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Use and transformation of beaches as a tourism resource by promoters and managers in oceanic islands. A conflict for geoheritage conservation and social preferences in the canary islands

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ABSTRACT

In the case of the Canary Islands (Spain), human occupation on beaches has generated environmental and landscape transformations and a loss of their geoheritage values. In this sense, this archipelago could be a good example to demonstrate the paradigm at the regional scale at first and island scale at second, that the colour and composition of the beaches are determinant for urban-tourist development. The beaches with the colour and composition that managers and promoters prefer most are those that have withstood the greatest anthropogenic pressure, and may lead to socio-environmental conflicts. For this, the aim of this work is to characterize and identify beach typologies according to their sedimentological characteristics, the degree of urban-tourist occupation, and the environmental changes and artificialisation that have taken place over the last sixty years in the beaches of La Palma, Tenerife and Fuerteventura. For this purpose, the General Catalogue of Beaches and Maritime Bathing Areas (the latter were excluded from the study) issued by the Canary Islands Government was used. This source was spatially and statistically analysed using a Geographic Information System (GIS) and related to socio-environmental variables extracted from geo-referenced sources. Orthophotos from 1957 and more recent years were also used for the historical characterization. Finally, this information was contrasted with social preferences, obtained from online surveys, about the physical configuration of Canarian beaches. Results show that the quantity and distribution of beach types (grain size and beach colour) differ for each island, and that beach use depends on its typology, with sandy beaches being the most used as an urban-tourist resource and pebble-cobble beaches the most transformed to respond to sand beach user demand. These and other factors that have affected the evolution of these beaches and the degree of conservation of their natural functions and geoheritage values are discussed. The responses to the survey show significant patterns related to user profile and preferences regarding the beach environment and recreational services. The importance of social preferences and beach transformation is discussed to understand the evolution of beach management in the Canary Islands and the identified conflicts.

1. Introduction

Beaches provide a wide variety of ecosystem services including, among others, the provision of habitats (Defeo et al., 2009; Beck et al., 2001), buffering against extreme wave events (Barbier et al., 2011) and food production (Defeo et al., 2009). Since around 1960, leisure and tourism has emerged as the most exploited cultural ecosystem service (Enriquez-Acevedo et al., 2018), to such an extent that in many cases it has destabilised the natural beach balance (Marrero-Rodríguez et al., 2021; Pinardo-Barco et al., 2023). In this context, many coastal cities and islands base their economy on sun and beach tourism (Klein et al., 2004). However, most of these already mature destinations are facing

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new challenges caused by demand profile changes towards less massive types of tourism, such as geotourism, which are closer aligned to the conservation of coastal resources (Simancas et al., 2020; Marrero-Rodríguez and Dóniz-Páez, 2022). Due to overexploitation, sun and beach tourism causes both environmental alterations to the physical environment, such as water pollution from wastewater discharges or the appearance of cyanobacteria (Cohen, 1978), and social alterations (Pizam and Milman, 1986), such as displacement of the local population, tourism phobia and a reduction in the quality of the visit due to overcrowding. In parallel, many of these environments are characterised by an important geoheritage values, derived from the interaction of sedimentary and volcanic processes and high levels of biodiversity (Dóniz-Páez et al., 2020).

Beaches are places visited by users with varying social profiles (age, gender, origin, level of education, etc.) and different motivations when choosing the natural and anthropic attributes they prefer (Roca and Villares, 2008). Segmenting preferences according to social profile is crucial to understand the opinions and priorities of beach users (Vaz et al., 2009; Lukoseviciute and Pereira, 2021). Knowledge about preferences can serve as guidelines for those in charge for better management of beach services and the conservation of the environment's natural values, thereby increasing the level of user satisfaction (Chen and Teng, 2016). These are criteria that can improve the planning and decision-making process (Ramires et al., 2018; Lucrezi et al., 2018).

To satisfy user needs, which sometimes exceed the carrying capacity of these spaces (Da Silva, 2002), beaches are often subjected to adaptation and transformation actions. Among others, these include the installation of showers, sunbeds, kiosks, etc. (de Schipper et al., 2021), the execution of daily cleaning tasks (Pinardo-Barco et al., 2023), widespread construction in their immediate surroundings (García-Romero et al., 2016), the deployment of infrastructures to create calm waters and prevent erosion (Lorenzoni et al., 2012), and even the incorporation of sand from other places (Asensio-Montesinos et al., 2020) which, on many occasions, do not have the same characteristics (colour, grain size, composition) as the beach to which they are applied.

In the context of this research associated with the study region, three-quarters of small countries are islands of fewer than one million inhabitants, and small island regions tend to suffer from economic limitations. At the same time, these regions commonly specialise in tourism due to the availability of accessible natural resources such as beaches, landscapes, and sunny weather. In many cases, this type of region presents a comparative advantage for tourism, and therefore its economy is often strongly dependent on this industry (Santana-Gallego et al., 2011).

Many tourism developers and promotors continue to compete for the best coastal areas, which, paradoxically, are often the least altered and usually with a more natural appearance. For its part, beach colour is an important component of the coastal landscape (Pranzini et al., 2010) and varies according to the colour of the sand and rocks adjacent to the beach (Wiegel, 2006). In turn, sand colour depends on the relative proportions of bioclasts and lithoclasts (Calhoun and Field, 2008), which are often mixed in different ratios (Gómez-Pujol et al., 2013). Colour is a variable that has traditionally been considered when selecting stretches of coastline for urban-tourist development. This is based on the assumption that tourists prefer beaches with white and golden sand (Williams and Micallef, 2009) and that they show a progressive dislike for the beach as the sand becomes darker in colour (Pranzini and Vitale, 2011). Sand colour is especially important on tropical beaches where foreign tourists tend to have a greater demand and desire for white sand than on mid-latitude beaches (Baldacchino, 2010). As argued by Pranzini et al. (2016: 1): "influenced by travel agency brochures and TV documentaries, who strictly associate a tropical beach with white coral sand, tourists are frequently disappointed to find dark coloured – if not completely black, e.g. derived from basalt rocks – sand, which is frequently found on many volcanic islands".

