belongs to the Pampa coastline, which is low with few landforms and full of dunes located parallel to the coast creating a ridge. In general, the sea and wind create wide sand dune beaches which partially or totally obstruct the drainage of the rivers that descend into the sea, resulting in ponds, marshes and estuaries of saline soils with acidity

acidity problems. The waterfront of the Mar Chiquita department extends for a total of 67 km.

For the purpose of this work, it is considered the coastal region included within the reserve area "Parque Atlántico Mar Chiquito", the one which expands from the Mar de Cobo's border to the Villa Gesell department for approximately 30 km. At the same time, the Mar Chiquita waterfront is divided into two large areas. The first one extends from the border of the Mar de Cobos beaches to the mouth of the lagoon, which coincides with the urban area and is part of the buffer and transition zone in the reserve zoning. The second section extends from the mouth of the lagoon towards north until the border of the Villa Gesell beaches, located in the core area of the reserve. In Figure 1 the delimited study area.

3. Materials and Methods

3.1. The operational framework

To attain the proposed objectives, a combination of approaches and approximations were selected. The main approach was achieved by using a geo-historical analysis. The reason for choosing this analysis responds to the need for a retrospective study of the changes that have occurred in the Mar Chiquita waterfront over the past 60 years.

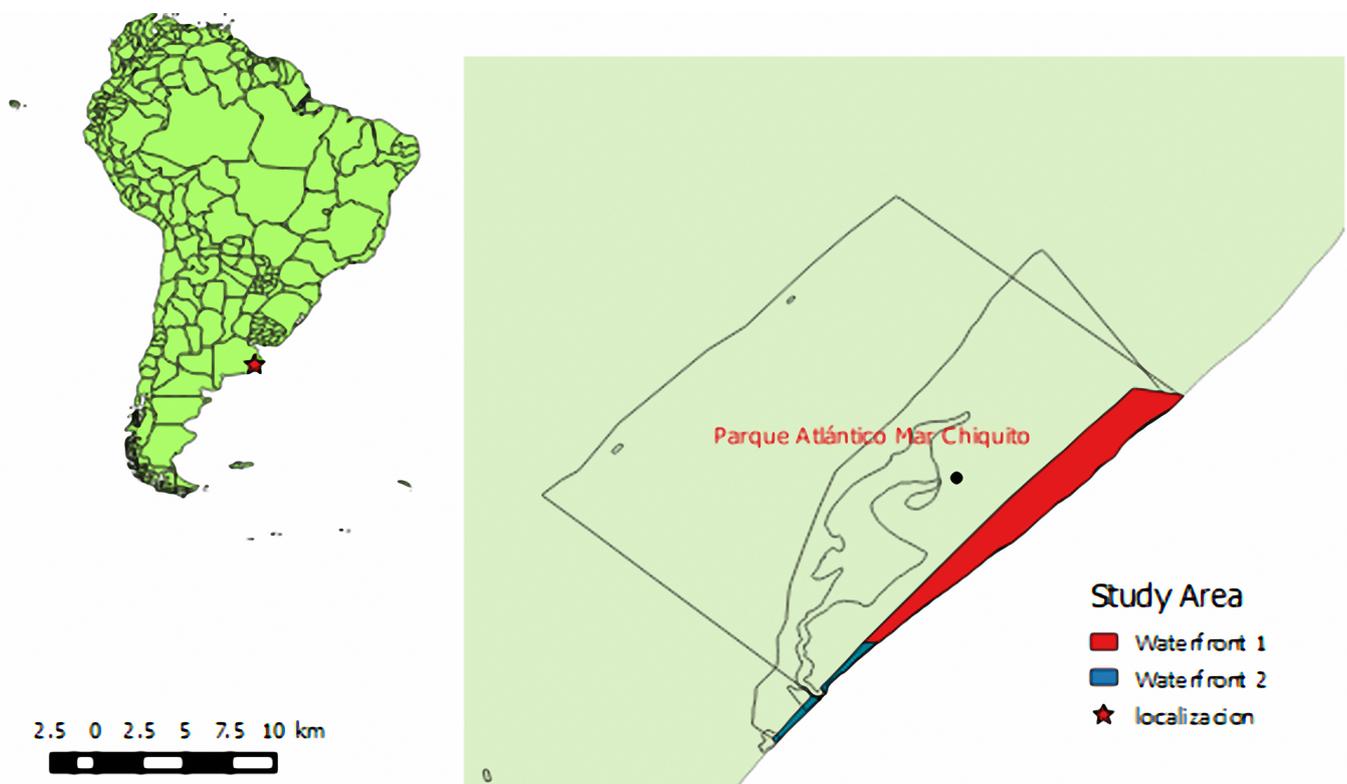


Figure 1 - Study area on the waterfront of the "Parque Atlántico Mar Chiquito" Reserve.

Figura 1 – Área de estudo na beira-mar da reserva do "Parque Atlántico Mar Chiquito"

This approach takes into account the concept of coastal system proposed by Muñoz (2003) and the Integrated Coastal Zone Management (ICZM). Even though the changes will always be understood from an integrated view, the following division into three subsystems shall be considered: physical-natural, socio-productive and legal-administrative.

3.2. Materials and data collection

A number of photographic records and aerial images were used as material: aerial photographs from 1931 (Admiralty Hydrographic Division), two Google Earth images from 2003 and 2013 and other aerial photographs from 1996 to 2013 (“Interpretation Centre of the Biosphere Reserve Parque Atlántico Mar Chiquito”).

The Mar Chiquita blueprint from 1949 (Venancio, 1951) as well as different surveys, records and statistical data were also consulted in order to complement the previously mentioned information. A third source of data were the bibliographic documents that have studied the changes and transformations on the Mar Chiquita coastline.

3.3 Data analysis

The evaluation process includes several important steps. The information collected in the first stage, along with the field observation, was used to identify the main land-uses and activities that are currently developed in the area. The second step consisted in processing the bibliographic documents by applying the geohistorical analysis in order to recognize the changes occurred on the waterfront and to describe the present situation.

Analysis of the current problems

Muñoz (2003) performs an analysis of the different views over time in terms of defining and addressing problems in the coastal areas. According to him, the problems have basically three stages or levels:

1. Deficiencies on the social system and organizational structure that allows and sometimes even supports the step to the next stage;
2. The development of a specific human activity that involves the malfunction of the area or other coastal resources;
3. An impact on: the same activity or another activity, one or more coastal resources, the established order, or simultaneously on more than one of the previously mentioned groups (Muñoz, 2003).

According to the author, the deficiencies on the social system and organizational structure would be the source of the problem while the human activity is the cause and the negative impact is the consequence. Thus, based on the idea that there are deficiencies on the Mar Chiquita’s social system and organizational structure

and by knowing the current uses and activities, is that we represent the existing problem with a graph of cause and effect.

Incompatibility and Conflitiveness

The functionality of uses and activities should be intended specially in terms of relations between them: synergy, complementarity, neutrality, malfunction or incompatibility.

For these concepts are understood:

- Synergy: when the confluence of two or more uses are mutually reinforcing.
- Complementarity: when a positive development in the direction of an application involves next to another.
- Neutrality: when developing a use or activity is independent of another.
- Competition and/or malfunction: when developing a use or activity means the decrease for the development of another.
- Incompatibility: two uses are incompatible with each other when achieving one implies the failure of another.

To describe relationships of conflict and incompatibility of uses (and other problems arising), matrices of compatibility and problem trees were used. These techniques allowed us to systematized the critical analysis of the current situation, which were then compared and discussed with the results of other studies related to this issue.

The development of this process of data analysis allowed us to suggest strategies of management for the Mar Chiquita coastal area.

4. Results

4.1. Geohistorical analysis of land- uses and activities

The territorial transformations on the Mar Chiquita waterfront can be divided into two phases: the first one, mainly characterized by the action of natural phenomena and the second one, with a strong intervention and action of humans. The use and development of the waterfront increases chronologically, accompanying the development and growth of the town.

For each of the sectors analyzed, the following uses have been identified:

Waterfront 1

This portion of the waterfront recorded fewer uses and activities and less territorial transformations. Their analysis must inevitably be divided into two periods: until 1996, and after the declaration of the natural reserve.

In the first period we can identify three types of applications. The first one is linked to the recreational use of the area near the mouth of the lagoon, although with very few visitors and low impact. The second one is referred to the urbanization of area, which has between 100 and 230 inhabitants (INDEC, 2001). While the urban sector or infrastructure was not planned, this area was affected by the fixation of sand dunes that altered the natural dynamics of the sector.

The third use is related to the coastal protection methods. As it will be further explained in details, Mar Chiquita suffers, since the 40s, one of the most important natural phenomena of coastal erosion in the province of Buenos Aires. Consequently, a series of interventions were performed in order to try to attenuate this problem. In this sector of the waterfront it can be mentioned a project that had a major impact; the construction of a breakwater at the mouth of the lagoon in 1973. This managed to secure the mouth of the lagoon, which had suffered from fluctuations up to 2500 meters.

After 1996, this area is included in the core zone of the reserve. Therefore, as of this date, its only use is as a natural area. No major changes in this sector have been recorded in the last ten years, but the continued erosion in Mar Chiquita has produced variations in relation to the quantity of sand available on the beaches.

Waterfront 2

Historically, this sector has suffered the largest number of transformations since it has focused almost on all uses and activities.

Coastal Defense

Although most of the coastal defense activities have been developed since the 80's, these activities are linked to historical natural processes, covering even periods prior to those described in this work. In any case, the coastal defense has been associated with the first stage of this analysis, which runs from 1949 to 1983. During these years, one of the most extraordinary natural phenomena of coastal erosion took place in the province. Various studies show that there was an inland shoreline displacement of 320 meters during a period of 32 years with an average of 10 meters per year (Lagrange, 1993; Merlotto & Bértola, 2008; Supporting Information I).

Another natural phenomenon that occurred over these years was the displacement of the lagoon mouth. The fluctuations were around 5000 m and have changed its original conformation from north to south (Lagrange, 1993; Supporting Information II).

Following these natural phenomena one of the most important uses begins to develop; coastal protection. Because of the severe erosion problems from previous years, a series of protective coastal methods were performed by the public sector.

The first intervention was in 1973 when a breakwater was built in the southern sector of the mouth of the lagoon that allowed its current configuration (remodeled again in 1983). The second stage starts in 1982 and coincides with the further development of the town and better positioning as a tourist destination. This allows, on one hand, an increase in the uses of the waterfront by the local community and a more active intervention of the public sector.

Over the years different techniques were applied. Firstly, pneumatics were located in line to protect the coastline, and then other concrete elements were used as shown in Supporting Information III).

In 1991 four jetties were built at the south of lagoon mouth; three of which currently still protect the area along the streets Funes, Gallardo and San Martín. The last one is the longest one, reaching 80 m length. Along with this project, the previously mentioned methods, such as the pneumatics and concrete elements, were considerably improved while other rocks were also used to protect these sectors in risk. However, these sectors also create a great visual pollution due to the presence of iron debris scattered along the beaches.

From an administrative point of view, the legal issue of coastal erosion in the province falls under the Laws 11,723 from 1995, 13,516 from 1998, and especially 12.122 from 2006 declaring the Mar Chiquita coast as an emergency zone.

From a legal framework, several plans and projects were presented to defend the waterfront. In 2006 the project called "protection and stabilization of the waterfront on the Mar Chiquita district" was implemented (Merlotto & Bértola, 2007; Bértola *et al.*, 2013). scheme of works made from 1991 to the present is shown in Supporting Information IV.

Urbanization

Among other human factors, the presence of buildings and roads along the coastline damages the environment, mainly because they were built on the first line of sand dunes that provides sediment to the beach, maintains its dynamic balance and constitutes the rainwater reserve of the area.

During the early twentieth century the uses and activities in this area were limited. Mar Chiquita had not yet been established as a touristic destination and had a low percentage of residents. Constructions were just beginning and it was in 1949 that the first plan of subdivision of the town (File 69-25-49) was approved.

The date of this subdivision coincided with the foundation of the town. The initial criteria for the subdivision followed the ruling principle at the time, to urbanize as close as possible to the beach. For this reason, blocks and streets were laid out in an area implying dune re-

moval, leveling and/or fixed with man made forestation. Due to these actions, natural dynamics were quickly and sharply altered, constituting one of the causes for the severe erosion between 1949 and 1957. Until 1979, in the south sector of the town alive dunes could be found, while in the remaining area they were fixed. This coincides with the lowest rates of erosion in the first sector. From that date on, with the urbanization and the expansion of the vegetation on the south sector, erosion rates began to increase, ranking among the highest in the town (Merlotto & Bértola, 2008). More information about the delimitation of the coastal zone it is provided in Supporting Information V.

