Using multivariate statistics to assess ecotourism potential of water-bodies: A case-study in Mauritania

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HIGHLIGHTS

- We propose a new non-heuristic method to assess ecotourism potential.
- The multivariate approach was applied successfully to Mauritanian water-bodies.
- The method showed statistically the variables' contribution to ecotourism potential.
- The two-step approach is scalable and replicable worldwide.
- Stakeholders can find here a useful framework for planning and managing ecotourism.

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ABSTRACT

Evaluating the ecotourism potential of sites is a key issue in tourism management. Multiple methodologies have been developed to assess the ecotourism potential of sites. However, there are many constraints affecting their quality. Methodologies independent of subjective criteria and weights are lacking, compromising following interpretations on where to allocate efforts for ecotourism development. We propose a new approach to circumvent these issues that combines independent statistical procedures to assess ecotourism potential. By combining multi-criteria with ordination and clustering algorithms, this two-stage statistical approach allowed identifying suitable water-bodies for ecotourism development in Mauritania and independently assessed which features are related with ecotourism potential. The method was able to group sites for different ecotourist demands, which has implications for policy makers and tourism planners trying to optimize investments while protecting biodiversity and supporting communities. We provide a framework that is scalable and applicable by stakeholders operating in ecotourism planning and management worldwide.
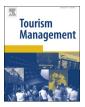
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1. Introduction

Ecotourism is considered an efficient tool for biodiversity conservation (Fennell, 2015; Lindsey, Alexander, du Toit, & Mills, 2005; Mossaz, Buckley, & Castley, 2015; Penteriani et al., 2017). It helps building environmental awareness among ecotourists and local communities (Honey, 2008; Reimer & Walter, 2013) and can fund effectively conservation initiatives (Kirkby et al., 2010, 2011), resulting in several positive net-effects of environmental outcomes (see Bricker & Kerstetter, 2017; Buckley, 2009; and; Weaver, 2002). Ecotourism may be a potential tool for the reduction of poverty in low-income countries (Goal 1 of the United Nations Sustainable Development Goals) and the sustainable economic

development of poor communities with decent employment for all (Goal 8; http://www.un.org/sustainabledevelopment/sustainable-development-goals/; see Reimer & Walter, 2013; Saarinen & Rogerson, 2013; Scheyvens, 1999). Despite potential negative impacts, such as marginalization of local communities and species habituation to human presence (see Penteriani et al., 2017; Weaver, 2002), ecotourism is widely being promoted as a strategy that fosters beneficial relationships between tourism, the environment and local communities living in low-income countries, especially in Africa (Lindsey et al., 2005; United Nations, 2017).

The potential of ecotourism in contributing to poverty alleviation and threatened species preservation has been claimed for African deserts (Santarém & Paiva, 2015; Weaver, 2001), particularly for the Sahara-Sahel ecoregions (Brito et al., 2014, 2016). All countries in the region are low-income nations, most of them exhibiting low human development index (UNDP, 2016). Historically, they have been underfunded for poverty alleviation and biodiversity loss retention schemes (Durant et al., 2012; Waldron et al., 2013). Mauritania is one of these African arid countries, where around 40% of people live in rural areas, lacking both infrastructural and health conditions (FAO, 2013). The country displays multiple cultural, biological and landscape values that may be suitable for sustaining ecotourism projects (Vale, Pimm, & Brito, 2015). Mauritanian water-bodies are of particularly relevance, as they are rich in human heritage and biodiversity. On the one hand, they may be surrounded by well-preserved villages where traditional livelihoods and secular ceremonies still occur. There are ancient wells for cattle watering, evidences of intense intellectual activity propagated by caravans crossing the *ksours* (Mauritanian towns) since the Middle Ages, and archaeological remains in the form of rock-paintings (Hosni, 2000; UNESCO, 2003). On the other hand, water-bodies may hold up to 78% of the endemic fishes, amphibians, reptiles and mammals of Mauritania (Vale et al., 2015). They gather large concentrations of water-birds(Cooper, Shine, McCann, & Tidane, 2006), that provide bird-watching opportunities. The surrounding habitats, where dunes intersect with unique desert-adapted agricultural patches (oasis), and the presence of geological formations (waterfalls) on rock canyons are of great interest for ecotourism. In addition, several water-bodies contain relict West African crocodile populations (Brito, Martínez-Freiría, Sierra, Sillero, & Tarroso, 2011) that have been considered as a national flagship species (Telleria, Ghaillani, Fernandez-Palacios, Bartolome, & Montiano, 2008), which supports the development of species-based conservation and ecotourism programmes (Veríssimo et al., 2013, 2014).

