

# BEACH USERS' PERCEPTIONS OF COASTAL REGENERATION PROJECTS AS AN ADAPTATION STRATEGY IN THE WESTERN MEDITERRANEAN

KEYWORDS: Beach users, Coastal management, Climate change adaptation, Dune regeneration

## ABSTRACT

Some coastal environments facing climate change risks are starting to be managed with nature-based solutions (NBS). Strategies based on the rehabilitation of green infrastructures in coastal municipalities, such as renaturalization of seafronts, are considered adaptive to the effects of climate change but may cause misconceptions that could lead to social conflicts between the tourist sector and the society. A survey was carried out to study user perceptions on the effects of climate change, preferences for adaptation strategies, and the assessment of projects of dune reconstruction. We find that while beach users recognize the benefits of NBS for environmental conservation and storm protection, they show little concern about possible effects of climate change on recreational activity and have limited understanding about the protective capacity of NBS. Thus, a greater effort must be made to better explain the impacts of climate change and the potential benefits of NBS in coastal risk management.

## 1 INTRODUCTION

The emerging concept of nature-based solutions (NBS) has a strong impact as a new paradigm in natural resource management. The application possibilities for NBS are highly diverse and have gained relevance in many disciplines, such as urban and landscape management, agronomy and forestry, and water management (Keesstra et al., 2018; Laforteza, Chen, van den Bosch & Randrup, 2018; Zölch, Henze, Keilholz & Pauleit, 2017). Furthermore, NBS provide new approaches for tackling highly relevant global challenges at social, economic, and

environmental levels, including that of climate change mitigation and adaptation (Cohen-Shacham, Walters, Janzen & Maginnis, 2016; Kabisch et al., 2016; Kabisch, Korn, Stadler & Bonn, 2017b). NBS have proven promising not only in environmental management of water treatment and carbon sequestration (Liquete, Udias, Conte, Grizzetti & Masi, 2016; Shao et al., 2017; Wild, Henneberry & Gill, 2017) but also for improving public health in urban environments (van den Bosch & Ode Sang, 2017). Ongoing research evaluates benefits for mental and physical health and well-being (Kabisch, van den Bosch & Laforteza, 2017a; van den Bosch & Ode Sang, 2017), due to temperature regulation and reduction of stress and allergen levels (Cariñanos et al., 2017; Panno, Carrus, Laforteza, Mariani & Sanesi, 2017; Vujcic et al., 2017). NBS have wide-ranging applications in agronomy, where organic materials and revegetation approaches have been successfully used to tackle challenges of soil degradation and erosion, which improve management practices in both organic and conventional farming (Keestra et al., 2019; Kirchhoff, Rodrigo-Comino, Seeger & Ries, 2017). To manage coastlines in the wake of global change, NBS have been increasingly proposed as more-sustainable, cost-effective, and ecological alternatives to conventional coastal engineering for use in reducing flood risks (Narayan et al. 2017; Saleh & Weinstein, 2016), impeding coastal erosion (Nguyen, 2018), and dealing with rising sea levels (Davis, Krüger & Hinzmann, 2015; Temmerman et al., 2013).

In European politics, NBS have also received more attention, as the EU recently developed a Research & Innovation (R&I) agenda on NBS to include renaturing cities and territorial resilience (European Union [EU], 2015). The agenda builds on a wealth of knowledge from previous EU Framework Programmes and policy initiatives to include blue-green infrastructures, biodiversity and ecosystems, sustainable urban development, natural resource management, climate change mitigation and adaptation, and disaster risk reduction.

A recent example is given by the European Horizon 2020 OPERANDUM project<sup>1</sup> (OPEN-air laboratories for Nature-based solutions to Manage environmental risks). This project aims to develop and validate NBS to mitigate the impact of hydro-meteorological phenomena in risk-prone areas, with a focus on stakeholder engagement and acceptability). In this context, NBS are defined as solutions "inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience" (Favre, Fritz, Freitas, de Boissezon & Vandewoestijne, 2017). Ongoing research shows that nature-based flood protection can be more cost effective, use less raw materials, increase system adaptability, create recreational space, improve water quality, increase carbon sequestration, and improve productivity of fisheries (Temmerman et al., 2013; van der Nat, Vellinga, Leemans & van Slobbe, 2016). As NBS address a variety of societal challenges in sustainable ways, they are expected not only to contribute to green growth and citizen well-being, but also to provide business opportunities (EU, 2015).

In the Mediterranean context, beach tourism is a key economic driver for coastal regions yet has produced severe degradation of natural resources, mainly due to overcrowding, increased urbanization patterns, and coastal management focused on recreational use. NBS for coastal management may now provide a promising opportunity to align touristic activities with sustainable adaptation to global changes. However, there is a general perception among stakeholders and decision-makers that, while NBS are often quite affordable and have positive additional consequences for ecosystem services, they are not as effective as conventional grey infrastructure at reducing the impact of hazards (EU, 2015).

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<sup>1</sup> <https://site.unibo.it/operandum/en>

In coastal management, possible NBS strategies include vegetating foreshores, reconstructing coastal wetlands, marshlands, and dune systems, and applying innovative measures of beach and shoreline nourishment (Borsje et al., 2017; Hanley et al., 2014; Saleh & Weinstein, 2016; Vuik, Jonkman, Borsje & Suzuki, 2016). Although research on the effectiveness of most nature-based coastal protection methods is still limited as compared to research on the effectiveness of conventional hard-engineering methods (Morris, Konlechner, Ghisalberti & Swearer, 2018), it has been shown that vegetated foreshores can significantly dissipate wave energy during severe storm events (Vuik et al., 2016), and that dune systems and sand banks will be essential for future coastal defence (Hanley et al., 2014). A physical and economic analysis at regional and local scales in Northeastern USA also demonstrated that coastal wetlands play an important role in reducing risk and property damages from flooding (Narayan et al. 2017). In a case study for the Gulf of Mexico, nature-based adaptation measures were among the most cost-effective options for flood protection, with a favourable cost-benefit ratio (Reguero, Beck, Bresch, Calil & Meliane, 2018). Studies from the UK, Belgium, and France have shown similar results, comparing efforts for tidal marsh restoration with maintaining dykes and other hard-engineering structures over the long term (Temmerman et al., 2013). In addition, ecosystems provide cultural services that have non-material benefits, which are nonetheless essential for coastal tourism. However, these have often been underappreciated and are neither well quantified nor well integrated into economic assessments (de Groot et al., 2012). Finally, time has shown that hard-engineering solutions: *i*) often lead to new coastal instabilities, such as disruption in sediment supply and relocation of vulnerability problems to other parts of the coast; and *ii*) impede natural dynamics for self-regulation of coastal ecosystems (Dugan, Hubbard, Rodil, Revell & Schroeter, 2008; Esteves, 2013).

Since the beginning of the 2000s, the Intergovernmental Panel for Climate Change has also started to recognise that numerous open strategies need to be developed and implemented (Intergovernmental Panel for Climate Change [IPCC], 2001). This would move beyond the traditional “hard” paradigm of coast control or coastal protection to allow for more dynamic and socio-ecologically resilient alternatives, such as coastal accommodation and retreats based on natural protection against sea storms and rising sea levels. The fifth IPCC report and studies on needs for adaptation highlight the social, environmental, and economic benefits of no-regret strategies in climate change adaptation, which permit a low-cost reduction of risks under various climate change scenarios (Heltenberg, Siegel & Jorgensen, 2009; IPCC, 2014; Woodruff, Meerow, Stults & Wilkins, 2018;). Working with NBS as flexible and self-adjusting options is considered a key element of a no-regret strategy for coastal defence and adaptation (van Wesenbeeck et al., 2014),

Some countries, such as the Netherlands, have historically incorporated natural protection measures (e.g., dune systems) as an essential part of coastal protection (van Koningsveld & Mulder, 2004). However, the traditional coastal defence strategy in Spain was to create seawalls and other rigid structures (Roca & Villares, 2012). In 2015, NBS appeared for the first time in legally-binding Spanish coastal management policies. As an outcome of the Spanish strategy for coastal adaptation to climate change (EACCC, Estrategia de Adaptación de la Costa al Cambio Climático), the Spanish Climate Change Office (OECC) presented the “Plan de Impulso al Medio Ambiente para la Adaptación al Cambio Climático en España” (PIMA ADAPTA; Plan to Promote the Environment for Adaptation to Climate Change in Spain), which contains specific projects in different coastal areas of Spain that aim to prepare the coast for the potentially adverse impacts of climate change. Among other measures, the plan includes various NBS, such as reinforcement and restoration of dune systems.