In this context, the present research study aims to answer five main questions, four of which are directly related to the urban-tourist occupation of beaches in the Canary Islands. For this purpose, three islands (La Palma, Tenerife and Fuerteventura) were selected out of the eight islands that make up the archipelago. Taking into account this spatial context, the first four questions are as follows: i) Is the availability of the beach resource the same on all the islands studied? ii) Which of the islands studied have experienced the greatest artificialisation of their beach environments? iii) Which are the most commonly used types of sediment, in terms of colour and composition, for the creation of artificial beaches in urban-tourist developed areas? and iv) Do urban beaches, subject to greater pressure and artificialisation, currently maintain their natural colour and composition? Finally, a fifth question linked to the local social environment is posed: v) What preferences do resident users in the Canary Islands have regarding the degree of transformation of the immediate surroundings of the beach and its colour and composition, and what is the importance of these attributes for them? The goal is to verify whether resident user preferences are related to actual beach management and promotion, or, on the contrary, whether management is principally aimed at creating a tourist product for foreign users. The aims of this work therefore include characterizing and identifying beach types according to certain sedimentological characteristics (colour and composition), knowing the degree of anthropogenic transformation associated with these sedimentological characteristics, and acquiring information about social preferences regarding the natural attributes of the beaches. With the above aims in mind, a study is also undertaken of the degree of urban-tourist occupation, including artificialisation, which has taken place in the beach surroundings, and, finally, the socio-environmental factors and conflicts which have generated some of the environmental changes detected on Canarian beaches over the last sixty years are discussed.

2. Study area

The Canary Islands form a volcanic archipelago located in the Atlantic Ocean. The Canary coasts are predominantly rocky, with beaches representing only 17% of their total perimeter of 1550 km (Criado et al., 2011). The extent of beach formation depends on the nature and age of each island. In the older islands, exposed to erosion for longer periods of time, there are relatively wide and gently sloping coastal platforms which favour the transport of sediments by coastal dynamics (Criado et al., 2011) and their subsequent stabilization. The composition of marine sands presents a high proportion of organic materials, including shells, molluscs, and seaweed meshes (Meco and Stearns, 1981), in some islands, while in others lithoclasts predominate (Mangas & Pérez-Chacón Espino, 2023). For these reasons, a strong contrast can be detected between islands following a clear E-W gradient. On the coasts of the eastern islands (Fuerteventura, Lanzarote and La Graciosa), the availability of organogenic sediments is very abundant, but decreases towards the central islands (Tenerife and Gran Canaria) and is very scarce in those to the west (El Hierro, La Palma and La Gomera).

According to Alonso et al. (2019), in the Canary Islands there are four main beach types of different origin: i) sandy beaches: wave-formed accumulations, with sand been the dominant grain size; ii) mixed beaches: wave-formed accumulations of sand and gravel (pebbles-cobbles), with the latter been the predominant grain size during winter and the former (sand) during summer, although some beaches remain stable throughout the year; iii) wave-formed accumulations of gravel (pebbles-cobbles) that do not change during the year; and iv) artificial beaches: created by artificial structures and with sand acquired from elsewhere or from the crushing of pebbles.

With respect to human uses, the beaches were a resource virtually unexploited by the islands' inhabitants until the arrival of tourism. In this sense, beach use was limited to occasional bathing for curative or leisure purposes, livestock cleaning, and a very limited extraction of sand for the construction of houses (Sabaté-Bel, 1993) or crop dressing. However, from the 1960s onwards, these uses were progressively replaced by mass sun and beach tourism and by major important urban-tourist developments aimed at satisfying the leisure needs of an ever-increasing number of users (Peña-Alonso et al., 2019).

Three islands were chosen for this study: La Palma, Tenerife and Fuerteventura (Fig. 1). The aim was to have a sufficiently diverse sample of beaches at regional (three islands) and island level (total samples per island), considering volcanic islands at different ages and stages of development and, therefore, with different conditions to facilitate beach formation.

The main features of each island are briefly explained below, following a chronological order from oldest to most recent: i) Fuerteventura is the closest island to the African continent (100 km), with an age of over 20 Ma, an elongated shape (1659 km^2) and a 385 km perimeter. Its age explains why it is the most eroded, and it is characterised by its lower altitude (the highest point, on the Jandía peninsula, is just 817 m above sea level). The coasts of Fuerteventura, unlike most of the other islands, have long stretches of small cliffs, and wide beaches are quite frequent; ii) Tenerife occupies a central position in the Canary archipelago. It is 11.86 Ma old and both the largest (2034 km^2) and the highest of the islands (3718 m above sea level). It contains landforms directly related to volcanism (e.g. stratovolcanoes, calderas, ridges) and originating from erosion and deposition processes (ravines, cliffs, beaches, etc.); and iii) La Palma is located at the western end of the archipelago and is the youngest of the selected islands, less than 1.8 Ma old. Located on the Canary hotspot, it has intense volcanic activity. The island has a perimeter of almost 200 km, a surface area of 708 km^2, and an altitude of 2426 m above sea level at its highest point. The coastline is dominated by cliffs, which are sometimes interrupted by coastal volcanic platforms (lava deltas) caused by lava flowing into the sea during different eruptions. Its beaches are normally associated with the mouths of ravines (Carracedo et al., 2001; Ferrer-Valero et al., 2019; Marrero-Rodríguez and Dóniz-Páez, 2022).

3. Methodology

The methodology comprises four stages. Firstly, the beaches and the variables that characterize them were selected using the General Catalogue of Beaches and Maritime Bathing Areas of the Canary Islands (Gobierno de Canarias, 2023). Secondly, a spatial and statistical analysis was carried out. Thirdly, the changes that the beaches have undergone over time were studied in relation to changes in their typology, their degree of naturalness and the sediment they are formed by. And fourthly, a survey of residents was carried out to find out whether or not their preferences, with respect to beach type, matched the way beaches are used as a resource for urban-tourist development.