However, the urbanization and settlement process was developed slowly and even today Mar Chiquita remains a very small town. The various censuses reflect a permanent population of 133 inhabitants in 1980; 162 inhabitants in 1991; 394 inhabitants in 2001 and 487 inhabitants in 2010 (INDEC, 1991, 2001, 2010).

It is noteworthy that there are a lot of second residences and according to the Ministry of Tourism and Environment of the town during the weekends the town often congregates up to 5,000 people. In the last decade the development of the waterfront has slowed its pace due, on the one hand, to the changes in legislation and secondly, to the erosion problems and cultural awareness of the risks.

Discharges

The treatment of both, municipal solid waste and sewage, has historically been very poor and there are currently large gaps. Storm drains into beaches have not been built; consequently, streets perpendicular to the shore and sloping toward her act as such. In various sectors of the urbanized waterfront it can be seen "canals" as rainwater drains on the beach and dragging sand into the sea. These phenomena are observed only in some streets, mainly in Avenue San Martín which is the only paved road (Supporting Information VI).

Sand Mining

The growth of coastal cities during the 1970s and 1980s greatly increased the demand for sand, and this area served as supplying for other Departments of the interior of the province. Sand mining has been considered one of the most important causes of coastal degradation in the Department of Mar Chiquita (Fundación & Municipalidad, 1991).

Sand mining was banned in 1977 (Decree Law No. 8,758) in Mar Chiquita and other Departments. However, in the 1980s and 1990s the extraction performed by public state entities was allowed and conducted by the city of Mar Chiquita on beaches located at the south of the district (Merlotto & Bértola, 2007).

Sand extraction was carried out without control and organization during a long time, mainly between the 60's and 70's. Despite the ban in 1977 there have been numerous incidents of illegal extraction in the later years. Today this use has virtually disappeared and sand mining rarely occurs.

Activities Related to Leisure and Tourism

For many years Mar Chiquita was considered as a spot near the city of Mar del Plata. This was observed even after its foundation as a town; the process of urbanization was slowly developed and has never grown into a large urban center. Despite this, it has always attracted interest on leisure and recreation. See Supporting Information VII.

A similar phenomenon occurs with tourism. Mar Chiquita responds to a mass tourism scheme, "sand and sun", although the extent of this activity is relatively smaller compared to other destinations in the Buenos Aires Atlantic coast. Tourist activity is developed in the waterfront and around the area of the lagoon, although only the first sector is of interest in this work.

According to the municipal delegation of Mar Chiquita, beside its 487 inhabitants, between 600 and 1000 temporary residents arrive on winter weekends and between 1000 and 3000 on summertime. Based on the load capacity scheme proposed by Yepes (1998), Bertoni (2013) estimated that the number of users on the beaches of Mar Chiquita is comfortable.

The Coastline as Natural Area

Other forms of coastal use identified by Muñoz (2003) is as a natural space. This purpose in Mar Chiquita is materialized through the various statements as a protected area. In Mar Chiquita there are three jurisdictions administering the territories under protection. During the first years of town development there was no protection, until in 1996 an international recognition created the Atlantic Biosphere Reserve Parque Mar Chiquito. After that it obtained recognition at provincial and municipal level. It is noteworthy that the protection extends to even the entire urban area of the town. The use as a natural area for the purposes of this paper has two distinct sectors. While the coastal sector number 1 has a strict protection, the second is considered as a buffer and transition zone.

The use as a natural area doesn't implied major changes or territorial transformations on the waterfront. This is because most of the interventions described in previous sections were performed before the reserve declaration. However, being the sector under strict protection has established a certain balance and from 1996 to the present has barely been transformed.

Use as natural space takes place in the coastal area 2 and has very low environmental impact. It is only ac-

cessible through visits organized by the Visitor Interpretation Centre, limited to a maximum number of 50 visitors per day.

4.2. Problems associated with uses and activities

For this type of analysis it is important to understand that the population is the main element and acts as a physical environment transformer. Activities to be considered are many, and can be categorized by type or scales.

Of the uses currently being developed in the city and those that have generated a transformation that still persists, the relationship of conflict can be analyzed through the problems they generate.

According to the approach developed by Munoz (2003) and based on the idea that there are deficiencies on the social and organizational structure in Mar Chiquita, can be expressed by a graph of cause and effect as shown in Supporting Information VIII. Different uses and activities generate impacts individually, but it is also important to consider the effects that cause altogether. Direct evidence problems are coastal erosion and pollution. However, each of them not only has been influenced by other coastal uses but also as a whole, generating major impacts: environmental degradation and loss of homes.

Coastal Erosion and destroyed of houses

Coastal erosion is one of the oldest problems in this area and even today remains a serious concern. It is strongly influenced by natural processes but is also enhanced by human action. Erosion is partly generated by sand extraction that affects the sedimentary material involved in the littoral drift. The extractive activity not only affects areas where it is carried out, but also increases the erosion of northern beaches (Marcomini & López, 1999).

Urbanization is another use that increases the phenomenon. In the early years, forestation and fixation of sand dunes avoided beach recovery and sedimentary natural balance. Subsequently, the processes of real estate expansion implied sand dune removal and the progress of construction near the sea limited the beaches dynamic sector.

The infrastructure also influences the erosion. In this case, works of coastal protection generate sand accumulation in one sector, but expand the erosion processes northward reaching similar levels of coastal regression (10 m/year) (Isla, 1992; Merlotto & Bértola, 2007).

Another use that creates an erosive impact is urban waste. Although it has been observed that there is no sewage or storm water drains with direct access to the sea, it is noteworthy that in some cases drainage of certain streets towards the beach generates erosion.

Activities related to leisure and tourism should also be considered in this problem. Externalities generated re-

garding erosion are related to construction and fittings of space to provide services to tourists and the excessive human pressure that may be generated during the summer season.

The loss of housing is a problem associated with coastal erosion that virtually took place since the beginning of the development, in 1949, until the present. It was mentioned previously that the average landwards displacement of the coastline was 10 meters per year. It was recorded between 299 and 320 meters of regression in the considered period (Lagrange, 1993; Merlotto & Bértola, 2008).

The loss reached 409 lots, according to Lagrange (1993), while Merlotto & Bértola (2008) estimated a total of 444 lots located in the coastline and 7 houses, totaling 451 properties disappeared by the coastline retreat. Total surface loss for 2007 taking into account the original plan was 64.36 hectares (Merlotto & Bertola, 2008).

Pollution and environmental degradation

Pollution in the study area is usually presented in two ways: in liquid form and as solid waste. Solid waste is mostly dumped by tourists and recreationists, but also dragged from the streets of the city to the beach on rainy days.

Liquid waste is coming through rainwater that drags urban area pollution and is poured onto the beach through the streets that has sloping onto it. Also can be submitted through the mouth of the lagoon, where the pollution comes from the lagoon itself.

Environmental degradation as a problem arises as the result of the combination of all the above negative impacts. Excessive, inappropriate or poorly regulated and managed use produces a gradual degradation and primarily affects the quality of the resource. The importance of this issue is even greater when taking into account the rebound effect of this problem. Like the uses and activities contribute to environmental degradation, this effect will decrease the possibilities of use of space and will reduce the quality of recreational experiences. For this reason, is needed seek to develop activities in a sustainable framework to prevent it become self-destructive

4.3. Incompatibility and conflictuality

Faced the identification of problems and dysfunctions in the uses and activities, is necessary to establish a land use planning. To do this, one of the main issues is to define compatibility.

This task is closely linked with the assessment of the aptitude of a territory. In this assessment process existing activities must be considered, as well as also potentials ones. For the first case (which is addressed in this study) needs and expectations of the population should

be analyzed, in combination with locations relative to the physical environment natural vocation and (economic, social and environmental) sustainability, but especially its functionality in terms of relations between them: synergy, complementarity, neutrality, dysfunction or incompatibility (understanding these concepts as expressed in the methodology).

Supporting Information IX shows the relationships between uses and activities identified in the study area.

5. Discussion

Several studies have addressed some problems of the Mar Chiquita waterfront, some of which have been taken as a source of information for this study. Mostly, these studies are focused on space transformations that have taken place in this area, either by natural factors or changes related to the growth and development of the town.

Perhaps the issue that has attracted most attention is coastal erosion. Many authors have studied this problem (Schnack *et al.*, 1983; Lagrange, 1993; Isla, 1997; Merlotto & Bértola, 2007) and it can be said that there are coincidences regarding the gravity of the situation and even as to the quantification of the coastline retreat. Most notable in this regard are recent studies that have shown the ineffectiveness that have so far the coastal defense works that have been implemented (Isla, 2006; Bértola *et al.*, 2013).

Other studies have addressed the processes of urbanization in the province of Buenos Aires and many have included analysis of the development of tourism and environmental impacts generated on the beaches. The studies of Dadón (2000), Dadón *et al.* (2002) and Bertoni (2013) are the most significant in this area.

However, few studies have focused on addressing the incompatibility of uses, land use planning and environmental conflicts. Conflicts are common in any society and in any kind of space, but the case of Mar Chiquita has an important feature. The late development of this area coupled with certain intrinsic characteristics resulted in a declaration as a protected area in 1996. This situation involved a tendency towards a development paradigm based on sustainability, which could in some way alter the use of space and its resources.

These changes are clearly evident in the study area of this work, where it can be seen as a sector of the waterfront it joined a strict protection zone, while in the other sector uses of varied nature are allowed. In accordance with the identified waterfront uses the following actors can be identified: the local community, tourism entrepreneurs, real estate developers, staff affected to the conservation and protection of the reserve, tourists and the public sector.

Some of these actors advocate a specific interest in a use or activity, while others may have more than one

inference. Thus, real estate developers and tourism operators have an economic motivation linked to the further development and expansion of its activities. The same can happen with tourists and visitors, who demand free access to the beach and the existence of infrastructures close to the beach or on the same beach. Also, the local community, the public sector and even the conservation agents require the existence of economic activities and a certain degree of development, but must worry about the care of resources and sustainability understood in all its dimensions.

Taking it as a starting point, the analysis of existing problems in the waterfront and the table of incompatibilities between uses and activities can establish relations of conflict between the different actors. The relationships of conflict in Mar Chiquita waterfront can be summarized in a binomial of development *versus* conservation, and the search of a third option within the paradigm of sustainable development. On one hand, this contrast is reflected in the need of the local people and their representatives to generate economic activities and develop infrastructural projects that can provide an improvement on services and quality of life. However, on the other hand, is manifested the need to make rational use of coastal space and ensure their long-term sustainability.

From this broad view of the conflict other conflictual relationships are derived that may exist between each group of actors or between the occasional exercise of a use over another. The difficulty of handling these situations is to set limits and create respect for them.

The table of relationships indicates which uses are currently living in this area and indicates potential sources of conflict. Setting limits on certain uses and activities depend on the development vision that is intended and on the future scenarios to which it points.

Regarding the planning of protected areas in recent years they have shown certain tendencies. In the first instance there is a concern relating to the competition for space and the lack of land use planning that threatens conservation units (Burkart, 2005; McDonald *et al.*, 2009; Morea, 2014). This concern in the case of biosphere reserves is greater due to the coexistence of urban development and productive use within the reserves themselves (Riddiford *et al.*, 2014). Regarding the latter, other authors have highlighted the importance and value that can have the stakeholders participation in the operation and management of these areas (Borrini-Feyerabend *et al.*, 2012; Calado *et al.*, 2014; Borrini-Feyerabend *et al.*, 2012)

Therefore, in addition, another big trend in investigations of protected areas is related to the planning of land use and the search for new methods of zoning and design that allows to achieve the compatibilization of biodiversity conservation with the use of resources (Gar-

cía-Frapolli *et al.*, 2007; Geneletti & van Duren, 2008; Ruiz-Frau *et al.*, 2015).

In this case, management and planning of the territory, and particularly at the coastal front, remains an open account. However, some initiatives in recent years reveal an emerging willingness to guide actions in this direction. As example of this, it can be highlighted the launch in 2011 of the 2010-2020 Strategic Plan of Mar Chiquita Department, which includes among its objectives the management and planning of the territory. Although to the date there is little progress, in the year 2012 began the Urban Management Plan.