Taking into account the high impact of tourism and the high population density along the Spanish coastline, a strategy that only considers the surface of beaches will not be successful over the long-term for tackling coastal protection and adaptation. Recent approaches addressing the concept of NBS also include a systemic focus that analyses the relationship between social systems and ecosystems, in which stakeholder participation plays a key role in the implementation of NBS. The adoption of a truly systemic perspective for NBS concepts is still extremely difficult (Nesshöver et al., 2017) point out the need for further research on NBS to the four main categories of ecosystem services (provision, regulating, supporting, and cultural) across different scales (Laforteza et al., 2018). Although there are some proposals for ecosystem-based coastal management and adaptation (Elliff & Kikuchi, 2015; Sheaves et al., 2016), very few approaches strengthen the alignment of adapting to climate change with beach tourism. In coastal areas, tourism accounts for large amount of the socio-economic demands; in turn, socio-economic demands and conditions have been found to influence the implementation of NBS, both positively and negatively (Hălbac-Cotoară-Zamfir, Keesstra & Kalantari, 2019). Therefore, the possibilities to create co-benefits between NBS and beach tourism is of interest, in order to assess the potential of coastal adaptation by means of NBS.

Raymond et al. proposed a framework for measuring co-benefits of NBS that are divided into the following stages: 1) identify the problem or opportunity; 2) select and assess NBS and related actions; 3) design NBS implementation processes; 4) implement NBS; 5) frequently engage stakeholders and communicate co-benefits; 6) transfer and upscale NBS; and 7) monitor and evaluate co-benefits across all stages (Raymond et al., 2017). This framework is similar to the general framework for climate change adaptation (IPCC, 2014) or to the framework used for understanding adaptation barriers that may arise during the three stages, which comprise an infinite loop of continuous learning and improvement. The first phase

addresses problem understanding and information gathering as a base for the planning phase, during which different measures are appraised and selected in order to be then implemented and monitored during the last stage (Moser & Ekstrom, 2010). For the assessment and identification of sustainable solutions, it is also indispensable to understand barriers and opportunities for NBS, the institutional and social embedment of management practices, and social factors that may drive the implementation of NBS (Kalantari, Ferreira, Keesstra & Destouni, 2018). Further, to facilitate nature-based interventions from a systemic point of view, it is necessary to ensure the involvement of multiple stakeholders as well as the general public. Social involvement is crucial to consolidating links between humans and natural resources as well as for improving knowledge about the impact and sustainability of NBS. An analysis of social perceptions concerning risk an NBS in touristic coastal environments would be expected to provide critical information about the human dimension of coastal adaptation, which could be highly relevant for decision-makers and coastal managers. Notably, holistic risk management strategies require a profound understanding of risk perception and response behaviours, a willingness to relocate, and effective access to information (Jongman, 2018)

The goal of this work is to analyse social perception about NBS in coastal defence and adaptation strategies, in order to find ways to align beach tourism with coastal management in face of climate change and touristic pressure, by means of identified benefits and drawbacks produced by NBS projects. This study is embedded in a framework for adaptation evaluation that includes an assessment of problem framing and theoretical opportunities.

This analysis focuses on beach users in order to explore their concerns, if any, about eroding beaches at locations where NBS strategies are being implemented. The survey was taken at three tourist resorts along the Catalan coast where dune systems are undergoing regeneration to improve beach conditions and to adapt to challenges posed by climate change.

Understanding the public concern about the effects that climate change have on beach-related aspects as well as on leisure activities is a critical first step, as risk assessment is fundamental for recognizing the need to act as well as for accepting interventions of coastal defence and adaptation. Further, this study explores public attitudes towards different adaptation strategies—both hard-engineering and NBS—as well as the factors that are important for beach users when adaptation measures are selected and implemented. This permits the coastal defence strategies that are usually applied in this area to be compared with innovative NBS, from a tourist's perspective. These case studies allow an assessment of impact and changes caused by regeneration of coastal ecosystems and their natural protection capacity, in areas where touristic use and environmental conservation come into conflict.

## 2 CASE STUDY DESCRIPTION AND MANAGEMENT STRATEGIES

This work analyzed three case studies in which projects of dune regeneration and renaturation were carried out on the western Mediterranean coast. The overarching aim is to rehabilitate nature in spaces next to beaches that are semi-urbanized, unused, or used as parking lots, to recover ecosystem functions and services. The interventions are part of projects financed through public funds. The three case studies analyzed allowed us to evaluate the local perceptions of the projects, each of which had an educational element meant to facilitate the understanding and acceptance of the solutions, which aimed to improve the ecosystem of coasts with well-established tourism. Specifically, the regions analyzed are some of the main tourist areas of the Northwestern Mediterranean (Fig. 1). The tourist attractions of Catalonia are divided into three major areas: Barcelona, as a model of urban attraction, is the main destination, with almost 40% of the overnight stays; the Costa Dorada, which comprises the main destinations for sun and beach, with 21%; and the Costa Brava, with 18%. This market

had 20.5 million tourists in 2017; in addition, local visitors, and especially those from Barcelona and its metropolitan area, also take advantage of the attractiveness of these coasts, either staying at a second residence at the coast or simply spending a day at the beach.

Fig. 1: Overview of the case studies localized in the western Mediterranean coast, with images of the interventions.

The first project, in the Costa Dorada, consists of the dune regeneration of Les Madrigueres in El Vendrell, south of Barcelona. The project is financed within the framework of a Spanish state plan for environmental adequacy and transit easement, with additional funding from a local environmental group. The other two projects are being carried out in the Costa Brava, in the northern Catalan coast: one in the municipality of Sant Pere Pescador, as part of PIMA-ADAPTA; and the other, in La Pletera, l'Estartit of Torroella de Montgrí, as a European LIFE project.

The intervention zones are characterized by different levels of urbanization and population densities, as well as by different recreational activities close to the beaches. All three beaches are tourist locations near protected natural environments or along conservation routes. Las Madrigueres beach is part of the municipality of El Vendrell, with 36,568 inhabitants and well-developed urban and tourist infrastructures. In contrast, the beaches of the Costa Brava are in more rural environments and close to natural parks, where agriculture plays an important role and the population density is only significant in the tourist seasons. The Can Comes beach in Sant Pere Pescador is adjacent to the Gulf of Roses and the Parc Natural dels Aiguamolls, and La Pletera is in a natural area included in the Natura 2000 Network that is part of Parc Natural del Montgrí, Illes Medes, and Baix Ter.

In the beaches of the three case studies, increased erosion and a retreating coastline are the most urgent problems for responsible beach management. The erosion problem is more concerning in the Les Madrigueres beach and La Platera, while the Can Comes beach has higher sand reservoirs. Low levels of sand in and around the Les Madrigueres beach in El Vendrell can be traced back to the urbanization up to the first coastal line, and in La Pletera beach, to the presence of a harbour that inhibits natural sand exchange. In Les Madrigueres beach and in La Pletera beach, beach nourishment is already ongoing, in order to compensate losses. Climate change is expected to aggravate coastal retreat and erosion in the study areas (Jiménez, Valdemoro, Bosom, Sánchez-Arcilla & Nicholls, 2017), while a rising sea level is a major risk, especially for the area of Sant Pere Pescador (Can Comes beach), as this is an extremely low lying area. As the coastal area of Catalonia has already suffered from sea water intrusion due to an overconsumption of fresh water, which lowered the groundwater table during dry periods, climate change with potentially more intense dry periods and a higher sea level may increase the frequency of these events along the Catalan coastal areas.

#### 4 METHODS

In the beach user survey, we assess beach users' perceptions regarding the climate change impacts on recreational activities and values, for the first adaptation stage of framing the problem. Having a high level of social awareness is the key for the public to recognize the need to act, adapt, and accept proposed adaptation measures, and a lack of awareness may present a huge barrier to adaptation. Therefore, in the first section, we examine the perception of climate change impacts. To introduce the general public contribution into the adaptation planning stage, we then assess the general attitude of beach users towards different measures in the section on the perception of different strategies. To identify potential for conflict that may represent a barrier during the planning stage, we added a question on factors to consider

for selecting strategies. As the surveys were undertaken at three beaches that are adjacent to dune restoration projects, we were able to directly evaluate the benefits and drawbacks the NBS measures perceived by beach users.

