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Estimating the risk of loss of beach recreation value under climate change

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ABSTRACT

Shoreline recession due to the combined effect of waves, tides and sea level rise is increasingly becoming a major threat to beaches, one of the main assets of seaside tourist destinations. Given such an uncertain future climate and the climate-sensitive nature of many decisions that affect the long term, there is a growing need to shift current approaches towards probabilistic frameworks able to take uncertainty into account. This study contributes to climate change research by exploring the effects of erosion on the recreation value of beaches as a key indicator in the tourism sector. The new paradigm relates eroded sand to geographic and socioeconomic aspects and other physical settings, including beach type, quality and accesses, yielding monetary estimates of risk in probabilistic terms. Additionally, we look into policy implications regarding tourism management, adaptation and risk reduction. The methodology was implemented in 57 beaches in Asturias (north of Spain).

1. Introduction

During the second half of the last century, residential use and industrial and service activities around many beaches worldwide intensified, giving the so-called sun and sand tourism (Aguilo et al., 2005; Sarda, Mora, Ariza, Avila, & Jimenez, 2009) a major boost. Thus, the fact that these systems are already eroding generally (Bird, 1985; Hinkel et al., 2013) poses serious risks to one of the primary resources of coastal regions, which not only maintains biodiversity and coastal protection but also provides recreation services. However, in 1994, the US Army Corps of Engineers admitted that an eroding shoreline was a serious threat to tourism and therefore to the US economy. Although there is evidence that climate change and resulting sea level rise (SLR) will cause the coastline to recede inland (Wong et al., 2014), coastal erosion is also triggered by many other factors, which raises difficulties with respect to developing appropriate management strategies (Phillips & Jones, 2006). The effect of local waves, storm surges and very large tides greatly contributes to sediment transport, and therefore to erosion. In response, while some coastal systems may be able to undergo a landward retreat, others will experience coastal squeeze (Jackson & McIlvenny, 2011), which occurs when an eroding shoreline approaches seawalls or resistant natural cliffs. This squeezing leads to adverse impacts on the environment and society, such as habitat destruction, increased exposure to flooding and loss of beach recreation value. In light of this unprecedented threat, research on climate change risks and adaptation in coastal areas with respect to tourism and recreation, a relatively unexplored field, is becoming increasingly important (Schliephack & Dickinson, 2017). However, the existing limitations of future climate and socioeconomic projections do not leave much choice but to make decisions in the context of uncertainty. For this reason, there is a growing need to shift away from widespread uncertain deterministic approaches (e.g., Bruun, 1962) and move towards probabilistic frameworks that enable effective risk-based coastal planning and management. In this setting, we aimed to bridge the gap between the scientific community and relevant stakeholders, such as tourists and local users and decision makers, who are often unaware not only of the physical processes but also of the scope, potential consequences, and implications of climate change. To this end, we developed a methodology to assess the erosion-driven loss of beach recreation value in probabilistic terms. Without limiting its generality, the procedure was applied to 57 beaches on the coast of Asturias, a region located in the northwest of Spain along a 345 km coastal shoreline stretch.

Among the most common aspects of coastal management are beach sediment management and use (Ariza, Jiménez, & Sardá, 2008), requiring coastal managers and tourism businesses to fully understand users' preferences, perceptions and economic valuations based on their own experiences (Blakemore & Williams, 2008). The most extended existing asset valuation techniques include the following: i) declared preferences such as contingent valuation (based on questionnaires) and choice experiments (based on simulated experiments), which differ in the way the attributes are presented and in the structure of the willingness-to-pay question (Birdir, Ünal, Birdir, & Williams, 2013); ii) revealed preferences, such as the widely accepted travel cost method, which accounts for the asset access costs (Loomis & Santiago, 2013),

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and the hedonic pricing method, which Parsons and Powell (2001) used to estimate the value of the land loss using datasets on housing sales from that time; and iii) market-based methods, such as cost-based methods (either avoided or defensive costs) and the production function, in which beaches are assumed to be environmental assets that contribute to the supply of goods or services to social agents. However, while the literature is quite diverse in terms of beach quality assessments (e.g., Morgan, 1999; Roca, Villares, & Ortego, 2009), less attention has been given thus far to the quantitative valuation of recreation. The two concepts of sun and beach tourism and beach recreation are strongly linked through cause and effect. For almost two decades, Houston (2013) focused a large part of his research on highlighting the importance of beaches to the United States economy. He noted that if California's beaches were unavailable for recreation, users would instead spend approximately $2.4 billion outside of the United States (King & Symes, 2003), highlighting the severe disadvantage of relegating recreation to a lower priority. Hence, local tourists would substitute other forms of recreation for beach recreation if beaches were eroded significantly. More recently, Alexandrakis, Manasakis, and Kampanis (2015) capitalized the value of the eroded beach in revenues from tourism businesses through hedonic pricing modeling, in which the beach value was determined by its width and the tourism businesses located there. From the beach recreation perspective, changes to the economic recreation value were estimated by King, McGregor, and Whittet (2016) through a benefit transfer approach that used information on weather, water quality, and beach facilities and services, among others. In the present paper, we used a production function–-based approach to monetarily estimate the extent of potential losses of beach recreation value due to climate change–induced erosion. The analysis combines a set of environmental and social criteria along with correction factors tailored to beach-specific characteristics, quality and services.

