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Case study

Assessment of the relationship between geomorphological evolution, carrying capacity and users' perception: Case studies in Emilia-Romagna (Italy)

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HIGHLIGHTS

- Shoreline analysis shows erosional trend in the littoral.
- Users' perceive overcrowding mostly during the week-end.
- Physical carrying capacity is exceeded in both study areas.
- Low management level reduces the effective carrying capacity.

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ABSTRACT

Several published studies on beach management have defined sustainable strategies for the maintenance of their recreational capacity. However, coastal geomorphology and evolution have rarely been taken into consideration. To complete these studies, we analyzed the geomorphological characteristics, the users' perception and beach carrying capacity of two coastal stretches. Geomorphological characteristics were obtained from aerial photos and field survey data; beach perception was assessed through questionnaires and interviews while the beach carrying capacity was calculated using two distinct methods. Our results suggest that the physical carrying capacity can be defined using geomorphological analyses, while the effective carrying capacity can be evaluated using the users' perception analysis.

1. Introduction

In 2012, the European Union stated that more than 30% of the Mediterranean population lives close to the coast (European Union, 2012). In 1979, the European population was estimated to be 95 million and increased to 143 million by 2000; In 2005, this population was projected to reach 174 million by 2025 (UNEP/MAP/BP/RAC, 2005). As a consequence, about 25,000 km of the 46,000 km of Mediterranean coastlines are urbanized (European Union, 2012). Furthermore, most Mediterranean coastal destinations are associated with mass tourism and intensive land development. In addition, as outlined by Lanquar (2011), the Mediterranean region is the world's leading tourist destination receiving nearly 30 percent of the world's international tourist arrivals. In 2012, the UNEP/MAP forecasted that in 2030, up to 500 million tourists per year will visit the Mediterranean.

The growth of coastal tourism has led to urban development (tourism capacities, support infrastructures) often associated with degradation or alteration of the coastal environment (Bas Amelung & Viner, 2006; Hall, 2001). As coastal tourism needs are always growing, the probability of increasing environmental hazards (for instance, CO_2 emissions, the loss of natural environments, impacts

Abbreviations: LC, Lidi di Comacchio; LV, Lido di Volano; LN, Lido di Nazioni; LP, Lido di Pomposa; LS, Lido degli Scacchi; PG, Porto Garibaldi; MM, Milano Marittima; UPA, Users' perception analysis; PCC, Physical carrying capacity; RCC, Real carrying capacity; ErFc, Erosion Factor; PreFc, Precipitation Factor; AccFc, Accessibility Factor; OMC, Optimal Management Capacity; HhFc, Holiday home Factor; ProxFc, Proximity Factor; ECC, Effective Carrying Capacity; Final ECC, Final Effective Carrying Capacity.

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on marine ecosystems) is becoming increasingly serious, presenting the need for sustainable solutions and implementations, which are obtainable, while balancing tourism's advantages (economic benefits, GDP increase) with environmental sustainability. The major direct pressure from coastal tourism on the marine and coastal environment is produced by the demand for space; and the subsequent beach erosion has been recognized as the main threat to tourism by the World Tourism Organization (2001). Approximately one-fourth of the EU Mediterranean coastline suffers from erosion, with some variation among countries (UNEP/MAP, 2012). According to Commission & Others (2004), about 15,000 km of the Mediterranean coastline have been eroded and about 1500 km of the EU Mediterranean coast have been transformed to "artificial coast" protected by defense structures.

Coastal erosion is becoming one of the most serious environmental concerns faced by coastal communities, aggravated by the prospect of accelerated sea level rise due to climate change (Amelung & Viner, 2006; Bigano, Hamilton, & Tol, 2006; Crouch, 1995; Gössling & Hall, 2006; IPCC., 2014; Rossello, 2005; Witt & Witt, 1995) and the accumulated negative effects of mismanagement practices (Commission & Others, 2004). In fact, because beach erosion and climate changes impacts affect recreational opportunities of the beaches, it may undermine the carrying capacity of the coastal zone by reducing the amount of beach designated to public use (Calado, Ng Kiat Borges, Alves, & Sousa, 2011; Phillips & Jones, 2006). A number of studies have been performed on the expected impacts of climate changes on tourism: Michailidou, Vlachokostas, and Moussiopoulos (2016) present a methodological framework to plan climate change mitigation and adaptation measures in tourism context; Perch-Nielsen, Amelung, and Knutti (2010) drawn several future scenarios of European destinations considering a redistribution of climate resources for tourism; Amelung, Nicholls, and Viner (2007) explored the potential implications of climate change for global tourism, with special emphasis on seasonality, furthermore, different scenarios for sea level rise have been drawn: Kopp et al. (2014) found a global sea level rise of 30–120 cm between 2000 and 2100; Tsimplis et al. (2013) and Shaltout, & Omstedt (2015), found that the Mediterranean sea level displayed a significant positive trend of 2.6 cm/decade from 1993 to 2010 period. Consequently, sea level rise in the Mediterranean will induce beach loss, severe erosion and major flooding events. Climate changes will influence the choice of destination, the season and the length of stay.

