The DIBA: A dynamic assessment tool for beach quality on protected areas

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Abstract

The Dynamic Index for Beaches in protected areas (DIBA) is introduced as a dynamic method for evaluating the quality of beaches in protected areas. The aim of this dynamic approach is to assess quality on a weekly basis so that different scores may be obtained throughout the bathing season. The index is made up of three sub-indices encompassing the main concerns regarding beaches in protected areas, i.e. the environment, landscape and recreation. These sub-indices consist of nine indicators and four sub-indicators; the five indicators are recorded yearly and the four sub-indicators are recorded weekly. The procedure is tested at four selected beaches on Spain's Mediterranean coast and gives good overall scores although these decrease throughout the bathing season. The DIBA is a useful tool for managers of beaches and protected areas because it can be used to characterize and compare beaches. With minor adjustments, this procedure may be applied to other beaches in protected areas in the Mediterranean basin.

Keywords

DIBA, beach management, beach quality index, coastal protected areas, Mediterranean

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1. Introduction

Tourism is one of the largest-growth industries in the world and has one of the highest economic impacts, accounting for one job in eleven and about 30% of the world's services and exports (UNWTO, 2014). According to the WTO (2015), international tourism generated US$ 1,522 billion in 2014, with only fuel and chemicals generating more. International tourist arrivals in 2015 were above 1,100 million which is a growth of 4.4% from 2013. Europe received 51% of those arrivals, which is equivalent to 609 million people, and the Southern Mediterranean region registered growth of over 5%. A good deal of this tourism occurs in coastal regions because tourist resorts are mainly located on the seashore (Velvet, 2013), beaches being fundamental to tourism demands (e.g. Klein, Osleeb & Viola, 2004; Houston, 2013). The WTO estimates that tourism will increase by 3.5 to 4.5% in Europe, thus placing the continent in the third place in world ranking (WTO, 2015), and most of this growth will be on the Mediterranean coast.

The Mediterranean basin faces a large number of social and ecological risks caused by, for example, unsustainable water consumption, forest fires and erosion (EEA, 1999). Among those tendencies, high artificial rates of land cover are particularly important, both from a quantitative and a qualitative point of view, as they are usually irreversible. GRATET (2013) analyzed the urban development in a number of tourist destinations and found that more than 75% of the tourist area is covered by residential, tourist and commercial zones. Rates of coastal development are very, reaching 100% in some cases (Table 1). Mullins (1991) analyzed urban development caused by tourism growth, and several other studies have identified urban spatial patterns dominated by tourism accommodation, urban spaces specifically built for tourism and urban-tourism sprawl (e.g. Pons, Rullán & Murray, 2014; Rovira & Anton-Clavé, 2014). In the coming years it is predicted that more coastlines will become built up (Benoit & Comeau, 2005).

With this in mind, particular attention must be paid to non-built-up areas in coastal tourism regions because their scarcity makes them a rare commodity (Blay, 2012; Harris, Nel, Holness & Schoeman, 2015). Most of these sites are in protected natural areas which are rare and under pressure in high-density urban coastal environments and must therefore be specially preserved (Eagles & McCool, 2002). The European Union's Natura 2000, the largest network of protected areas in the world, has 4342 sites in the Mediterranean biogeographical region; a GIS analysis reveals that 28.93% of those sites are partially or totally located less than 1km from the seashore. Since many protected areas are as tourist attractions, they are noticeable affected by human activity.

Beach users' preferences have been studied on numerous occasions (Breton, Clapés, Marquès & Priestley, 1996; Tudor & Williams, 2006; Roca & Villares, 2008; Lucrezi, Saayman & Merwe, 2016). Desirable attributes frequently mentioned by beach goers include scenery, cleanliness, sand and water properties and facilities such as showers or shops. Other desirable attributes are related to comfort and include tranquility and policies to reduce noise, prohibit smoking and control dogs. Overcrowding rates are often quoted because beach-goers' often seek calmness and peace. Unsurprisingly, beaches with more commodities are among the most sought-after and are usually among the most crowded. Urban and non-urban beaches are noticeably different here in that users of the former attach less importance to tranquility that do users of the latter (Roca & Villares, 2008; Rangel-

Buitrago, Correa, Anfuso, Ergin & Williams, 2013). Nevertheless, People's preferences and perceptions can often be exaggerated and must be interpreted carefully because they are fluid cultural responses that may vary quickly (Breton et al., 1996).

Several methods are used to assess beach quality in an objective and systematic way. Since 1987, the Blue Flag award has been adopted *de facto* as an international certification of beach quality, including beaches in protected areas. Its aim is to promote coastal sustainability by awarding scores for over thirty criteria grouped into four categories: environmental education and information, water quality, environmental management, and safety and services (Blue Flag, 2016). Although some of these items appear relevant to beach management, the award is regarded as inadequate for assessing beach quality. Lucrezi, Saayman & Merwe (2015) observes three aspects that bring into question the usefulness of the Blue Flag award: (1) the award does not consider important aspects relating to ecosystem functions, including geomorphology and floral characteristics; (2) some criteria, such as water quality, are considered more important than others and should be assessed on a more regular and consistent basis; (3) some management practices appear to be inconsistent with beach protection, such as litter removal using heavily machinery. Several studies have questioned the validity of the Blue Flag award as a universal and reliable indicator for beach certification as it focuses more on management rather than quality (Ariza, Sardá, Jiménez, Mora & Ávila, 2008; Boevers, 2008; Mir-Gual, Pons, Martín-Prieto & Rodríguez-Perea, 2015; Fraguell, Martí, Pintó & Coenders, 2016).