On the other hand, from the province of Buenos Aires through the Unit for the Coordination of Integrated Coastal Management was launched in 2008 the Comprehensive Plan of Bonaerenses Coast, which among its most ambitious goals, intends to enact the Law of Coast of the province of Buenos Aires. However, progress has been considerably slow and none of the goals has not yet been achieved.

6. Conclusions

This work aimed to analyze the different uses and activities that have been developed in the Mar Chiquita waterfront since 1949 and to describe the conflicts and incompatibility relationships between them. Results show that Mar Chiquita has suffered considerable territorial transformations, but also important environmental, cultural, social, economic and administrative changes.

The cause of these changes is that among the uses and activities that were recorded, many are totally incompatible or have some degree of incompatibility. Behind these incompatibilities, there are economic, social and environmental conflicts, involving all sectors of society.

Furthermore, the bibliographic review shows that there are a considerable amount of studies addressing topics such as the development of tourism on the beaches of the province of Buenos Aires, the coastal urbanization, the environmental impact and the phenomena of coastal erosion; however, very few of them apply a holistic perspective. In that context, land use planning and integrated management of the coastal front is an outstanding account from their effective planning and implementation, but also from the scientific and academic approach.

Based on the results and the problems and conflicts identified in this study, the following lines of action are proposed:

- **Establish a land management strategy:** guided by instruments such as ICZM, establish a rearrangement of uses and activities that incorporate the normative to allow incompatibilities and articulate the current legislative dispersion, and the complex jurisdictional framework.

- **Rethinking the management system:** given the large number of players involved and the complex jurisdictional framework, it is evident the need to design a management model by the public sector, but that actively involves all parts, as an alternative to excel inter-sectoral conflicts.

- **Redesign of the protected area:** as a corollary of the previous recommended actions, will be necessary to evaluate the functionality of the Biosphere Reserve boundaries and zoning regarding the new proposed system. The effectiveness of the protected areas design has become a centerpiece in the quest for joint the binomial use and preservation.

Finally, results here obtained should be useful to contribute with the ICZM processes because it shows which are the main uses and activities and puts in evidence the relationships of incompatibility and conflicts between them. This information should be an important source for developing strategies of use and coastal zone management.

Appendix

Supporting Information associated with this article is available on-line at http://www.aprh.pt/rgci/pdf/rgci-646_Morea_Supporting-Information.pdf

References

- Bértola, G.R.; Merlotto, A.; Cortizo, L.; Isla, F.I. (2013) - Playas de bolsillo en Mar Chiquita provincia de Buenos Aires. *Revista de la Asociación Geológica Argentina* (ISSN: 1851-8249), 70(2):267-278, Asociación Geológica Argentina, Buenos Aires, Argentina. Available on-line file://localhost at http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S0004-48222013000200010
- Bertoni, M. (2013) - *Turismo Sustentable y Transformaciones Territoriales El caso del Partido de Mar Chiquita, Provincia de Buenos Aires*. 217p., PhD thesis, Universidad Nacional del Sur, Bahía Blanca, Argentina. Unpublished.
- Borrini-Feyerabend, G.; Dudley, N.; Jaeger, T.; Lassen, B.; Broome, N.P.; Phillips, A. (2012) - *Governance of Protected Areas: From understanding to action*. 124p., IUCN. Gland, Switzerland. ISBN: 978-2831716084
- Burkart, R. (2005) - Las áreas protegidas de la Argentina. In: A. Brown, U. Martinez Ortiz, M. Acerbi & J. Corcuera (eds.), *La situación ambiental argentina*, pp.399-404, Fundación Vida Silvestre, Buenos Aires, Argentina. ISBN: 978-9509427143. Available on-line at <https://www.researchgate.net/publication/228373957> Las areas protegidas de la Argentina
- Cousseau M.B.; Astarloa M. Díaz de; Figueroa D.; Martos P.; Reta, R. (2003) - *La Laguna Mar Chiquita, Provincia de Buenos Aires, Argentina. Características físicas y fauna ictícola*. 20p., Grupo Ictiología, Dto. de Ciencias Marinas, Facultad de Ciencias Exactas y Naturales, UNMdP, Mar del Plata, Argentina. Unpublished.
- Dadón, J.R. (2000) - Historia ambiental y turismo en la costa bonaerense: De playas, vacaciones y ecología. *Todo es Historia* (ISSN: 0040-8611), 450:54-62, Buenos Aires, Argentina. Available on-line at <http://www.ecologiamarina.com.ar/download/hateb.pdf>
- Dadon, J.R.; Chiappini, G.; Rodríguez, M. C. (2002) - Impactos ambientales del turismo costero en la provincia de Buenos

- Aires. *Gerencia ambiental* (ISSN 0328-7963), 9(88):552-560, Buenos Aires, Argentina.
- Dadón, J.R.; Matteucci, S.D. (2006) - Caracterización de las grandes regiones costeras argentinas. In: Federico Isla & Carlos A. Lasta (eds.), *Manual de manejo costero para la provincia de Buenos Aires*, pp.11-39, *Universidad Nacional de Mar del Plata*, Mar del Plata, Argentina. ISBN: 978-9875441828.
- Fundación CEPA; Municipalidad de Mar Chiquita (1991) - *Documento de Base Pautas para una Planificación Preventiva del Parque Atlántico Mar Chiquita*. 53p., Mimeo, La Plata, Argentina
- García-Frapolli, E.; Ayala-Orozco, B.; Bonilla-Moheno, M.; Espadas-Manrique, C.; Ramos-Fernández, G. (2007) - Biodiversity conservation, traditional agriculture and ecotourism: Land cover/land use change projections for a natural protected area in the northeastern Yucatan Peninsula, Mexico. *Landscape and Urban Planning*, 83(2):137-153. DOI: 10.1016/j.landurbplan.2007.03.007
- Geneletti, D.; Van Duren, I. (2008) - Protected area zoning for conservation and use: A combination of spatial multicriteria and multiobjective evaluation. *Landscape and Urban Planning*, 85(2):97-110. DOI:10.1016/j.landurbplan.2007.10.004
- IGM (2001) - *Atlas geográfico de la República Argentina*. 8th ed., 127p., Instituto Geográfico Militar (IGM), Buenos Aires, Argentina.
- INDEC (1991) - *Censo Nacional de Población, Hogares y Vivienda*. Instituto Nacional de Estadística y Censos (INDEC), Buenos Aires, Argentina. Available on-line at http://www.indec.gov.ar/nivel4_default.asp?id_tema_1=1&id_tema_2=16&id_tema_3=81
- INDEC (2001) - *Censo Nacional de Población, Hogares y Vivienda*. Instituto Nacional de Estadística y Censos (INDEC), Buenos Aires, Argentina. Available on-line at <http://200.51.91.245/argbin/RpWebEngine.exe/PortalAction?&MODE=MAIN&BASE=CPV2001ARG&MAIN=WebServerMain.inl>
- INDEC (2010) - *Censo Nacional de Población, Hogares y Vivienda*. Instituto Nacional de Estadística y Censos (INDEC), Buenos Aires, Argentina. Available on-line at http://www.indec.gov.ar/nivel4_default.asp?id_tema_1=2&id_tema_2=41&id_tema_3=135
- Isla, F.I. (1992) - Balance sedimentario y estacionalidad en 8 playas de Mar del Plata. *Thalassas* (ISSN: 0212-5919), 11:11-21, Universidade de Vigo, Spain.
- Isla, F.I. (1997) - Seasonal Behaviour of Mar Chiquita Tidal Inlet in Relation to Adjacent Beaches, Argentina. *Journal of Coastal Research*, 13(4):1221-1232, Coastal Education and Research Foundation, Coconut Creek, FL, U.S.A. Available on-line at <http://www.jstor.org/stable/4298731>
- Isla, F.I. (2006) - Erosión y defensa costeras. In: Federico Isla & Carlos A. Lasta (eds.), *Manual de manejo costero para la provincia de Buenos Aires*, pp.125-147, *Universidad Nacional de Mar del Plata*, Mar del Plata, Argentina. ISBN: 978-9875441828.
- Lagrange, A.A. (1993) - *Desde Mar del Plata una visión diferente: Mar, Playas y Puerto*. 556p., Ediciones Fundación Bolsa de Comercio de Mar de Plata, Mar del Plata, Argentina. ISBN: 987-9927109
- Marcomini, S.C.; López, R. (1999) - Alteración de la dinámica costera por efecto de la explotación de arena de playa, partidos de General Alvarado y Lobería, Provincia de Buenos Aires. *Revista de la Asociación Argentina de Sedimentología* (1853-6360), 6(1-2):1-18, La Plata, Argentina. Available on-line at <http://www.scielo.org.ar/pdf/raas/v6n1-2/v6n1-2a01.pdf>
- McDonald, R.I.; Forman, R.T.; Kareiva, P.; Neugarten, R.; Salzer, D.; Fisher, J. (2009) - Urban effects, distance, and protected areas in an urbanizing world. *Landscape and Urban Planning*, 93(1):63-75. DOI: 10.1016/j.landurbplan.2009.06.002
- Merlotto, A.; Bértola, G. R. (2007) - Consecuencias socio-económicas asociadas a la erosión costera en el balneario Parque Mar Chiquita, Argentina. *Investigaciones Geográficas*, 43:143-158. DOI: 10.14198/INGEO2007.43.08
- Merlotto, A.; Bértola, G.R. (2008) - Evolución urbana y su influencia en la erosión costera en el balneario Parque Mar Chiquita, Argentina. *Papeles de geografía* (ISSN: 1989-4627), 47:143-158, Universidad de Murcia, Murcia, Spain. Available on-line at <http://revistas.um.es/geografia/article/view/41271>
- Morea, J.P. (2014) - Situación actual de la gestión de las áreas protegidas de la Argentina: Problemáticas actuales y tendencias futuras. *Revista Universitaria de Geografía* (ISSN: 0326-8373), 23(1):57-75, Universidad Nacional del Sur, Bahía Blanca, Argentina. Available on-line at http://www.scielo.org.ar/scielo.php?pid=S1852-42652014000100003&script=sci_arttext&tlng=en
- Muñoz, J.M. Barragán (2003) - *Medio ambiente y desarrollo en áreas litorales: introducción a la planificación y gestión integradas*. 160p., Servicio de Publicaciones de la Universidad de Cádiz, Cadiz, Spain. ISBN: 978-8428109086.
- Ruiz-Frau, A.; Possingham, H. P.; Edwards-Jones, G.; Klein, C. J.; Segan, D.; Kaiser, M. J. (2015) - A multidisciplinary approach in the design of marine protected areas: Integration of science and stakeholder based methods. *Ocean & Coastal Management*, 103:86-93. DOI: 10.1016/j.ocecoaman.2014.11.012
- Schnack, E.J.; Álvarez, J.R.; Cionchi, J.L. (1983) - El carácter erosivo de la línea de costa entre Mar Chiquita y Miramar, provincia de Buenos Aires. pp.118-130, *Actas del Simposio Oscilaciones del Nivel del Mar durante el Último Hemiciclo Deglaciar en la Argentina*, Mar del Plata, Argentina.
- Venancio, U. (1951) - Balneario Parque Mar Chiquita. Folleto de loteo. *Folleto de loteo, Pecoraro Hnos SRL Impresiones*, Buenos Aires, Argentina.
- Yepes, V. (1998). Planificación y gestión turística de playas. 43p., *Actas del Curso sobre gestión Integral de la Costa*, Madrid, España.

