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A combined DPSIR and SAF approach for the adaptive management of beach erosion in Monte Hermoso and Pehuen Co (Argentina)

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ABSTRACT

Coastal areas experience multiple pressures from anthropogenic activities that negatively change the ecological and environmental status of beaches and impact human welfare. The focus of this paper is coastal erosion, an issue that is very relevant for Argentina, the second largest nation in Latin America with an extensive coastline of nearly 5000 km. Coastal erosion decreases the attractiveness of coastal areas for tourism development, leading to considerable economic impacts. In this paper, two complementary approaches, the Driver-Pressure-State-Impact-Response (DPSIR) and the Systems Approach Framework (SAF), were used to analyse two beach resorts in Argentina: Monte Hermoso and Pehuen Co. Application of the SAF included stakeholder mapping, governance (institutional) mapping and issue identification. During the participatory meetings with stakeholders and decision makers, the problem of coastal erosion was identified as the most important in the region. The joint approach of DPSIR and SAF contributed to: (i) the determination and description of the economic drivers of coastal erosion; (ii) the identification of the associated activities and pressures; (iii) the assessment of the ecological and environmental state of coastal areas; (iv) the assessment of impacts of environmental changes on human wellbeing; and finally (v) a proposal of the possible management responses for mitigating the coastal erosion problem and the sustainable development of the region to the responsible authorities.

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1. Introduction, context and scope

1.1. Importance of beaches, pressures and need for adaptive management

Beaches are unique environmental systems where natural, socio-economic and administrative components interact (Ariza et al., 2008; James, 2000). They significantly contribute to human welfare, providing many different valuable goods and services such

as leisure and recreation, coastal defense, conservation, employment, cultural heritage and identity, nutrient cycling, habitat for plants and animals (Marshall et al., 2014; Lozoya et al., 2011). Beaches represent the most complex, dynamic and sensitive land-forms of coastal environments (Dahm, 2003; Hansom, 2001) that experience irreversible changes caused by natural and anthropogenic pressures. A high demand is placed upon beach resources to meet the high expectations of tourists for leisure and recreation.

Seaside tourism is one of the fastest growing areas of the contemporary tourism market (Hall, 2001; Holden, 2008; WTTC, 2014) that has significant environmental, cultural, social and economic effects, both positive and negative (Ghulam Rabbany et al., 2013). It is an important driver of socio-economic progress

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through export revenues, the creation of jobs and enterprises, and infrastructure development (WTTTC, 2014). However, if not properly planned, tourism activities and associated urban development can have destructive effects on biodiversity and pristine environments, and consequently lead to the degradation of coastal resources (Ghulam Rabbany et al., 2013). In turn, the degradation of coastal resources compromises the delivery of many ecosystem services crucial to human welfare and national economies (Dayton et al., 2005).

The problem of environmental quality deterioration of coastal zones as a consequence of high anthropogenic pressures is an issue of worldwide concern (Brown and McLachlan, 2002; Brown et al., 2014; Newton and Weichselgartner, 2014; Schlacher et al., 2008). The most common problems of modern beaches include coastal erosion, water and sand pollution, deterioration of coastal dunes and harmful effects on biota (Brown and McLachlan, 2002; Calvao et al., 2013). The importance of beach management for the preservation of coastal areas has been recognised by the municipalities and local governments of coastal regions worldwide (Phillips and Jones, 2006). Beach management has become a very important component of Integrated Coastal Zone Management (Micallef and Williams, 2002) and improving beach quality is a shared goal for all stakeholders (Duvat, 2011).

1.2. Coasts and beach resorts of Argentina

Coastal areas represent 18% (about 515 000 km²) of the territory of Argentina where 36% of population live (CIA, 2014; Rojas et al., 2014). Intensive urban development of coastal regions exposes these to natural hazards that in turn negatively influence human wellbeing (Caló et al., 1998, 2005; Campuzano et al., 2013). Previous studies show that there are many challenges for the management of coastal areas in Argentina, but foremost is a lack of coastal management plans and established good practices (Fernandez et al., 2006; Lemay, 1998). Both the anthropogenic activities associated with tourism, infrastructures, industries, and non-anthropogenic effects such as climate variability aggravate the erosion problem.

Coastal tourism is a very important activity in Monte Hermoso and Pehuen Co, which developed based on beach tourism, hospitality and tourist activities. These localities are the warmest beach resorts in Argentina with relatively high water temperatures and therefore are one of the best beach destinations for tourists from all over the country (Huamantínco Cisneros and Piccolo, 2011) and are centres of intense touristic development. The population increases several fold during the prolonged 7 month beach season (London et al., 2013; Rojas et al., 2014). Monte Hermoso receives visitors even in the low season with an average stay of 2–3 days (London et al., 2012). These two sites were chosen for the study because of the multiplicity of ecosystem services they provide and the crucial importance of the ocean and coastal resources for the economy and daily life of the inhabitants (London et al., 2012).

The study sites present both similarities and contrasts. Monte Hermoso is a medium size town (about 6500 residents) with well-developed infrastructure and accommodation units. It is the tourist centre with the greatest growth and expansion in the southwest of Buenos Aires province (Caló et al., 2000; Censo, 2010; Vaquero et al., 2007). Tourists seek Monte Hermoso as a “sea and beach” holiday destination (UNS, 2008). Pehuen Co is a small town (about 700 residents) known as “a forest beside the sea”. It is a low density eco-tourism site with a fully preserved forested design of unpaved street and low houses (Celsi and Monserrat, 2008; Rojas et al., 2014). According to the surveys conducted by the Office of Tourism of Coronel Rosales, “pursuing peace and nature” is the main motivation of beach visitors. Despite these differences, both sites share the same issues: coastal erosion, sustainability of the

artisanal fisheries and a rapid urban growth without urban planning. According to London et al. (2013), in Monte Hermoso and Pehuen Co, the system will continue to be in danger of erosion if the human intervention persists in the same way, i.e. a “business as usual” scenario. There is an increasing need to address integrated coastal and beach management in Monte Hermoso and Pehuen Co, because the main source of income and economy of those areas is based on “sun and beach” tourism (Celsi and Monserrat, 2008; Fiori et al., 2004; London et al., 2013; Vaquero and Pascale, 2003).

1.3. DPSIR and SAF approach frameworks

The DPSIR framework, provides an overall mechanism for analysing environmental problems, with regards to sustainable development (Borja et al., 2006). Despite several criticisms and appreciations, the DPSIR framework is still a useful tool (Gari et al., 2015). The evolution of the DPSIR is traced from the Stress-Response framework, developed initially by the Organization of Economic Co-operation and Development (OECD) in 1993, but modified and adopted later by European Environmental Agency (EEA) in 1999 to its present form (Gari et al., 2015). The present interpretation of the DPSIR framework links cause-effect relationships among the 5 categories.

- (i) **Drivers** function through social, demographic and economic developments in societies and associated human activities that exert pressures on the system.
- (ii) **Pressures** (e.g. the changes in use of land and resources). These pressures result in changes in the state of the environment.
- (iii) **State** reflects the level and trends of degradation and relates to the current status of the environment and ecosystem that determines the consequent ability to support demands placed on it and to deliver sustainable ecosystem services to the benefit of humans.
- (iv) **Impacts** are effects of the changes in the state of ecosystem and environment on human welfare (e.g. human life and safety, public health and well-being) and society (e.g. economy and employment).
- (v) **Responses** include management measures and societal attempts to prevent, compensate, ameliorate or adapt to changes in the state of the environment (e.g. policies, regulations, adaptive management) (EEA, 1999).

The Systems Approach Framework (SAF) is a Decision Support Systems (DSS), developed by the Science and Policy for Coastal System Assessment (SPICOSA) project during 2007–2011 (<http://www.coastal-saf.eu/>). The application of SAF starts from issue identification (with consultation with stakeholders and managers) and continues with four steps: system design, system formulation, system appraisal and system output (Tett et al., 2011). The SAF approach considers coastal zone as an integrated ecological-social-economic system (Newton, 2012) and supports the efficiency of decision-making processes. In turn, efficient management decisions contribute to the improvement of the state of socio-ecological systems with regard to sustainability, economical efficiency, and social equity.