3.1. *Source for the beach selection*

One of the sources of information that supports this research is the General Catalogue of Beaches and Maritime Bathing Areas of the Canary Islands (Gobierno de Canarias, 2023), drawn up as an instrument for the use by different public administrations and citizens in general, in accordance with Article 4 of Act 116/2018, of 30 July, which regulates means for the application of the rules and instructions for human safety and for the coordination of ordinary emergencies and civil protection on beaches and other maritime bathing areas of the Autonomous Community of the Canary Islands. The following variables were extracted from this source: i) surrounding conditions: urban (located in urban areas. With many types of commercial services, accommodation and

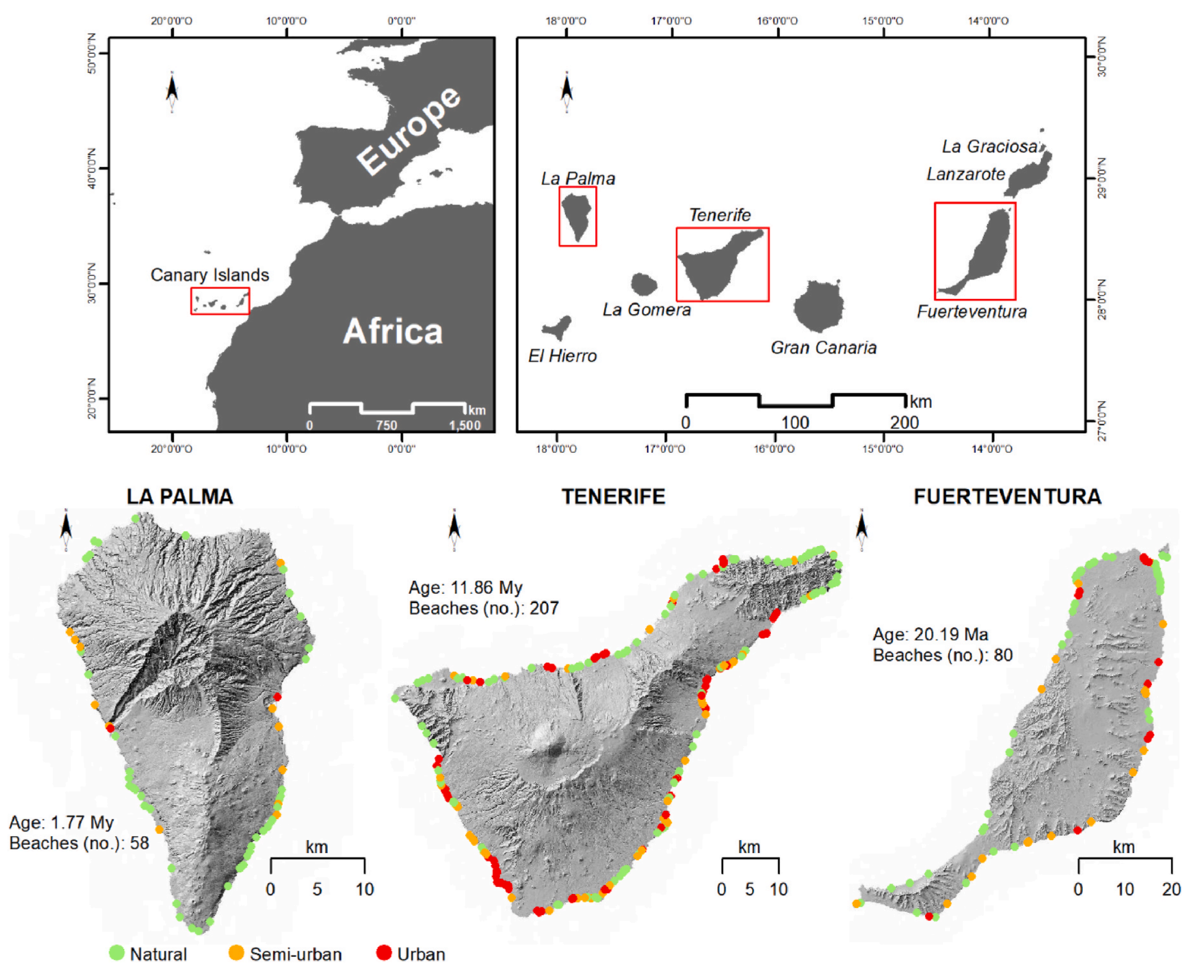

Fig. 1. Study area and beaches identified in the General Catalogue of Beaches and Maritime Bathing Areas (Gobierno de Canarias, 2023a).

facilities. Their recreational value is often far from their conservation value), semi-urban (entities located in medium or low population density areas. With reduced accessibility and moderate attendance. The degree of artificiality of the coastline is less than at urban beaches. The number of facilities is limited), and isolated referred to in this study as 'natural' (Located far from urban and semi-urban areas. Accessibility is reduced. Access is possible by private transport, on foot or by boat, but not by public transport. Such beaches are often preserved. Usually no facilities for users) (Peña-Alonso et al., 2018); ii) composition: this information is associated to the dominant type of beach material, which, together with its categories, correspond to an adaptation of the proposal made by Alonso et al. (2019). In this work, the categories are sandy (size <2 mm), mixed (sandy and pebble-cobble) and pebble-cobble (size >2 mm); and iii) colour: this variable corresponds to the predominant colour associated with the beach as a whole. For the purposes of the present study, the categories are simplified to white, golden and black/dark brown.

3.2. Spatial and statistical analysis

To analyse beach type and their spatial distribution across the islands studied, the area of each beach was considered as a unit of measurement. This data, stored in shapefile format, allowed calculation of the geometry of each vector in terms of surface area (m^2) using geographic information systems (GIS). Using the table of attributes in the same file, the number of beaches and the percentages of surface area were calculated for the three variables set out in section 3.1.