The questionnaire consisted of a series of questions that are closed-ended, which allows them to be treated statistically. In this work, we analyze two questions that were asked at all three beaches, and two questions that were asked at only one of the three beaches. At the Can Comes and La Pletera beaches, surveys were distributed that focused on the threats of climate change and the respondents' opinions about the dune restoration project. At the Les Madrigueres beach, the survey contained the same questions as well as additional ones to evaluate possible measures for adaptation and coastal protection.

#### I) Perception of climate change impacts

Users of all three beaches were asked about their level of concern about the effects that climate change would have on: the recreational activities at the beach; safety while swimming; aesthetic effects on landscape; the ecosystem integrity of dunes and protected areas; the width of the beach; severity and frequency of flooding; and availability of drinking water in coastal areas. The level of concern was measured according to a Likert-type scale (1, not at all worried; 2, not very worried; 3, fairly worried; and 4, very worried); the option "do not know" was also given.

#### II) Perception of different adaptation strategies

For the case study of Les Madrigueres, the levels of acceptance of general measures for preventing and compensating sand loss, such as *i)* sand replenishment, *ii)* dune restoration, *iii)* building rigid infrastructures, *iv)* managed realignment, or *v)* doing nothing, were evaluated. Survey participants could assign one option (4, very adequate; 3, adequate; 2, not

very adequate; or 1, inadequate) to each of the measures mentioned above. In the context of adaptation assessment, this question is relevant in order to assess social acceptability of various possible options and to combine the surveyed opinions with environmental effectiveness and economic feasibility before implementation. The perception of tourists, in the given Mediterranean context, is also relevant from an economic point of view, as compatibility of adaptation options with tourism is desirable for maintaining these changes in this sector.

### III) Factors to consider for selecting strategies

Questions in the evaluation were concretised by focusing on different criteria that may be important in the selection adaptation measures. To assess the relative importance of factors necessary for selecting measures, the factors were assigned an order of importance on their: *i) effects on the aesthetic value of landscape, ii) overall effectiveness, iii) environmental protection, iv) economic cost, and v) durability.*

### IV) Assessment of the impacts of NBS

Solutions based on dune reconstruction were implemented in the three case studies, allowing the options and effects of the produced changes to be monitored from a social point of view. An evaluation was carried out at all beaches about the effects that the project had on different aspects related to access, environmental conservation, and the protective function, using a Likert-type scale (1–5: much worse [1], worse [2], no change [3], better [4], much better [5]); the option “do not know” was also given.

The data were analyzed using a descriptive analysis of the four questions. As no assumptions were made about the data having a normally distribution, non-parametric tests were applied to find differences between the three case studies. Specifically, the Kruskal-Wallis test was

applied to the questions common to all case studies, in order to evaluate differences between the beach survey participants; the Wilcoxon signed-rank test was used to compare distributions of response options for different questions; and the Kendall rank correlation coefficient was used to find associations between different questions and different items of a question.

The perception surveys were carried out on the beaches adjacent to the interventions during July (the high seasons for beach users) of 2016 (at the Can Comes and Pletera beaches) and July of 2017 (at the Les Madrigueres beach), during the initial phases of the projects, with beach users who were willing to participate. In total, 230 people were surveyed, with more than 70 users for each beach. The questionnaires were available in English, French, Catalan, and Spanish; at the Les Madrigueres beach, which has mainly domestic tourism, the majority of the surveys taken were in Catalan or Spanish. Beach users were asked randomly to participate in the survey while sunbathing during days of one weekend (Friday, Saturday, and Sunday).

## 5 RESULTS AND DISCUSSION

The vast majority of beach users who responded to the questionnaire were middle-aged (with 73% aged 31 to 65, 21%, 16 to 30, and 6%, older than 65 years). Most were from Catalonia (80%), among these about a quarter (22% of total participants) came from Barcelona city and 16% from adjacent municipalities. Only a minimal percentage of beach users were from the rest of Spain (8%) or from abroad (11%). This distribution of place of origin was very similar in all three cases, with the exceptions that Les Madrigueres beach had a relatively large percentage of local users, while Sant Pere Pescador had a larger percentage of foreigners. Both the Sant Pere Pescador and La Pletera beaches are located in a rural environment, and the vast majority of beach users arrived to these beach by private vehicle. At El Vendrell, which

has a more urban setting, about half of the users arrived by private vehicle, and the other half, on foot. In general, very few people used a bicycle or public transport to get to the beach.

The reasons people gave for choosing a beach were diverse; in all three cases, the tranquillity and atmosphere of the beach were important considerations, and for many people, the proximity to their residence was a reason. At El Vendrell, only few people mentioned physical characteristics or the environment as an incentive to come to the beach. On the other hand, for both the Sant Pere Pescador and La Pletera beaches, the environment and physical characteristics played very important roles in the decision of which beach to go to. Additionally, many people indicated that the opportunity for sports activities was a main reason to come. In the evaluation of their physical characteristics and facilities, all beaches were rated positively, although the landscapes of La Pletera and Sant Pere Pescador were highlighted as especially positive.

#### Perception about climate change impacts

Understanding people's perceptions about the risks caused by climate change is key to communicating its possible consequences in an effective manner, as well as for explaining the need for intervention. Investigating the perceived impact of different risks, activities, and elements of the landscape allows us to better understand the extent to which beach users are prepared for future changes, and how they will receive certain protection measures.

In the three case studies, beach users were asked to indicate their level of concern regarding the effects that climate changes could have on recreational activities, swimming safety, beach width, dunes and protected areas, the landscape, flooding risks, and the availability of drinking water.

Here, we worked with the null-hypothesis ( $H_{10}$ ) that perception of the impacts of climate change and the anticipated effects do not depend on the case study, respectively on the beach where they were undertaken. The alternative hypothesis ( $H_{1a}$ ) was that the effects of climate change are perceived differently by beach users in different case studies. Seeing that the p-values are all above the significance level  $\alpha$  of 0.05, we maintain  $H_{10}$  and the assumption that the results are independent from the case studies; in this case, the results represent a general impression of beach users regarding the impact of climate change. Therefore, the descriptive analysis in Fig. 2 summarizes the opinions of all the perceptions collected in the three surveys.

In the following section, we also analyse differences between items of the question, by means of a Wilcoxon signed-rank test at a significance level  $\alpha$  of 0.05, to evaluate the statistical significance of the differences resulting from the descriptive analysis. The null-hypothesis ( $H_{10}$ ) was always that differences between rankings of two items follows a symmetric distribution around zero, thus that there is no systematic difference between the two items. The alternative ( $H_{1a}$ ) was that the concern about the first aspect ( $A_1$ ) is lower than the concern about the other ( $A_2$ ).

The results shown in Fig. 2 suggest that the level of user concern about the possible effects of climate change on their recreational activity ( $A_1$ ) was low as compared to their concern for effects on the availability of drinking water ( $A_2$ ) or on the aesthetic value of landscape. The Wilcoxon signed-rank test confirms this hypothesis, as the p-values recommend working with  $H_{1a}$  (p-value < 0.001 for comparison with landscape and availability of drinking water). Further, the effects of climate change on aspects directly related to touristic activities on the beach, such as recreational activities, swimming safety, and the width of the beach, were of less concern than the effects on water availability (comparison between effects on width of the beach ( $A_1$ ) and on availability of drinking water ( $A_2$ ): p-value < 0.001). Changes of water

availability is one of the most publicized and well-known aspects of climate change, and it corresponds with the largest group of concerned users: half (50.4%) of respondents stated they were “very worried”. Overall, there was a low level of concern about the effects of climate change on recreational activities: this had the largest group (32.2%) who indicated that they were “not very worried”; further, only 18.2% stated they were “very worried” about “swimming safety” or “width of the beach”. Notably, the high level of sensitivity of beach users towards the availability of drinking water reflects the historical experience of water scarcity and recurrent droughts in this Mediterranean context. The severe episodes of drought have had a significant presence in the media, which has a decisive influence on public opinion (Uzzell, 2000). Thus, media reports amplify or reduce the perception of risk; for the example of water availability, having high media coverage over the last two decades is decisive for public opinion. Furthermore, in tourist environments such as those studied, the high season coincides with the dry season, resulting in aquifers that are overexploited and carry the risk of saltwater intrusion; this consequently produces problems in the drinking water supply, which both citizens and tourists experience directly. Although marine storms carry risks, for instance for swimming safety, they take place mainly during the low tourist season; therefore, these risks are not perceived as direct threats to recreational activities practiced during the peak season.

Fig. 2: Overall levels of concern about the effects of climate change on different aspects, expressed by all users of the three beaches.