Based on these values, the potential for ecotourism development in the desert water-bodies of Mauritania is promising, but requires urgent assessment and research-informed planning, given the local societal development and biodiversity conservation needs. One potential caveat to developing such assessments in these regions is related to the lack of a systematic approach to evaluate the ecotourism potential of sites with knowledge-based and well-informed criteria for ecotourism planning.

This paper proposes a new method that aims to go beyond subjective criteria and weights in ecotourism site planning by combining independent statistical procedures to assess ecotourism potential. By combining multi-criteria with ordination and clustering algorithms, the two-stage statistical approach is used here to identify suitable water-bodies for ecotourism development and to assess independently which features are related with ecotourism site-potential.

2. Approaches to evaluate ecotourism potential

Ecotourism is a relatively new concept in tourism planning but its basic elements and dimensions have been discussed for decades in studies on tourism and natural resource management (Fennell, 2015; Honey, 2008; Stronza, 2007; Weaver, 2001). There are numerous definitions for ecotourism (see Donohoe & Needham, 2006). In general, it refers to responsible travel to natural areas with an aim to use tourism demand for conservation goals, environmental education and local communities benefits (Diamantis, 1999; TIES, 2017). There is a strong focus on sustainable tourism development with an emphasis on ecologically sound and driven practices (Saarinen, 2006). Therefore, comprehensive biodiversity evaluations and assessments are often included to ecotourism planning. In this context, multi-criteria approaches combining ecological and social data, and spatial analyses conducted in Geographical Information System (GIS) environments have been integrated to assess the ecotourism potential of many sites around the globe.

The multi-spatial layers and the continuous analyses allowed by GIS tools increase the spatial accuracy of predictions and the information handled, thus assisting in the decision-making process (Dhami, Deng, Burns, & Pierskalla, 2014; Dhami, Deng, Strager, & Conley, 2017). For instance, GIS and participatory methods (Delphi and Analytic Hierarchy Process, AHP) were used to map ecotourism as a cultural service (Nahuelhual, Carmona, Lozada, Jaramillo, & Aguayo, 2013), high resolution IKONOS images and GIS were used for planning useful resources to ecotourism (Fung & Wong, 2007), and visitor's preferences were assessed for mapping weighted and unweighted potential sites for forest-based ecotourism development (Dhami et al., 2014).

Despite the plethora of methods being proposed for assessing cultural ecosystem services (where ecotourism is included), there are still constraints affecting the quality of those assessments. Most studies rely on a priori controlled approaches that require weighting of variables, either via inquiries or expert-knowledge scoring. While they are often practical, such approaches have also been criticized (Kliskey, 2000), and methods that are independent of subjective criteria and weights are still lacking (Milcu, Hanspach, Abson, & Fischer, 2013).

Circumventing a priori classification approaches requires independent methods that assess the contribution of variables without necessarily weighting them, such as ordination methods and clustering algorithms. Principal Component Analysis (PCA) is a statistical procedure that uses orthogonal transformations to convert observations of possible correlated variables into linearly uncorrelated variables, which emphasizes variation and brings out relevant patterns in a dataset (Hotelling, 1933). PCA produces a series of orthogonal uncorrelated axes, where the first component accounts the largest possible variability in the data and the following components account for decreasing proportions of the variability. Cluster analysis is an unsupervised learning task in data mining that consists in grouping a set of objects in a way that objects in the same group (called a cluster) are more similar to each other than to those in other groups (Tryon, 1939). Both statistical approaches have been applied independently in tourism research. For instance, PCA was used to assess social preferences for recreation demands in a three-stage procedure for mapping recreation potential (Peña, Casado-Arzuaga, & Onaindia, 2015) and to identify suitable variables associated to the implementation of recreation activities (Kliskey, 2000), while cluster analysis was used to identify distinct groups of adventure travellers (Sung, 2004).