3.3. Analysis of beach evolution by typology: a long-term study of cases

Selecting solely urban beaches in the 'surrounding conditions' field, we proceeded to identify variations in the dominant substrate (sandy, mixed and pebble-cobble) and colour. For this purpose, each beach was firstly associated with a predominant substrate typology and colour according to its immediate surrounding conditions (year 2023, spatial resolution: 20 cm/pixel) and with what was detected in the 1957 orthophoto in black and white of the Spatial Data Infrastructure of the Canary Islands (IDE Canarias), obtained from a photogrammetric flight by the Cartographic and Photographic Center (CECAF by its initials in Spanish) and orthorectified at 40 cm/pixel (except Tenerife at 20 cm/pixel). This spatial resolution has allowed us to identify changes in composition and approximate colour changes using digital level thresholds calculated from the red band of the 2023 orthophoto, in this sense, in sedimentary systems the highest values of digital levels correspond to white sand and the lowest to black sand (García-Romero et al., 2018). For these thresholds, natural beaches were used because they had not been transformed, in order to obtain digital sand levels without changes caused by human activities. Finally, information from the Official Bulletins of the Canary Islands and information from the Ministry for Ecological Transition and the Demographic Challenge were used to confirm the cases of transformed beaches. In this regard, using overlay tools implemented in GIS, the beaches were related to the 1:25, 000 national topographic reference map, available for download from the website of Spain's National Geographic Information Center (CNIG by its initials in Spanish) in the 'Vector maps and cartographic and topographic bases' section, which includes hydrographic information with network structure and Spain's National Geographic Institute's reference information on transport networks and population settlements. More specifically, the beaches were superimposed with ravine mouths (indicating beaches formed in natural conditions, mainly of dark-coloured pebbles, cobbles and boulders due to the volcanic origin of the islands) and with the urbanised areas to calculate how much of the beach area may have been occupied. Finally, using the 2022 territorial RGB orthophoto of 16 cm spatial resolution (IDE Canarias), the beaches where environmental changes may have occurred were identified, detecting the surface area, the predominant substrate (composition) and the current colour, thereby enabling the detection of differences with respect to their origins or the year 1957.

Beach classification was made according to grain size, following Alonso et al. (2019) and without considering their origin: i) sandy; ii) mixed (sand and pebbles-cobbles); iii) pebbles-cobbles).

3.4. Analysis of local population preferences for beach use

A survey (supplementary material) was carried out via the internet (social networks and different websites, including Involcan and Volturmac, associated to tourism services in the Canary Islands) to determine the preferences of those surveyed regarding the use and enjoyment of the beaches, especially in relation to the occupation of the immediate surroundings, the services provided, and the composition and colour of the beach, and to obtain data associated with the profile of those surveyed. The survey was designed using a Google forms template (Google Forms: Free Online Surveys for Personal Use), a tool that allows the generation of surveys or questionnaires directly in the web browser, without the need for special software, and which can also be used for public distribution, storage and data management.

Based on the information obtained through the surveys, statistical analyses were carried out to determine the relationships between the profile of the respondents and their preferences. For this purpose, it was necessary to code both the questions, to facilitate their understanding in the tables in the Results section, and their different response categories (Table 1). The relationships shown were calculated from bivariate correlations (Spearman test) using the IBM SPSS STATISTICS 21 programme, classifying the variables linked to the survey questions into three thematic groups: i) Preferences regarding the natural attributes of the beaches; ii) Preferences regarding beach services; and iii) Profile and motivation of beach users.

The results shown in this research were filtered to analyse those linked to the responses of people with current residence in the Canary Islands, who may have a greater attachment to the natural heritage of their environment. It is understood that those new or relatively new to a territory normally perceive the space mainly in terms of functional utility, whereas lifelong residents give it a sentimental value due to historical continuity (Wójcik, 2013). The aim here is to find out what the preferences of resident users are and, at the same time, check whether there has been a conflict between the preferences of local society and the way beaches are managed and environmentally transformed by the relevant administrations.

A total of 953 questionnaires were completed during the month of July 2023, of which 785 were used for this study, with responses from non-residents or people from outside the Canary Islands being discarded. In the results and discussion section we show the main characteristics, in particular the profile and preferences, of the respondents (see Table 2).

4. Results

The results shown below are structured in three blocks. The first section shows the distribution of beach types according to the variables considered (typology, grain size and colour). The second section analyses the types of transformation for the urban-touristic development (e.g. by promoters and managers) that have taken place around the different beach types on the selected islands and the degree of impact on each type. Finally, the third section considers the profile and preferences of local users who visit and use the beaches of the Canary Islands.

4.1. Beach type distribution

4.1.1. Beach type by occupation of surrounding area (urban, semi-urban and natural)

Fig. 2A shows that the island with the highest number of beaches is Tenerife (207), followed by Fuerteventura (80) and finally La Palma

Table 1
Survey questions, associated variables and their categories, which were processed for a Spearman correlation analysis.

Questions/variables	Code	Categories/code for statistical analysis							
		1	2	3	4	5	6	7	8
Importance and preferences regarding beach natural attributes									
Is beach length important to you?	**importance_length**	YES	NO						
What length of beach do you prefer?	**preference_beach_length**	Short	Medium	Long					
Is the grain size of the beach important to you?	**importance_material**	YES	NO						
What type of beach based on grain size do you prefer?	**preference_material**	Sandy	Mixed	Pebble-cobble					
Is the colour of the sand on the beach important to you?	**importance_colour**	YES	NO						
What sand colour do you prefer?	**preference_colour**	White	Golden	Black/Dark brown					
Importance and preferences regarding beach services									
What kind of environment do you prefer?	**preference_environment**	Urban beaches	Semi-urban beaches	Natural beaches					
How important are the following beach services to you?									
- Car parks	**importance_carparking**	Unimportant	Low	Neutral	Important	Very			
- Toilets	**importance_toilets**	Unimportant	Low	Neutral	Important	Very			
- Shower and feet washes	**importance_shower**	Unimportant	Low	Neutral	Important	Very			
- Umbrella and sunbeds rental	**importance_hammock**	Unimportant	Low	Neutral	Important	Very			
- Locker rental	**importance_locker**	Unimportant	Low	Neutral	Important	Very			
- Nautical rental	**importance_watersport**	Unimportant	Low	Neutral	Important	Very			
- Children's area	**importance_childrensarea**	Unimportant	Low	Neutral	Important	Very			
- Sports area	**importance_sports**	Unimportant	Low	Neutral	Important	Very			
Profile and motivation of beach users									
Island of residence	**residence_island**	La Palma	La Gomera	El Hierro	Tenerife	Gran Canaria	Fuerteventura	Lanzarote	
Age[a]	**age (years)**								
Educational level	**study_level**	Primary school incomplete	Primary school	Secondary school	Further education (Sixth Form/ College)	Further education – Apprenticeships	Other type of vocational training	Higher education – University undergraduate	Higher education- University postgraduate
Accompanying people	**who_visit**	Alone	With partner	With family	With a group of friends	Other			

[a] Quantitative.