A number of environmental management systems for beaches have been launched in recent years, some with the purpose of redressing procedures that have ceased to function in the intended manner (Ariza et al., 2008). Comprehensive indexes tend to consider key parameters beach quality which, according to Williams and Micallef (2009), are safety, facilities, water quality, cleanliness and scenery. The Beach Quality Index (Ariza, Jimenez, Sarda, Villares, Pinto, Fraguell, Roca, Marti, Veldemoro, Ballester & Fluvia, 2010) has been adopted in Spain, is based on thirteen sub-indices weighted and related by linear aggregation, and has been developed to assess overall quality in Mediterranean urban and urbanized beaches. Botero et al. (Botero, Pereira, Anfuso, Cervantes, Williams, Pranzini & Silva, 2014) developed the Index of Environmental Quality for Tourist Beaches as a tool to assess sustainability in Colombian beaches; it uses thirty parameters, including coastal scenery, safety and security, urban development, zoning, and environmental protection, which are major issues related to environment and recreation on tourist beaches. The Beach Evaluation Index (Lucrezi et al. 2016) was adopted in South Africa and is made up by three sub-indices: the Beach Description Index, the Human Dimension Index and the Monetary Index, which together provide a descriptive matrix of 131 indicators. This tool, which can be generalized to beaches around the world, was specially designed for sandy beaches and tested on recreational ones. Other composite indexes focus on economic aspects, such as the Integrated Beach Index (Cervantes & Espejel, 2008) which has been applied to urban beaches in California, Mexico and Brazil, whereas others focus on scenery and aesthetic qualities, such as the well-known procedure proposed by Ergin et al. (Ergin, Karaesmen, Micallef & Williams, 2004) and applied worldwide (Williams, Micalef, Anfuso, Gallego-Fernandez, 2012; Rangel-Buitrago et al., 2013; Williams & Khattabi, 2015). All these procedures provide static information about beaches relating to an undefined time or, in some cases, to an undefined bathing season.

The present study tests the Dynamic Index for Beaches in Protected Areas (DIBA), a tool that can assess beach quality in protected areas in a dynamic manner. Due to tourist pressure on fragile protected areas in highly urbanized coastal environments, it is necessary to create an index to dynamically measure and compare the quality of beaches throughout the tourist season and, at the same time, determine their carrying capacity. This index was applied on a weekly basis during the bathing season to four selected Spanish beaches and is intended to be generalized to other Mediterranean beaches.

2. Methods

The DIBA model consists of three sub-indexes which cover the three main aspects used to assess beaches in protected areas: environment (E), landscape (L) and recreation (R). Each sub-index has a set of indicators, sub-indicators and components which may have a value on their own or may be averaged. All values are normalized to a 0-1 scale, where 0 corresponds to the lowest quality and 1 to the highest. Integration is carried out using a linear combination method which involves adding or multiplying weighted and normalized data. The DIBA is modelled on the index by Ariza et al. (2010) but introduces new items, weighting criteria and adjustments to fit it to beaches in protected areas. The final model of the DIBA is shown in Figure 1.

The final results are shown on a numerical scale ranging from 0 to 1. The scale is adapted to a nominal scale so that restrictive criteria and knowledge can be used to increase understanding of the studied areas (Table 2).

The research was supported by a panel of experts who checked the sub-indices' components and weightings. The panel included geographers, landscapers, protected area managers and NGO members chosen for their involvement in coastal issues.

Crowdedness was assessed by 42 valid questionnaires conducted on beach goers during August 2015. The questionnaire consisted of opened and closed questions and followed a structure similar to that used by Silva (2002).

This procedure provided several measurements a week throughout the bathing season (June, July and August) of 2015. This means a long-term and constant series of data (13 weeks). Measurements were taken simultaneously on the same day of the week (Thursday) for all beaches in order to obtain a synoptic picture for the entire period under study. Field work was undertaken on Thursday as this day is representative of any week-day; week-ends were assumed not to be representative of the week they belonged to but rather were classified as being like any week-day in August. This was also the case for users' frequentation and overcrowding scores.

2.1. Environmental sub-index (E)

This sub-index measures environmental items related to the quality of beaches. It consists of two indicators: Water Quality (WTQ), which includes the sub-indicators Microbiological Water Quality (MIB) and Mesobilogical Water Quality (MEB), and Land Quality (LQ), which encompasses the Vegetation Species Richness (VSR) and Landform Diversity (LFD) sub-indicators.

This sub-index does not include environmental indicators considered in other studies (e.g. Lucrezi et al., 2016) such as pollutants, cyanobacteria, seaweed or marine predators. This is because these are uncommon in beaches on the northern shore of the Mediterranean and their appearance is thus considered as accidental.

The indicators are integrated in accordance with the following equation which places a good deal of importance on both low WTQ scores and high LQ quality; furthermore, low WTQ scores may neutralize LQ scores. The algorithm is formulated as follows:

E = (WTQ*0.50)*(LQ*0.50)

WTQ = (MIB*0.50)+(MEB*0.50)

LQ = (VSR*0.60)+(LFD*0.40)

2.1.1. Water Quality sub-index (WTQ)

2.1.1.1. Microbiological Water Quality (MIB)

The microbiological water quality indicator is set in accordance with Directive 2006/7/CE, a European directive on the management of bathing water quality. This act ensures microbiological hygiene by measuring organisms that cause fecal pollution (Table 3).

On most of the northern Mediterranean shore, water quality is good and sewage treatment is proficient, so Directive 2006/7/CE is not violated and high water quality standards are generally assumed (Ariza et al., 2010). Consequently, a positive value for this parameter in the E sub-index does not improve the final score, although low values may neutralize final scores. This sub-index is calculated according to the regulations ISO 7899-1 and ISO 9308-3. Measurements must be taken weekly and the analyses are carried out by government officers because these values are legally regulated. However, some agencies only provide measurements every two weeks.