Legislation

- Decreto-Ley N° 8.912/77* [1977] - *Ley de Ordenamiento Territorial y Uso del Suelo*. Gobierno de la Provincia de Buenos Aires, La Plata, Argentina. Available on-line at <http://www.gob.gba.gov.ar/legislacion/legislacion/d-8912.html>
- Ley N° 11.723* [1995] - *Ley Integral del Medio Ambiente y los Recursos Naturales*. La Plata, Argentina. Available on-line at <http://www.opds.gba.gov.ar/index.php/leyes/ver/64>
- Ley N° 13.516* [2006] - *Protección, conservación, mejoramiento y restauración de los recursos naturales y del ambiente en general. Modificación de la Ley N° 11.723*. Gobierno de la Provincia de Buenos Aires, La Plata Argentina. Available on-line at <http://www.gob.gba.gov.ar/legislacion/legislacion/l-13516.html>
- Ley N° 12.122* [1988] - *Emergencia litoral marítimo de Mar Chiquita*. Gobierno de la Provincia de Buenos Aires, Buenos Aires, Argentina. Available on-line at <http://www.carbap.org/root/MostrarDocumento.asp?id=642&accion=4>

The conflict in the coastal area of Sines (Portugal): Elements for settlement through dialogue*

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ABSTRACT

Conflicts frequently emerge in border areas between population and industry, often located in coastal regions. The municipality of Sines, in Portugal, with cultural traditions connected to the sea and fishing activities, is a paradigmatic case where this problem has existed for decades. Knowing that dialogue has provided good results in settling neighbourhood conflicts, a study was conducted to characterise its environmental and social aspects and thus contribute to the knowledge of the factors that influence individual attitudes towards the environment, aiming to establish dialogue platforms and environment integration between the population and industry in Sines.

A holistic study was carried out, together with a survey of two convenience samples composed of key social players from the local population and industry. Although the obtained results do not confirm any clear situation of pollution in Sines area, it was however found that there exists a conflict between the local population and neighbouring industry, associated with the presence of the port and the industrial site and the resulting hazards for the environment and public health.

In this context, it is noted that social space has a modelling effect on individual behaviour, and physical proximity is the main factor in the perception of the risk by local key players from Sines population. It was also noted that the surveyed companies have been integrating principles of social responsibility in their management policies, mainly due to media pressure on the industrial activity, but also due to the environmental accidents which had previously occurred within the area.

This study, although exploratory, shows the willingness of the social players in Sines to cooperate in protecting the environment and public health, with benefits resulting from that cooperation. This allows to anticipate success in settling the conflict in Sines through dialogue. There were identified the following fundamental elements to the implementation of dialogue platforms:

- i) Dissemination of environmental information promotes public participation,
- ii) Risk perception is influenced by the physical proximity of the sources of environmental and public health degradation, and
- iii) People exclusion from the decision-making processes causes a breach of trust towards those responsible for environmental management.

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It is concluded that dialogue contributes to the prevention and settlement of conflicts between the population and industry, which usually occur in environmentally sensitive areas such as the coastal regions, through environmental integration and the building of trust at the local level, thus obtaining more solid and legitimate solutions for coastal management project concerns.

Keywords: risk, public participation, perception, citizenship.

RESUMO

O conflito na zona costeira de Sines (Portugal): elementos para a resolução através do diálogo

Conflitos acontecem frequentemente em áreas de fronteira entre populações e indústria, muitas vezes localizadas em zonas costeiras. O município de Sines, em Portugal, de tradições culturais ligadas ao mar e às atividades piscatórias, é um caso paradigmático onde este problema se faz sentir desde há décadas. Sabendo-se que o diálogo tem demonstrado bons resultados na resolução de conflitos de vizinhança, procurou-se caracterizar os aspetos ambientais e sociais envolventes, de forma a contribuir para o conhecimento dos fatores que condicionam os comportamentos individuais em matéria de ambiente, tendo em vista a implementação de plataformas de diálogo e a integração ambiental entre a população e a indústria de Sines.

Realizou-se um estudo de caso holístico complementado por um inquérito aplicado a duas amostras de conveniência, constituídas por atores sociais chave da população e da indústria local. Embora os resultados obtidos não evidenciem uma clara situação de poluição na região de Sines, constata-se porém que existe um caso de conflito que opõe a população à indústria vizinha, que se associa à presença do complexo portuário e industrial, e aos riscos que daí resultam para o ambiente e a saúde pública.

Neste contexto, verifica-se que o espaço social tem um efeito modelador das atitudes individuais, e que a proximidade física é o principal fator para a construção da perceção de risco pelos atores sociais locais. Verifica-se igualmente que as empresas inquiridas têm vindo a integrar nas suas políticas de gestão princípios de responsabilidade social, muito pela pressão mediática que se exerce sobre a atividade industrial, mas também pelos acidentes ambientais anteriormente ocorridos na região.

Este trabalho, embora exploratório, vem demonstrar a disponibilidade dos atores sociais de Sines para a colaboração na proteção do ambiente e da saúde pública, resultando até benefícios dessa colaboração, o que permite antecipar o sucesso na resolução do conflito em Sines através do diálogo. Foram identificados elementos fundamentais para a implementação de plataformas de diálogo:

- i) a divulgação de informação ambiental promove a mobilização das pessoas para a participação pública,*
- ii) a perceção do risco é influenciada pela proximidade física aos fatores de degradação ambiental e da saúde pública, e*
- iii) o afastamento das pessoas dos processos de tomada de decisão causa quebras de confiança nos responsáveis pela gestão ambiental.*

Conclui-se que o diálogo contribui para a prevenção e resolução de conflitos, que opõem as populações à atividade industrial e que usualmente ocorrem em áreas ambientalmente sensíveis como são as zonas costeiras, pela integração ambiental e pela construção de laços de confiança à escala local, obtendo-se assim soluções mais robustas e mais legítimas em projetos de gestão litoral.

Palavras-chave: *risco, participação pública, perceção, cidadania.*

1. Introduction

Industrial activity has always associated pollutant emissions, a cause of environmental impacts (Brito *et al.*, 2011). In cases of proximity to population centres, these impacts often contribute to popular unrest, often escalating into conflict situations (Schüpphaus, 2007). Sines, an old fishing town (Correia, 2008), located on the west coast of Portugal (figure 1) is a paradigmatic example of a conflict area, where the population is opposed to neighbouring industry.

Practically kept in its natural state until then, the construction of the harbour and the industrial complex at Sines coastal area in the early seventies (Soledade, 1999), and the relocation of the local fishing port and subsequent uninstalation of the fishing fleet, started a fast industrial and population growth (CMS, 2014) which changed forever the lives of the people in Sines (Pacheco, 1999). Since then, protests against the dete-

rioration of local marine resources and air quality have become common (CMS, 2014).

In these cases, experience has shown that the neighbourly relationships between population and industry can be improved through dialogue (Schüpphaus, 2007). However, according to Andrade and Schiavetti (2015), the settlement of social-environmental conflicts is a complex task, since they are surrounded by a “constellation of independent factors” (Lewin, 2004), requiring that their analysis should be done case by case (Torre, 2015).

It is also known that the surrounding social space has a modelling effect in individual behaviour (Ávila & Castro, 2002), influencing each person to adjust to rules of conduct which they, at each moment, perceive as socially correct (Cameron, 2005). On what constitutes risk, people build their own perceptions (Nunes, 2000) by means of a complex network of psychological, social



Figure 1 - Location of the city of Sines, Portugal (source: Google Earth).

Figura 1 - Localização do município de Sines, Portugal (fonte: Google Earth).

and cultural factors (Lima, 1995), conditioned by their own capacity for understanding (Filho *et al.*, 2010). According to Drucker (2012), risk perception-building is conditioned by what one knows, perceived as a loss resulting from some event (Flynn & Slovic, 2000), where the media (Balle, 2003) has also an important part (Schmidt, 2008).

On the other hand, since the fifties, the growing deterioration of environmental conditions, and people's awareness of it together with higher media coverage of environmental accidents (Mendes & Seixas, 2005), has lead companies to search for new action strategies (Mascarenhas & Costa, 2011). More than a simple attempt to turn "green" activities with a "bad reputation", as the chemical industry and energy production (Porter & Kramer, 2006), companies are integrating people's concerns into their management policies (Freeman, 2010), and adopting principles of sustainable management, assuring this way their competitiveness (Rondinelli & Berry, 2000).

Since these problems are mostly felt locally (Pinto, 2006), this study addresses the conflict in the Sines coastal area, and the elements which condition the availability for dialogue of local population and industries on what concerns environment and human

health protection, being justified by their social aspects and also by the environmental fragility characterising the coastal systems with a heavy industrial presence (Lourenço & Asmus, 2015). This study also systematises behaviours that allow preventing and anticipating situations of potential conflict, aiming to promote environmental citizenship and sustainable development.

2. Material and methodology

2.1. Methodological framework

In the social sciences, according to Lewin (2004), research should start by analysing the issue as a whole, and from there the detail for each particular aspect, thus keeping oriented to the initially set goals. The analysis model adopted (figure 2) is based on a hypothetical-deductive empiric research model of the reasons for the conflict in Sines, and the influences and rationalities that determine each person's behaviour in respect to the environment (Quivy & Campenhoudt, 1995).

2.2. Case study

A holistic case study (Yin, 2006) was carried out, spreading the research field to the surrounding environmental and social aspects in order to answer the "how" and "why" questions (Yin, 2001) to the exist

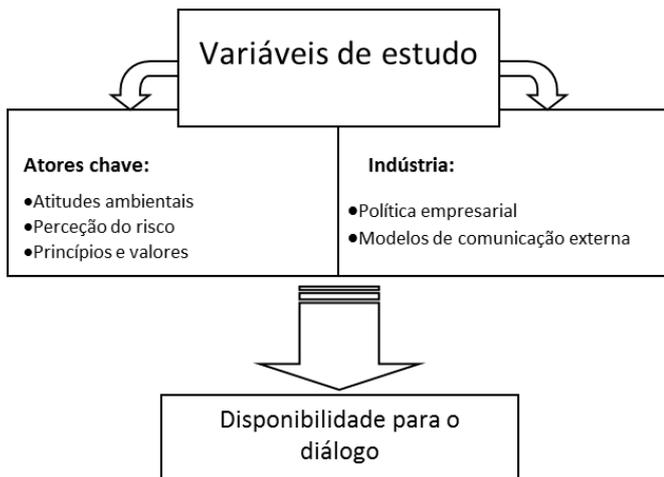


Figure 2: Analysis Model - Factors that influence the availability for dialogue of Sines population and industry.

Figura 2: Modelo de análise - Fatores que mais influenciam a disponibilidade da população e da indústria de Sines para o diálogo.

ence of conflict within the Sines area. Information was collected using as resources documentary analysis, direct observation, and consulting data bases available on online institutional sites, using triangulation of data whenever possible (Sousa & Baptista, 2011). Special attention was paid to conservation of the information in order to avoid interpretation bias resulting from subjective epistemological meanings of the author (Carmo & Ferreira, 2008).

2.3. Social Players Survey

This case study was complemented with two direct questionnaire surveys (Quivy & Campenhoudt, 1995) to identify the elements conditioning the willingness to engage in dialogue, applied to non-probabilistic convenience samples (Carmo & Ferreira, 2008), which were composed of key players, drawn from both the local population and the industry of Sines (Barnett, 2002).

Key players from Sines population

A panel of 55 social players was selected from associations and non-governmental agencies registered in the municipality of Sines [Support Information I], which, by their role and social standing, sharing values and objectives, become opinion centres for their community (Freixo, 2012). Although small, this sample (Carmo & Ferreira, 2008) allowed the understanding and interpretation of meanings in specific social and cultural contexts, becoming representative of the Sines population and their willingness to cooperate with the surrounding industry in protecting the environment and human health (Sousa & Baptista, 2011).

The questionnaire [Support Information II] was adapted from surveys carried out both nationally and within Europe, under the scope of the Observa (Almeida, 2004;

Gonçalves, 2007) and Eurobarómetro (EC, 2010; EC, 2011) programmes, according with the interests of this study. The goal was to describe the environmental attitudes and perceptions of the population of Sines and their relationship with local industry. The survey was tested (Sousa & Baptista, 2011) and carried out between May and August 2014 with a success rate of 58%, with no events during this period that could affect the results of this research. The answers to the survey [Support Information VI] were validated (Quivy & Campenhoudt, 1995), having been accepted all received questionnaires. The collected data were compiled in contingency tables and graphic representations (Reis, 2008), avoiding transcription errors (Sousa & Baptista, 2011).