Table 2
Profile of surveyed beach users.

PROFILE	Total (%) n = 785
Island of residence	
La Palma	4.56
La Gomera	0.63
El Hierro	1.14
Tenerife	67.09
Gran Canaria	16.33
Fuerteventura	2.66
Lanzarote	7.59
La Graciosa	0
Don't know/No answer	0
Sex	
Male	41.66
Female	57.32
Other	0,63
Don't know/No answer	0.38
Age	
Below 25	6.88
Between 25 and 44	48.92
Above 44	43.95
Don't know/No answer	0.13
Educational level	
No schooling	0.00
Primary school incomplete	0.51
Primary school	3.42
Secondary school	8.62
Further education (Sixth Form/College)	1.90
Further education – Apprenticeships	4.94
Other type of vocational training	11.79
Higher education – University undergraduate	25.73
Higher education- University postgraduate (MA, PhD)	42.84
Don't know/No answer	0.25
Accompanying people	
Alone	20.33
With partner	25.48
With family	27.68
With a group or friends	25.41
Other	0.86
Don't know/No answer	0.24
Main reasons for visiting the beaches of the Canary Islands	
Swimming and sunbathing	29.14
Walking and strolling	20.81
Enjoying scenery and nature	30.58
Water sports	5.86
For children's play	5.19
Beach sports	6.37
Other	1.64
Don't know/No answer	0.41

with 58. However, the surface area occupied by beaches (%) is greatest in Fuerteventura with 6,352,438 m^2, representing 0.38% of the island, followed by Tenerife with 1,441,469 m^2 (0.07%) and La Palma with 339,021 m^2 (0.05%). Fig. 2B shows the distribution of beach type according to the degree of transformation of its surroundings (urban, semi-urban and natural) on each island. As can be seen, the island with the highest proportion of natural beaches vs. total beaches in terms of both number and surface area is La Palma (74.14% and 70.70%, respectively), followed by Fuerteventura (61.25% and 56.23%, respectively) and, lastly, Tenerife (44.44% and 45.15%, respectively).

With respect to the number of semi-urban beaches, represented as a percentage according to the sample for each island, similar percentages are found on the three islands studied (La Palma, 22.41%; Tenerife, 21.26% and Fuerteventura 22.50%). The surface area percentages show greater variability, with Fuerteventura leading in this regard (37.19%), followed by Tenerife (18.36%) and La Palma (16.78%). The island with the most urban beaches is Tenerife (number and surface area as % of total number and total beach surface area = 34.30% and 36.48%, respectively), followed by Fuerteventura (16.25% and 6.56%, respectively) and, finally, La Palma (3.45% and 12.51%, respectively). La Palma has a higher percentage of its surface area occupied by urban beaches than Fuerteventura, although this could be attributable to the sample of the former having only two beaches compared to Fuerteventura's 13. In general terms, however, it can be deduced that the beaches that receive the least pressure from their immediate surroundings are those in La Palma, followed by those in Fuerteventura, where semi-urban beaches predominate. Finally, if these data were to be used as indicators of the pressure exerted on the beach environment, Tenerife is the island with the greatest urban transformation of its beaches.

4.1.2. Beach type by natural characteristics: composition and colour

As can be deduced from Fig. 3A, La Palma has the highest percentage of natural pebble-cobble beaches and the highest surface area percentage occupied by that beach type (70.69% and 31.23%, respectively). The same island also has significant percentages in terms of the number and surface area of natural mixed type beaches (37.93% and 26.58%, respectively). As far as sandy beaches are concerned, their greatest representation is also to be found on natural beaches. The other beach types (semi-urban and urban) show a similar pattern, but with unrepresentative percentages. For its part, Tenerife has a large representation of pebble-cobble beaches (number, %), but in terms of surface area (%) sandy beaches, regardless of type (urban, semi-urban or natural), are those with the greatest presence. Finally, practically all of Fuerteventura's beaches are made of sand, except for some natural mixed beaches (21.25% and 9.23%), a few natural pebble-cobble types (6.06%

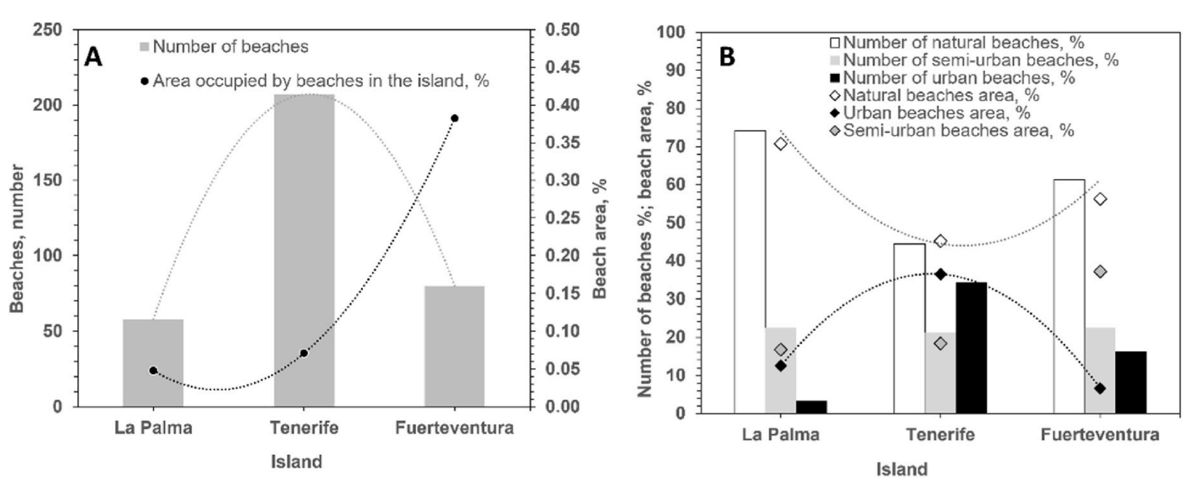

Fig. 2. A: Number of beaches on each island and surface area occupied by them as % of total island surface area; B: Number and surface area of urban, semi-urban and natural beaches by island as % of total number of beaches and total surface area of beaches.