2.1.1.2. Mesobiological Water Quality (MEB)

Mesobiological quality is established by the number and type of jellyfish detected on the seashore (Table 4). Jellyfish are a serious nuisance for beachgoers, even in low numbers and can disrupt people's enjoyment of the beach, as the respondents' questionnaires revealed. Given this, it is surprising that measuring numbers of jellyfish is not a widely used methodology for assessing swimming water quality (Pendleton, Martin, & Webster, 2001; Cervantes & Espejel, 2008; Botero et al, 2014).

The data is acquired by field work in which a 100 m transect is sampled every kilometer along the beach; if the beach measures less than one kilometer, the entire shoreline is sampled. Jellyfish are counted both on the beach and in the sea in a five meter buffer on either side of the water's edge. As in the previous index, a good value does not make a difference to the final score, but a poor one may neutralize it. Consequently, MEB penalizes beaches for the presence of stinging jellies and the abundance of non-stinging ones, but does not reward their absence. Measurements are required weekly.

2.1.2. Land quality (LQ)

The Land Quality indicator is made up of two sub-indicators: vegetation species richness (VSR) and landform diversity (LFD).

2.1.2.1. Vegetation species richness (VSR)

Vegetation species richness takes into account the number of plant species in the vicinity of the beach. Only indigenous plants and those with a non-cosmopolitan distribution are considered as indicator plants (Table 5).

Data is acquired by field work in which the inventory plot is a 100 m buffer area from the external border of the beach with no vegetation heading inland. A point is given to each different species recorded; if the species is included in Annex II of the European Commission's Habitats Directive, Directive 92/43/CE, the species is given an extra point. After 21 plants have been recorded, no further points are given. The final result is multiplied by 0.60 and add to the landform diversity sub-indicator because vegetation is regarded as better environmental indicator than geomorphology (Zonneveld, 1995). This inventory is conducted yearly.

2.1.2.2. Landform diversity (LFD)

Landforms have been shown to be useful for assessing beach quality (Pintó, Martí & Fraguell, 2014) and their diversity is assessed by identifying and inventorying different types. The inventory records two different types: those caused by the deposition of sediment and those cause by erosion (Table 6).

Data is acquired by surveying the beach. The final result is multiplied by 0.40 and added to the VSR sub-indicator. This inventory is undertaken yearly.

2.2. Landscape sub-index (L)

This sub-index measures the beaches' aesthetic qualities, although some of the aspects considered also take into account environmental qualities. The sub-index consists of four indicators: appearance (APP), artificial land cover (ALC), heritage (HRT) and view shed (VSH). This sub-index includes most of the components used in other well-known procedures for a beach's aesthetic qualities (Ergin et al., 2004; Rangel-Buitrago et al., 2013; Williams, Rangel-Buitrago, Anfuso, Cervantes & Botero, 2016).

The indicators are integrated with the following algorithm, which gives preference to view sheds as these play a key role in landscape appraisal (Linton, 1968):

LI= (APP*0.2)+(ALC*0.4)+(HRT*0.2)+(VSH*0.2)

2.2.1. Appearance (APP)

The appearance indicator assesses a beach's aesthetic qualities and cleanliness by recording water color, levels of litter and oil patches, among other components. Data is acquired by field work using a slightly more restrictive procedure than the one suggested by Coastwatch (http://coastwatch.org). Data is gathered from a 100 m transect sampled every kilometer along the beach; if the beach measures less than 1 km, then the whole beach is sampled. Data is collected on land and in the sea in a 5 m buffer on either side of the water's edge. Only items of litter that are larger than 10 cm are considered (Table 7).

The result of this indicator is the most frequent value (i.e. mode) in every survey. The result is directly add to the others indicators in the landscape index. Measurements are required weekly.

2.2.2. Artificial land cover (ALC)

Artificial land cover is calculated by weighting for land cover existing in a 500 m buffer area from the seashore. The weighting is lowered as the level of natural land cover diminishes; consequently, a built environment gives a lower score than an unbuilt environment. Final normalization was given by an expert panel (Table 8). Data is acquired by GIS analysis and land cover maps at a scale of 1:25.000.

Scores are calculated according to the percentage for each category and multiplied by the normalized value. Results are added up and divided by 100 so they can be adjusted to a 0-1 scale. It is important to notice that this index shows the degree of artificial land cover but does not provide an aesthetic evaluation. This analysis is undertaken yearly.

2.2.3. Heritage (HRT)

Heritage values are determined by recording the historical and cultural features existing in a 1 km buffer around the beach. Examples of heritage elements are archaeological sites, watchtowers, windmills, lighthouses or salt-water lakes. Facilities such as purpose-built viewing points or environmental education centers are also included in this group (Table 9). Data is obtained by field work; if local heritage inventories exist, these can also be used.

Each heritage item is multiplied by 0.1 and final scores are added up; up to 10 items can be considered. It is important to notice that this index counts the number of heritage items, not their meaning or significance. This analysis is undertaken yearly.

2.2.4. Viewshed (VSH)

Viewshed is assessed by weighting land cover in a 25 km radius around the shoreline; both the inland and offshore areas of the shoreline are assessed to determine the skyline viewsheds. Land cover is normalized according to expert criteria and previous works on landscape aesthetics (Linton, 1968; Dunn, 1974; Daniel, 2001) (Table 10). Data is acquired by GIS analysis, and land cover maps are surveyed at a scale of 1:25.000.

Scores are calculated on the basis of the percentage for each category and multiplied by the normalization value. Results are added up and divided by 100 so they can be adjusted to a 0-1 scale. This analysis is undertaken yearly.