The high level of concern for the aesthetic value of landscape, which reaches a similar level of concern as for water (an essential element of life), with a test result suggesting that  $H_{10}$  should be maintained ( $p$ -value = 0.290), shows how important this aspect is for the beach user. Indeed, this has been observed previously, with landscape being highly linked to the

assessment of beach quality and far more important for beach selection than aspects such as access, facilities, or user density, irrespective if the beaches are urban or more natural (Nelson & Botterill, 2002; Roca & Villares, 2008).

For all of the aspects considered in the survey, there was a relatively high incidence of the “fairly worried” responses that did not vary greatly between users of the different beaches. This result is similar to the results of surveys of the European Perception of Climate Change (Steentjes et al., 2017). The frequency of “fairly worried” responses suggests that people tend to select politically correct options. This phenomenon could also explain the high level of concern for environmental aspects, such as dune systems, protected areas, and the landscape, and further suggests that climate change is perceived mainly as an environmental risk.

Among the relevant risks and impacts of climate change are the more frequent phenomena of coastal floods and erosion, mainly caused by an increase in sea levels combined with greater recurrence and intensity of marine storms (IPCC, 2014). In this context, the low level of concern for the loss of beach width or for flooding suggests that the risks of climate change are perceived as vague and distant in space and time; this has already been seen in other works (Klinke & Renn, 2002; Slovic, 2000).

Perceptions are influenced by the nature of environmental processes themselves and depend on personal proximity, temporal and spatial scales, and degrees of uncertainty, among other factors (Slovic, 2000). In this case, the characteristics of climate change, together with having recreational experiences that are closely associated with moments of meteorological tranquillity, are not helpful for allowing the severity of the phenomenon to be perceived.

To calculate the effects of climate change on the sun-and-beach tourism sector, it is important to understand the reactions or changes in user behaviour when faced with the effects of

climate change. Therefore, in one of the case studies (that of the Les Madrigueres beach), beach users were asked what they would do in the case of a reduced beach area. The results showed that 42.5% of users would accept a reduced space and would continue to visit the same beach, while 25% of users would change the beach, 27.4% would no longer come during the high season, and 5% would completely stop going to the beach. Although this result only reflects the attitude of beach users from one case study, it suggests that climate change will have an effect on the recreational use of beaches. However, it also points out that there are users with a strong link to a specific beach, who would be more willing to accept an increase in user density than to change their habits. It should be kept in mind that climate change will affect different places distinctly, probably leading to a redistribution of tourism. This study had a stronger focus on domestic tourism, as many beach users have a second residence at, or personal ties to, the places investigated, which could encourage their tendency to accept a reduced space. However, as we have already shown previously, perception of beaches, and recreational experiences at beaches, are also linked to the frequency and density of users (Roca, Riera, Villares, Fragell & Junyent, 2008); in any case, at semi-urban beaches like these, values of 12–15 users/m<sup>2</sup> would already have a negative impact on tourism and could not be exceeded.

#### Perception of coastal protection strategies

When planning coastal protection measures for tourist areas, understanding the general perceptions of beach users can be very relevant for decision-making stakeholders, especially for anticipating or managing conflicts. Specifically, the evaluation of the different strategies and the criteria that are important for beach users when coastal protection methods are implemented can show individual preferences as well as the levels of understanding of the intervention; further, it can reveal gaps in information and misunderstandings. It is especially

interesting to see how well beach users understand NBS, as this can facilitate environmental education, environmental awareness, and involvement of users in the surveillance and care of these types of interventions.

In the case study at Les Madrigueres beach, the main coastal protection strategies for combating coastal erosion and beach loss were assessed. In Fig. 3, the acceptability of each coastal protection measure is presented. In this survey, dune creation and restoration is the most accepted measure by beach users. Notably, analysis of the answer distributions revealed that 75% of beach users considered it to be an adequate or very adequate measure. The use of sand replenishment and rigid structures for beach maintenance and erosion compensation is common in Spain and seems to be well known, as few users responded "I do not know" when asked about these measures. Not surprisingly, therefore, most users also consider sand replenishment an adequate or very adequate measure (62.5%); in contrast, there is a certain rejection of rigid structures, as this was rated significantly lower than the strategy of managed realignment. In this question we also compared the evaluation of measures by means of a Wilcoxon-signed rank test, again working with  $\alpha = 0.05$  and the null-hypothesis (H<sub>10</sub>): differences between rankings of two measures are assumed to follow a symmetric distribution around zero, such that there is no systematic difference between the evaluations of two measures. The alternative (H<sub>1a</sub>) was that the difference is less than zero, thus that one measure (M<sub>1</sub>) is less appreciated than another measure (M<sub>2</sub>).

Comparing rigid structures and rigid structures, a Wilcoxon signed-rank test showed that H<sub>10</sub> should be rejected. Further, it suggested to hypothesize that rigid structures (M<sub>1</sub>) are less appreciated than managed realignment (M<sub>2</sub>) (p-value < 0.001), and that the difference between beach nourishment (M<sub>1</sub>) and reconstruction of dune systems (M<sub>2</sub>) (p-value < 0.001) is also significant. This cannot be stated for the differences between beach nourishment and

managed realignment (p-value = 0.218). Only a quarter of beach users feel that using rigid structures for coastal protection from increased erosion is an appropriate option, while 50% would accept a relocation of infrastructure. This high level of acceptance is surprising, given the high social and economic costs involved in the implementation of this measure, which are often accompanied by intense social conflicts (Roca & Villares, 2012). Further, the relatively positive perception of this option does not correspond with other studies that were carried out, for example in England, where the respondents preferred rigid structures over managed realignment (Jones & Clark, 2014). It must be kept in mind, however, that the users questioned in England were owners of land in the affected areas, which surely affected their perceptions of the measure. Notably, the results of this study show that most beach users perceive a need to improve coastal protection structures, as most rejected the “do nothing” option, which was considered as an “inadequate” option by half of the beach users and “not very adequate” by a further 15%. Moreover, the high incidence of “do not know” answers indicates either that there was some confusion when evaluating this option (to do nothing), or that people did not perceive it as a true option, despite the fact that for beaches with very natural characteristics, “do nothing” can be a valuable option that allows the ecosystem to be rebalanced and to establish a new, stable coastal profile that is more inland.

Fig. 3: The level of suitability perceived by beach users in Les Madrigueres beach for each coastal management strategy.

The best accepted NBS measure was dune restoration. However, the results do not clearly show whether this preference is maintained when considering defence preparation against more extreme events, such as severe storms or flooding. Studies in the Ebro delta in Catalonia have shown that more value is given to rigid structures than to soft measures when it comes to protecting property and infrastructures against strong storms (Roca & Villares, 2012).

Considering the high concern for the effects to the landscape, it is possible that the preference of users in this study for soft measures is at least partly due to their positive aesthetic effects.

#### Factors to consider for selecting strategies

Comparing the different factors relevant to the selection revealed that there were few differences in the global consideration of the importance of each factor. Fig. 4 summarizes the assigned ranks for each factor. The descriptive analysis of the ranking shows that efficacy reaches higher incidence in positions of greater importance, and durability in lower ranks of lower importance. The results distribution shows many participants in this survey considered durability to be less important than environmental protection and efficacy.

Evaluating the factors to be considered when selecting methods also revealed that users gave considerable importance to the effect of the measure on the aesthetic value of landscape (Fig. 4). The effects on landscape were often selected as the second-most important factor, with 43.7% of beach users considering it to be one of the two most important factors. These results are in line with those from the first question, where the level of concern was considerably high for the impact on landscape. The Kendall rank correlation showed that economic cost and environmental protection are slightly anti-correlated ( $\tau = -0.45$ ); in other words, people who place great importance on environmental protection tend to place less importance on the economic cost, and vice versa. No other significant correlation was observed between other factors, as the Kendall- $\tau$  values are all close to 0.

Fig. 4: Incidence in each rank of importance assigned to different factor for the selection of adaptation strategies.

Comparing interventions using rigid infrastructures with the options based on the reconstruction of natural structures, we see a clear preference for renaturation. In a study on

the preferences of beach users for selecting measures of coastal defence at other Mediterranean beaches (in Greece, Italy, and France), opinions about the most appropriate measure differed from those in the present study, with a tendency to favour rigid structures. However, with regard to the most important factors for selection, all studies revealed very similar opinions, with efficiency considered to be the most important aspect but with aesthetic aspects, environmental protection, and economic costs also taken into account (Koutrakis et al., 2011). Finally, it is highly likely that, in all studies, the users' accurate knowledge about the measures—their advantages, disadvantages, and costs—has a great influence; thus, it is important to impart a deeper understanding about the distinct measures to beach users.