1.4. Objectives of the study

The objectives of this study are:

- (i) to analyse the main economic drivers of coastal erosion;
- (ii) to analyse the pressures derived from anthropogenic activities;

- (iii) to assess the ecological and environmental state of the beaches;
- (iv) to assess the social-economic impacts of environmental and ecological changes on human welfare;
- (v) to suggest possible management measures and responses to mitigate coastal erosion and to support the sustainable development of these areas to the responsible entities.

2. Geographical setting and human geography of the study sites

The study sites are two beaches that belong to the coastal towns of Monte Hermoso and Pehuen Co, situated near the city of Bahía Blanca on the Atlantic coast in the south of the Buenos Aires Province in Argentina (Fig. 1). Bahía Blanca is the largest city of the Southwest region of Buenos Aires Province, located in a strategic position due to its availability of commodities, vast transport system, its role as an energy supply node and the abundance of qualified human resources (London et al., 2012).

Monte Hermoso and Pehuen Co are neighbouring coastal towns, located along the E-W stretch of the coast, 20 km apart from each other. Monte Hermoso constitutes a municipality by itself since 1979 (Caló et al., 2000) and Pehuen Co belongs to the Coronel de Marina Leonardo Rosales Municipality. The coast between the two towns is characterized by a long, dissipative, sandy beach with a low slope that is backed by sand dunes. The area has a mesotidal regime with semidiurnal tides (Delgado et al., 2012). There is no evidence of sea level rise in the study sites, but analysis of tides records have showed that the mean sea level rise for Argentina is estimated in 1.6 mm/year from data starting in 1900 (London et al., 2013; Bird, 2010).

Monte Hermoso and Pehuen Co are located in a temperate climate zone of Argentina characterized by a temperate humid subregion with scarce rainfall. The mean annual temperature is 13.6 °C and pressure of the region is 1017 hPa. The alternate influence of polar fronts and large air masses from the north generates significant variability in the weather conditions. The Atlantic

high-pressure centre originates a fan-shaped mass of warm and moist air that enters in the continent from the NE. The Pacific anticyclones originate winds, which have high moisture content but which become cold and very dry when flowing across the Andes. In the summer, these winds transport suspended dust that generates a desiccant and erosive action. Prevailing winds are from the N and NW with average speeds of 24 km/h (Perillo et al., 2014). The winds from the sea cause significant coastal erosion.

The area located between the 17 km at the west of Pehuen Co to the Eastern boarder of Monte Hermoso belongs to the Geological, Paleontological and Archaeological Provincial Reserve that was proposed for inscription to UNESCO World Heritage site in 2014. The reserve has very special and unique characteristics and covers an area of approximately 16, 2 km² along the beach (UNESCO, 2014). Outcrops of clayey rocks composed by fine grained sediments of a reddish-brown colour were revealed by the marine ingression of the Holocene (Bayon et al., 2012; Rojas et al., 2014; UNESCO, 2014). These include fossils and footprints of the autochthonous fauna that inhabited South America during the Late Pleistocene, before the Great American Biotic Interchange. Remains of vertebrates such as birds, mammals, freshwater fish, amphibians, reptiles can also be found, as well as megafauna. Among the most remarkable are tracks of more than 90 cm long that can be seen imprinted in the rocks of the beach. The first discoveries of mammals were carried out in this area by Charles Darwin in 1832 and were one of the inspirations for his ideas about evolution. Ancient footprints of early humans from around 12,000 years old have also been identified very near to Monte Hermoso (London et al., 2012).

3. Methods

3.1. Analytical frameworks

The analytical frameworks used in this study are:

- (i) the Driver-Pressure-State-Impact-Response (DPSIR) framework (Carr et al., 2007; Gari et al., 2015) and

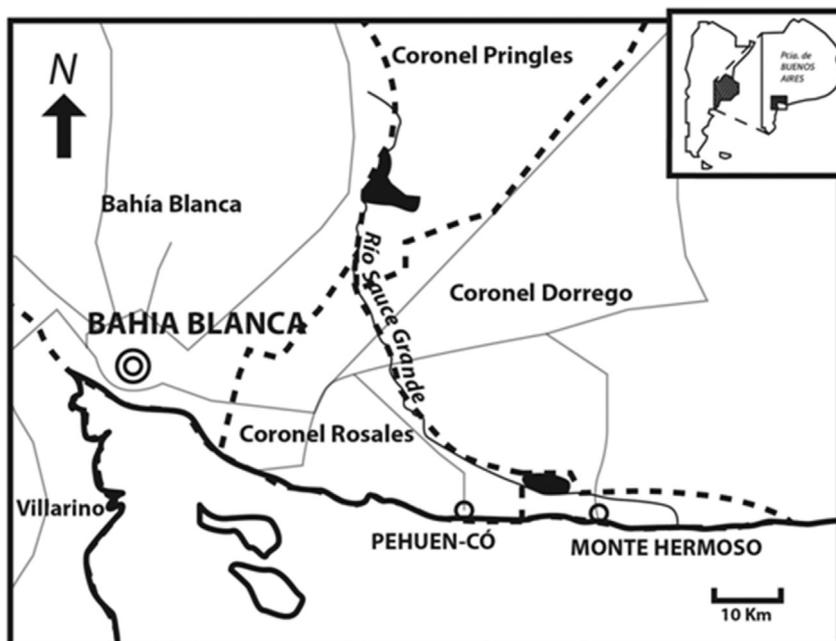


Fig. 1. Location map of Monte Hermoso and Pehuen Co in the Buenos Aires Province of Argentina (dash lines represent municipality borderlines and full lines represent roads). Credits: Estefanía Berninsone.

(ii) the Systems Approach Framework (SAF) (Newton, 2012).

3.1.1. DPSIR framework

The DPSIR framework, the main method used in this study, was adapted for beaches and applied using its main components. In this particular study the sectoral economic drivers were considered. The components of the DPSIR framework were assessed through the comprehensive literature review on the socio-ecological system in the study areas and through the consultation with stakeholders. The reviewed literature included doctorate thesis, project's deliverables and articles of natural and social science perspective, which were published in the international journals and national institutional journals. The focus was on the coastal erosion and associated effects on the environment and society. The interaction with stakeholders allowed an identification of their vision on the emerging issues and drivers related to the environmental challenges in the study areas. The combination of the scientific knowledge and cooperation with the stakeholders allowed formulation of the perspective management responses to mitigate the coastal erosion issue.

3.1.2. SAF protocol

The SAF approach was applied in this study in order to support the permanent dialog between governance, stakeholders, scientists and society through formal and informal meetings (Hopkins et al., 2011, 2012). The complimentary steps of the SAF approach were used including (i) issue identification, (ii) stakeholder mapping and (iii) governance (institutional) mapping. These steps are related, because (i) this allows us to identify and focus on the problems that are the most critical for the study areas; (ii) the involvement of the appropriate stakeholders is a crucial step in any adaptive management and some stakeholders are "issue specific", or more central to one issue than another, which is important to co-develop solutions and management responses for the issues; (iii) this allows the identification of the institutions (e.g. local or regional government) that are relevant to the decision-making regarding the specific policy issue identified (McFadden et al., 2010).

3.2. Stakeholder meetings

The present research was carried out within the COMET-LA project (<http://www.comet-la.eu/>) following a participatory approach with different stakeholders (SH) and decision makers (DM) meetings held from January 2012–November 2014 at regular intervals. Among the different groups of stakeholders who participated in workshops were local government stakeholders (municipalities, tourism, industry and public works), local environmental institutions, academic and education institutions, non-governmental organizations (NGOs), and other stakeholders (e.g. radio journalists, lifeguards and park rangers). The questionnaire surveys were used during those meetings in order to assess the stakeholders' perceptions regarding sustainability and state of coastal areas under this study.

The major achievement of this approach was a high level of commitment and recognition of the importance of such meetings by both groups (SH and DM). Stakeholders meetings allowed (i) discussion of conflicts, (ii) raising awareness of the crucial dependence of users on ecosystem services provided by the coastal areas, (iii) sharing knowledge and perceptions of ecological problems and socioeconomic consequences (London et al., 2013). Moreover, communication between different stakeholders during the workshops allowed integration of learning and decision making, which is a defining feature of adaptive management (Williams and Brown, 2012).