2.3. Recreation sub-index (R)

This sub-index measures social and cultural items related to beaches' recreational capacity. The index consists of three indicators: facilities (FAC), frequentation (FRQ) and recreational activities (RTA). This sub-index is specially intended for beaches in protected natural areas, which are quite different from beaches in urban or semi-urban environments. This is the reason why both the meaning and the interpretation of some indicators may differ slightly from those used in other procedures focused on built-up beaches (Cervantes & Espejel, 2008; Ariza et al, 2010). Some common components, such as the presence of public telephones or illumination at night (Lucrezi et al., 2016) were left out because they are not relevant to beaches in protected areas. The indicators are integrated using the following algorithm which prioritizes FRQ due to its importance in fragile areas.

$$RI= (FAC*0.25) + (FRQ*0.5) + (RTA*0.25)$$

2.3.1. Facilities (FAC)

The facilities indicator records signs, parking lots and other commodities to measure ease of access to the beach. Information about protection of the environment is also taken into account given its importance to the social function of protected areas (Eagles & McCool, 2002). Data is acquired by field work (Table 11).

The sub-index takes into account signposting within 500 m of beach and signposting further away from the beach. The parking lot indicator records whether parking lots are legal or not. The environmental protection indicator records the beach's level of protection and whether beachgoers can acquire environmental information there. The results of all the indicators are added up using a linear sum; the maximum score may be 1. This analysis is undertaken yearly.

2.3.2. Frequentation (FRQ)

Frequentation refers to the amount of visitors to the beach and it is useful for assessing overcrowding. This indicator is related to beach usage patterns and carrying capacity, and it is of the utmost importance when considering recreational issues. Data is obtained by field work and GIS analysis. Scores are based on the number of users per 100 m^2 plots and thus the amount of sand available to each user; the higher the sand availability the higher the score, as such beaches clearly do not suffer from overcrowding (Table 12). Three threshold values of sand avaliability per user are given in accordance with the literature (Yepes, 1999; Silva, 2002; Ribeiro, Ferreira & Silva, 2011; Zacarias, Williams & Newton, 2011), the expert panel's criteria and the responses to questionnaires.

The number of beachgoers is counted by direct survey, using 1:2.500 orthophotos as a reference; this procedure was chosen because it is more accurate than positioning with GPS devices. Visitors are always counted on the same day of the week at the same time for all beaches; the count follows the seashore and marks the position of each visitor in the orthophoto. For better referencing, a 100*100m grid was placed in the orthophoto, and all landmarks, such as paths, lifeguard sites or stabilized dunes were highlighted. This methodology, though highly time consuming, brought better results than any other GPS-based procedure. Measurements are required weekly.

2.3.3. Recreational activities (RTA)

Recreational activities, either because of their abundance or their type, may degrade the landscape and damage the reputation of beachgoers because protected areas are not considered recreational areas (at least in their entirety). The main recreational activities on the beaches studied include water sports, recreational fishing, shell fishing and buggy racing. Data is acquired by field work (Table 13).

A synoptic survey of the beach is obtained by counting recreational activities at the same time as frequentation. Counting ceases after the score reaches 10 scores. Data is added up linearly and integrated to the R sub-index. Measurements are taken weekly.

3. Study area

The fieldwork was conducted on the Catalan coast in north-eastern Spain. Four recreational beaches located in protected areas were selected: Muntanyans, Cala Fonda, Riumar and Trabucador (Fig. 2). The two former beaches belong to the Costa Daurada tourism brand and the two latter to the Terres de l'Ebre, both of which are recognized brands that attract tourists through their sun, sea and sand (Mariné-Roig & Anton Clavé, 2016). The beaches present both similarities (e.g. sandy beaches, Blue Flag awards) and dissimilarities (e.g. some beaches are in a small pocket bays while others are exposed; some are easy to reach from resorts while others are quite remote.) All of them are in protected areas recognized by the European Union and other international organizations, and they appear as attractions in all tourist brochures for the region (Tripadvisor, 2016).

3.1. Muntanyans

Muntanyans is a long (3 km) sandy beach with an average width of 25 m located between the villages of Torredembarra and Creixell, which have developed into coastal resorts since early the 1990s. The beach separates the sea from an area occupied by low (< 3 m) dunes partially covered with scattered vegetation; beyond the dunes, there is a marsh area. The beach, dunes and marsh are included in the European Union's Natura 2000 because of their importance as a stopover for migrating birds (e.g. *Cygnus olor*), a nesting site for others (e.g. *Charadrius alexandrinus*), and endangered flora (e.g. *Pancratium maritimum*). A cord separates the beach from the dunes and the marshes; some paths, hides and information panels are provided to teach the visitors about its natural environment. Seven paths (about

200 m long) flanked by cords link the beach to campsites beyond the protected area; bars, showers and lifeguards are provided along the beach.

3.2. Cala Fonda

Cala Fonda is a small (150 m long, 40 m wide) pocket of sandy beach bordered by 20 m of yellowish limestone cliffs standing by the sea. The whole area is surrounded by pine forests, and there are no nearby settlements or tourist facilities. This is an isolated beach which can only be reached by sea or by a 25 minute walk through a pine forest as there are no roads. The beauty and color of the beach, cliffs and forests mean that they are protected by the Natura 2000 network. The blue sea, the yellow cliffs and green forests together make a lovely vista that is highly sought after by tourists who like to get off the beaten track. Its isolation and dramatic landscape makes this beach a popular destination among naturist beachgoers.

3.3. Riumar

Riumar is a 1 km long and 60 m wide sandy beach that skirts a shallow bay. It is enclosed by high (> 3 m) sea dunes which are active near the beach and partially fixed by scattered vegetation towards the interior; at the dunes are over 200 m wide at their widest point. This beach is on the northern side of the Ebro Delta Natural Park, which is protected by the Natura 2000 network, the Ramsar convention and the UNESCO’s Man and Biosphere Program. The beach has bars, showers and lifeguards, and is a popular destination with families due to its abundant sand and shallow water. The landscape is astonishing and the blue of the sea and sky and the golden dunes combine to make intense contrasts of color. The beach has been chosen as a setting for commercials and movies on several occasions.