#### Assessment of the impacts of NBS

An assessment of the changes produced by the dune restoration projects at the three beaches allowed us to analyze how beach users perceived their benefits (or ecosystem services) as well as the trade-offs (the project's losses or gains). As in the first question, we applied a Kruskal-Wallis test with the same hypothesis, in order to analyse the influence of the different locations on the outcome of the project evaluation. Although the results are very similar for all three case studies, we do not assume that they are independent from the case study, but rather that they depend on local differences. The results of the Kruskal-Wallis test suggest that  $H_{10}$  (e.g., that the results are independent between case studies) should be maintained for cycle lanes and walkways (p-value = 0.236), Information and signage (p-value = 0.182), and dune restoration and revegetation (p-value = 0.207), but that access (p-value < 0.001), parking (p-value = 0.011) and storm Protection (p-value = 0.006) should be assumed to be influenced. Therefore, we provide a differentiated descriptive analysis in Fig. 5.

The projects were generally associated with reductions in vehicle accessibility and parking—changes that are generally called into question, as mobility to beaches far from urbanization

is dominated by private motorized vehicles (Roca et al., 2008). On the other hand, improvement of walking and biking routes to the beaches was perceived as positive and highlighted the elements related to environmental conservation (dune restoration and revegetation) and coastal defence (protection against storms) (Fig. 5). Comparing the three beaches, the effects on parking and access have been perceived less negatively in the Can Comes beach at Sant Pere Pescador than in the other two beaches.

Overall, it seems that the educational function of these interventions has improved, based on the positive assessment of the aspect concerning information and signage. Nonetheless, it would be necessary to determine how much each specific beach user improved in his/her perception to verify the impact of these projects in terms of environmental education; this aspect is however beyond the scope of this work.

Fig. 5: Assessment of changes produced by the dune restoration projects regarding different aspects relevant for beach users.

The aspects of environmental conservation, such as dune restoration and revegetation, obtained the most positive ratings. The protective function of these interventions—that is, storm protection—was also perceived to be positive, but the number of people indicating an improvement is lower.

Here, we also tested the differences in the evaluation of dune restoration and revegetation, and storm protection using the Wilcoxon-signed rank test, with  $\alpha = 0.05$  and the null-hypothesis ( $H_{10}$ ), which assumes differences between ranks of two aspects follows a symmetric distribution around zero), thus that there is no systematic difference between the perceived benefits of NBS for dune restoration and revegetation than for storm protection. The alternative hypothesis ( $H_{1a}$ ) was that the difference between ranks are less than zero. In

other words, NBS might be perceived to be less beneficial for storm protection than for environmental restoration and revegetation. However, the p-values did not confirm that people perceive lower benefits for storm protection than for dune restoration and revegetation: p-values were above 0.05 for all beaches (Les Madrigueres: p-value = 0.507; Can Comes: p-value = 0.181; La Pletera: p-value = 0.313), thus  $H_{10}$  should be maintained. On the other hand, there was a high incidence of “do not know” responses to this part of the question, which suggests a certain confusion or incomprehension when evaluating this aspect. This response behaviour also affects the test results, as missing values are excluded from the calculation of rank differences. In an overall evaluation, just under half of the respondents (47%) felt that the interventions would improve the protective function. For conservation aspects, such as revegetation, 64% felt positively about dune regeneration as an improvement of environmental conservation. It can be concluded that most beach users perceived benefits for the environmental conservation aspects (dune restoration and vegetation), and that the evaluation of storm protection capacity was in general positive; however, the implications of NBS for storm protection seemed to be not always well understood. Different factors can explain these perceptions. On the one hand, as there is an incipient policy for dune restoration on this coastline, beach users do not have experience with NBS as coastal defence options and find it difficult to acknowledge that protection of the inland and sand regulation are natural functions of dune systems. On the other hand, this perception also suggests certain shortcomings in environmental communication mechanisms in terms of their ability to explain interventions that have a more holistic nature.

We applied a Kendall rank correlation to address the questions about climate change concerns and project appraisal, but we did not find significant associations with results for correlation coefficients close to 0. On the other hand, we found stronger correlations in the evaluation of

different aspects of the project, with strong correlations between access and parking ( $\tau = 0.603$ ), and dune restoration and revegetation and storm protection ( $\tau = 0.622$ ). We can observe that, to some extent, all aspects are positively correlated with coefficients above 0, so we can conclude that people have rather general opinions about the projects, evaluating them either rather positively or rather negatively. In the case of Les Madrigueres, we especially studied associations between the different adaptation measures in general and the project assessment, especially concerning storm protection. The appraisal of dune reconstruction, hard structures, and managed realignment is weakly correlated with most aspects of the project assessment, while the appraisal of beach nourishment and “do nothing” is slightly anti-correlated with the project assessment. Although we expected that people who consider dune reconstruction a promising management strategy would appreciate the project especially for its storm protection capacity, we could not confirm this with the Kendall correlation, obtaining  $\tau = 0.080$  for the correlation between reconstruction of dune systems and storm protection.

## 6 CONCLUSIONS

As coastal areas are exposed to high risks due to severe effects of climate change (e.g., rising sea levels and extreme climate events), sustainable adaptation strategies, such as the use of NBS as coastal defences, are necessary to cope with adverse impacts. Overall, the concern about how climate change effects recreational and beach-related activities and aspects is quite low as compared to the concern for more general and environmental aspects. Indeed, climate change is often communicated as a purely environmental issue, leaving aside its social and economic dimensions. The climate change events that proceed slowly, infrequently, or with low intensity (e.g., rising sea levels) are perceived to be remote from personal influence.

The analyses carried out in this study are focused on the beach users' perceptions on renaturalization and dune restoration projects. The results have shown that these type of projects are very well accepted by beach users, especially in terms of the benefits they provide for conservation, protection, and education, although some trade-offs have to be accepted, mainly concerning access of motorized vehicles to the beach. As beautiful landscapes and environment quality positively affect the recreational value of a touristic region, the renaturalization and reinforcement of dune systems present a coastal defence strategy that may benefit the touristic sector and the competitiveness of the region. Furthermore, user preferences for soft-engineering options (such as beach nourishment) or nature regeneration, rather than conventional hard-engineering options, suggest a positive attitude towards solutions that improve environmental quality, landscapes, and adaptive capacity, which at the same time should be understood as a method of maintaining regional competitiveness in the touristic sector. Although the effectivity of defence strategies seems to be a crucial aspect for beach users when planning defence interventions, other factors such as environmental protection, economic costs, and effects on landscape need to be taken into account as well. A clear importance ranking of selection criteria could not be found, highlighting the degree of potential conflicts when it comes to the selection of most adequate measures.

As more beach users indicate benefits for nature conservation and landscapes than for protective characteristics of intact ecosystems, both their confidence in NBS as a form of coastal defence and their understanding of the protection services provided by ecosystems seem to be limited, but further studies are necessary to understand these associations.

Risk communication and education therefore have a fundamental role to play in changing attitudes and perceptions over the long term. The main conclusion of this study suggests that studying social perceptions is crucial for the evaluation of possible co-benefits of NBS. In order

to promote a more adaptive approach to coastal risk management, the gaps identified between concerns and expert opinions need to be translated into a set of recommendation practices, such as promoting information and communication events and launching more visible restoration initiatives. Considering the heterogeneity of beach users and tourists, and their different origins and backgrounds, awareness-raising is a cross-border task that should play a key role in beach tourism management.

## References

Borsje, B. W., Vries, S. de, Janssen, S. K. H., Luijendijk, A. P., Vuik, V. (2017). Building with Nature as Coastal Protection Strategy in the Netherlands. *Living Shorelines: The Science and Management of Nature-Based Coastal Protection*, (PIANC 2011), 137–155.

Cariñanos, P., Casares-Porcel, M., Díaz de la Guardia, C., Aira, M. J., Belmonte, J., Boi, M., ... Vega Maray, A. M. (2017). Assessing allergenicity in urban parks: A nature-based solution to reduce the impact on public health. *Environmental Research*, 155, 219–227.

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). Nature-based solutions to address global societal challenges. IUCN International Union for Conservation of Nature.

Davis, M., Krüger I., Hinzmann, M. (2015). Coastal Protection and Suds – Nature-based Solutions. RECREATE Project Policy Brief No. 4

de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., ... van Beukering, P. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services*, 1(1), 50–61.

Dugan, J. E., Hubbard, D. M., Rodil, I. F., Revell, D. L., & Schroeter, S. (2008). Ecological effects of coastal armoring on sandy beaches. *Marine Ecology*, 29(SUPPL. 1), 160–170.