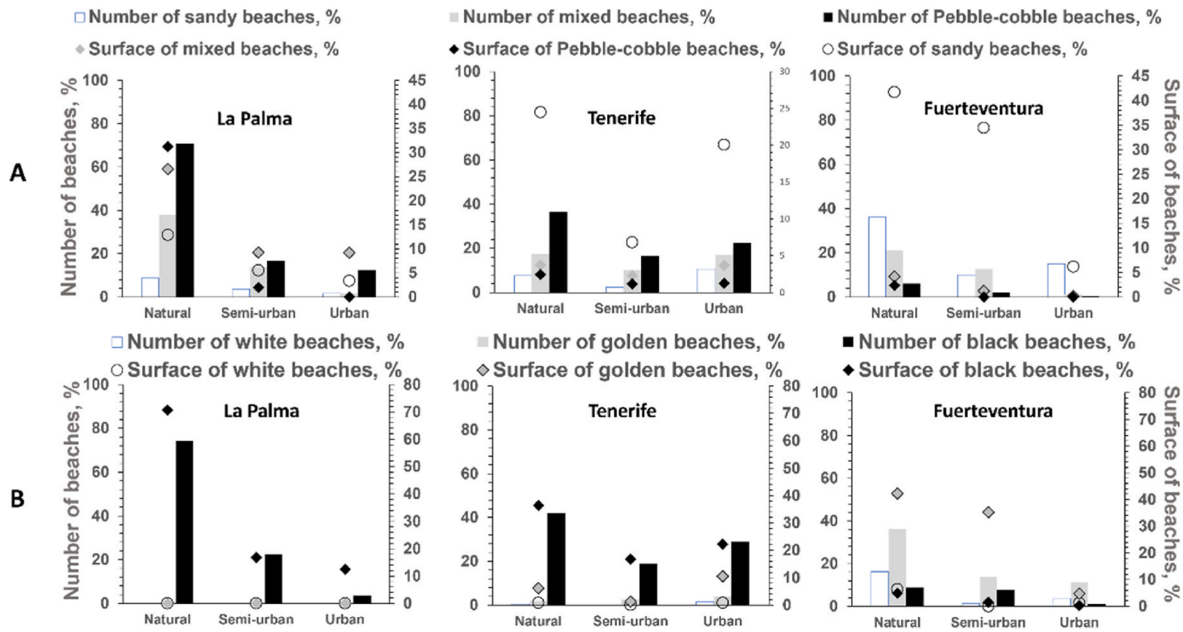

Fig. 3. Beach distribution by composition, colour, island and beach type (natural, semi-urban, urban). A: Distribution by beach composition (sandy, mixed, pebble-cobble). B: Distribution by beach colour (white, golden, black).

and 5.32%), and some semi-urban mixed types (12.5%).

Fig. 3B shows, as with beach composition, a gradient in terms of beach colour from the younger islands to the west towards the older islands to the east. A dark beach colour predominates in La Palma and Tenerife, in natural, urban and semi-urban types, with the exception of 13.15% of the surface area of Tenerife urban beaches with a golden colour. In Fuerteventura, the golden colour predominates on all beach types, with in some cases white observed on natural beaches (15.25%). Dark colours are scarce, both on natural and semi-urban beaches (8.75% and 7.5%, respectively).

4.2. Beach transformations for the urban-touristic development: urban beaches

4.2.1. Types of transformation observed on urban beaches

To determine whether urban beaches have maintained their natural colour and composition a diachronic analysis was carried out that allowed us to detect whether some of their sedimentological characteristics have undergone changes between the first half of the past century and the present day. In addition, the beaches were classified using the following criteria: Type I, beaches associated with ravine mouths and transformed through sediment input for the purposes of aesthetic change, where infrastructures are also installed around them for their maintenance or to offer recreational activities (e.g. marinas); Type II, beaches transformed through the construction of infrastructures; Type III, beaches occupied by urban-tourist development; and Type IV, artificial beaches. It was found that numerous mixed or pebble-cobble beaches, located at the mouths of ravines, have been transformed into artificial sandy beaches. According to Alonso et al. (2019), the incorporation of sediments seeks to either restore beaches which have undergone erosion processes, modify the beach colour to lighter tones, modify the beach grain size (e.g. Tazacorte beach, Fig. 4A associated to Type I), or to construct the beach from zero (e.g. Las Vistas beach, Fig. 4E associated to Type IV). In the latter case, the beaches are normally found on coastlines with small cliffs or volcanic lava flows, which is to say the actions taken involve natural pebble-cobble beaches. To stabilize the imported sand and consolidate the beach, there is a need for the construction of infrastructures which modify and, at the same time, compromise the original geological and geographic heritage.

Other beaches are the direct result of the accumulation of sand through coastal dynamics after the construction of infrastructures (Type II) such as dikes and/or breakwaters (e.g. Troya beaches I and II, Fig. 4B), and are additionally helped by the import of sand with an origin similar to that used in artificial beaches (Type IV) or beaches whose transformation is undertaken for the purposes of aesthetic change (Type I). The actions taken to create artificial beaches can give rise to new erosion processes through the alteration of coastal sedimentary dynamics as the sediments are concentrated in infrastructure-assisted beaches and excess sediment can change direction in the form of plumes and not reach these erosive beaches (note the erosion in Honda beach: Fig. 4C).

Finally, the transformations in Type III beaches (occupation by urban-tourist development (e.g. Corralejo beaches, Fig. 4D) produce different effects, including beach area reduction (loss of geological and geographic heritage surface area), changes to the sedimentary dynamics and, hence, beach composition and colour, and, finally, sedimentary instability, especially when the urban-tourist occupation takes place behind the beach with resulting coastal narrowing processes which, due to the current rising sea level, could lead to coastal squeeze processes (Pontee, 2013).