3.4. Trabucador

Trabucador is a long (about 6 km) remote and exposed sandy beach consisting of a 130 m wide spit on the southern side of the Ebro Delta Natural Park. This beach is remarkably scenic as the eastern side of the spit faces the open sea while the western side faces a bay opposite to the mainland coast. The area has some low dunes and scattered vegetation and its most remarkable feature are the vistas; water bodies on both sides of the spit and the mountains on the distant mainland coast create a surreal sensation that is very appreciated by visitors who like to get off the beaten track. At the end of the spit, a little peninsula contains a saltwater lake. Flamingoes (*Phoenicopterus roseus*), turtles and other marine life are easy to see. In addition to naturalists, the beach attracts domestic tourism and surfers who usually camp in vans. No specific areas are delimitated, though nudism is a common practice.

4. Results

The DIBA shows the final scores for each beach for every week in the bathing season (Table 14). Final scores vary across the beaches and weeks, but the general trend is as good with average values of 0.66. Higher scores are found in the E sub-index, though the MIB and MEB sub-indicators may neutralize final scores if those scores are lower. L and R sub-indices have the same averages, although R scores are more variable mainly owing to the

FRQ scores, which tend to lower final scores, and to the RTA scores, which tend to increase them.

Riumar and Trabucador in the Ebro Delta Natural Park performed particularly well, whereas the overall scores for Muntanyans were the worst of all four beaches. This is especially true in August because of the higher FRQ rates. Scores for Riumar are slightly higher than those for Trabucador, and Riumar obtained the maximum score on three occasions (4^{th} week of June and 1^{st} and 5^{th} week of July).

This dynamic procedure shows that Riumar and Trabucador have good DIBA scores for eleven weeks (84.6% of the bathing season), whereas Muntanyans has good scores for three weeks and Cala Fonda has only one (7.69%).

5. Discussion

The main aim of this research was to design and test a procedure to assess the quality of four Spanish beaches in protected areas. By developing the DIBA, a number of specific goals were also achieved. The first was to synthesize as many items as possible for assessing beaches in protected areas. The second was to develop a dynamic procedure for assessing quality throughout the bathing season. Finally, the last objective was to enable beaches to be compared.

5.1. Synthetizing items

Several items and a number of parameters have been used in other procedures for assessing beach quality. Ergin et al. (2004) designed a procedure based on 26 parameters, Cervantes & Espejel (2008) used 47 indicators, Ariza (2010) used a composite index based on 13 sub-indices, and Lucrezi at al. (2016) demonstrated a matrix based on 131 indicators. The DIBA was created with three sub-indices consisting of 9 indicators and 4 sub-indicators, which at first sight may seem a low number. The sub-indices refer to environmental, landscape and recreational issues encompassed by Williams & Micallef (2009) “big five”. Although other procedures use more indicators to assess beaches, it is not clear that they have greater overall efficacy. According to Lucrezi at al. (2016), some indicators cannot always be recorded due to the multi-faceted characters of beaches or the various approaches that may be taken to certain items. Furthermore, field work for a good deal of parameters is hampered by a significant lack of information. This is also true when it comes to gathering field data using non-standard or inappropriate sampling methods. In addition to this, a large number of indicators is not synonymous with better performance or more in-depth analysis, as many items may record basic or irrelevant information and make no real improvement to the index’s performance.

However, the DIBA does include a set of indicators relevant to beaches in protected areas (i.e. vegetation, landforms) which are left out of other procedures, such as the Blue Flag assessment (Boevers, 2008).

Certain indicators used in the literature were not adopted in the present study as they were considered irrelevant to the beaches studied, for example erosion, marine predators, security, recreational activities and so on (Botero et al., 2014). These were not applied to the beaches analyzed in the present study as they would not have produced additional information regarding beaches in protected areas or the environments in which they are located.

5.2. Dynamic procedure

By assessing beach quality on a weekly basis throughout the bathing season, the DIBA takes a dynamic approach to assessing beach quality. This is of the utmost importance because beach behavior and quality is not the same throughout the bathing season, and mean scores might not be representative of reality. By taking weekly records, more reliable data can be obtained and a deeper understanding of beaches can be achieved. Non-dynamic methods are useful for procedures that focus on permanent or long-term qualities such as scenery, economic value or simply general assessment (e.g. Ergin et al., 2004; Cervantes & Espejel, 2008). But for fragile environments or for rapidly changing situations, a dynamic procedure provides a more accurate picture of the world. This is also true for procedures used in management and applied studies (Botero et al., 2014). Similarly, Lucrezi et al. (2016) points out that repeating the analyses is important to prevent any given situation from being regarded as representative.

Different preferences and perceptions are explained by the characteristics of the beaches and the beach-user profile (Roca & Villares, 2008). Therefore, a dynamic procedure helps prioritize environmental educational programs that are specifically tailored to visitors to protected areas.

The DIBA index consists of six parameters (indicators or sub-indicators) that are recorded on a yearly basis (e.g., vegetation or viewshed) and which thus provide reliable information for the whole year. Although they are recorded this way, some parameters (e.g., heritage) do not need to be taken on a yearly basis because they are not expected no change noticeably during this period. Five parameters (indicators or sub-indicators) are collected weekly and some of them are heavily weighted, so substantial differences in the final score may be found if they are taken on a long-term basis. Finally, it is important to point out that two parameters (micro and mesobiological water quality) can neutralize E and lower noticeably DIBA scores, as happened for Riumar (1st and 2nd August) and Trabucador (5th July and 1st August).