Aiming to ensure sustainable tourism and avoid significant losses of beach recreation value in the future, predictions of coastal recession need to be more reliable than ever (Ranasinghe, Callaghan, & Stive, 2012). Thus, the common practice of adopting a single value of coastal recession due to a single value of SLR is proving unsuitable for emerging risk management frameworks, which require probabilistic estimates of the combined effect of a range of climatic and non-climatic drivers and their associated uncertainties (e.g., expressed in terms of confidence levels) (Ranasinghe et al., 2012; Toimil, Losada, Camus, & Diaz-Simal, 2017a). While assessments of the impact of beach erosion are fewer than those of coastal flooding, risk and consequence valuations are even fewer. Wainwright et al. (2015) used an economic model to determine an optimal development setback location based on whether investment at a particular location is economically viable, given the amount of damage expected by coastal processes. Also focusing on the use of quantitative risk analysis for establishing setback lines, Jongejan, Ranasinghe, Wainwright, Callaghan, and Reyns (2016) combined the calculated probability density functions of annual recession extremes with property value data to obtain erosion risk estimates. Both studies yielded probabilistic estimates of coastline recession driven by combined storm erosion and SLR. While the methodology was applied only to a single beach, efficient coastal management requires the scope of the analysis to be extended across an entire region. Thus, the probabilistic erosion risk assessment we present herein not only accounts for the local tide, waves, storm surges, and SLR uncertainty but has also been implemented at regional scale (i.e., 57 beaches), resulting in robust estimates of shoreline change over the whole century for both un-interrupted and inlet-interrupted coastlines (Toimil et al., 2017a).

To our knowledge, this assessment is unique in terms of coastal planning and management, as it sets out a procedure to probabilistically determine the loss of beach recreation value due to a combination of climatic drivers throughout the twenty-first century in a large area. Thus, the paper seeks to provide an insight into the risks of inaction towards beach recreation and discusses their policy implications in terms of tourism management, adaptation and risk reduction.

2. A case study of the Asturian coast (north of Spain)

Asturias is a Spanish region bordered by the Cantabrian Sea to the north, by the regions of Cantabria to the east and Galicia to the west and has 345 km of elongated, rectilinear and steep-sloped coastline. While featuring long stretches of cliffs, this area also boasts more than two hundred beaches, of which 57 were included in the assessment, particularly those that are sandy and longer than 200 m (see Fig. 1). The selected beaches are deemed pocket-type, which broadly implies that gradients in longshore sediment transport can be assumed to be negligible. Besides, 5 out of the 57 beaches are adjacent to tidal-dominated estuaries, and therefore are subject to the potential effects that these systems can have on their erosion/accretion patterns (Ranasinghe, Duong, Uhlenbrook, Roelvink, & Stive, 2013). In this regard, it is important to note that due to anthropogenic influences that include upstream damming and dredging induced by a change in land use, there is no significant fluvial sediment supply to be integrated into the sediment budget.

The beaches all have macrotidal (2–5 m spring tidal range) and semi-diurnal tidal regimes, and they are mainly constituted by fine (0.2–0.3 mm) quartz sand. The most energetic waves come from the northwest to the north-northwest sectors, and are characterized by significant wave heights that may reach 10 m and peak periods of up to 20 s. When these combine with unusual levels of storm surges and high spring tides, significant damage to the waterfront may result. Between December 2013 and March 2014, a series of storm events hit the Asturian coast, causing severe coastal flooding and noteworthy beach erosion (Toimil et al., 2017a). The cumulative effects of successive storms over the beaches prevented them from recovering and providing the proper recreation services during the next summer period.

The region has an Atlantic climate characterized by relatively mild and humid winters, as well as warm summers, although they are colder than in the rest of Spain. Air temperatures vary both seasonally and daily, and averages range from 9 °C (13 °C–5 °C) in January to 21 °C (23 °C–16 °C) in July. Since the ocean also has effects on precipitation, rainfall is particularly abundant, especially from October to April. Easter often marks the beginning of the beach season, and the weather is relatively warm and sunny until well into October, and even extending further into November. Two main beach seasons can thus be distinguished: from April 1 to October 31 and from November 1 to March 31, hereinafter denoted as *recreation season* and *non-recreation season*, respectively.

Asturias is eminently a coastal region. Currently, 50% of the population lives within the coastal strip, where a major growth occurred during the second half of the twentieth century. The Asturian coast generates more than 48% of the economic flows and hosts approximately 55% of the major infrastructure in the region. As the Asturian tourist sector has largely been based on its natural heritage, between 8% and 11% of the GDP of the entire territory (20.7 billion[1] EUR in 2013 according to FBBVA, 2017) is linked to tourism, either directly or indirectly. Although beaches are prevalent among the range of existing tourism options, the contribution of beach tourism to tourist-related GDP is an estimated value, given the geographical proximity of beaches, mountains and cultural activities within the territory, and the possibility to combine them on the same day. In 2015, Asturias received 7 million tourists, of which 82.3% were national, 14.6% international, and the remaining 3.1% intraregional. According to official touristic statistics, 47% of tourist activity was beach related, with culture and sports making up the remaining 53%. In light of these data, we assume beach-related GDP to be 971 million EUR in 2016. With respect to the

[1] 1 billion EUR = 1000 million EUR.