Elliff, C. I., & Kikuchi, R. K. P. (2015). The ecosystem service approach and its application as a tool for integrated coastal management. *Natureza & Conservação*, 13(2), 105–111.

Esteves, L. S. (2013). Is managed realignment a sustainable long-term coastal management approach? *Journal of Coastal Research*, 65, 933–938.

European Union (2015). Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities Final Report of the Horizon 2020 Expert Group on 'NBS and Re-Naturing Cities.' D-G of R&I.

Faivre, N., Fritz, M., Freitas, T., de Boissezon, B., & Vandewoestijne, S. (2017). Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges. *Environmental Research*, 159, 509–518.

Hălbac-Cotoară-Zamfir, R., Keesstra, S., & Kalantari, Z. (2019). The impact of political, socio-economic and cultural factors on implementing environment friendly techniques for sustainable land management and climate change mitigation in Romania. *Science of the Total Environment*, 654, 418–429.

Hanley, M. E., Hoggart, S. P. G., Simmonds, D. J., Bichot, A., Colangelo, M. A., Bozzeda, F., ... Thompson, R. C. (2014). Shifting sands? Coastal protection by sand banks, beaches and dunes. *Coastal Engineering*, 87, 136–146.

Heltberg, R., Siegel, P. B., & Jorgensen, S. L. (2009). Addressing human vulnerability to climate change: Toward a 'no-regrets' approach. *Global Environmental Change*, 19(1), 89–99.

Intergovernmental Panel for Climate Change (2001). *Climate Change. Impacts, Adaptations and Vulnerability. Contribution to the Third Assessment Report of the Intergovernmental Panel of Climate Change*. Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change (2014). *Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects: Working Group II Contribution to the IPCC Fifth Assessment Report*. Cambridge: Cambridge University Press.

Jiménez, J. A., Valdemoro, H. I., Bosom, E., Sánchez-Arcilla, A., & Nicholls, R. J. (2017). Impacts of sea-level rise-induced erosion on the Catalan coast. *Regional Environmental Change*, 17(2), 593–603.

Jones, N., & Clark, J. R. A. (2014). Social capital and the public acceptability of climate change adaptation policies: A case study in Romney Marsh, UK. *Climatic Change*, 123(2), 133–145.

Jongman, B. (2018). Effective adaptation to rising flood risk. *Nature Communications*, 9(1), 1986.

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., ... Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society*, 21(2), art39.

Kabisch, N., van den Bosch, M., & Laforteza, R. (2017a). The health benefits of nature-based solutions to urbanization challenges for children and the elderly – A systematic review. *Environmental Research*, 159, 362–373.

Kabisch N., Korn H., Stadler J., Bonn A. (2017b) Nature-Based Solutions to Climate Change Adaptation in Urban Areas—Linkages Between Science, Policy and Practice. In: Kabisch N.,

Korn H., Stadler J., Bonn A. (eds) Nature-Based Solutions to Climate Change Adaptation in Urban Areas. Theory and Practice of Urban Sustainability Transitions. Springer, Cham.

Kalantari, Z., Ferreira, C. S. S., Keesstra, S., & Destouni, G. (2018). Nature-based solutions for flood-drought risk mitigation in vulnerable urbanizing parts of East-Africa. *Current Opinion in Environmental Science & Health*, 5, 73–78.

Keesstra, S., Nunes, J., Novara, A., Finger, D., Avelar, D., Kalantari, Z., & Cerdà, A. (2018). The superior effect of nature based solutions in land management for enhancing ecosystem services. *Science of the Total Environment*.

Keesstra, S. D., Rodrigo-Comino, J., Novara, A., Giménez-Morera, A., Pulido, M., Di Prima, S., & Cerdà, A. (2019). Straw mulch as a sustainable solution to decrease runoff and erosion in glyphosate-treated clementine plantations in Eastern Spain. An assessment using rainfall simulation experiments. *Catena*, 174, 95–103.

Kirchhoff, M., Rodrigo-Comino, J., Seeger, M., & Ries, J. B. (2017). Soil erosion in sloping vineyards under conventional and organic land use managements (Saar-mosel valley, Germany). *Cuadernos de Investigacion Geografica*, 43(1), 119–140.

Klinke, A. & Renn, O. (2002). A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based, and Discourse-Based Strategies 1. *Risk Analysis*, 22(6), 1071–1094.

Koutrakis, E., Sapounidis, A., Marzetti, S., Marin, V., Roussel, S., Martino, S., ... Malvárez, C. G. (2011). ICZM and coastal defence perception by beach users: Lessons from the Mediterranean coastal area. *Ocean & Coastal Management*, 54(11), 821–830.

Laforteza, R., Chen, J., van den Bosch, C. K., & Randrup, T. B. (2018). Nature-based solutions for resilient landscapes and cities. *Environmental Research*, 165, 431–441.

Liquete, C., Udias, A., Conte, G., Grizzetti, B., & Masi, F. (2016). Integrated valuation of a nature-based solution for water pollution control. Highlighting hidden benefits. *Ecosystem Services*, 22, 392–401.

Morris, R. L., Konlechner, T. M., Ghisalberti, M., & Swearer, S. E. (2018). From grey to green: Efficacy of eco-engineering solutions for nature-based coastal defence. *Global Change Biology*.

Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences*, 107(51), 22026–22031.

Nelson, C., & Botterill, D. (2002). Evaluating the contribution of beach quality awards to the local tourism industry in Wales - The Green Coast Award. *Ocean and Coastal Management*, 45(2–3), 157–170.

Narayan, S., Beck, M. W., Wilson, P., Thomas, C. J., Guerrero, A., Shepard, C. C., ... Trespalacios, D. (2017). The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Scientific Reports*, 7(1), 9463.

Nesshöver, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., ... Wittmer, H. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. *Science of the Total Environment*, 579, 1215–1227.

Nguyen, T. P. (2018). *Melaleuca* entrapping microsites as a nature based solution to coastal erosion: A pilot study in Kien Giang, Vietnam. *Ocean and Coastal Management*, 155, 98–103.

Panno, A., Carrus, G., Laforteza, R., Mariani, L., & Sanesi, G. (2017). Nature-based solutions to promote human resilience and wellbeing in cities during increasingly hot summers. *Environmental Research*, 159, 249–256.

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., ... Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science & Policy*, 77, 15–24.

Reguero, B. G., Beck, M. W., Bresch, D. N., Calil, J., & Meliane, I. (2018). Comparing the cost effectiveness of nature-based and coastal adaptation: A case study from the Gulf Coast of the United States. *PLOS ONE*, 13(4), e0192132.

Roca, E., Riera, C., Villares, M., Fragell, R., & Junyent, R. (2008). A combined assessment of beach occupancy and public perceptions of beach quality: A case study in the Costa Brava, Spain. *Ocean & Coastal Management*, 51(12), 839–846.

Roca, E., & Villares, M. (2008). Public perceptions for evaluating beach quality in urban and semi-natural environments. *Ocean and Coastal Management*, 51(4), 314–329.

Roca, E., & Villares, M. (2012). Public perceptions of managed realignment strategies: The case study of the Ebro Delta in the Mediterranean basin. *Ocean and Coastal Management*, 60, 38–47.

Saleh, F., & Weinstein, M. P. (2016). The role of nature-based infrastructure (NBI) in coastal resiliency planning: A literature review. *Journal of Environmental Management*. Academic Press.

Shao, C., Chen, J., Chu, H., Laforteza, R., Dong, G., Abraha, M., ... Qi, J. (2017). Grassland productivity and carbon sequestration in Mongolian grasslands: The underlying mechanisms and nomadic implications. *Environmental Research*, 159, 124–134.

Sheaves, M., Sporne, I., Dichmont, C. M., Bustamante, R., Dale, P., Deng, R., ... Swinbourne, A. (2016). Principles for operationalizing climate change adaptation strategies to support the

resilience of estuarine and coastal ecosystems: An Australian perspective. *Marine Policy*, 68, 229–240.

Slovic P. (2000) *The perception of risk*. Earthscan Publications, 473 p

Steentjes, K., Pidgeon, N., Poortinga, W., Corner, A., Arnold, A., Böhm, G., ... Tvinnereim, E. (2017). *European Perceptions of Climate Change: Topline findings of a survey conducted in four European countries in 2016*. Cardiff: Cardiff University.