5.3. Comparison of beaches

This research allowed a number of aspects related to beach quality to be compared at four selected beaches and their global performance on the DIBA index to be determined.

The beaches' scores on the DIBA decrease over the 13 weeks of the bathing season. Scores for all the beaches are neutral or good. These overall positive scores are unsurprising because beaches in protected areas are usually outstanding, particularly when it comes to aesthetic qualities (Rangel et al., 2013). Consequently, even if a beach in a given set performs particularly well, this may only be indicated by slight differences in its final score. A high correlation may be seen between overcrowding and reduced beach quality because crowdedness is particularly weighted. Lower scores may be improved via a number of actions but as has been noticed on other occasions, human factors are easier to improve than physical factors (Williams et al., 2016).

The kind of comparison undertaken in the present study can be beneficial for many reasons. The most evident is that, by contrasting different beaches within a same region or geographical area, managers have more information and are thus better able to plan activities and assess carrying capacity. By introducing minor items or readjusting weighting, the index can also be used to assess beaches in different environments. Beaches vary widely and flexible procedures are needed to assess them (Botero et al., 2014). Consequently, the DIBA can be used as an alternative to other widely used quality assessment procedures such as the Blue Flag award.

6. Conclusions

The aim of this study was to develop a dynamic procedure to assess beach quality in protected areas. Four beaches on the Spanish Mediterranean coast were chosen for the case study. The DIBA proved to be a useful tool for evaluating beaches because it collects data on a weekly and therefore dynamic basis throughout the bathing season. Its composite index allows good and bad parameters to be identified and the resulting scores to be explained. The four beaches tested generally obtained good scores, with lower scores recorded during certain weeks due to overcrowding and poor water quality.

A number of items important to beach management (e.g., economic indicators) were deliberately excluded from the DIBA as they were considered to be outside the scope of the present research. However, in certain cases it may be interesting to complement the DIBA with economic indicators. One limitation of this study is that it did not record beachgoers’ attitudes to the beaches they visited, although this was because the index was intended to focus on beach quality rather than on the impressions of tourists.

The tool is useful for comparing different beaches, not only during the bathing season but throughout the year, and its application over the long-term will provide a better understanding both of beaches and protected areas.

Geolocation information

Mediterranean, Spain, Catalonia

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Tables

Residential, tourist and commercial zones	Built-up area (%)	Built-up coastal index (%)
Antalya-Analya (Turkey)	90.62	80.51
Benidorm-Costa Blanca (Spain)	95.80	74.03
Marbella (Spain)	95.39	97.75
Nice-Côte d'Azur (France)	94.15	98.52
Salou-Costa Daurada (Spain)	93.82	86.45
Rimini (Italy)	79.56	100.00

Table 1. Built-up area and built-up coastal index for the main Mediterranean tourist destinations.

Source: GRATET (2013).

Numerical values	Nominal scale
< 0.50	Deficient
≥ 0.50 - < 0.65	Neutral
≥ 0.65 - < 0.85	Good
≥ 0.85	Very good

Table 2. Correspondence between numerical values and nominal scale.

	Very good	Norm. value	Good	Norm. value	Deficient	Norm. value
Fecal streptococcus	<100	1.0	100-185	0.5	>185	0.0
Escherichia coli	<250	1.0	250-500	0.5	>500	0.0

Table 3. Microbiological water quality assessment. Scores are expressed in colony-forming unit, cfu/100ml. MIB scores are normalized to a 0-1 scale (Norm. value column)

Species	Degree of harm	Very frequent	Norm. value	Less frequent	Norm. value	Absent	Norm. value
Pelagia noctiluca	high	>21	0.0	≤20	0.0	0	1.0
Rhizostoma pulmo	medium	>21	0.0	≤20	0.0	0	1.0
Cotylorhiza tuberculata	low	>21	0.0	≤20	0.5	0	1.0
Aequorea forskalea	low	>21	0.0	≤20	0.5	0	1.0

Table 4. Mesobiological water quality assessment. All four commonest jellyfish in the Mediterranean are listed. Scores are expressed as numbers of individuals. MEB scores are normalized to a 0-1 scale (Norm. value column).

	Low richness	Norm. value	Medium richness	Norm. value	High richness	Norm. value
Number of species	<10	0.1	11-19	0.5	>20	1.0

Table 5. Vegetation species richness assessment. Scores are expressed in numbers of individuals. VSR scores are normalized to a 0-1 scale (Norm. value column).

	Landform features	Norm. value
Erosion	cliffs ≥ 10 m	0.6
	cliffs < 10 m	0.3
	features (stack, sea caves, tafoni, etc.)	0.1 per feature up to 3 features
	good color contrast	0.1
Deposition	dunes ≥ 5 m	0.6
	dunes < 5 m	0.3
	features (spit, tombolo, shoal, etc.)	0.1 per feature up to 3 features
	good color contrast	0.1

Table 6. Landform diversity assessment. Values are expressed in number of landforms. LFD scores are normalized to a 0-1 scale (Norm. value column).

Item	Very good	Norm. value	Good	Norm. value	Deficient	Norm. value
Water color	blue	1.0	blue-greenish	0.5	greenish, brownish, yellowish, greyish	0.0
Water transparency	≥ 1.5 m	1.0	1.5-0.5	0.5	≤ 0.5	0.0
Algae patches	0	1.0	1	0.0	>1	0.0
Dead animals	0	1.0	1-3	0.5	>3	0.0
Oil patches	0	1.0	1	0.0	>1	0.0
Cigarette butts	0-6	1.0	7-14	0.5	>14	0.0
Litter on sand	0-6	1.0	7-14	0.5	>14	0.0
Litter floating in water	0-3	1.0	4-7	0.5	>7	0.0

Table 7. Appearance assessment. Scores are expressed in units. APP scores are normalized to a 0-1 scale (Norm. value column).

