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Zoning for a multiple-use marine protected area using spatial multi-criteria analysis: The case of the Sheik Seid Marine National Park in Eritrea

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ABSTRACT

Marine and coastal areas worldwide are now facing increasing pressures, particularly from intensified human activities; marine protected areas (MPAs) are therefore designated to conserve marine biodiversity, and zoning has been used as an effective means to minimize conflicts between human use and biodiversity conservation and that among different users. However, there are currently very few zoning practice examples of MPAs reported in developing countries. In this paper, an interdisciplinary method combining spatial multi-criteria analysis (SMCA), geographic information system (GIS) and stakeholder consultation to develop a zoning scheme in the multiple-use MPAs of Eritrea is illustrated. Three higher-level criteria and eight lower-level criteria are identified based on the value-focused approach to multi-criteria analysis, and stakeholder preference is represented by pair-wise comparison (AHP analysis). Subsequently, the simple additive weighting (SAW) method is used to determine the suitability of an area for each protection level using spatial analysis software. Through this study, a zoning scheme considering both the scientific soundness and the practical feasibility of the Sheik Seid Marine National Park (SSMNP) in the Eritrean waters is proposed. The method could serve as a model for developing a zoning plan for those similar cases, particularly in the developing countries with data and financial and technical limits.

1. Introduction

Marine protected areas (MPAs) are protected areas used for conservation purposes. As stated in Aichi Target 11, “by 2020…10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures and integrated into the wider landscapes and seascapes” [1], designating MPAs as an important area-based measure to protect biologically rich habitats and thereby conserving biodiversity. However, this simple numeric indicator of area coverage is the only element of Target 11, as there are many other crucial elements, among which effective, equitable biodiversity management tops the lists [2]. The primary importance of zoning/zonation for effective management of MPAs has been widely discussed in various regions [3,4].

Multiple-use zoning means dividing the marine area into different zones in which uses are regulated to accomplish specific goals [5]. The goals within each zone may vary from providing a high level of protection for marine habitats, such as nursery areas and breeding sites [6], to being set aside for reasonable uses (extractive or non-extractive), including research, education, resource extraction, fishing, and tourism. Multiple-use zoning also identifies areas of importance or sensitivity for natural or cultural heritage [7].

The zoning method plays an important role in its enforcement; the more transparent and objective the decision-making process is, the greater the likelihood of acceptance by the stakeholders and public will be [8,9]. There are a few analytical tools and approaches to develop the zoning scheme, among which InVEST and Marxan have been largely discussed recently [10]. However, there is no “best” method because the suitability of a zoning method depends on its ability to satisfy the features of the area to be designated, such as political and administrative issues, the objectives and the size of the MPA, the availability of the baseline data, and financial resources.

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Therefore the objective of this paper is to develop a suitable and feasible zoning method for those MPAs featuring the data, financial and technical limits that are common in the developing countries, taking as an example the multiple-use Sheik Seid Marine National Park (SSMNP) in Eritrea. Using SSMNP as a case study, Section 2 explicitly illustrates the step-by-step zoning approach with spatial multi-criteria analysis as a core component; Section 3 describes the detailed results and provides further discussion of the results; finally, Section 4 presents the conclusions.

2. Methods and materials

Ocean zoning is an area-based management activity that divides ocean spaces based on various compatible or conflicting sea uses at the spatial and temporal scale [11]. Two types of MPA-related zoning can be identified in practice: one is MPA site selection in a comprehensive ocean zoning, and the other is the zoning practice in a designated MPA. Both can be described as "deciding what to protect and what to allow where" at different scales [12]. Various tools for MPA zoning, varying in data/information requirements, technology level and financial support, have been applied worldwide. Initially, more attention was paid to scientific rigour; as a result, the zoning process is rooted in protected species features or their habitat assessment to evaluate the suitability of protection [13,14]. However, the issue of "paper parks" failing in the compliance of MPAs by various users has resulted in an argument about the effectiveness evaluation of MPAs [15–17]. Increasing numbers of discussions on multiple-use MPAs are also appearing [18]. The key principle of zoning methodologies for multiple-use MPAs is the introduction of social objectives through the stakeholder involvement process based on the original methods considering the natural features only [10].