Temmerman, S., Meire, P., Bouma, T. J., Herman, P. M. J., Ysebaert, T., & De Vriend, H. J. (2013, December 5). Ecosystem-based coastal defence in the face of global change. *Nature*. Nature Publishing Group.

Uzzell, D. L. (2000). The psycho-spatial dimension of global environmental problems. *Journal of Environmental Psychology*, 20(4), 307–318.

van den Bosch, M., & Ode Sang, Å. (2017). Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews. *Environmental Research*, 158, 373–384.

van der Nat, A., Vellinga, P., Leemans, R., & van Slobbe, E. (2016). Ranking coastal flood protection designs from engineered to nature-based. *Ecological Engineering*, 87, 80–90.

van Koningsveld, M., & Mulder, J. P. M. (2004). Sustainable Coastal Policy Developments in The Netherlands. A Systematic Approach Revealed. *Journal of Coastal Research*, 20(2), 375–385.

van Wesenbeeck, B. K., Mulder, J. P. M., Marchand, M., Reed, D. J., de Vries, M. B., de Vriend, H. J., & Herman, P. M. J. (2014). Damming deltas: A practice of the past? Towards nature-based flood defenses. *Estuarine, Coastal and Shelf Science*, 140, 1–6.

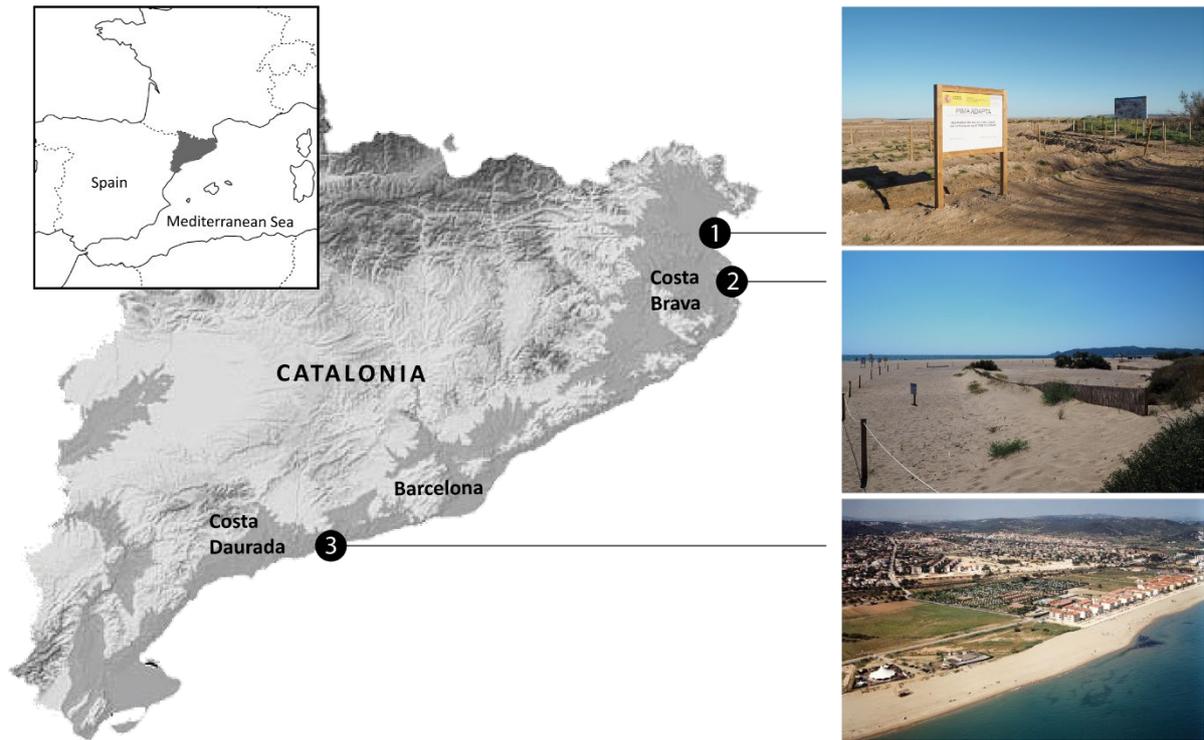
Vuik, V., Jonkman, S. N., Borsje, B. W., & Suzuki, T. (2016). Nature-based flood protection: The efficiency of vegetated foreshores for reducing wave loads on coastal dikes. *Coastal Engineering*, 116, 42–56.

Vujcic, M., Tomicevic-Dubljevic, J., Grbic, M., Lecic-Tosevski, D., Vukovic, O., & Toskovic, O. (2017). Nature based solution for improving mental health and well-being in urban areas. *Environmental Research*, 158, 385–392.

Wild, T. C., Henneberry, J., & Gill, L. (2017). Comprehending the multiple 'values' of green infrastructure – Valuing nature-based solutions for urban water management from multiple perspectives. *Environmental Research*, 158, 179–187.

Woodruff, S. C., Meerow, S., Stults, M., & Wilkins, C. (2018). Adaptation to Resilience Planning: Alternative Pathways to Prepare for Climate Change. *Journal of Planning Education and Research*, 0739456X1880105.

Zölch, T., Henze, L., Keilholz, P., & Pauleit, S. (2017). Regulating urban surface runoff through nature-based solutions – An assessment at the micro-scale. *Environmental Research*, 157, 135–144.



1. *Can Comes*,  
Municipality of Sant Pere Pescador

2. *La Pletera*,  
Municipality of Torroella de Montgrí

3. *Les Madrigueres*,  
Municipality of El Vendrell

Fig. 1: Overview of the case studies localized in the western Mediterranean coast, with images of the interventions.

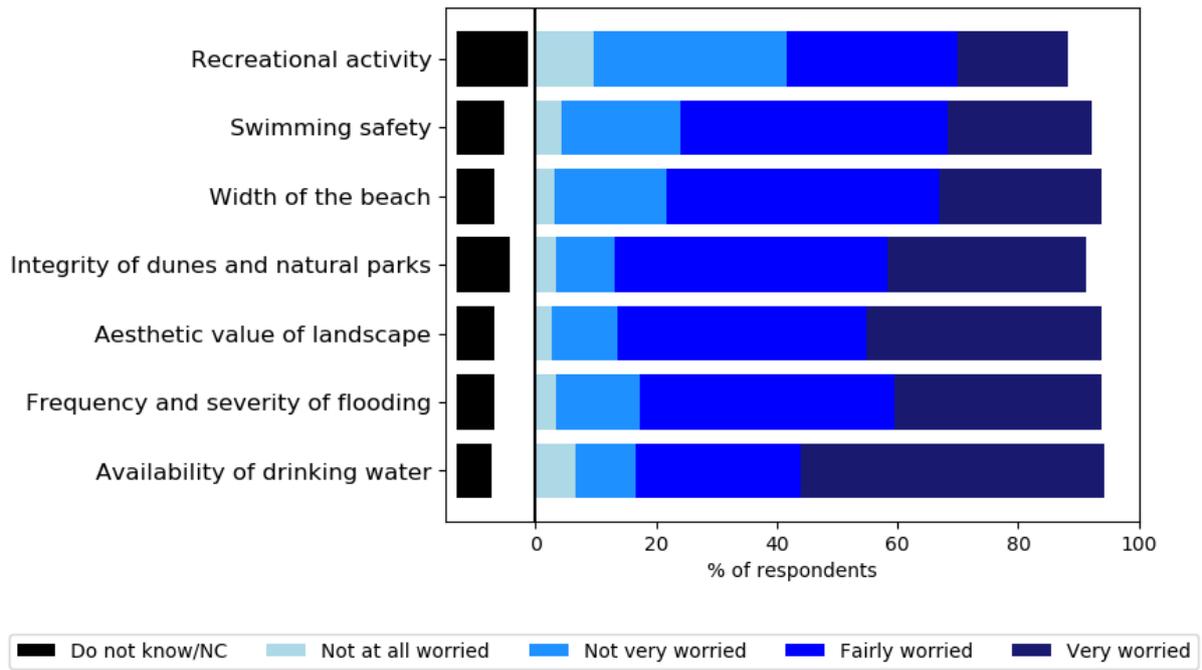


Fig. 2: Overall levels of concern about the effects of climate change on different aspects, expressed by all users of the three beaches.