4.2.2. Alteration and transformation of urban beaches by composition and colour

Fig. 5 (top) shows the locations of urban beaches transformed in each island as the result of the different anthropic actions indicated in section 4.2.1. According to the General Catalogue of Beaches, La Palma has two urban beaches. The analysis conducted detected that the Tazacorte and Santa Cruz de La Palma beaches have both been transformed, with both categorized as black in colour and mixed in composition (Fig. 5, center). It can be argued that urban beach transformation in La Palma has been principally due to the modification of sediment associated to ravine mouths in order to avoid erosion, to change the sediment type and colour and to gain beach surface area (Fig. 4, Type I).

Tenerife has the largest number of transformed urban beaches (40, representing 19.32% of all beaches on the island), especially in terms of the surface area of sandy golden (28.23%) and black (18.58%) types, and mixed golden and black types (4.45% and 17.82%, respectively) (Fig. 5, center). A priori, the pebble-cobble beaches have not suffered

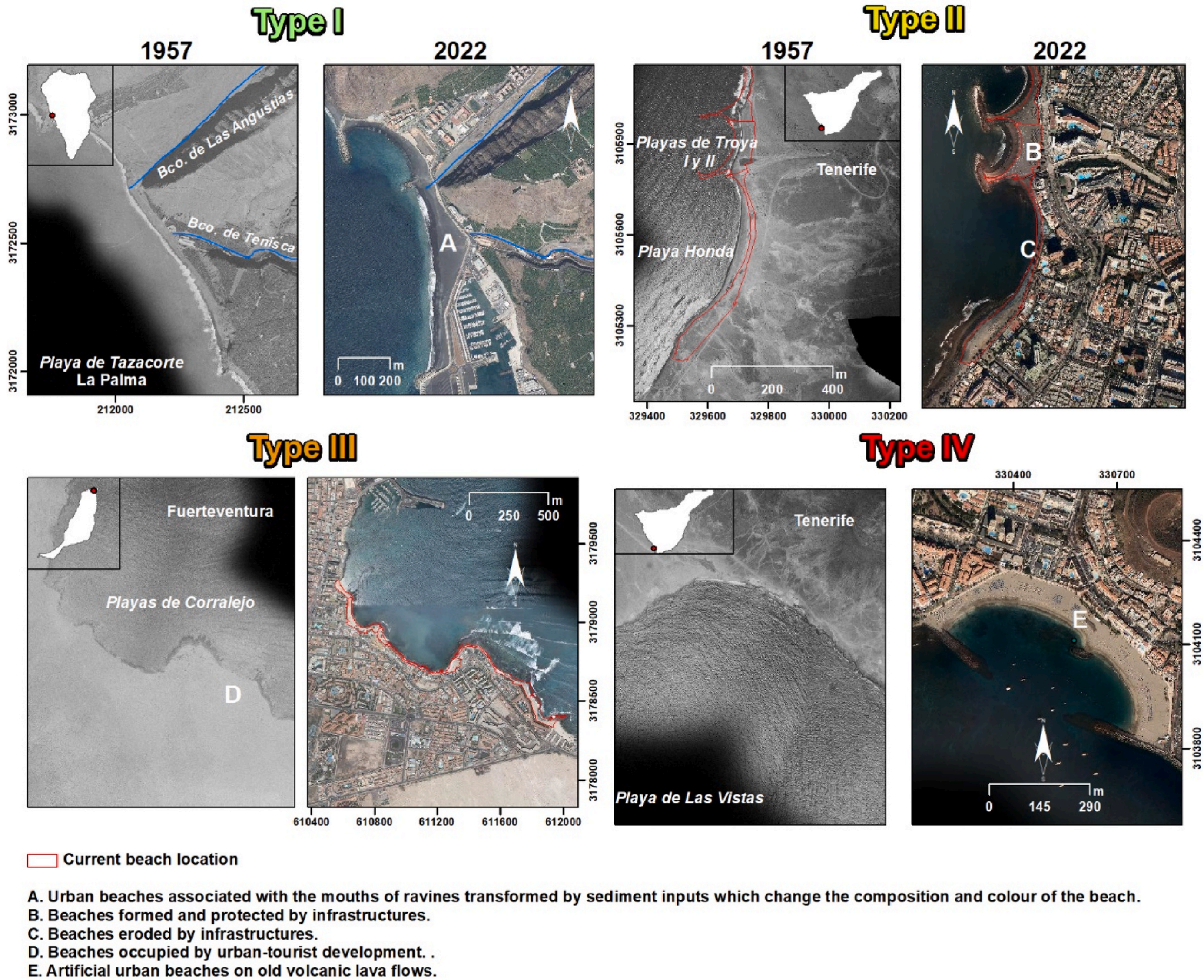

Fig. 4. Causes of the transformations of urban beaches selected in the present study.

significant transformations. In general, the main reasons for urban beach transformation in Tenerife are related to Types IV and II beaches, namely totally artificial beaches andr beaches that are the direct result of the accumulation of sand through coastal dynamics after the construction of infrastructures which, on occasions, give rise to erosion processes on beaches whose sedimentary provision has been cut by the same infrastructures. In the case of beach types I and III, their presence is only slight, with a few cases observed in the north, east and south of the island.

Finally, only 8 beaches (10% of the total number of beaches) have suffered transformations in Fuerteventura, and of these eight beaches the most notably in terms of the surface area of sandy white and golden beaches (5.38% and 52.54%, respectively) of these eight beaches, with 5.62% mixed golden beach types (Fig. 5, graphics center). The main transformations are associated to totally artificial beaches (Type IV) in the east of the island, and to Type III beaches in the north and south which are characterised by their urban-tourist occupation.

In short, it can be deduced that the most transformed beaches in terms of composition are the sandy type followed by the mixed type. In fact, as can be seen in Fig. 5 (bottom, flow diagram), Type I, III and IV (artificial) beaches with pebble-cobble composition are not transformed (the latter have practically no possibility of showing a white or golden colour due to the relation with the volcanic origin), and therefore are less attractive for urban-tourist use. The relationship between transformed type II beaches and pebble-cobble beaches could be explained by the fact that among the effects of this type of transformation, erosion processes are usually significant, giving rise to the outcropping of this type of material.