Among all of the MPA zoning studies, various methods, including geographic information systems (GIS), Marxan (with Zones), user consultation/stakeholders involvement including questionnaire surveys, economic analysis, and decision support tools (such as nonlinear multi-objective decision-making (MODM) models), were used [19–24].

A trend of using high-tech tools combining GIS and decision support tools is observed from the above-described literature. The advance of these technologies greatly improves the quantification of the zoning process and thereby benefits the visualization of the results; however, it also requires high-level demands on data and information, analysis capacity and financial support, which is still a problem for those developing countries. Managers anywhere actually require timely and cost-effective techniques [25]. Therefore, in this study, a step-by-step method balancing scientific justification and practice feasibility was proposed to address the above-described issues, using an MPA of Eritrea as a case study.

2.1. Study site: Sheik Seid Marine National Park

Although there are traditionally managed fishing-prohibited coastal ecosystems (e.g., mangroves and lagoons) in some parts of the country, no coastal or marine protected areas have been officially declared in Eritrea [26]. Planning processes for MPAs are underway as part of the integrated coastal zone management initiatives [27]. Currently, two islands, Sheik Seid Island and Dessie Island (Fig. 1), out of the 354 largely uninhabited islands were proposed to be declared as marine protected areas to "conserve the nations' major biodiversity elements and rehabilitate some of

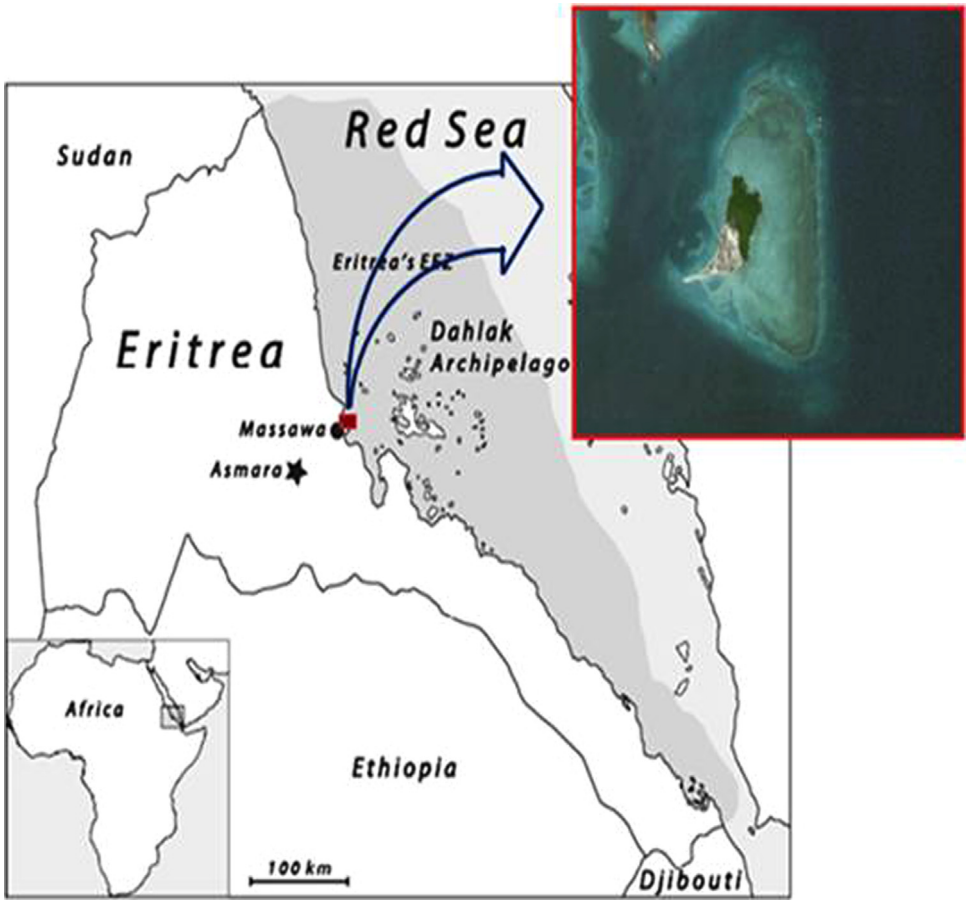

Fig. 1. Study site.