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Evaluating ten years of management effectiveness in a mangrove protected area

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ABSTRACT

Creating protected areas (PAs) intended to counteract the effects of human activities on the environment is a significant step towards conserving coastal and marine ecosystems. Various countries have introduced legal mechanisms to create and manage their important ecosystems, such as mangroves. Despite the significance of evaluating the effectiveness of PAs, literature on the topic is scarce, especially pertaining to the mangrove ecosystems. Therefore, the present study intended to evaluate the management of a PA located in northeastern Brazil throughout the first decade of the current century (2003, 2006, and 2012). The management of the PA was considered inadequate, and the level of efficacy even declined progressively, although a slight improvement was recorded in 2006. The respective levels of effectiveness were 35%, 50%, and 15% for 2003, 2006, and 2012. The improvement recorded in 2006 was attributed to a new management plan and the ensuing environmental actions, such as monitoring and management programs, PA zoning, and others. The worst management performance was indicated for the following assessment parameters, namely, administrative matters (public administration), biogeographic characteristics, and threats. One of the main reasons for the low management effectiveness is that the mangrove PA is located in an urban area of one the most densely populated cities in Brazil, namely, Fortaleza, (7786 inhabitant/km^2). The location has led to an increase in the number of threats to the PA and has strongly influenced the biogeographic characteristics. The urbanization in and around the area has resulted in the PA being isolated, with no connection to other ecosystems through ecological corridors. Both direct measures and strategic planning are required to facilitate continuous improvement of the management effectiveness of PAs. This strategy is imperative in countries with tropical ecosystems characterized by significant biodiversity, which is vulnerable to anthropogenic effects.

1. Introduction

The recognized ecological and economic importance of mangrove ecosystems has been discussed and emphasized in various studies (Badola et al., 2012; Uddin et al., 2013; Barbier, 2014). Mangrove forests contain natural resources and ecosystem services of immense value to people and the environment (Carney et al., 2014; Giri et al., 2015). These include fisheries, forest products, pollution abatement, carbon storage, nursery habitats, and coastal protection against natural disasters, such as tsunami and cyclones. However, as mangrove ecosystems could be located close to urbanized areas, anthropogenic activities, such as the continuous discharge of contaminated water, could influence these systems detrimentally. Such negative influences are particularly prevalent in the developing countries of South America, Asia, and Africa. The conservation of mangrove forests is currently a significant environmental challenge and the creation of effective strategies to

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promote such conservation is therefore urgently needed (Roy, 2014).

The current rate of mangrove deforestation is 150,000 ha per year, which is ~1% of the global mangrove occurrence. Moreover, this rate has even reached 2–3% annually in some countries. Sixteen percent of the >70 mangrove species are currently under threat (Polidoro et al., 2010). Therefore, it is imperative that these coastal ecosystems are managed effectively and their protection is reinforced. Furthermore, as only 6.9% of mangroves worldwide are located within protected areas (Giri et al., 2010), additional protected areas (PAs) should be urgently delineated in the effort to reduce the rate of loss.

Since the previous century, PAs have been employed in various developing countries to conduct integrated coastal management (ICM). These protected areas are used in the planning and management of most of the popular coastal holiday destinations, islands, and tropical ecosystems, such as mangroves (Satumanatpan et al., 2014). Protected areas can potentially conserve tropical coastal resources and provide social and economic benefits to the local communities. In addition, PAs play an important role in the conservation of biodiversity and the implementation of ambitious multilateral agreements on the environment, such those proposed at the 2010 Convention on Biological Diversity (CBD) (Stoll-Kleemann, 2010; Carranza et al., 2014). However, the percentage of marine and coastal protected areas considered successful or effective with respect to ecological and/or socio-economic factors is debatable (Bennett and Dearden, 2014a). Evaluating the management effectiveness of protected areas has been an ongoing challenge in coastal conservation, mainly in the tropical regions (Gaston et al., 2006; Garces et al., 2013). Management effectiveness evaluation (MEE) has gained global recognition as an important framework to promote the continuous improvement of conservation efforts in protected areas (Addison et al., 2015). However, studies in developing countries on this topic are scarce.