Key players of Sines industry

According to the INE [National Statistics Institute] (2014), in 2011 there were 1,435 companies based in Sines. 4.9% of these were working in the energy and transformation sectors and had contributed that year 44% of the total business volume, employing 16% of the active population in the municipality. A panel of eight companies was chosen [Support Information III], which, due to their size and activity, represents the critical social and environmental aspects of industry in Sines (Freixo, 2012). Although limited, this panel (Carmo & Ferreira, 2008) characterises the universe of companies in Sines and their availability to cooperate with the local population in protecting the environment and human health (Sousa & Baptista, 2011). The questionnaire [Support Information IV] was devised in keeping with the goals of this study, to describe the policies, and the public communication methods of the companies, as well as their motivations to integrate public consultation into their management practices. The questionnaire was tested (Sousa & Baptista, 2011) and carried out between December 2013 and January 2014, with a success rate of 50% and with no events during this period that could affect the results of this research. The *corpus* of the analysis [Support Information V] was composed from the received questionnaire replies (Quivy & Campenhoudt, 1995).

Statistical processing

To describe the degree of association between the predictive factors of the study variables, the non-parametric statistical Spearman rank-order correlation coefficient (r_s) (Equation 1) was applied to the closed answers (ordinal scales) (Reis, 2008; Heiman, 2011). In this way it is attempted to describe the type and strength of the relationship between the elements under analysis (Heiman, 2011).

$$r_s = 1 - \frac{6 \sum d^2}{N(N^2 - 1)}$$

Content analysis

To derive a description of the policies and external communication models adopted by the surveyed companies, content analysis techniques were applied, following the criteria for thematic and frequency categorisation proposed by Bardin (2011), in terms of comprehensiveness and significance (Vala, 1989). Given the small number of responses significance intensity were not considered (Vala, 1989).

3. Case Study

The municipality of Sines

The municipality of Sines includes the parishes of Sines and Porto Covo and is located in the coastal area of Alentejo, district of Setúbal, occupying an area of 202.7 sq. Km. In 2011 it had a population of 14,238 inhabitants and 5,621 family households (INE, 2014). Although it is traditionally associated with maritime activities, agriculture also plays a significant role in the traditions and culture of the Sines (Soledade, 1999).

It can be stated that the social tensions in Sines starts with the construction of the harbour and industrial sites in 1973, a process in which the population was neither consulted nor involved in, and that deeply changed the local way of life (Pacheco, 1999). But it is during the eighties that this tension reaches its pick due to a series of accidents in the region (Nunes & Matias, 2003), mainly the explosion of the oil tanker *Campeón* on August 15, 1980; the oil spill by the oil tanker *Marão* on

July 14, 1989; and the oil slick caused by the dumping of ballast water by *The Ogennitor* on May 5, 1990.

The population of Sines has, since then, showed a high concern about environmental issues, both by creating partnerships and by participating in street protests in defence of the environment. On May 28, 1982, the fishermen of Sines interrupted their activities and boycotted the activity of the industrial port (CMS, 2014), and on June 8 of the same year the first “green strike” occurs in Portugal, stopping all economic activity in the city of Sines (Pacheco, 1999). In November, 1995, the local fishermen once again interrupted their activity as a way of protesting against the degradation of fishing resources occurring within the region (Pacheco, 1999).

The harbour and industrial complex in Sines presently occupies an area of over 3,000 ha, hemming the urban area (figure 3). It includes a petrochemical plant, a crude oil refinery and a coal-fired power plant.

Environment quality in Sines

According to the environmental data available for the Sines region (Table 1), the quality of the surface waters mostly presents low levels of pollution (SNIRH, 2014). Concerning the quality of groundwater, eleven (11) measurements were carried out between 2007 and 2012 showing changes of the natural values in six (6) different parameters (SNIRH, 2014). On the quality of the coastal and transition waters, which have been monitored since 2008, the results for the whole Sines area present maximum quality (SNIRH, 2014).

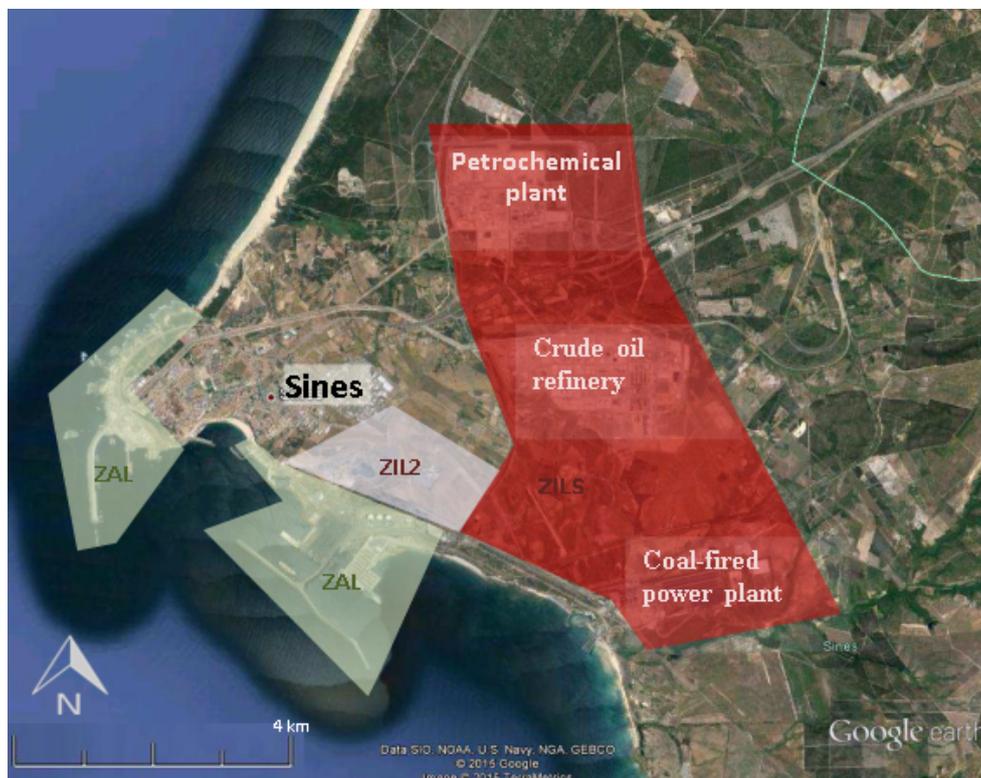


Figure 3 - Complex of Sines - Implementation of port and industrial areas (source: Google Earth).

Figura 3 - Complexo de Sines - Implantação das áreas portuária e industrial (fonte: Google Earth).

Table 1 - Quality of surface water in Ribeira de Moinhos (26D/50), in Sines, in the period between 2009 and 2013, according to the SNIRH data (2014).

Tabela 1 - Qualidade da água superficial na estação de Ribeira de Moinhos (26D/50), em Sines, no período compreendido entre 2009 e 2012, de acordo com os dados do SNIRH (2014).

		RIBEIRA DE MOINHOS (26D/50)						
		Ammoniacal nitrogen (mg/l NH ₄)	CBO (5 days) (mg/l)	CQO (mg/l)	Total Phosphate (mg/l PO ₄)	Total Nitrate (mg/l NO ₃)	Dissolved Oxygen (field) (%)	pH (field) (Sr)
31-03-2009		0,1	3	10,0	-	6,7	52	7,6
22-02-2010		0,49	5	45,4	-	2,0	-	7,2
15-12-2010		0,04	7	51,0	-	2,0	101	8,4
11-03-2013		0,41	3	21,0	0,071	4,1	48	-
13-06-2013		0,08	3	11,0	0,031	13,0	37	-
28-08-2013		0,29	3	16,0	0,031	6,3	39	-
A1	MVR	0,05	3	-	0,4	25	70	6,5-8,5
	MVA	-	-	-	-	50	-	-
A2	MVR	1	5	-	0,7	-	50	5,5-9,0
	MVA	1,5	-	-	-	50	-	-
A3	MVR	2	7	30	0,7	-	30	5,5-9,0
	MVA	4	-	-	-	50	-	-

MVR - Maximum value recommended

○ > MVA

MVA - Maximum value admissible

● > MVR

As far as the quality of the air is concerned (Figure 4) the obtained results show, in general, a classification of “good” (APA, 2014). However, the issue of air quality in Sines became relevant during 2011 and 2012, when several episodes of a stench occurred, 657 complaints having been filed between January 2012 and October 2014 (CMS, 2014).

Health and society

The region of Sines has also been submitted to several studies on human and social health. In 2003, the SINESBIOAR project (Nave & Fonseca, 2004) aimed to understand:

- i) How the population evaluates the industrial complex and the risks to human health, and
- ii) The variables influencing the perception of those risks.

The obtained results reveal that the individual perception of the risk increases with the physical proximity to the complex. On the other hand, it is also verified that the low levels of environmental information within the region boosts fears and uncertainties, stressing the concerns of the people about the presence of the industrial sites and the resulting health risks (Nave & Fonseca, 2012).

In 2012, the results obtained from the GISA project (Nave & Fonseca, 2012) to evaluate the quality of the air in the Alentejo coast and the risks to public health, showed there was a positive statistical association, although moderate, between the quality of the air and the low birth weight of the children born between 2007 and 2010, having been exposed during pregnancy to tobacco smoke (Ribeiro *et al.*, 2012).

In this field, and according to the data of INE (2015), the children born between 1995 and 2013 in Sines and near-by municipalities present birth weights lower than the national average during this period, with a frequency of 95% of lower weights for Sines municipality (figure 5).

Considering the results of this case study in the municipality of Sines, although changes of the natural conditions have been registered in the near past, it cannot be stated that there is indeed a pollution case within the region. This suggests that the causes of conflict in Sines are related to perceived social and cultural issues than with the environment. The construction of the harbour and industrial complex in the area, in which the population was not involved, that enforced a sudden change of the traditional way of life of the Sines population, might have influenced their attitude against the causes of that

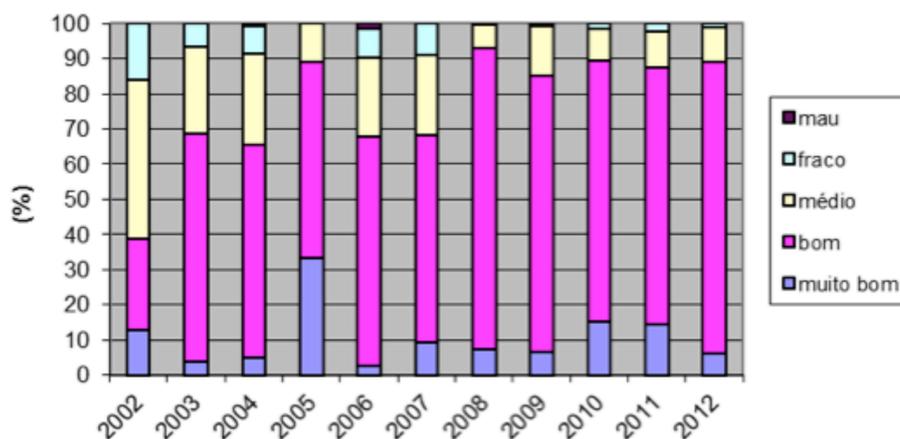


Figure 4 - Air quality in Sines in the period 2002-2012, according to the QualAr data (2014).

Figura 4 - Qualidade do ar em Sines no período 2002-2012, de acordo com os dados da QualAr (2014).

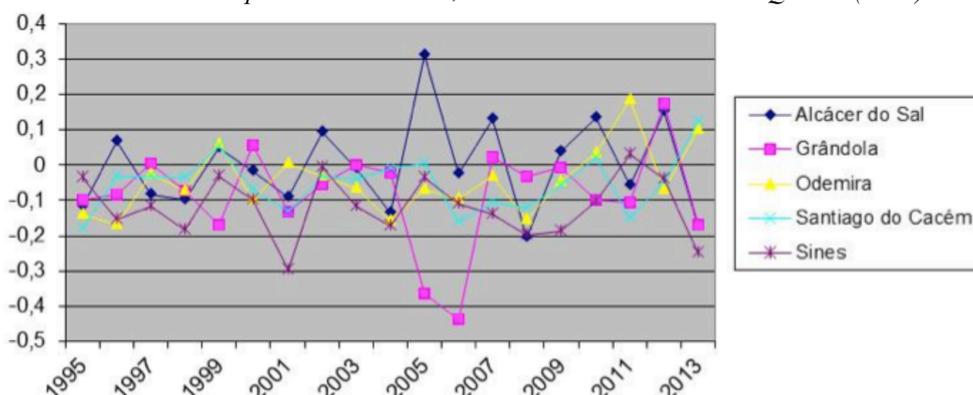


Figure 5 - Difference in average birth weight of children born in the municipalities of Sines relative to the national average, in the 1995-2013 period, according to the INE data (2014).