Land cover class	Norm. value
Open water	1.0
Coastal morphology	1.0
Natural vegetation	1.0
Croplands	0.5
Built-up area	0.0

Table 8. Artificial land cover assessment. ALC classes are normalized to a 0-1 scale (Norm. value column).

Item	Norm. value
Heritage item	0.1

Table 9. Heritage assessment. Scores are expressed in units.

Item	Norm. value
Inland water	0.5
Marine water	0.8
Coniferous forest	1.0
Sclerophyllous forest	0.9
Broad-leaved forest	1.0
Shrub and grassland	0.8
Irrigated herbaceous crops	0.8
Non-irrigated herbaceous crops	0.7
Irrigated fruit trees	0.8
Non-irrigated fruit trees	0.7
Road network	0.0
Continuous urban fabric	0.5
Bare land	0.5
Beaches, dunes and sand plains	0.8
Non-continuous urban fabric	0.0
Inland marshes	0.8
Vineyards	0.7
Burnt areas	0.0
Industrial or commercial unit	0.0

Table 10. Viewshed assessment.

	Features	Norm. value	Features	Norm. value	Features	Norm. value
Signposting						
	Signposting exists beyond 500 m at all accesses points to the beach	0.3	Signposting exists in the nearest 500m at any access point to the beach	0.2	No signposting	0.0
Park lot						
	Legal parking lot	0.2	Illegal or unregulated parking lot	0.1	No parking lot	0.0
Environmental information						
	Information about the environment and environment law.	0.3	Information about the environment law, only. Information about the environment, only	0.2	No environmental information	0.0
Commodities						
	Lifeguard service	0.2	Showers, bins, cocktail bar, etc.	0.1	No commodities	0.0

Table 11. Facilities assessment. ACS scores are normalized to a 0-1 scale (Norm. value column).

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Item	Very good (m^2/user)	Norm. value	Good (m^2/user)	Norm. value	Deficient (m^2/user)	Norm. value
Sand availability	>10	1.0	5-10	0.5	<4,9	0.0

Table 12. Frequentation assessment. FRQ scores normalized to a 0-1 scale (Norm. value column).

Activity	Number of users doing activity (at all the beach count)	Norm. value	Number (at all the beach count)	Norm. value
Dog walking	<5	0.0	≥ 5	0.2
Buggy racing	<4	0.0	≥ 4	0.4
Water sports	<5	0.0	≥ 5	0.1
Recreational fishing	<5	0.0	≥ 5	0.1
Shell fishing	<5	0.0	≥ 5	0.1
Others	0	0.0	≥1	0.1

Table 13. Recreational activities assessment.

	E				L				R				DIBA			
	M	CF	R	T	M	CF	R	T	M	CF	R	T	M	CF	R	T
1st week June	0.76	0.70	1.00	0.46	0.59	0.68	0.59	0.74	0.75	0.40	0.83	0.78	0.67	0.62	0.75	0.68
2nd week June	0.76	0.70	0.75	0.35	0.59	0.68	0.61	0.74	1.00	0.40	0.88	0.88	0.73	0.62	0.71	0.67
3rd week June	0.76	0.70	0.75	0.35	0.59	0.68	0.63	0.76	0.50	0.65	0.88	0.88	0.61	0.68	0.72	0.68
4th week June	0.76	0.70	1.00	0.46	0.59	0.68	0.63	0.76	0.50	0.40	0.88	0.90	0.61	0.62	0.79	0.72
1st week July	0.76	0.70	1.00	0.46	0.59	0.68	0.61	0.72	0.50	0.40	0.88	0.90	0.61	0.62	0.78	0.70
2nd week July	0.76	0.70	1.00	0.46	0.59	0.68	0.61	0.72	0.50	0.40	0.98	0.73	0.61	0.62	0.80	0.66
3rd week July	0.76	0.70	0.75	0.46	0.59	0.68	0.61	0.74	0.48	0.40	0.73	0.73	0.60	0.62	0.68	0.67
4th week July	0.76	0.70	0.75	0.46	0.59	0.68	0.63	0.72	0.50	0.40	1.00	0.78	0.61	0.62	0.75	0.67
5th week July	0.76	0.70	1.00	0.23	0.59	0.68	0.57	0.70	0.75	0.40	0.98	0.90	0.67	0.62	0.78	0.63
1st week August	0.57	0.70	0.50	0.35	0.59	0.68	0.63	0.70	0.50	0.40	0.58	0.73	0.56	0.62	0.59	0.62
2nd week August	0.76	0.70	0.50	0.46	0.59	0.68	0.63	0.72	0.50	0.40	0.63	0.73	0.61	0.62	0.60	0.66
3rd week August	0.76	0.70	1.00	0.46	0.59	0.68	0.61	0.76	0.50	0.40	0.58	0.73	0.61	0.62	0.70	0.68
4th week August	0.76	0.70	1.00	0.46	0.59	0.68	0.63	0.70	0.50	0.40	0.60	0.78	0.61	0.62	0.72	0.66

Table 14. Sub-indices and final score for the DIBA index. Beach key: M: Muntanyans; CF: Cala Fonda; R: Riumar; T: Trabucador. More information about ranges and numerical values is shown on Table 2.