4. Results

4.1. Issue identification

During the seminars and participatory workshops it became clear that coastal erosion was the key environmental problem according to most stakeholders in Monte Hermoso and Pehuen Co. Hence, the issue of coastal erosion was identified as the main focus of this paper. The results of questionnaire surveys as well revealed that the loss of sand and chronic erosion were major problems in Monte Hermoso and Pehuen Co. Coastal erosion as a result of the geographical location is exacerbated by urban settlements (Bustos, 2012; Huamantincio Cisneros, 2012), and primarily affects socio-ecological system of both study sites (London et al., 2013).

4.2. DPSIR framework applied to the coastal erosion issue in Monte Hermoso and Pehuen Co

Application of the DPSIR (Driver-Pressure-State-Impact-Response) framework allowed an assessment of the (i) drivers and (ii) pressures of the coastal erosion issue, (iii) state of the ecosystem and the environment, (iv) impacts on human welfare and society and (v) proposal of the possible management responses to mitigate the coastal erosion issue (Table 1).

The results obtained from the application of the DPSIR framework revealed that tourism, along with construction and urban development, are the main economic drivers of the coastal erosion issue in both study areas. The associated human activities cause pressures, among which are damaging and trampling of the dune system, compression of soil, impermeabilization of surfaces, physical removal of sand and dunes, and obstruction of sand transport. These pressures induced changes in the state of the ecosystem and environment and resulted in beach and dune erosion, decrease in sand quality and loss of beach surface, decreased capacity of soil to store water, damages and decrease of coastal habitats, flora and fauna. Changes in the ecosystem and environment effect human well-being through the impacts associated with the reduced safety and a danger to human life, reduce of drinking water, loss of infrastructure and property, loss of cultural heritage, decreased appeal for tourism, potential loss of jobs and income and perspective collapse of region's economy. The possible responses included regulations and adaptive management measures such as restriction and regulation of the access to the beach, prohibition of vehicular traffic, education and information, ecotourism, application of coastal protection techniques, regulation of urban sprawl, monitoring and sanctioning, etc. These results are discussed in the following section.

5. Discussion

5.1. Driving forces of coastal erosion problem

5.1.1. Seaside tourism (economic driver)

The growing popularity of seaside tourism in the study areas influenced a rapid development of coastal areas and resulted in the expansion of the population level due to the influx of tourists and people who wish to live near the beach. According to the stakeholders, the affluence of tourists has become more constant along the whole year. Overcrowding and improper use of coastal resources causes environmental changes including coastal erosion and, moreover, it effects human welfare (Gosling, 2002). The current laws in this region do not promote sustainable tourism (Rojas et al., 2014a). According to Dadon and Matteucci (2002), the main cause of observed human impact is the proliferation of activities derived from tourism without proper planning. The resulting

Table 1
DPSIR framework applied to assess the coastal erosion issue in Monte Hermoso and Pehuen Co (Argentina).

Drivers	Pressures	State	Impact	Responses
Tourism	Damaging and trampling of the dune system; Compression of soil.	Erosion of dunes; Decreased vegetation; Decreased nesting of birds; Decrease of dune habitats; Decreased capacity to store water.	Potential loss of life due to the effects of storms; Loss of the infrastructure; Loss of the access to the certain sectors of the beach; Loss of the hospitality and private property; Loss of jobs in tourism sector; Deterioration of freshwater resources (contamination or deterioration of water storage wells and clean drinking water).	Restriction of the access to certain areas of the beach; Restriction of the recreation on dunes; Prohibition of vehicular traffic over the beach and dunes; Education and conservation; Promotion of ecotourism and development of ecotourism plans; Application of coastal protection measures, preferably soft.
Construction and urban development	Physical removal of sand and dunes; Physical obstruction of sand transport; Impermeabilization of surfaces.	Erosion of dunes; Decrease of sand quality; Decrease of sand and beach surface; Decrease of vegetation and fauna.	Decreased safety of bathers due to change in beach morphology and increased rip currents; Loss of the infrastructure; Loss of the hospitality and private property; Decreased appeal as a tourist destination; Loss of income and potential collapse of region's economy; Loss of jobs in the tourism sector; Potential loss of the unique heritage.	Regulation of urban sprawl and urban planning; Application of coastal protection measures, preferably soft; Monitoring, control and sanctioning of extraction of sand through municipal ordinances; Protection of unique cultural heritage by guarding and restricted access.

pressures increase beach and dune erosion and hence coastal degradation.

5.1.2. Construction and urban development (driver)

Urban development in the study areas included construction of tourism, industrial and transportation facilities. The building of infrastructure, construction of hotels and private property close to the beach caused decrease in beach surfaces and disappearance of dunes. This happened due to the lack of the urbanization plan in Monte Hermoso or Pehuen Co (London et al., 2012; Rojas et al., 2014). The Provincial Law for Territorial Order and Use of Land (N°8912), which was in force from 1977 to 1999, prohibited building only behind 100 m from the tide line. Later in 1999, the Water Code (Law 12,257) prohibited building in a line of 150 m from the ocean. Provincial decree N°3202 that defined a defense band of 250 or 300 m from the foot of the dune, limiting the increase of towns over the beach (London et al., 2012) was established only in 2006.

Although there are no large touristic enterprises, both towns have a high number of facilities to receive tourists, such as hotels, apart-hotels, and private house renting, camping, and restaurants. In Monte Hermoso, the problem of beach erosion is closely related to the urbanization (Huamantínco Cisneros, 2012). Construction of buildings for tourism activities represents a secondary source of income, where 74% of dwelling houses are second homes built during the last decades (London et al., 2012). In Pehuen Co, the western and central zones suffer from erosion due to the building of infrastructure and private property on the vegetated front dunes which interrupts the dynamics of sand between dune and sea (Bustos et al., 2011; Perillo et al., 2014).

5.2. Pressures emerging from the driving forces, which influence coastal erosion

5.2.1. Pressures associated with tourism activity

Beaches in Monte Hermoso and Pehuen Co are open access resources that are regulated by the government. This means that there is open public access and use of the beaches and dunes (Rojas et al., 2014). Tourists access the beach over the dunes and disperse for sunbathing and recreation. Coastal dunes attract visitors as they provide good view points and sun shelters. Recreational use of dunes results in higher soil bulk density due to compaction and reduced organic matter (Priskin, 2003). Increased pressure through

the foot access to the beach over the dunes by visitors and sunbathing on the dunes increases trampling and damage to the dune systems (Davenport and Davenport, 2006).

Another common issue in the study areas is the vehicular access and traffic over the beach and dunes. The effect of off-road vehicles (ATVs) on the beach system is similar to human trampling but is much more severe (Priskin, 2003). Although it was locally prohibited in Monte Hermoso in 2006, cases of uncontrolled car traffic still occur. On the contrary, Pehuen Co allows vehicular traffic on the beach except in the summer period (within the urban sector) and in the archaeological reserve areas (Rojas et al., 2014). On weekends, average of 300 vehicles per day access the beach (Perillo et al., 2014). Vehicles compact the sand at depth, but loosen the surface of the beach, making it more susceptible to wind and wave erosion (Webb and Wilshire, 1983). Furthermore, the traffic of off-road all-terrain vehicles (ATVs) such as quad bikes is another very common activity and important issue in both towns. For instance, the “Enduro de Monte Hermoso” event is a large race of ATVs over the dunes and beach, which is organised annually in Monte Hermoso. More than 300 vehicles participated in the 2015 race (Monte Hermoso, 2016). The deep tread of the tyres of the ATVs, useful for stability, causes damage to the environment, especially to fragile coastal dunes. The traffic of ATVs leads to the physical displacement and compression of sediment (Davenport and Davenport, 2006; Li et al., 2007; Schlacher and Morrison, 2008). Additionally, the tractors that fishermen use to take their boats to the sea have a destructive effect on the dunes and beach. Tourism not only brings a major demand for the fish but also provides a complementary economic activity: sport fishing. Traffic greatly increases during summer season when both activities (tourism and fishery) reach their peak.