Figura 5 - Diferença dos pesos médios à nascença das crianças nascidas nos concelhos de Sines no período de 1995 a 2013, de acordo com os dados do INE (2014).

change, represented by the neighbouring industry (Correia, 2008).

On the other hand, the social and public health studies which were carried out, show the concerns of the people towards the proximity of the Sines complex, and the resulting hazards for their health and safety, being exacerbated by the lack of available information (Nave & Fonseca, 2012). Although not quantified, these studies show the existence of a real danger to public health, resulting from local environmental factors related to the industrial activity (Augusto *et al.*, 2012).

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4. Results and discussion

4.1. Key players from the Sines population

Environmental behaviour

Questioned about those day-to-day subjects that most arouse their interest, as a way to evaluate their capacity to engage in environmental participation, it was found that the respondents are generally interested in environmental issues (100%), as well as in new scientific and technological discoveries (97%). According to Torre (2014), a higher physical and cognitive proximity raises people's awareness and sensibilities, with a corresponding acquisition of practices and values (Pinto, 2004).

About their direct involvement (Table 2), the respondents are available to participate in environmental actions, even more than at national level, regarding the results obtained in 2002 (Nave, 2004). They were, however, identified barriers to a more effective participation, such as the lack of time or opportunity (67%), suggesting a certain incapacity or disclaimer of the respondents in protecting the environment (Castro, 2004).

Table 2 - The involvement in environmental issues found in the population survey of Sines (2014) and in the II Inquérito Observa (2002).

Tabela 2 - O envolvimento nos assuntos do ambiente encontrado no inquérito à população de Sines (2014) e no II Inquérito Observa (2002).

	Survey to the population of Sines (2014)	II <i>Observa</i> Inquiry (2002)
Attended a public meeting on environment	84%	16%
Signed a petition or participated in a street protest	81%	19%
Contributed money to an environmental group	31%	69%
Participated in an event promoted by an environmental organisation	69%	31%

These results show a strong positive correlation between individual interests in daily life and their involvement in environmental issues [$r_s(32) = +0,992$; $p < 0,001$]. Being individual behaviours influenced by social conduct norms (Lewin, 2004), these results reveal the commitment of the respondents to environmental issues, suggesting that a higher disclosure and dissemination of scientific information (Torre, 2014) encourages and enhances public participation (Vasconcelos, 2006).

Risk perception

Knowing that fears and uncertainties may cause potential environmental conflicts (Beck, 2015), the respondents were questioned about the environmental problems existing within the Sines area, in such a way as to discern their perceptions of the surrounding environmental risks. The results show a clear association of risk with the environmental aspects which are uppermost in the minds of the respondents (Nave & Fonseca, 2004), such as smoke emissions from factory chimneys (66%), disposal of toxic waste in the ground (47%), sewer discharge on the beach (47%), and oil slicks (41%).

The main concerns among the respondents are also anthropogenic and associated to industrial activities, such

as diseases caused by air pollution, industrial hazards and soil contamination by industrial waste (Table 3). In 2002, at the national level, the main concerns of the Portuguese were water and food contamination, as well as forest fires (Delicado, 2007).

Table 3 - Environmental concerns found on the population of Sines survey (2014) and the II Inquérito Observa (2002).

Tabela 3: Preocupações ambientais encontradas no inquérito à população de Sines (2014) e o II inquérito Observa (2002).

	Survey to Sines population (2014)	II <i>Observa</i> Inquiry (2002)
Diseases by air pollution	88%	62%
Industrial hazard	88%	43%
Industrial waste contamination	75%	52%
Contamination of tap water	72%	75%
Food contamination	69%	66%
Oil slicks	69%	42%
Earthquakes	38%	31%
Forest fires	31%	69%
Floods caused by natural phenomenon	25%	29%

There is also a strong positive association between those believed to be the main causes of environmental degradation, industrial activity (100%) and big multinational companies (97%), and the most potential environmental threats within the region [$r_s(32) = +0,999$; $p < 0,001$].

These results reveal an important concern of the respondents with environment and health, which is enhanced by the presence of the industrial sector in the daily lives of the population of Sines (Nave & Fonseca, 2004), thus confirming that the people who live closer to big industrial undertakings tend to stress the environmental risks more strongly (Langlois, 2012; Che *et al.*, 2013).

Principles and values

Regarding to accountability, the respondents show low trust in the institutions responsible for environmental management (Table 4), *i.e.* the State and the Companies. In this field, was noted trust in the regional public institutions and local authorities, as well as in the health professionals and scientific experts. The results now obtained, naturally reflect the social and local circumstances of the Sines area, where the proximity to the regional institutions is stronger. In the case of the media, there is a perceived high breach of trust compared to the national results of 2002 (Schmidt *et al.*,

2004), due to the critical thinking and higher environmental maturity of the Sines population (Torre, 2014), where this issues are a constant in the daily routine of the people.

Table 4 - Trust in sources of information about environment found in the population of Sines survey (2014), on the II Observa Inquiry (2002) and on Eurobarometer (2002).

Tabela 4 - Confiança nas fontes de informação quando se trata de assuntos do ambiente encontrada no inquérito à população de Sines (2014), no II inquérito Observa (2002), e no Eurobarómetro (2002).

	Survey to Sines population (2014)	II Observa Inquiry (2002)	Eurobarometer (2002)
Scientists and scientific experts	81%	65%	40%
Health professionals and doctors	91%	70%	-
Environment and consumer organisations	78%	65%	37%
Local authorities	84%	49%	8%
European institutions	69%	44%	9%
Media	59%	75%	29%
National government	47%	61%	7%
Industrial organisations	25%	21%	3%

It should be noted that the present social and economic circumstances also have a strong influence on individual behaviour, often translated into dissatisfaction, and the blaming of government institutions (Schmidt, 2008).

The results now obtained reveal a strong positive association between the value assigned to environment protection (100%), the lack of institutional trust in the national government [$r_s(32) = +0,976$; $p < 0,001$], and the industrial organisations, [$r_s(32) = +0,965$; $p < 0,001$]. This may be due to the lack of environmental information (Alves *et al.* 2012) published in the Sines region (Nave & Fonseca, 2012), and people being excluded from the decision-making processes concerning the environment (Felt, 2000; Schmidt *et al.*, 2004). Even so, it is expected that the people in charge of environmental protection fulfil their duty to assure that protection (Lima & Schmidt, 1996).

4.2. Key players of Sines industry

Corporate policy

In order to make a description of the effective availability of the companies (latent contents) to enter into dialogue with the local population, the policies and motivations (explicit contents) for the adopted external

communication process were addressed, having been defined three analysis dimensions (Bardin, 2011): (1) Emotional; (2) Instrumental; and (3) Ethics.

1) The emotional dimension refers to the motivation to communicate, as an intention or will to communicate, although without any effective physical action. Either by principle or because they are required to (Rondinelli & Berry, 2000), the respondent companies recognise that there are benefits arising from implementing processes to engage with the local population:

“collect information on their concerns and interests” (Company #1); “the environment certification granted in 2001 and the registration in EMAS in 2010 [...] imply this motivation” (Company #2); “abiding to the legal requirements and Company decisions” (Company #3); “a population [...] supporter and enthusiastic about the proactive role of the company in the local economy and development”, “assure the satisfaction of all stakeholders”, “security and environment are two of the priorities [...] minimizing the environmental impact of the activity” (Company #4).

The respondent companies are, however, reluctant to adopt these type of mechanisms, what is probably due to the bad image created around the industry (Schmidt, 2000), and for fear of being exposed to public opinion (Freeman, 2010). This issue, together with popular mistrust, due to former accidents in the region, many times exaggerated by the media (Schmidt, 2000), as well as the lack of knowledge from the people, form barriers for companies to enter into dialogue with the local population. However, this negative and adverse image of industrial activity seems to be changing:

“has no knowledge of the activity and performance in what concerns environment and human health risks”, “normally associates local industry has being highly pollutant” (Company #1); “situations on environmental hazards occurred within the Sines area” (Company #2); “consider that the activities being carried out were dangerous and could put at risk the local communities”, “I feel that they can understand better the incidents which occur” (Company #3); “the success [...] in what concerns security levels might have transmitted an image of credibility and seriousness” (Company #4).

The absence of negative elements is noted, whether opposition or denial, concerning the implementation of external communication processes. This unanimity reflects the social maturity and availability of the respondent companies to be involved with population in dialogue.

2) The instrumental dimension of external communication is reflected in the company’s practices, mainly with

reference to the adopted dialogue models (Rondinelli & Berry, 2000). The obtained results show that, more than available, the respondent companies have already adopted and implemented communication processes oriented to dialogue with the local population, e.g. open door events for schools and other guests:

“emphasis of the contact with the local population and their representatives”, “regular visits to the premises”, “the visit and contact with the premises, the industrial process, the environmental and safety issues” (Company #2); “In this type of event the company shows its premises and products”, “organizes open door events for its workers’ families, friends and representatives of the local community” (Company #3); “the delivery of specific products [and] match the actions and messages to each one”, “involving the stakeholders, namely the general population, is part of the [company] communication principles” (Company #4).

It was verified that for the respondent companies, the motivations for effective communication (Rondinelli & Berry, 2000) are to promote their corporate image, assure the longevity of the company, and to improve activity performance. The dialogue with the population gives credibility to the corporations (Freeman, 2010), and allows returns concerning, for example, negative impacts not previewed (Rondinelli & Berry, 2000):

“inform about the work of the company so that the population is enlightened” (Company #1); “hear the opinions and concerns of those surrounding us”, (Company #2); “through information [...] remove the fear from the population”, “since they don’t have the necessary knowledge, they see it with mistrust and fear” (Company #3); “the perception of environmental impact [...] favours the predisposition of the local population to understand and take action in case of emergency”, “an informed population [...] is a facilitator population” (Company #4).

3) The ethics dimension refers to communication as an expression of social corporate responsibility (Rondinelli

& Berry, 2000), leading to a more interventionist action in the community (Schmidt, 2008). This way, the external communication processes are the means to spread the environmental culture among the population:

“assure that communication reaches the population in a clear and understandable language” (Company #1); “fundamental for a culture of total transparency and proximity” (Company #2); “the communication we send to the representatives of the community [...] allows to build trust” (Company #3); “becoming an active and decision-making member in the evolution of the community, characterised by the presence of industry”, “sustainability is the bonding concept of the fundamental messages from [the company]” (Company #4).

External communication models

So that the fundamental elements for establishing dialogue could be identified, the respondent companies were questioned about the external communication models they adopted when aiming at dialogue with the population.

At an organisational level it is verified that dialogue becomes effective with the operationalization of the means and mechanisms necessary to implement the processes of external communication, having to be defined:

- A policy of transparency and commitment;
- Specialised technical skills;
- Specific information content, and
- Characterization of the audience.

However, there are risks in its implementation, which might result in a breach of trust in the process. These risks may arise from an inadequate process or communication failure by the corporation, the use of information in an exaggerated way, or even due to bad faith on the part of the public using this processes.

As for the communication components (Sousa, 2010), it is noted that for the respondent companies it is the population that should start the dialogue, posing the focus of the speech on the receiver (Figure 6). This

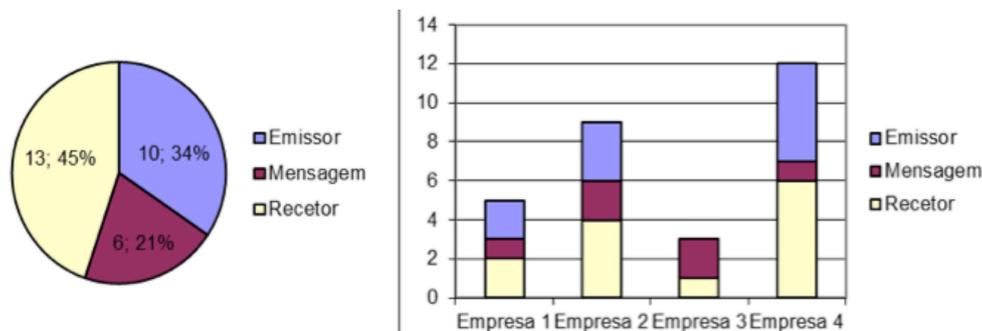


Figure 6 - Distribution of communication components.