Consequently, several questions should be addressed to define and implement sustainable strategies. These questions are: what are the current and future physical beach capacities? Who are the tourists? Does the management of the beaches and their surrounding areas meet the tourists' expectations?

Several approaches have been adopted to determine the physical beach carrying capacity, which can be defined as the number of units that a beach can physically carry at the same time (Silva, Alves, & Rocha, 2007; Williams & Micallef, 2009). This carrying capacity is related to both the physical properties of the beach, such as width and available surface, in addition to social aspects and beach management, such as safety, water quality, crowding, facilities, scenery, litter (Andric, 1962; Getz, 1983; Godschalk, & Parker, 1975; Mawhinney, 1973; Piqueras, 1999; Silva, 2002). Recently, these analyses have been improved by adding the user perception analysis (UPA) of the beach (Marin, Palmisani, Ivaldi, Dursi, & Fabiano, 2009; Micallef & Williams, 2004; Vaz, Williams, Pereira, Silva, & Phillips, 2009; Zacarias, Williams, & Newton, 2011), useful for developing beach management policies (Dahm, 2003; Santos, Friedrich, Wallner-Kersanach, & Fillmann, 2005). Several beach UPAs have been developed in order to define the behaviors and preferences of the beach users and to assess their opinions on different beach-related aspects, such as environmental and water quality, coastal erosion and crowding tolerance. For these reasons, UPA is associated with the *social* carrying capacity, defined as "the maximum visitor density at which beach-goers still feel comfortable and uncrowded" (De Ruyck, Soares, & Mclachlan, 1997; Silva, 2006).

Recently, several approaches have been developed leading to a better evaluation of beach users' perception and beach carrying capacity, although beach users' relations with the geomorphological characteristics of the beaches are often overlooked. Therefore, the aims of this paper are to first assess the physical and social features of coastal areas before developing an integrated methodology for tourism management and/or related strategies for specific areas (What strategies can be used? Have they been previously implemented? What lessons can be learned?).

Several field surveys were conducted in two pilot sites along the Emilia Romagna coast in order to analyze its geomorphological characteristics and to evaluate shoreline evolution, beach users' perception, environmental qualities and management and the carrying capacity. This paper provides a brief description of the main characteristics of the two study areas, the methodology used, and the results obtained from geomorphological analysis. It also discusses the users' perception and the carrying capacity assessment of the beaches. Finally, the conclusion presents several tourism strategies and proposes several possible improvements of the methodologies.

2. Study area

The Emilia-Romagna coast is one of the most famous coastal destinations in the northern Adriatic Sea (Italy) and it extends for about 110 km from Po di Goro to Cattolica. The coastline of Lido di Comacchio (hereafter called LC) is 16 km-long and goes from Po di Volano to Porto Garibaldi (Fig. 1-a) and includes five coastal villages: Lido di Volano (LV), Lido di Nazioni (LN), Lido di Pomposa (LP), Lido degli Scacchi (LS) and Porto Garibaldi (PG), comprising a total of 71 beach resorts. The coastal stretch of Milano Marittima (MM) is 2.2 km long comprising 44 beach establishments; it is located between the Cupa channel and the Salina channel (Fig. 1-a).

These resorts (locally called "bagno") are administrative concessions or private properties of a portion of the beach, where facilities/services are offered to beach users with different costs depending on the season (Fig. 1-b). Beach establishments, as noted by Valdemoro and Jiménez (2006), allow individuals to get a more homogenous spatial distribution of users across the beach and therefore to exploit almost the entire emerged beach surface (Fig. 1-c).

The two coastal areas consist of low sandy beaches derived from ancient swamp and alluvial deposits (Martinelli, Zanuttigh, De Nigris, & Preti, 2011). The seabed slope is generally very gentle, some 0.4° (Bondesan et al., 1995). The emerged beach width is variable and ranges from 20 m to 60 m from LV to LP and from 60 to more than 100 m from LS to LP, while in MM the beach width is some 50 m (Martinelli, Zanuttigh, & Corbau, 2010; Montanari & Marasmi, 2011). The same authors indicated that intense coastal erosion is often observed from LV to LP and along the first 500 m south, to the jetty of the Cupa channel (Fig. 1-a).

According to their geomorphological characteristics, these coastal zones are generally considered dissipative or intermediate (Wright & Short, 1984), even though this assertion does not seem to represent the local situation, since most of the active dunes present evident "features" of erosion and border a narrow beach and a moderately steep nearshore (Corbau, Simeoni, Melchiorre, Rodella, & Utizi, 2015). Prevailing waves and winds are from the north-east