5.2.2. Pressures associated with construction and urban development

The coastal zones of Monte Hermoso and Pehuen Co are subject to a high pressure from the construction of buildings and infrastructure on the beach and dunes (Fernandez et al., 2006; Huamantínco Cisneros, 2012; Rojas et al., 2014). The construction of houses in front of the coast continues. The cultural rule of these beaches is that the tourists (or residents) want to be very close to the beach. The responsible authorities stated that of the 355 permits that were given for the construction of buildings in Monte Hermoso in 2015, 320 (90%) were for new buildings, and the

remaining 35 (10%) were for rebuilding and enlarging existing structures. The physical removal of sand and vegetation cover, the obstruction of sand dune dynamics, soil compaction from buildings and impermeabilization of the land surface by means of paving are responsible for frequent landslides, destabilisation and coastal erosion (Foster et al., 1999; Kondolf and Podolak, 2014).

5.3. State of the environment

The destructive human activities associated with tourism, construction and urban development in Monte Hermoso and Pehuen Co result in environmental degradation of the coastal areas (Del Pozo and Brondolo, 2002; Huamantincio Cisneros, 2012; Laura Monserrat et al., 2012).

A study on the erosion and sediment balance during 2008–2011 in Monte Hermoso showed that the urbanised sectors were the most affected by coastal erosion due to the replacement of dunes by buildings (Huamantincio Cisneros, 2012). The recent analyses of the volumetric and geomorphologic changes of the beach sector, located west of the urban area, have indicated a significant change due to atrophic interventions. For the period 2013–2015, the sediment loss of $-49, 6 \text{ m}^3 \text{ m}^{-1} \text{ year}$ was indicated, with the maximum loss of $120, 8 \text{ m}^3$ (Huamantincio Cisneros et al., 2015). The shape of the dune has been reduced and it may soon completely disappear. Human pressures on the western sector of the beach are lighter. However, there is significant sediment loss, mostly related to the strong winds. Storm events in 2008 led to a sediment loss of -120.4 m^3 (Huamantincio Cisneros, 2012). The central sector of the beach seems to be relatively stable to coastal erosion processes. However, the removal of dunes in order to build a boulevard caused the loss of sand that was used to nourish the beach (NuestroMar, 2015).

A study of the beach geomorphology and dynamics during 2007–2010 in Pehuen Co revealed that almost the entire beach of Pehuen Co is susceptible to erosion (Bustos, 2012). Between 1974 and 1996, the coast of Pehuen Co suffered from erosion and lost between 2 and 5 m of shoreline per year. Significant beach erosion continues (NuestroMar, 2015). The western and central zones of the beach are the most urbanised and vulnerable to coastal erosion. The last available results of the measurements of the coastal dynamics showed that the annual variation of sediment of the urbanised area of the beach in 2007–2010 was -20.3 m^3 . A negative sediment balance of maximum 18.4 m^3 occurred in 2007–2008 and major rates of sediment loss (up to -60 m^3) were recorded during the winter 2008 (Bustos et al., 2011; Bustos, 2012). Moreover, the construction of the coastal road on the dune damaged the vegetation cover of tamarisk (*Tamarix gallica*). The eastern zone of the beach is less vulnerable, with a moderate risk of coastal erosion. This is due to less urbanization close to the first line of dunes and rare predominant winds, which could cause erosion. However, the front beach lacks sediment. The reserve zone of the beach is least vulnerable to erosion, because of much lower anthropogenic pressures. Despite the general tendency to accretion, some parts of the outcrops and fossils are uncovered and exposed to marine erosion that makes this area also vulnerable (Bustos et al., 2009a, 2011; Bustos, 2012).

5.4. Impacts on human welfare

Damaged coastal dunes and reduction of the beach surface in the study areas make these coasts more vulnerable to erosion, and to the risks of over-wash and flooding (Bustos et al., 2009b; Laura Monserrat et al., 2012). The potential drastic consequences of severe storms and flooding include loss of life, loss of infrastructure (roads, access paths to the beach etc.), loss of private property and

hospitality buildings. This is an important threat to Monte Hermoso and particularly to Pehuen Co, because the erosion of the dune reduces the beach and increases the risk of collapse of houses and touristic buildings near the coast (Bustos et al., 2009b). Additionally, the dune retreat in Pehuen Co has led to the closure of the coastal avenue and commerce near the sea, with the consequent negative impact and loss of the tourism revenue. Although the economic losses from coastal erosion have not been officially estimated at both study sites, there is a yearly impact of coastal erosion, such as loss in private capital and cultural value of the Reserve (Rojas et al., 2014).

Moreover, the beaches in Monte Hermoso and Pehuen Co have become more dangerous because of the environmental changes (creation of sandbars and channels) caused by joint effects of intensified winds and storms and anthropogenic activity. The increase of the rip currents, sandbars and sandbanks puts the safety of beach users at risk by increasing the risk of drowning (London et al., 2012; Rojas et al., 2014).

Another important issue in the study areas are a decreasing water storage potential and nutrient cycling due to the compaction and deterioration of soil by human activities (ATVs, sand mining). This can lead to the contamination of groundwater and surface water and subsequently impact the provision of clean drinking water (McLachlan and McGwynne, 1986; Soane and Vanouwerkerk, 1995).

Furthermore, the degradation of beach quality would consequently reduce the appeal for tourism, lead to the loss of the jobs, income and livelihood, and an eventual collapse of the region's economy. These problems are particularly relevant for the study sites, since the livelihood of most residents depends on beach tourism.

5.5. Management measures and responses by the responsible authorities

The governance mapping (SAF) and application of the DPSIR approach allowed the identification of possible management measures and responses to mitigate the coastal erosion issue in the study areas. The proposed management solutions and responsible authorities (e.g. national and local governments, other stakeholders) are presented in Table 2 and discussed below.

5.5.1. Regulation of the access to the beach

In the vulnerable areas, the access to certain areas of the beaches can be restricted to beach users in order to prevent the damage by trampling of the dunes and protect the threatened coastal dune vegetation. Additionally, the number of access points should be limited and their location should preferably be in the areas that have the greatest carrying capacity of visitors, or where the dunes are absent or bare, in order to avoid further damaging of the dune system (VanderMeulen and Salman, 1996). Most importantly, the construction of elevated wooden walking paths through the dunes mitigates sand erosion and prevents plants from the damage. The notice boards and signs to raise public awareness can be placed next to the walkovers to encourage people to use these and avoid cutting across other dune areas, thereby avoiding damage to the dune vegetation. Such measures are usually very successful, if the walkways are installed at the correct access points. They improve the access, as walking on the boards is easier than walking in the sand, and are readily adopted by the public.

5.5.2. Restriction of the recreation on dunes

Notice boards to raise public awareness of damage to the dunes can be placed as a first measure. If this is insufficient, fencing of dunes to prevent recreation on them can follow. Finally, recreation

Table 2

Management responses for mitigating the coastal erosion issue in Monte Hermoso and Pehuen Co (Argentina).

Management actions	Responsible authority
Regulation of the access to the beach	Ministry of Infrastructure and under-secretary for Public Works; Secretariat for Works and Services.
Restriction of the recreation on dunes	Provincial Organism for Sustainable Development; Secretariat for Works and Services.
Prohibition of vehicular traffic over the beach and dunes	Provincial Organism for Sustainable Development; Secretariat for Works and Services; Naval Prefecture of Argentina; Secretariats of tourism.
Regulation of urban sprawl and urban planning	Ministry of Federal Planning, Public Investment and Services; Provincial Organism for Sustainable Development; Ministry of Infrastructure and under-secretary for Public Works; Provincial Office for Hydraulic; The Provincial Office for Mining; Secretariat for Works and Services.
Education and information	Ministry of Science, Technology and Innovation; Provincial Organism for Sustainable Development; Secretariats of Tourism; Academic, scientific and education institutions; NGOs; Families.
Promotion of ecotourism and development of ecotourism plans	Ministry of Tourism; National Institute for the Tourism Promotion; Provincial Organism for Sustainable Development; Secretariats of Tourism; Park rangers and sustainable tourism actors; NGOs.
Monitoring, control and sanctioning of sand extraction	Under-secretary of Industry, Trade and Mining; Provincial Office for Mining; Secretariat for Works and Services.
Application of coastal protection measures	Ministry of Infrastructure and under-secretary for Public Works; Safety Ministry; Provincial Organism for Sustainable Development; Provincial Office for Hydraulic; Secretariat for Works and Services; Academic, scientific and education institutions.
Protection of unique cultural heritage	Ministry of Tourism; Provincial Organism for Sustainable Development; The Provincial Nature Reserve; NGOs.

on the dunes themselves (e.g. sunbathing, picnic) could be prohibited and fines might be charged for breaking this rule.