Figura 6 - Distribuição das componentes da comunicação.

underlines the reluctance of companies to be publically exposed (Freeman, 2010), suggesting that something has to happen to encourage them to assume a more collaborative role in the community.

4.3 Dialogue platforms

As referred to earlier, coastal systems are, by nature, environmentally fragile (Lourenço & Asmus, 2015) and, as mentioned by Andrade and Schiavetti (2015), they are often the arena for conflicts where different interests tend to collide. On the other hand, industry also prefers to be in coastal areas, mainly due to the easy access to sea routes. Thus the presence of port facilities is fundamental, as it is in Sines (CMS, 2014).

This study confirms that the close interaction between people and industry (Che *et al.*, 2012; Huang *et al.*, 2012) causes both environment and social conflicts (Schüpphaus, 2007). Nevertheless, although considering that the conflict in Sines is a reality caused by the industrial activity and air pollution (figure 7), the respondents are available to cooperate with industry to protect the environment and public health, even considering such cooperation advantageous for the population (69%), either through the involvement of people (41%), or for achieving a better environment (24%).

In turn, the survey results obtained from the industry's key players show the availability of the respondent companies for dialogue with the local population, although their motivation is essentially instrumental (figure 8), *i.e.* the corporations' communication practices

are motivated by the utility principle (Freeman, 2010), which is to promote the corporate image, assure the future of the company, and to improve the performance of their activities (Rondinelli & Berry, 2000).

However, there are possible barriers to the implementation of dialogue platforms (Vasconcelos *et al.*, 2009), relating mainly to the lack of time or opportunity of the population, or a fear of exposure to public opinion on the part of the industry. This reinforces the importance that external environmental mediation may have in settling local conflicts (Farrel & Weaver, 2000), acting as a facilitator of discussion, and promoting cooperative understanding through dialogue (Schüpphaus, 2007).

In this field, the regional and local administrative authorities, as they are closer and hence can better understand the local reality (Santinhos *et al.*, 2014), may play an important part in the environmental integration of population and industry, by establishing platforms of plural and integrating dialogue (Alves *et al.*, 2012), and in this way positively influence responsible environmental management.

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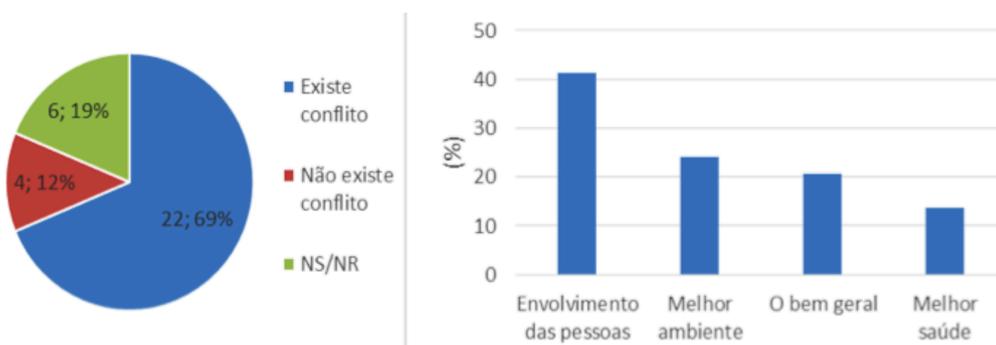


Figure 7 - The environmental conflict in Sines and the reasons for its existence.

Figura 7 - O conflito ambiental em Sines e as razões para a sua existência.



Figure 8 - Dimensional analysis of external communication policy.

Figura 8 - Análise dimensional da política de comunicação externa.

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5. Solution proposals and future works

The collected environmental data do not show a clear situation of pollution in Sines area, therefore the causes of conflict between the population and the industrial activity may result from social and cultural reasons (Correia, 2008), more than from degradation in the quality of the environment itself. To this it should be added the fact that the building of the port and industrial complex in Sines has been imposed without the population taking part in the process (Vasconcelos, 2006). It is thus important to carry on the study of the reasons that led to the conflict in Sines, and of the causes that originated and sustain it (Schüpphaus, 2007), thereby, contributing to an understanding of the neighbourhood conflicts involving population and industry.

Nevertheless, due to the episodes of modification in the natural conditions within the Sines area, it is fundamental to carry on, in the long term and broad-ranging, environmental and public health studies, to identify and describe local environmental characteristics, which are justified by the presence of the industrial complexes in Sines (Nave & Fonseca, 2004), and the environmental fragility of coastal systems (Lourenço & Asmus, 2015).

Because fears and uncertainties result from a lack of information, and cause gaps between the real performance of companies and people's perceptions of the risks to environment and human health (Rondinelli & Berry, 2000), it is necessary to create and develop a standard system of responsible self-regulation, based, for instance, on norm ISO 19600:2014 (ISO, 2014), which will ensure on one hand the trust of the population in environmental protection, and on the other an incentive for a wider involvement of corporations within the community (Schmidt, 2008).

Since the settlement of conflicts involving a population and industry can be achieved through clear and effective communication of the risks to the environment and public health, and by the participation of the people in the decision-making processes (Vasconcelos, 2009), it is important to carry out an action program to the promotion of social dialogue in Sines (Alves *et al.*, 2012), with the involvement of local authorities (Santinhos *et al.*, 2014), thus contributing to a better neighbourly relationship between the people and the industrial activity, and also by introducing new ways for local governance (Vasconcelos *et al.*, 2006).

6. Conclusions

Knowing that the neighbourly relationship between population and industry may be improved through dialogue, this study intends to contribute to the knowledge of the factors which condition the individual behaviours in what concerns the environment. The results show the availability of the key players, both from the population and the industry of Sines, to cooperate in the protection of the environment and public health, which allows to foresee the success in settling the conflict in Sines through dialogue.

Since the lack of knowledge causes fears and uncertainties as well as enhancing conflict, it is fundamental to create trustworthy communication channels that can inform the population of the relevant information, so that they can make their own decisions in an informed and conscious way. To bring the scientific speech closer to the people allows for more effective citizenship, thus creating new opportunities for local governance, where the agreed solutions become more legitimate and thus more efficacious.

The industrial organisations also have an important role to increase the environmental culture of the population, promoting environmental citizenship and sustainable development. Using their technical and scientific knowledge, acquired daily through their activity, the corporations have the opportunity to transform that information into knowledge, and, as social partners, share it with the community.

On the other hand, the physical proximity of industry is confirmed as the main factor in shaping the perception of risk. Because environmental problems are mostly felt locally, so it is also locally that the institutions are better prepared to address these kind of issues. In this field, involving the people in the decision-making processes is fundamental for the prevention of, and devising of solutions to, social and environmental conflicts.

It is thus concluded that construction of any industrial project in a coastal area, where the industry is side by side with population, must take into account the involvement of people in the decision-making processes, and local authorities to establish public dialogue, aiming to establish dialogue platforms and environment integration between the population and industry in Sines

Appendix

Supporting Information associated with this article is available online at http://www.aprh.pt/rgci/pdf/rgci-675_Barroqueiro_Supporting-Information.pdf

References

- Almeida, J.F. (2004) - *Os Portugueses e o Ambiente. II Inquérito Nacional às Representações e Práticas dos Portugueses sobre o Ambiente*. 402 p., Celta Editora, Oeiras, Portugal. ISBN: 9727741967.

- Alves, F.; Araújo, M.J.; Azeiteiro, U. (2012) - Cidadania ambiental e participação: o diálogo e articulação entre distintos saberes-poderes. *Saúde em Debate* (ISSN: 0103-1104), 36:46-52, Rio de Janeiro, Brasil. Available on-line at http://repositorioaberto.uab.pt/bitstream/10400.2/3160/3/RevistaSaudeDebate_pdf.pdf
- Andrade, J.C.P.; Schiavetti, A. (2015) - Artisanal fishing and local conflicts: the case of the 'Pedras de Una' fishing community, Bahia, Brazil. *Journal of Integrated Coastal Zone Management / Revista de Gestão Costeira Integrada*, 15(3):425-438. DOI: 10.5894/rgci536
- Augusto, S.; Pereira, M.J.; Máguas, C.; Soares, A.; Branquinho, C. (2012) - Assessing human exposure to polycyclic aromatic hydrocarbons (PAH) in a petrochemical region utilizing data from environmental biomonitors. *Journal of Toxicology and Environmental Health*, 75(13-15):819-30. DOI: 10.1080/15287394.2012.690685
- Ávila, P.; Castro, P. (2002) - Compreender a ciência: O inquérito à cultura científica dos portugueses. In: M. E. Gonçalves (org.), *Os portugueses e a ciência*, pp. 287-320, Publicações Dom Quixote, Lisboa, Portugal. ISBN: 9722022636.
- Balle, F. (2003) - *Os Media*. 127p., Campo das Letras, Porto, Portugal. ISBN: 9726106575.
- Bardin, L. (2011) - *Análise de conteúdo*. 281p., Edições 70, Lisboa, Portugal. ISBN: 978-9724415062.
- Barnett, V. (2002) - *Sample Survey Principles and Methods*. 218p., John Wiley & Sons, London, United Kingdom. ISBN: 978-0470685907.
- Beck, U. (2015) - *Sociedade de risco mundial: em busca da segurança perdida*. 448p., Edições 70, Lisboa, Portugal. ISBN: 978-9724418575.
- Brito, D.M.C.; Bastos, C.M.C.B.; Farias, R.T.S.; Brito, D.C.; Dias, G.A.C. (2011) - Conflitos socioambientais no século XXI. *PRACS: Revista de Humanidades do Curso de Ciências Sociais da UNIFAP* (ISSN: 1984-4352), 4(1):51-58, Macapá, AM, Brazil. Available on-line at <http://periodicos.unifap.br/index.php/pracs/article/view/371>
- Cameron, E. (2005) - *Facilitation made easy*. 166p., Kogan Page Limited, London, United Kingdom. ISBN: 0749443510.
- Carmo, H.; Ferreira, M.M. (2008) - *Metodologia da investigação. Guia para autoaprendizagem*. 375p., Universidade Aberta, Lisboa, Portugal. ISBN: 978-9726742319.
- Castro, P. (2004) - Cultura científica e confiança na ciência em matérias ambientais. In: L. Lima, M.V. Cabral & J. Vala, (org.), *Ambiente e desenvolvimento*, pp.79-112, Imprensa de Ciências Sociais, Viseu, Portugal. ISBN: 9726711177.
- Che, Y.; Yang, K.; Jin, Y.; Zhang, W.; Shang, Z.; Tai, J. (2013) - Resident's concerns and attitudes toward a municipal solid waste landfill: integrating a questionnaire survey and GIS techniques. *Environment Monitoring Assessment*, 12(185):10001-10013. DOI: 10.1007/s10661-013-3308-y
- Correia, C.; Eiró-Gomes, M. (2009) - Da compreensão pública da ciência ao compromisso público com a ciência: que percurso para Portugal? *6º Congresso SOPCOM*, pp.4857-4867, SOPCOM, Lisboa, Portugal. Available on-line at http://conferencias.ululsofona.pt/index.php/sopcom_iberico/sopcom_iberico09/paper/viewFile/256/290.
- Delicado, A. (2007) - Os portugueses e os novos riscos: resultados de um inquérito. In: M. E. Gonçalves (org.), *Os Portugueses e os novos riscos*, pp.245-274, Imprensa de Ciências Sociais, Viseu, Portugal. ISBN: 978-9726712053.
- Drucker, P.F. (2012) - *Uma sociedade funcional*. 384p., Publicações Dom Quixote, Alfragide, Portugal. ISBN: 9789722049269.
- European Commission (s/d) - *Science and Technology*. European Commission, Brussels, Belgium. Available on-line at http://ec.europa.eu/public_opinion/archives/ebs/ebs_340_en.pdf.
- European Commission (s/d) - *Attitudes of European citizens towards the environment*. European Commission, Brussels, Belgium. In: http://ec.europa.eu/public_opinion/archives/ebs/ebs_295_en.pdf.
- Farrel, J.; Weaver, R. (2000) - *The Practical Guide to Facilitation: A Self-Study Resource*. 175p., Berrett-Koehler Publishers, San Francisco, USA. ISBN: 1576750957.
- Felt, U. (2000) - A adaptação do conhecimento científico ao espaço público. In: M. E. Gonçalves (org.), *Cultura científica e participação pública*, pp.265-288, Celta Editora, Oeiras, Portugal. ISBN: 972774057X.
- Filho, W.L.; Alves, F.; Caeiro, S.; Ulisses, M.A. (ed.) (2010) - *Internacional Perspectives on climate change*. 315p., Springer, Cham, Switzerland. ISBN: 978-3319044880.
- Freeman, R.E. (2010) - *Strategic management*. 276p., Cambridge University Press, New York, USA. ISBN: 978-0521151740.
- Freixo, M.J.V. (2012) - *Metodologia científica – Fundamentos, métodos e técnicas*. 326p., Instituto Piaget, Lisboa, Portugal. ISBN: 978-9896591144.
- Gonçalves, M.E. (2002) - Imagens públicas da ciência e confiança nas instituições: Os casos de Foz Côa e da co-incineração. In: M. E. Gonçalves (org.), *Os portugueses e a ciência*, pp.157-197, Dom Quixote, Lisboa, Portugal. ISBN: ISBN: 9722022636.
- Gonçalves, M.E. (2007) - *Os Portugueses e os novos riscos*. 298p., Imprensa de Ciências Sociais, Viseu, Portugal. ISBN: 978-9726712053.
- Heiman, G.W. (2011) - *Basic statistics for the behavioural sciences*. 504p., Wadsworth, Belmont, USA. ISBN: 978-1285054865.
- International Organization for Standardization (2014) – *ISO 19600:2014 Compliance management systems – Guidelines*. 28p., ISO, Geneva, Switzerland.
- Langlois, E. (2012) - *Factors that shape environmental perceptions: the role of health and place*. 81p., Master degree thesis, University of New Orleans, United States of America. *Unpublished*.
- Lewin, K. (2004) - *Field theory in social science*. 422p., American Psychological Association (APA), Washington, DC, U.S.A. ISBN: 1557984158.
- Lima, M.L. (1995) - Viver com o risco: abordagens da psicologia social ambiental. *Psicologia: Ciência e Profissão* (ISSN 1414-9893), 9-10:39-54, Brasília, Brazil. Available on-line at http://www.scielo.br/scielo.php?pid=S1414-98932010000400007&script=sci_arttext
- Lima, V.L.; Schmidt, L. (1996) - Questões ambientais - conhecimentos, preocupações e sensibilidades, *Análise Social*, 31(135):205-227, Lisboa, Portugal. Available on-line at <http://analisesocial.ics.ul.pt/documentos/122339364216mPV3ik2Vu73C14.pdf>
- Lourenço, A.V.; Asmus, M.L. (2015) - Gestão Ambiental Portuária: fragilidades, desafios e potencialidades no porto do Rio Grande, RS, Brasil. *Journal of Integrated Coastal Zone Management / Revista de Gestão Costeira Integrada*, 15(2):223-235. DOI: 10.5894/rgci498
- Mascarenhas, M.P.V.; Costa, C.A.F. (2011) - Responsabilidade social e ambiental das empresas. Uma perspectiva sociológica. *Latitude*, 7(2):141-167. Available on-line at <https://repositorium.sdum.uminho.pt/bitstream/1822/23915/1/Responsabilidade%20Social%20e%20Ambiental%20das%20Empresas.%20Uma%20perspectiva%20social%20C3%B3gica.pdf>
- Mendes, J.M.O.; Seixas, A.M. (2005) - Ação coletiva e protesto em Portugal: Os movimentos sociais ao espelho dos media (1992-2002). *Revista Crítica de Ciências Sociais* (2182-7435), 72:99-127, Coimbra, Portugal. Available on-line at <https://rccs.revues.org/984>
- Nave, J.G. (2004) - Entre a cultura ambiental e o efeito NYMBY. In: J. F. Almeida (org.), *Os Portugueses e o Ambiente: II Inquérito Nacional às Representações e Práticas dos Portugueses sobre o Ambiente*, pp.237-336, Celta Editora, Oeiras, Portugal. ISBN: 9727741967.