Demarcating of mangrove protected areas is one of the widely adopted approaches to environmental conservation in the tropical areas. The performance of the mangrove PAs can be assessed based on their management effectiveness. Unfortunately, the results of such studies are not easily accessible and have yet to be widely shared among the conservation and scientific communities (Stoll-Kleemann, 2010). Moreover, few studies have examined the qualitative management effectiveness of these important ecosystems in a diachronic manner, e.g., over the course of a decade. Therefore, we have explored this aspect in a mangrove ecosystem located in a high-pressure urban area, namely, the Ceará River estuary in northeastern Brazil. This PA is situated in Fortaleza, the city with the highest demographic density in Brazil (7786 inhabitant/km^2) (IBGE, 2014). At 14.1 km^2, 60% of which is it located in urban zones, the mangrove area of Fortaleza is one of the largest urban mangroves in the world. Fishing and crab harvesting in the mangroves are important economical and subsistence activities for many families (Cavalcante et al., 2009) resident in the area. Despite various environmental laws to protect mangroves in Brazil, this particular ecosystem has been adversely affected by a variety of anthropogenic activities (Santos et al., 2014), such as urbanization and shrimp farming in the coastal zone (Queiroz et al., 2013; Tenório et al., 2015). Systematic studies on the management effectiveness of mangrove protected areas in developing countries are scarce. Brazil presents a particularly interesting instance for environmental policy establishment because of its democratic political system, fast economic growth, recent creation of protected areas in coastal/marine environments, and its importance in the global environment. Therefore, this paper aims to contribute to the scientific debate about management effectiveness in mangrove protected areas by means of a case study in the Ceará River estuary in Brazil.

2. Methods

2.1. Study site

Although the coastline of Brazil extends for more than 10,000 km, only 1.87% of the territorial waters benefit from some form of protection (Magris et al., 2013). Our study area was the EPA (Environmental Protected Area) in the Ceará River estuary, located on the Brazilian northeastern coast (Fig. 1). This tropical estuary has a semi-arid climate and is under threat from multiple contamination sources. The Ceará River basin is one of the three major water sources of the metropolitan area of Fortaleza, the state capital. This basin is under increasing pressure because of the disorderly urban expansion and the erection of numerous illegal constructions that contribute to the deforestation of the mangrove, erosion, and soil siltation, as well as the decline in the quality of the estuarine water. Agriculture and small boat traffic are minor sources of river pollution, whereas untreated sewage, urban drainage, and industrial effluents from electroplating, textiles, plastics, tanneries, and other factories constitute the main sources of contamination (Cavalcante et al., 2009; Nilin et al., 2013).

According to the classification of the Protected Areas National System (Portuguese: *Sistema Nacional de Unidades de Conservação* [*SNUC*]), conservation units (Portuguese: *unidades de conservação* [*UC*]) are a type of protected area (Portuguese: *áreas protegidas* [*PA*]). There are two groups of protected areas, namely, strictly protected areas (or restricted protection) and sustainable-use protected areas (or direct use) (Santos and Schiavetti, 2014). Our study area is located in an EPA that was established by state decree 25.413/1999. The management model is that of sustainable-use protected area, which includes the active participation of several social entities. The area covers 27,45 km^2 and is occupied, inter alia, by indigenous and poor urban communities.

2.2. Data collection and analysis

The methodology of this study comprised three steps, namely, data gathering and selection, field studies, and information analysis. Two different sets of sources were used during data gathering and selection. The first source comprised official data and documentation from the environmental protection agency responsible for the EPA (the state government), planning instruments, environmental legislation, scientific papers, and media material. The other source of information was the answers obtained from a questionnaire circulated to EPA managers in 2003, 2006, and 2012. As regards the questionnaire, we followed the methodology of Cifuentes et al. (2000), adapted from the Rapid Assessment and Prioritization of Protected Areas Management, e.g., RAPPAM protocol (Hockings et al., 2006). This methodology has been implemented in 53 countries, in more than 1600 PAs located in Europe, Asia, Africa, Latin America, and the Caribbean (Leverington et al., 2010). Further adaptations, based on Cook et al. (2014), have been adopted since. The authors (Cook et al., 2014) have recommended that the questions be explicitly formulated with regard to the assessment frame to limit undue influence on the evaluation of the effectiveness.

The questionnaire was organized into ten different groups of questions (management categories), which were further organized into variables and subvariables, called “variable” and “indicator,” respectively (Table 1).

The questions were evaluated and scores were allocated. Based on Cifuentes et al. (2000), evaluation matrices for each category