5.5.3. Prohibition of the vehicular traffic

More regulation and control to restrict vehicular traffic on the dunes and beach is necessary. A first measure can be a charge for beach access. The price can be increased to test the “willingness to pay” and eventually vehicular access and traffic could be prohibited along the entire beach area and within the coastal dunes. Exceptions can be applied for those vehicles that are necessary for cleaning, repair, public safety, and for local or state authorities, or for disabled access. The limitation of the vehicular access should be accompanied by the provision of free parking, so that those who choose to leave their vehicles can park them in a pre-designed area. Planting trees for shade makes these areas more attractive and boosts the vegetation cover. The parking should not be an impervious surface. The parking areas should also coincide with the boardwalk access points, the provision of toilets and refreshment facilities. Regarding the damage caused by the artisanal fishing activities, the launch sites for boats should be in specific places of the beach in order to reduce the impact on the dunes and the beach. The creation of a paved road linking both towns will also reduce the illegal beach transit between Monte Hermoso and Pehuen Co.

5.5.4. Regulation of urban sprawl and urban planning

A strategic urban plan that considers the coastline characteristics would minimize impacts on the natural environment.

Regulations that control the building heights and setback of lines for construction activity should be enforced in order to control urban sprawl and stop the urban spread over the beach. Construction on the dunes and beach should be totally prohibited. Regulations for urban planning can help to reduce impervious surfaces, minimize erosion processes and to decrease impacts on coastal communities. Additionally, new techniques of urban planning (e.g. GIS) and environmental management should be encouraged to achieve effective actions to tackle the urban sprawl.

5.5.5. Education and information

Education and information for public awareness raising is one of the most important, affordable and effective aspects of long-term management. Because the damage to dunes usually arises from human activities, environmental education and information aims to improve the awareness of beach-user to change their attitudes and behaviour that contributes to the sustainable use of dunes and beach in future. Community-based partnerships for dune restoration are very effective. Additionally, there are various other effective ways of providing information to visitors, such as information panels, establishment of visitor centres, dissemination of leaflets, brochures, maps and audiovisual presentations. Moreover, environmental education programmes in schools are an excellent method for educating the younger generations about coastal environments (Dahm et al., 2005; VanderMeulen and Salman, 1996).

5.5.6. Promotion of ecotourism and development of ecotourism plans

During the regular meeting with stakeholders, there was a notable lack of knowledge regarding the potential for ecotourism in both study areas. Evidence of this are the ENDURO event in Monte Hermoso and large amounts of solid waste and litter on the beaches (Rojas et al., 2014). Ecotourism is now defined as “responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education” (TIES, 2015). Education is meant to be inclusive of both staff and guests. Progress can be made through raising awareness about the necessity of more ecologically friendly tourism, as well as the promotion and implementation of ecotourism plans to mitigate ecological problems and to improve the natural characteristics of the beaches.

The ecotourism programmes should be co-developed by the stakeholders to incorporate interaction and education about local natural and cultural heritage that would contribute to the preservation of the natural environment while enhancing of the welfare of local people. Common ecotourism activities that could be effective in the study areas include seaside tourism, guided walks through national parks and natural reserves, bird-watching (approximately one thousand bird species have been identified in Argentina), eco-biking, archaeological and paleontological tourism.

5.5.7. Monitoring, control and sanctioning

Sand extraction is regulated by municipal by-laws in Pehuen Co (Decree N° 12/07) and in Monte Hermoso (N° 443/88). However, the illegal extraction of sand occurs in unauthorized sectors using heavy machinery (Rojas et al., 2014). The extraction of sand to supply the construction industry should be carefully monitored and knowledge-based on the proper investigation of local morphologic conditions in order to avoid habitat disruption and aggravation of erosion problems.

Ostrow (2010) shows that a series of decision and action points could coexist in a complex system, without entailing chaos. The decentralization in the management of some common-pool resources (e.x. the sand) helps communities to have an accurate control over the use and extraction, since the local knowledge on the resource and on the actors' behaviours permits implementation of more efficient mechanisms in monitoring and sanctioning. The implementation of polycentric governance requires that monitoring, control and sanctioning of extraction of sand through municipal ordinances be enforced. Finally, a law prohibiting the extraction of sand for commercial purposes from the beach zone could be enacted. Additionally, wardens to patrol the beach zone can be entrusted with greater authority to reduce illegal extraction operations (Gelabert, 1977).

5.5.8. Application of coastal protection measures

Coastal protection methods, such as hard and/or soft measures can be used for dealing with erosion problems. The hard measures include infrastructural designs and long-term investments such as seawalls, dikes, breakwaters and other coastal protection infrastructure (Sekovski et al., 2012; Semeoshenkova and Newton, 2015). Soft techniques, such as beach and dune nourishment, dune restoration and stabilisation, bioengineering, fencing and other non-structural measures mitigate coastal erosion without harmful effects to the ecological status of beaches and human welfare, and are preferable for conservation and economic reasons. The application of hard/soft measures should be supported by appropriate knowledge, and followed by an environmental impact study and an assessment of effectiveness (Semeoshenkova and Newton, 2015).

5.5.9. Protection of unique cultural heritage

The protection of the unique Geological, Paleontological and Archaeological Provincial Reserve is critical. Raising public awareness about this important and unique site through education and dissemination of information can significantly contribute to the protection and conservation of this ancient heritage. Educational visits and guided tours, especially for the young, future citizens, should be actively promoted. Protection can be further boosted by regular patrolling and by restricting the access to the beach zones where the footprints, fossils and natural outcrops are located.

5.6. Governance (institutional) mapping, defining the responsibilities related to management actions for mitigating coastal erosion issue in Monte Hermoso and Pehuen Co

In Argentina, there are 3 levels of political jurisdictions responsible for legislation regulating actions and resources: national (government), provincial (ministries) and local (the municipalities). The national governance institutions related to erosion management and sustainable development are the Ministry of Federal Planning, Public Investment and Services responsible for land uses for building and uses of resources; the Ministry of Science, Technology and Innovation; the Ministry of Tourism, which is also responsible for the management of national parks. There is also a decentralized institution, the National Institute for the Tourism Promotion, which implement projects and plans for the sustainable and competitive development of the domestic tourism. Additionally, the Safety Ministry has some influence, since it has the responsibility in facing the consequences of strong storms, floods or other natural disasters. The Naval Prefecture of Argentina (PNA) depends on this Ministry and has the policy power to control coastal traffic in the localities under study.

At the provincial level, the Ministry of Infrastructure and under-secretary for Public Works and the Provincial Office for Hydraulics are in charge of analysing possible solutions for water and coastal erosion problems. The Provincial Office for Mining (depending on the Under-secretary of Industry, Trade and Mining and the Ministry of Production, Science and Technology) is in charge of monitoring the use of sand in coastal zones. Another important authority is the Provincial Organism for Sustainable Development (OPDS), responsible for environmental policy. It aims to guarantee the sustainable and correct management of the environment, the preservation of biodiversity and the implementation of sustainable development planning (London et al., 2012).

At the local level, there are the municipal governments of Monte Hermoso and Coronel de Marina Leonardo Rosales. The secretariat for Works and Services controls the management of natural resources, as long as it is involved in urbanization planning and the control of public services. The Chamber of Commerce and Industry of Monte Hermoso and the Chamber of Commerce and Tourism Development of Pehuen Co regulate the commerce, hotels and restaurants. Additionally, in both municipalities there is a secretariat or office of tourism, committed to promote, supervise and execute planning destined for developing sustainable tourism. Moreover, stakeholders are grouped in informal organisations as lifeguards, volunteer fire brigade, rangers, the Rotary Club of Pehuen Co, the Residents Association “Amigos de Pehuen Co”, amongst others (London et al., 2012).