- Nave, J.G.; Fonseca, S. (coord.) (2004) – *Relatório final do inquérito SINESBIOAR*. Life/ISCTE/Observa/ICS, 121p., Lisboa, Portugal. *Unpublished*.
- Nave, J.G.; Fonseca, S. (coord.) (2012) - *Relatório Final GISA - Gestão Integrada de Saúde e de Ambiente no Litoral Alentejano- Componente sociológica*. ISCTE/IUL, 33p., Lisboa, Portugal. *Unpublished*.
- Nunes, J.A. (2000) - Públicos, mediações e construções situadas da ciência. In: M. E. Gonçalves (org.), *Cultura científica e participação pública*, pp.81-102, Celta Editora, Oeiras, Portugal. ISBN: 972774057X.
- Nunes, J.A.; Matias, M. (2003) - Controvérsia científica e conflitos ambientais em Portugal: o caso da co-incineração de resíduos industriais perigosos. *Revista Crítica de Ciências*, (ISSN: 0254-1106), 65:129-150, Logroño, Espanha. Available on-line at <http://dialnet.unirioja.es/servlet/articulo?codigo=1292658>
- Pacheco, F.O. (1999) - *Crónica da primeira greve ecológica em Portugal*. 253p., Gráfica AMD, Beja, Portugal.
- Pinto, J.R. (2006) - De uma política pública de ambiente e educação ambiental em Portugal a uma estratégia nacional de educação ambiental: sucessos e fracassos. *Revista Científica Galego-Lusófona de Educação Ambiental* (ISSN: 1887-2417), 1(1-2):75-101, Coruña, Espanha. Available on-line at http://ruc.udc.es/bitstream/2183/5017/1/AS_1-7.pdf
- Porter, M.E.; Kramer, M.R. (2006) - Strategy & Society. The link between competitive advantage and corporate social responsibility. *Harvard Business Review*, 84(12):78-87. Available on-line at <http://classes.uleth.ca/200803/mgt3031d/Porter & Kramer HBR.pdf>
- Quivy, R.; Campenhoudt, L.V. (2005) - *Manual de investigação em ciências sociais*. 276p., Gradiva, Lisboa, Portugal. ISBN: 978-9726622758.
- Reis, E. (2008) - *Estatística descritiva*. 245p., Edições Sílabo, Lisboa, Portugal. ISBN: 978-9726184768.
- Ribeiro, M.C.; Pinho, P.; Llop, E.; Branquinho, C.; Soares, A.; Pereira, M.L. (2014) – Associations between outdoor air quality and birthweight: a geostatistical sequential simulation approach in Coastal Alentejo, Portugal. *Stochastic Environmental Research and Risk Assessment*, 28:527-540. DOI: 10.1007/s00477-013-0770-6
- Rodrigues, M.L.; Duarte, J.; Gravito, P. (2000) - Os portugueses perante a ciência - O inquérito de 1996/97. In: Gonçalves, M.E. (org.), *Cultura científica e participação pública*, pp.33-40, Celta Editora, Oeiras, Portugal. ISBN: 972774057X.
- Rondinelli, D.A.; Berry, M.A. (2000) - Environmental citizenship in multinational corporations: Social responsibility and sustainable development. *European Management Journal*, 18(1):70-84. DOI: 10.1016/S0263-2373(99)00070-5
- Santinhos, A.J.; Martinho, A.P.; Caeiro, S. (2014) - Perceção das populações locais face à sustentabilidade dos serviços das zonas costeiras: o caso da Lagoa de Santo André, Portugal. *Journal of Integrated Coastal Zone Management / Revista de Gestão Costeira Integrada*, 14(3):413-427. DOI: 10.5894/rgci497
- Schmidt, L. (2000) - País: perceção, retrato e desejo. In: J. F. Almeida (org.), *Os portugueses e o ambiente*, pp.33-102, Celta Editora, Oeiras, Portugal. ISBN: 9727740758.
- Schmidt, L. (2008) - Comunicar ciência: o papel dos media e os problemas científico-ambientais'. In: L. Schmidt & J. P. Cabral (ed.), *Ciência e cidadania - Homenagem a Bento de Jesus Caraça*, pp.85-12, Imprensa de Ciências Sociais, Lisboa, Portugal. ISBN: 978-9726712183.
- Schmidt, L.; Nave, J.G.; O'Riordan, T.; Guerra, J. (2011) - Trends and dilemmas facing environmental education in Portugal: From environmental problem assessment to citizenship involvement. *Journal of Environmental Policy and Planning*, 13(2):159-177. DOI: 10.1080/1523908X.2011.576167
- Schmidt, L.; Truninger, M.; Valente, S. (2004) - Problemas ambientais, prioridades e quadro de vida. In: J. F. Almeida (org.), *Os Portugueses e o Ambiente: II Inquérito Nacional às Representações e Práticas dos Portugueses sobre o Ambiente*, pp.65-172, Celta Editora, Oeiras, Portugal. ISBN: 9727741967.
- Schüpphaus, M. (2007) - *Neighbourhood dialogue - Toolkit*. 70p., European Union Network for the Implementation and Enforcement of Environmental Law, Osnabrück, Germany. Available online at <http://impe.l.eu/wp-content/uploads/2010/02/2007-01-neighbourhood-dialogue-TOOLKIT.pdf>
- Soledade, A.F. (1999) - *Sines - Terra de Vasco da Gama*. 203p., Câmara Municipal de Sines, Santiago do Cacém, Portugal.
- Sousa, J.P. (2003) - *Elementos de teoria e pesquisa da comunicação e dos media*. 272p., Edições Univ. Fernando Pessoa, Porto, Portugal. ISBN: 978-9728184964.
- Sousa, M.J.; Baptista, C.S. (2011) - *Como fazer investigação, dissertações, teses e relatórios*. 174p., Pactor, Lisboa, Portugal. ISBN: 978-9896930011.
- Torre A.; Melot R.; Magsi H.; Bossuet L.; Cadoret A.; Caron A.; Darly S.; Jeanneaux P.; Kirat T.; Pham H.V.; Kolokouris O. (2014) - Identifying and measuring land-use and proximity conflicts: methods and identification. *SpringerPlus*, 3:85. DOI: 10.1186/2193-1801-3-85
- Vala, J. (1989) - A análise de conteúdo. In: Silva, A.S. e Pinto, J.M. (org.), *Metodologia das ciências sociais*, pp. 101-128, Edições Afrontamento, Porto, Portugal. ISBN: 978-9723605037.
- Vasconcelos, L. (2006) - O exercício da cidadania pela participação popular. In: I Fórum Social Português, *Um outro mundo é possível... mas não será fácil*, pp.21-27, Edições Colibri, Lisboa, Portugal. ISBN: 9727726631.
- Vasconcelos, L.; Oliveira, R.; Caeser, U. (2009) - *Governância e participação na gestão territorial*. 60p., DGOTDU, Lisboa, Portugal. ISBN: 978-9728569457.
- Yin, R.K. (2001) - *Estudo de caso: planeamento e métodos*. 205p., Bookman, Porto Alegre, Brazil. ISBN: 8573078529.
- Yin, R.K. (2006) - Case study methods. In: Green, J.L. et al (ed.), *APA Handbook of complementary methods in education research*, pp.141-155, American Educational Research Association, Washington, DC, U.S.A. ISBN: 978-1433810039.

Consulted on-line data basis

- Agência Portuguesa do Ambiente (s/d) - *QualAr - Base de dados on-line sobre qualidade do ar*. Agência Portuguesa do Ambiente, Lisboa, Portugal. <http://qualar.apambiente.pt/>.
- Câmara Municipal de Sines (s/d) - *Município de Sines*. Câmara Municipal de Sines, Sines, Portugal. <http://www.sines.pt/PT/Paginas/default.aspx>.
- Instituto Nacional de Estatística (s/d) - *Dados Estatísticos*. Instituto Nacional de Estatística, Lisboa, Portugal. <http://censos.ine.pt/xportal/xmain?xpid=CENSOS&xpgid=censos-homepage>.
- Instituto Nacional de Estatística (s/d) - *Dossiers Temáticos*. Instituto Nacional de Estatística, Lisboa, Portugal. http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCo d=0005612&contexto=bd&selTab=tab2.
- Sistema Nacional de Informação de Recursos Hídricos (s/d) - *Rede qualidade*. Agência Portuguesa do Ambiente, Lisboa, Portugal. http://snirh.apambiente.pt/index.php?idMain=1&idItem=1.4&ccdr=Alentejo&con c=SINES&ponto=516/127&zf=&click_x=&click_y=&tema=&tipo=Furo Vertical.

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