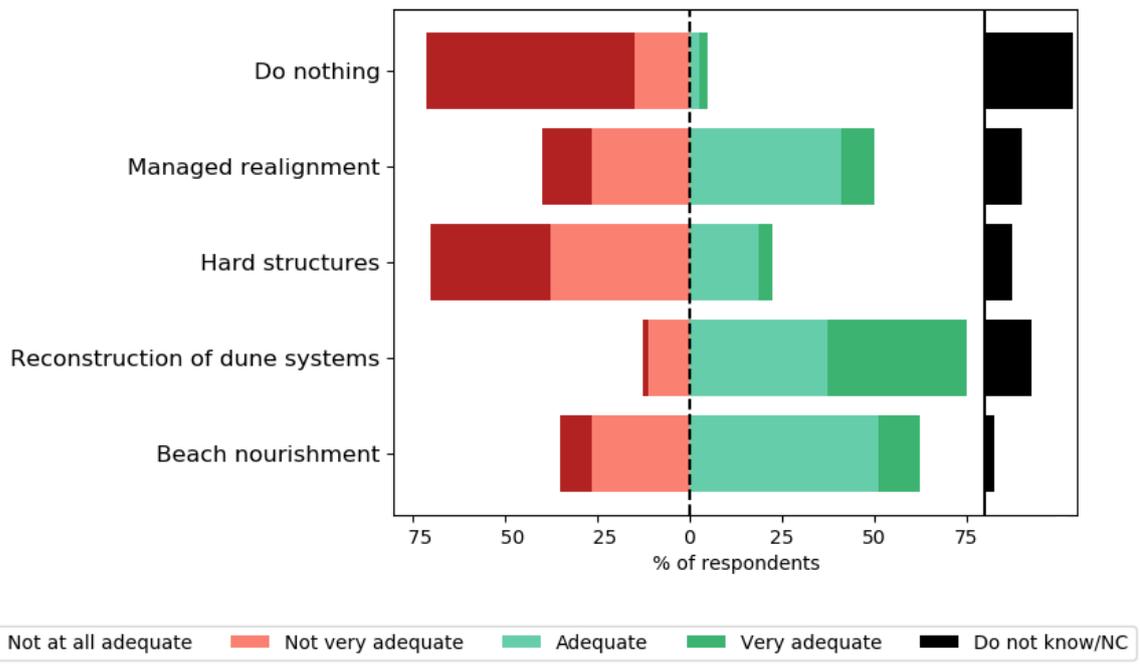


Fig. 3: The level of suitability perceived by beach users in Les Madrigueres beach for each coastal management strategy.

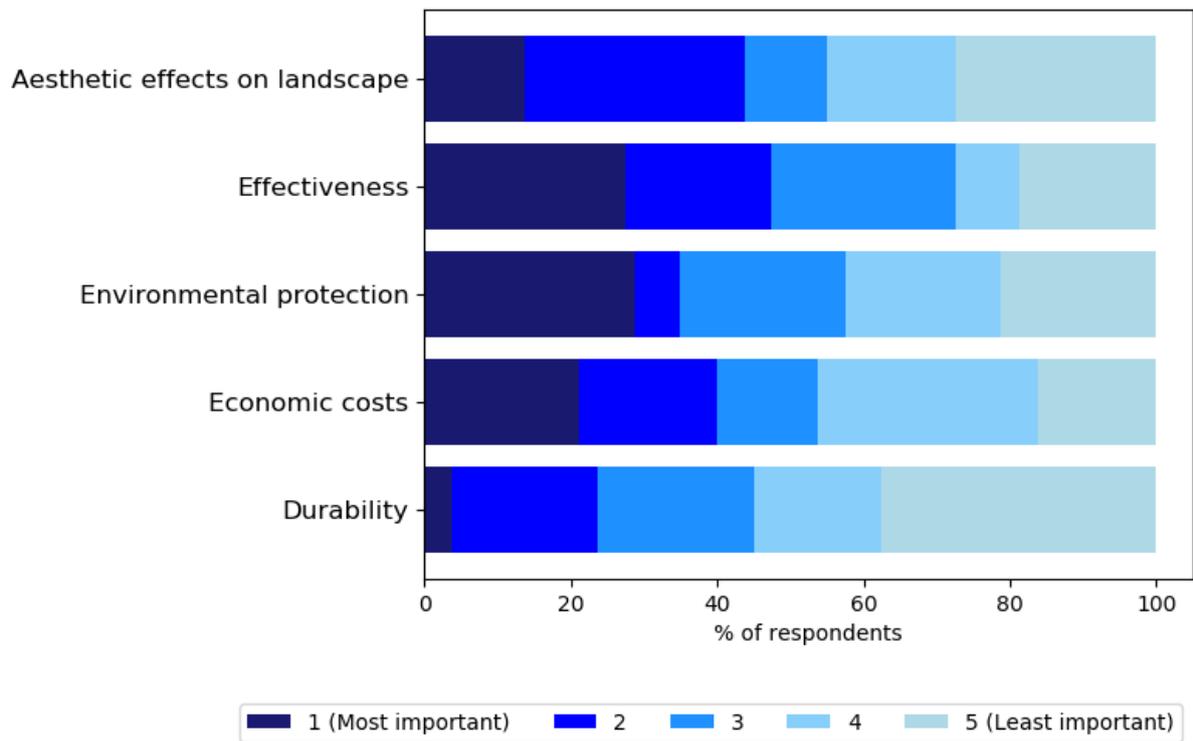


Fig. 4: Incidence in each rank of importance assigned to different factors for the selection of adaptation strategies.

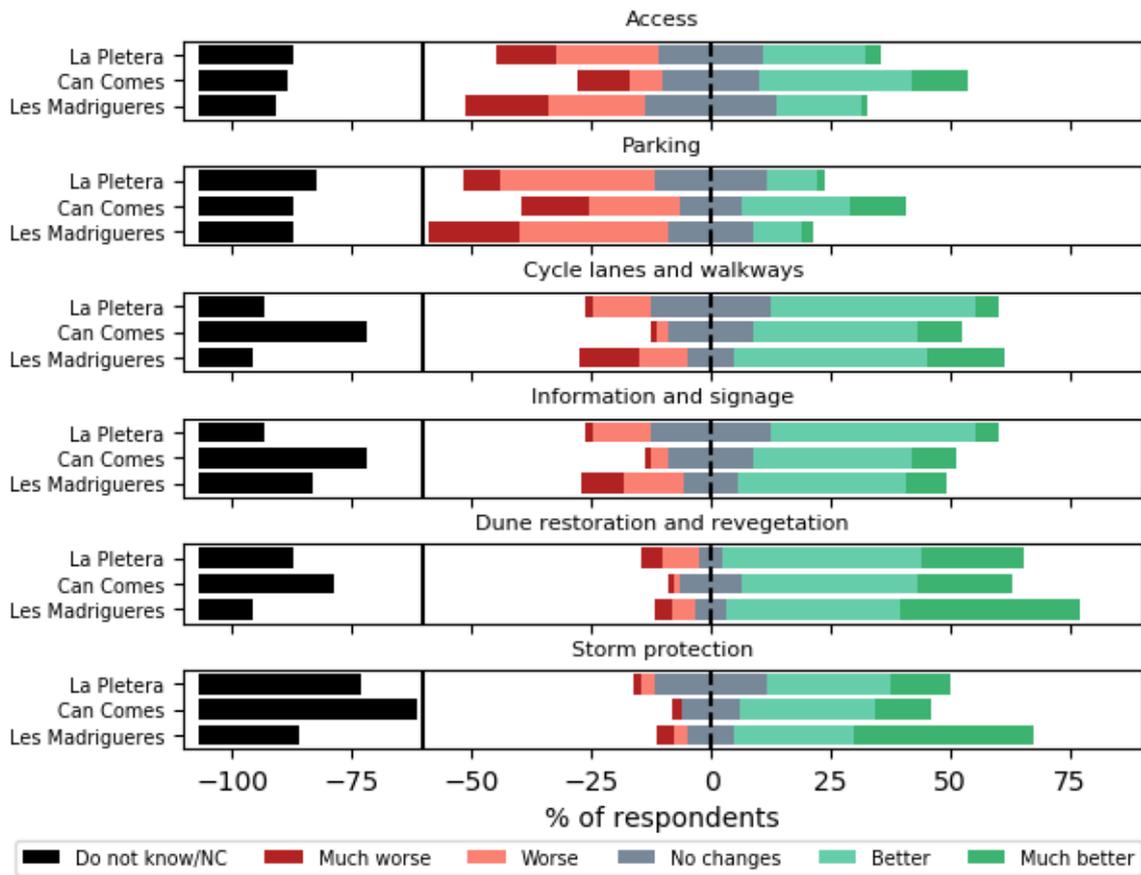


Fig. 5: Assessment of changes produced by the dune restoration projects regarding different aspects relevant for beach users.