A tiered (local-municipal-provincial-national) governance system may impede the execution of the prompt and proper decisions due to the lack of sufficient interactions between the different institutions. The complexity of the governance system leads to the overlapping of mandate areas and duties of different governmental levels and legal framework. Some institutional problems are derived from this, as revealed in the study. These include: (i) the

difficulty encountered by the stakeholders in order to observe correctly rights, obligations, and prohibitions, as well as the organization responsible for certain actions (control, sanctioning, managing); (ii) the increasing space to conduct lobbying activities or show opportunistic behaviours; and, (iii) the ease with which governmental organizations to disregard their obligations, as the control of sand extraction.

Unfortunately, the two resorts belong to different municipalities that may not share the same priorities and may not cooperate to resolve joint problems. Additionally, the conflicts between local and central government administrators can occur due to the differentiation of responsibilities for decision making. For instance, it was remarked by stakeholders in Pehuen Co that the authorities do not know the real problem of coastal erosion, because the decision-makers live far away from the area and don't conduct observations of the coast (London et al., 2012). Thus, there is a large lag-time between the identification of the problem by the actors experiencing it (local) and the decision by the responsible authorities (provincial, central). Such a drawback in the management process was also highlighted in some European studies. For example, in Spain the municipalities are the main 'victims' of erosion-induced problems, however, actions to solve or counteract these are designed and executed at different administrative levels, which complicates the problem resolution (Ariza et al., 2008a). Therefore, for the success and timeliness of the management decisions it is very important to build an efficient communication and coordination between local managers and central government. Good communication between the different managers and continuous improvement of the knowledge about local processes is pivotal. Additionally, the establishment of new informal institutions (e.g. NGOs) can be very useful for improving the delivery of the personal initiatives to the different levels of governance (Bowles and Gintis, 2002) and encouraging public involvement and participation rather than resistance.

6. Conclusions

The objectives of the study were fulfilled by the scientist-stakeholder cooperation. This resulted in an analysis of the coastal erosion issue, a better understanding of the interactions between drivers and pressures, as well as the consequent effect on the state of the environment and impacts on human welfare, and finally the identification of possible management responses and the responsible authorities.

- (i) the main economic drivers of the erosion induced problem in both study areas were identified as tourism, construction and urban development;
- (ii) the main pressures derived from the associated human activities (i.e. recreation on dunes, ATVs traffic, construction on dune) included trampling and damaging of dune system, compression and impermeabilization of soil, physical removal of sand and obstruction of sand transport;
- (iii) a significant change in the ecological and environmental status was detected in both study areas. This included damaged and eliminated dunes, significant plant cover reduction, biodiversity loss, significant loss of sediment and accelerated erosion, particularly in urbanised sectors;
- (iv) environmental and ecological changes impacted the socio-economical representation of both study areas and effected human welfare, which resulted in collapse of houses and tourist building near the coast, loss of beach surface for recreation, reduced safety of beaches. The potential impacts were identified and included a loss of unique cultural heritage, as well as loss of tourism appeal in both towns, with

associated loss of jobs and a potential collapse of the local economy;

- (v) the possible management responses were proposed and the responsible entities were identified. The responses include the regulation of the access to the beach, restriction of recreation on dunes, prohibition of vehicular traffic, regulation of urban sprawl and proper planning, public education and information, promotion of ecotourism, monitoring and sanctioning of illegal sand extraction, application of coastal protection measures and protection of unique cultural heritage.

The outcomes of this study can serve as a basis for building an appropriate governance and management response that would include a co-designed development plan. This approach can be used for the further research on existing socio-ecological problems in the study region and identification of the management priorities. Suggested management recommendations for mitigating the coastal erosion issue are widely applicable, however they should be adapted for local specifics.

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References

- Ariza, E., Sarda, R., Jimenez, J.A., Mora, J., Avila, C., 2008. Beyond performance assessment measurements for beach management: application to Spanish Mediterranean beaches. *Coast. Manag.* 36, 47–66.
- Ariza, E., Jimenez, J.A., Sarda, R., 2008a. A critical assessment of beach management on the Catalan coast. *Ocean Coast. Manag.* 51, 141–160.
- Bayon, C., Frontini, R., Vecchi, R., 2012. Middle Holocene settlements on coastal dunes, southwest Buenos Aires Province, Argentina. *Quat. Int.* 256, 54–61.
- Bird, E. (Ed.), 2010. *Encyclopedia of the World's Coastal Landforms*. Springer, Netherlands, ISBN 978-1-4020-8639-7, 1516 pp.
- Borja, A., Galparsoro, I., Solaun, O., Muxika, I., Tello, E.M., Uriarte, A., Valencia, V., 2006. The European Water Framework Directive and the DPSIR, a methodological approach to assess the risk of failing to achieve good ecological status. *Estuar. Coast. Shelf Sci.* 66, 84–96.
- Bowles, S., Gintis, H., 2002. Social capital and community governance. *Econ. J.* 112, F419–F436.
- Brown, A.C., McLachlan, A., 2002. Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. *Environ. Conserv.* 29, 62–77.
- Brown, S., Nicholls, R.J., Hanson, S., Brundrit, G., Dearing, J.A., Dickson, M.E., Gallop, S.L., Gao, S., Haigh, I.D., Hinkel, J., Jimenez, J.A., Klein, R.J.T., Kron, W., Lazar, A.N., Neves, C.F., Newton, A., Pattiaratchi, C., Payo, A., Pye, K., Sanchez-Arcilla, A., Siddall, M., Shareef, A., Tompkins, E.L., Vafeidis, A.T., van Maanen, B., Ward, P.J., Woodroffe, C.D., 2014. Shifting perspectives on coastal impacts and adaptation. *Nat. Clim. Change* 4, 752–755.
- Bustos, M.L., Contardi, E.T., Dos Santos, E.P., Garibotti, E.J., Genchi, S.A., Huamantincio Cisneros, M.A., Laura, D.E., 2009a. Análisis preliminar de usos y actividades en un sector de la reserva geológica, paleontológica, arqueológica y natural Pehuen Co - Monte Hermoso. In: Vaquero, M. Del C., Pascale, J.C. (Eds.), *El territorio, las actividades económicas y la problemática ambiental en el Sudoeste Bonaerense: Actas de las V Jornadas Interdisciplinarias del Sudoeste Bonaerense*. Universidad Nacional del Sur, Ediusn, Bahía Blanca, pp. 393–398.
- Bustos, M.L., Piccolo, M.C., Perillo, G.M.E., 2009b. Cambios en la geomorfología de la playa de Pehuen Co debido a la actividad de las olas el 26 de julio de 2007. In: Vaquero, M. Del C., Pascale, J.C. (Eds.), *El territorio, las actividades económicas y la problemática ambiental en el Sudoeste Bonaerense: Actas de las V Jornadas Interdisciplinarias del Sudoeste Bonaerense*. Universidad Nacional del Sur, Ediusn, Bahía Blanca, pp. 97–102.
- Bustos, M.L., Piccolo, M.C., Perillo, G.M.E., 2011. Efectos geomorfológicos de fuertes vientos sobre playas. El caso de la playa de Pehuen Co, Argentina. *Cuad. Investig. Geogr.* 37 (1), 121–142.
- Bustos, M.J., 2012. *Estudio Integrado Ambiental del Balneario de Pehuen Co (Tesis*