Figures

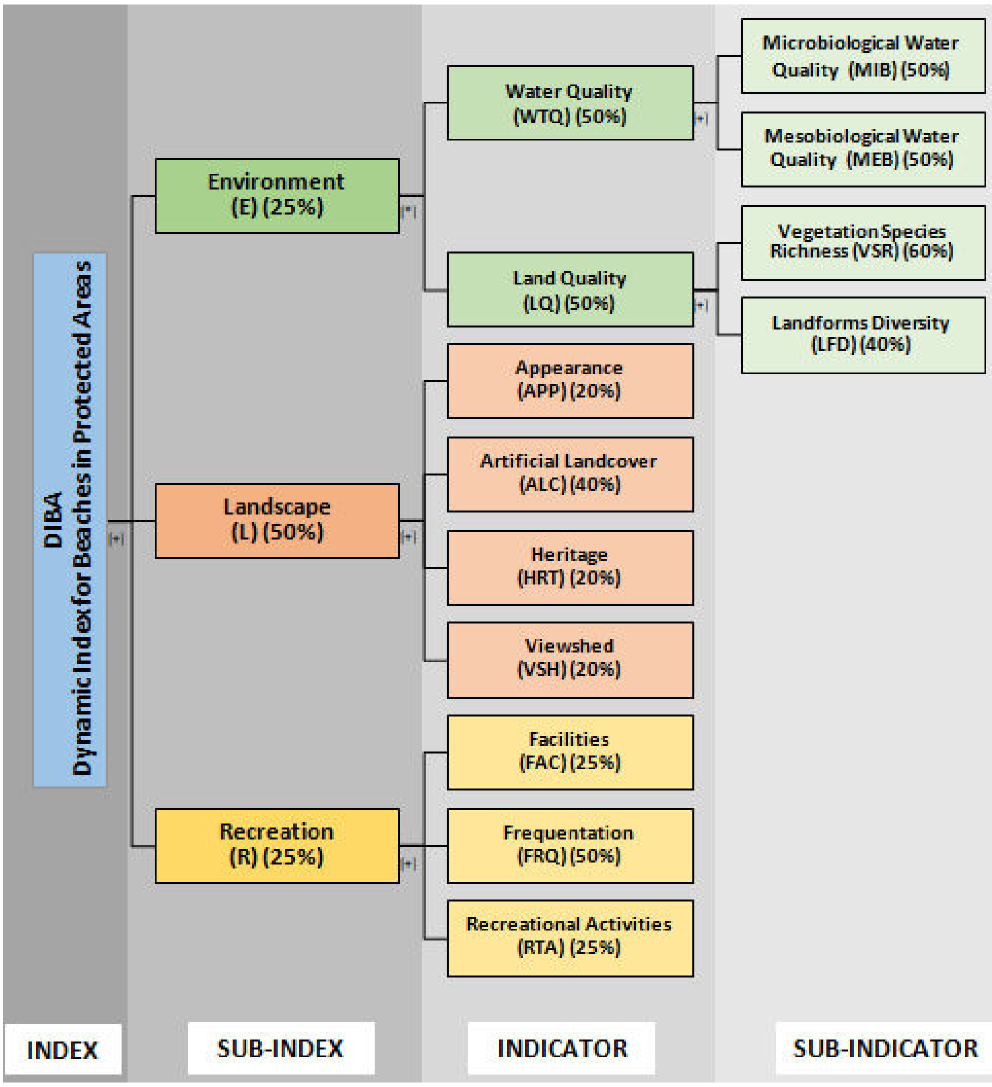

Fig. 1. The DIBA workflow.

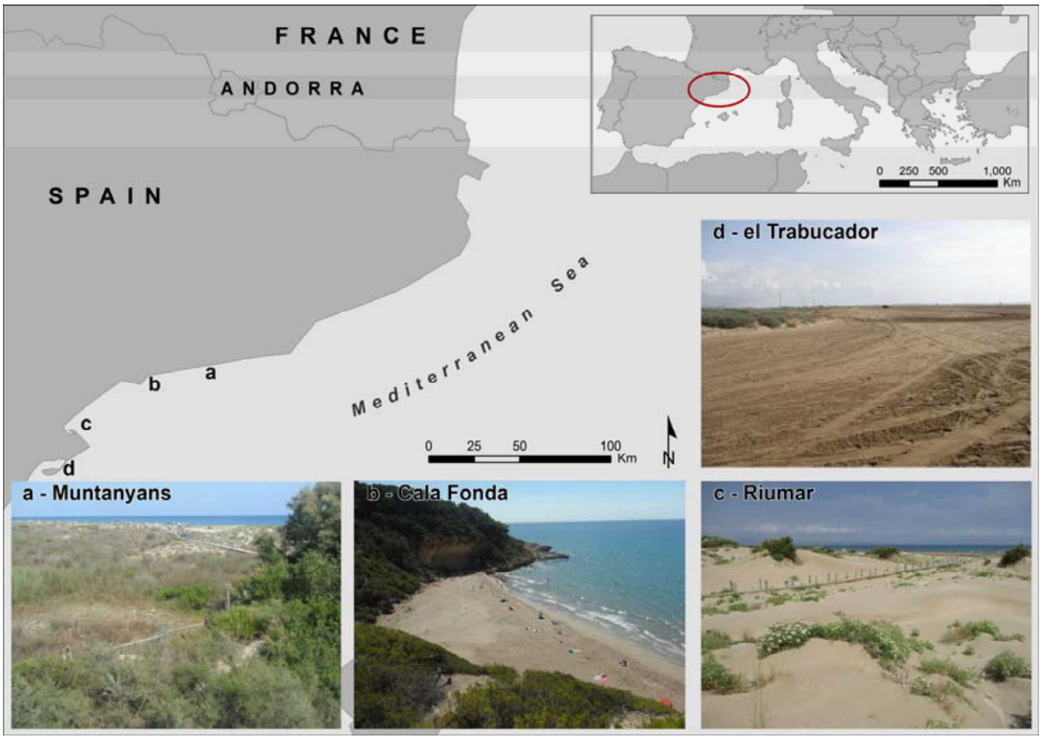

Fig. 2. Overview of the beaches.