- de doctor en Geografía). Universidad Nacional del Sur, 242 pp.
- Caló, J., Fernández, E., Marcos, A., Aldacour, H., 1998. Analisis preliminar del balance sedimentario de la playa de Pehuen Co, provincia de Buenos Aires, Argentina. *GEOACTA* 23, 1–12.
- Caló, J., Fernández, E., Marcos, A., Aldacour, H., Varela, P., 2000. Comparacion del efecto de dos tormentas en la ciudad de Monte Hermoso, Argentina. *Geoacta* 25, 40–48.
- Caló, J., Fernández, E., Marcos, A., Aldacour, H., 2005. Observaciones litorales ambientales de olas, corrientes y vientos de la playa de Monte Hermoso entre 1996 y 1999. *Geoacta* 30, 27–38.
- Calvao, T., Pessoa, M.F., Lidon, F.C., 2013. Impact of human activities on coastal vegetation – a review. *Emir. J. Food Agric.* 25, 926–944.
- Campuzano, F.J., Mateus, M.D., Leitao, P.C., Leitao, P.C., Marin, V.H., Delgado, L.E., Tironi, A., Pierini, J.O., Sampaio, A.F.P., Almeida, P., Neves, R.J., 2013. Integrated coastal zone management in South America: a look at three contrasting systems. *Ocean Coast. Manag.* 72, 22–35.
- Carr, E.R., Wingard, P.M., Yorty, S.C., Thompson, M.C., Jensen, N.K., Roberson, J., 2007. Applying DPSIR to sustainable development. *Int. J. Sustain. Dev. World Ecol.* 14, 543–555.
- Celsi, C.E., Monserrat, A.L., 2008. Lists of species. Vascular plants, coastal dunes between Pehuen Co and Monte Hermoso, Buenos Aires, Argentina. *Check List* 4 (1), 37–46.
- Dadon, J.R., Matteucci, S.D. (Eds.), 2002. Zona costera de la Pampa argentina. Recursos naturales, sustentabilidad, turismo, gestión y derecho ambiental. Lugar Editorial, Buenos Aires, p. 224.
- Dahm, C., 2003. Beach user Values and Perception of Coastal Erosion. Final. Environment Waikato Technical Report. Regional Council, Hamilton. East. Document 752677, 76 pp.
- Dahm, J., Jenks, G., Bergin, D., 2005. Community-based Dune Management for the Mitigation of Coastal Hazards and Climate Change Effects: A Guide for Local Authorities, 36 pp. Available at: <http://www.boprc.govt.nz/media/32260/ClimateChange-0505-CoastalHazardsandClimateReport.pdf> (accessed on 30.04.15.).
- Davenport, J., Davenport, J.L., 2006. The impact of tourism and personal leisure transport on coastal environments: a review. *Estuar. Coast. Shelf Sci.* 67, 280–292.
- Dayton, P., Curran, S., Kitchingman, A., Wilson, M., Catenazzi, A., Restrepo, J., Birkeland, C., Blabers, S., Saifullah, S., Branch, G., Boersma, D., Nixon, S., Dugan, P., Davidson, N., Vorosmarty, C., 2005. Chapter 19. Coastal systems. In: Hassan, R., Scholes, R., Ash, N. (Eds.), *Ecosystems and Human Well-being: Current State and Trends, Millenium Ecosystem Assessment*, vol. 1. Island Press, Washington, ISBN 1559633867, 917pp.
- Delgado, A.L., Vitale, A.J., Perillo, G.M.E., Cintia Piccolo, M., 2012. Preliminary analysis of waves in the coastal zone of Monte Hermoso and Pehuen Co, Argentina. *J. Coast. Res.* 28, 843–852.
- Del Pozo, O.M., Brondolo, 2002. Unidades de paisaje como instrumentos de ordenamiento territorial. Sector costero Monte Hermoso (Pcia. De Buenos Aires). *Rev. Univ. Geogr.* 11, 91–120.
- Duvat, V., 2011. Interest of quality-based policies for integrated coastal zone management implementation: lessons learnt from a French case study. *Ocean Coast. Manag.* 54, 831–843.
- European Environmental Agency (EEA), 1999. Environmental Indicators: Typology and Overview. European Environment Agency, 19 pp.
- Fernandez, E., Marcos, A., Calo, J., Aldacour, H., 2006. Balance sedimentario, parámetros meteorológicos y oceanográficos en un sector de la playa de Monte Hermoso, Provincia de Buenos Aires. *Asoc. Argent. Geofis. Geod.* 31, 11–22.
- Fiori, S.M., Cazzanigo, N.J., Estebenet, A.L., 2004. Winter distribution, density and size of *Mesodesma mactroides* (Bivalvia, actracea) in Monte Hermoso beach (Argentina). *Braz. J. Oceanogr.* 52 (1), 1–9.
- Foster, S.S.D., Morris, B.L., Chilton, P.J., 1999. Groundwater in urban development – a review of linkages and concerns. In: *Impacts of Urban Growth on Surface Water and Groundwater Quality. Proceedings of IUGG99, Symposium HS5*, 259. IAHS Publications, Birmingham, pp. 3–12.
- Gari, S., Newton, A., Icelly, J.D., 2015. A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. *Ocean Coast. Manag.* 103, 63–77.
- Gelabert, 1977. In: Cambers, G. (Ed.), *Managing Beach Resources in the Smaller Caribbean Islands. Papers Presented at a UNESCO – University of Puerto Rico Workshop*, 21–25 October 1996, Mayagüez, Puerto Rico. Coastal region and small island papers, No. 1, UPRLSGCP-UNESCO, Mayagüez, 269 pp.
- Ghulam Rabbany, Md, Afrin, S., Rahman, A., Islam, F., Hoque, F., 2013. Environmental effects of tourism. *Am. J. Environ. Energy Power Res.* 1 (7), 117–130.
- Gossling, S., 2002. Global environmental consequences of tourism. *Glob. Environ. Change Hum. Policy Dimens.* 12, 283–302.
- Hall, C.M., 2001. Trends in ocean and coastal tourism: the end of the last frontier? *Ocean Coast. Manag.* 44, 601–618.
- Hansom, J.D., 2001. Coastal sensitivity to environmental change: a view from the beach. *Catena* 42, 291–305.
- Holden, A., 2008. *Environment and Tourism*, second ed. Routledge, London, New York, ISBN 0415399548. 274 pp.
- Hopkins, T.S., Bailly, D., Stottrup, J.G., 2011. A systems approach framework for coastal zones. *Ecol. Soc.* 16.
- Hopkins, T.S., Bailly, D., Elmgren, R., Glegg, G., Sandberg, A., Stottrup, J.G., 2012. A systems approach framework for the transition to sustainable development: potential value based on coastal experiments. *Ecol. Soc.* 17.
- Huamantincio Cisneros, M.A., Piccolo, M.C., 2011. Caracterización de la brisa de mar en el balneario de Monte Hermoso, Argentina. *Characterization of the sea breeze in Monte Hermoso, Argentina. Estud. Geogr.* 72 (271), 461–475.
- Huamantincio Cisneros, M.A., 2012. Efecto de la variabilidad climática del balneario Monte Hermoso sobre su geomorfología costera y el confort climático (Tesis de Doctorado) (inédita). Departamento de Geografía y Turismo, Universidad Nacional del Sur.
- Huamantincio Cisneros, M.A., Perillo, G.M.E., Piccolo, M.C., 2015. Modificaciones morfológicas y volumétricas en un sector de playa de Monte Hermoso por intervención antrópica. In: Celsi, C., Cenizo, M. (Eds.), *Primeras Jornadas Bonaerenses sobre Conservación de Ambientes y Patrimonio Costero. Libro de Resúmenes. Fundación de Historia Natural*, 1, 2 & 3 Octubre 2015. Monte Hermoso, Buenos Aires, 7 pp.
- James, R.J., 2000. From beaches to beach environments: linking the ecology, human-use and management of beaches in Australia. *Ocean Coast. Manag.* 43, 495–514.
- Kondolf, G.M., Podolak, K., 2014. Space and time scales in human-landscape systems. *Environ. Manag.* 53, 76–87.
- Laura Monserrat, A., Celsi, C.E., Fontana, S.L., 2012. Coastal dune vegetation of the southern Pampas (Buenos Aires, Argentina) and its value for conservation. *J. Coast. Res.* 28, 23–35.
- Li, Q., Ayers, P.D., Anderson, A.B., 2007. Prediction of impacts of wheeled vehicles on terrain. *J. Terramech.* 44, 205–215.
- Lemay, M., 1998. Coastal and Marine Resources Management in Latin America and the Caribbean. Technical Report. Inter-American Development Bank, 57 pp.
- London, S., Recalde, M., Rojas, M., Zilio, M., Perillo, G., Bustos, L., Piccolo, C., Rodriguez, C., Fidalgo, G., Pascale, J., Berninson, L., Cisneros, A., Vaquero, C., Bordino, P., 2012. Stakeholder Vision on Social-ecological-system Situation in Argentina Case Study. In: *Community-based Management of Environmental Challenges in Latin America*, 38 pp.
- London, S., Rojas, M., Bustos, M.L., Huamantincio Cisneros, M.A., Ibañez, M.M., Scordo, F., Perillo, G.M., Piccolo, C.M., Pascale, G.H., Fidalgo, G., Bordino, P., Berninson, L., Vaquero, M., Rodriguez, C., Zilio, M., Recalde, M., 2013. D4.2: “Stakeholder Vision on Problems and Drivers Related to Environmental Challenges in Argentina Case Study”. In: *Community-based Management of Environmental Challenges in Latin America*, 71 pp.
- Lozoya, J., Sarda, R., Jimenez, J.A., 2011. Beach multi-risk assessment in the Costa Brava (Spain). *J. Coast. Res.* 408–414.
- Marshall, F.E., Banks, K., Cook, G.S., 2014. Ecosystem indicators for Southeast Florida beaches. *Ecol. Indic.* 44, 81–91.
- McFadden, L., Priest, S., Green, C., 2010. *Introducing Institutional Mapping: A Guide for SPICOSA Scientists*. Spicosa Project Report. Middlesex University, London, Flood Hazard Research Centre.
- McLachlan, A., McGwynne, L., 1986. Do sandy beaches accumulate nitrogen. *Mar. Ecol. Prog. Ser.* 34, 191–195.
- Micallef, A., Williams, A.T., 2002. Theoretical strategy considerations for beach management. *Ocean Coast. Manag.* 45, 261–275.
- Newton, A., 2012. A systems approach for sustainable development in coastal zones. *Ecol. Soc.* 17, 2.
- Newton, A., Weichselgartner, J., 2014. Hotspots of coastal vulnerability: a DPSIR analysis to find societal pathways and responses. *Estuar. Coast. Shelf Sci.* 140, 123–133.
- Ostrom, E., 2010. Beyond markets and states: polycentric governance of complex economic systems. *Am. Econ. Rev.* 100, 1–33.
- Perillo, G.M.E., Piccolo, M.C., Bustos, M.L., Huamantincio Cisneros, M.A., London, S., Scordo, F., Rojas, M., 2014. Evolución de los ambientes costeros de la Provincia de Buenos Aires (Argentina): ¿Cambio climático o efectos antrópicos? Número Especial: Cambio climático y sistema socioecológico. *Rev. Digit. REDESMA* 7, 37–48.
- Phillips, M.R., Jones, A.L., 2006. Erosion and tourism infrastructure in the coastal zone: problems, consequences and management. *Tour. Manag.* 27, 517–524.
- Priskin, J., 2003. Physical impacts of four-wheel drive related tourism and recreation in a semi-arid, natural coastal environment. *Ocean Coast. Manag.* 46, 127–155.
- Rojas, M.L., Recalde, M.Y., London, S., Perillo, G.M.E., Zilio, M.I., Cintia Piccolo, M., 2014. Behind the increasing erosion problem: the role of local institutions and social capital on coastal management in Argentina. *Ocean Coast. Manag.* 93, 76–87.
- Rojas, M., Zilio, M., London, S., Bustos, M.L., Huamantincio Cisneros, M.A., Scordo, F., Ferrelli, F., Perillo, G., Piccolo, M.C., Vitale, V., Bordino, P., Berninson, L., Pascale, J.C., 2014a. D4.3: “Stakeholder Visions and Perspectives on the Future from the Argentina Case Study”. In: *Community-based Management of Environmental Challenges in Latin America*, p. 44.
- Schlacher, T.A., Morrison, J.M., 2008. Beach disturbance caused by off-road vehicles (ORVs) on sandy shores: relationship with traffic volumes and a new method to quantify impacts using image-based data acquisition and analysis. *Mar. Pollut. Bull.* 56, 1646–1649.
- Schlacher, T.A., Schoeman, D.S., Dugan, J., Lastra, M., Jones, A., Scapini, F., McLachlan, A., 2008. Sandy beach ecosystems: key features, sampling issues, management challenges and climate change impacts. *Mar. Ecol. Evol. Perspect.* 29, 70–90.
- Sekovski, I., Newton, A., Dennison, W.C., 2012. Megacities in the coastal zone: using a driver-pressure-state-impact-response framework to address complex environmental problems (vol. 96, pg 48, 2012). *Estuar. Coast. Shelf Sci.* 104, 123.
- Semeoshenkova, V., Newton, A., 2015. Overview of beach erosion and quality issues in three Southern European countries: Portugal, Spain and Italy. *Ocean Coast.*

- Manag. 12–21. <http://dx.doi.org/10.1016/j.ocecoaman.2015.08.013>.
- Soane, B.D., Vanouwerkerk, C., 1995. Implications of soil compaction in crop production for tor quality of the environment. *Soil Tillage Res.* 35, 5–22.
- Tett, P., Mongrue, R., Levrel, H., Hopkins, T., Sandberg, A., Hadley, D., Fernandes, T., Hendrick, V., Mette, A., Vermaat, J., Gilbert, A., d'Hernoncourt, J., McFadden, L., Priest, S., Green, C., d'Alcona, M.R., 2011. Guide to System Design, v.3.09. SPI-COSA Project Report. Scottish Association for Marine Science, Oban, 41 pp.
- Universidad Nacional Del Sur (UNS), 2008. Encuestas Monte Hermoso. In: Analisis de demanda Monte Hermoso. Temporada 2008, 127 pp.
- VanderMeulen, F., Salman, A., 1996. Management of mediterranean coastal dunes. *Ocean Coast. Manag.* 30, 177–195.
- Vaquero, M. del C., Pascale, J.C., 2003. La definición del perfil turístico a través de la aplicación de un modelo de planificación participativa Plan de Desarrollo Turístico del Partido de Monte Hermoso", en *II Jornadas Interdisciplinarias del Suroeste Bonaerense*. Universidad Nacional del Sur, Bahía Blanca, pp. 613–623.
- Vaquero, M. del C., Rodríguez, C., Trellini, M., 2007. El turismo residenciado en Monte Hermoso, en *Ambiente natural, campo y ciudad, estrategias de uso y conservación en el sudoeste bonaerense: Actas de las IV Jornadas interdisciplinarias del sudoeste bonaerense*. Universidad Nacional del Sur, pp. 201–206.
- Webb, R.H., Wilshire, H.G. (Eds.), 1983. *Environmental Effects of Off-road Vehicles: Impacts and Management in Arid Regions*. Springer Verlag, N.Y., 534 pp.
- Williams, B.K., Brown, E.D., 2012. *Adaptive Management: the U.S. Department of the Interior Applications Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC, 595 pp.
- World Travel and Tourism Council (WTTTC), 2014. *Travel&Tourism Economic Impact 2014 World*, 20pp.

Web References

- Censo, 2010. Instituto Nacional de Estadística y Censos (Indec). Censo Nacional de Población, Hogares y Viviendas 2010. Available on. http://www.censo2010.indec.gov.ar/index_cuadros.asp (accessed on 13.04.15.).
- Central Intelligence Agency (CIA), 2014. The World Fact Book. Coastline. Available on. <https://www.cia.gov/library/publications/the-world-factbook/fields/2060.html> (accessed on 09.10.14.).
- Monte Hermoso, 2016. Monte Hermoso. Eventos Programados. Available on. <http://montehermoso.gov.ar/turismomh/eventos-programados/> (accessed on 12.02.16.).
- Nuestro Mar, 2015. Web de la Fundación Nuestramar, Noticias. La erosión costera continúa comprometiendo a las playas. Available on. http://www.nuestramar.org/noticias/ecologia_y_medioambiente082006_la_erosion_costera_continua_comprometiendo_a_las_playas (accessed on 18.12.15.).
- The International Ecotourism Society (TIES), 2015. What is Ecotourism? Available on. <https://www.ecotourism.org/what-is-ecotourism> (accessed on 16.02.16.).
- UNESCO, 2014. Middle Holocene Settlements on Coastal Dunes, Southwest Buenos Aires Province, Argentina. Available on. <http://whc.unesco.org/en/tentativelists/5851> (accessed on 16.02.16.).