As for beach colour in transformed beaches, a gradient is again observed between younger and older islands, with black predominantly used in the youngest island as terrigenous material of volcanic origin predominates (La Palma), with a progressive change to the golden and white beaches with a greater presence of bioclasts (Fuerteventura). This age-related transition has previously been observed and described for coastal perimeter landforms on the islands by Ferrer-Valero et al. (2019). A W-E gradient can also be observed with respect to beach transformation type. In La Palma, the beaches are Type I type, given the detected trend to change the type of sediment and gain surface area in beaches associated to ravine mouths. In contrast, in Tenerife the construction of beaches where no beach existed before predominates (Type IV artificial beaches). In Fuerteventura, as it already has extensive natural sandy beaches, the number of artificial beaches is lower. Type II beaches (with a double infrastructure-induced accumulation/erosion effect) are more common in Tenerife, and Type III beaches in

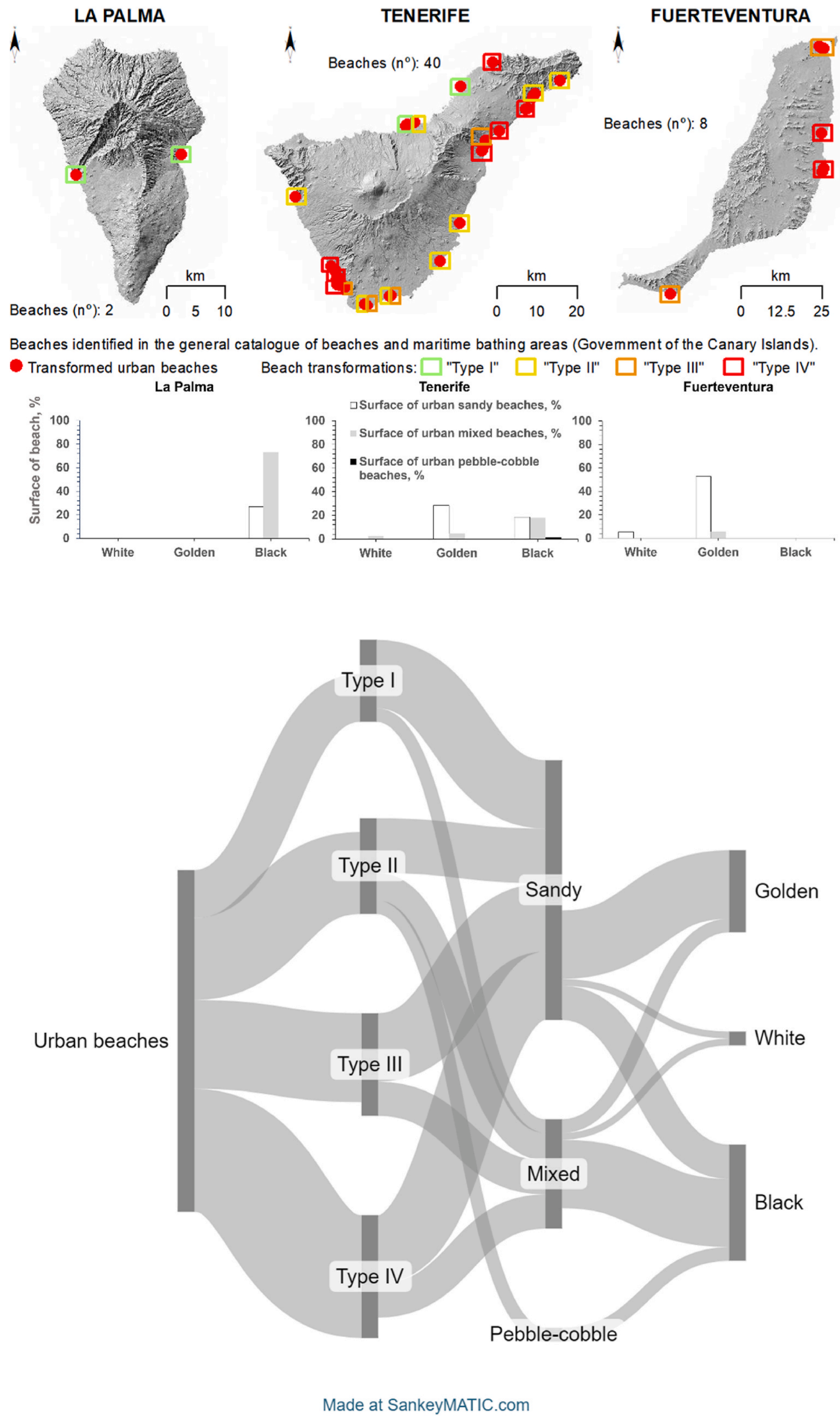

Fig. 5. Urban beaches with changes in colour and composition. Top: Location of urban beaches with detected transformations (by Type). Center: Urban beach distribution by island, composition and colour. Bottom: flow diagram with relationships between urban beaches, type of transformations, composition and colour, created by a free, open-source, browser-based application SankeyMatic (available at http://www.sankeymatic.com).

Fuerteventura (beach occupation by urban-tourist development).

4.3. *Profile and beach use preferences of local users*

4.3.1. *Social profile*

The survey was conducted with a total of 785 people (Table 2). The highest percentages of respondents were from the islands of Tenerife (67.09%), Gran Canaria (16.33%) and Lanzarote (7.59%), which was to be expected as these are the most populated islands (Díaz-Hernández, 2022). A total of 57.32% of those surveyed identified as women and 41.66% as men. A total of 48.92% were between the ages of 25 and 44, with 43.95% of older age, and 6.88% younger. As for educational level, 25.73% were university undergraduates and 42.84% postgraduates. Visits to the beach were made generally with family (27.68%), the person's partner (25.48%), friends (25.41%) or alone (20.33%). Finally, the main reasons for visiting the beach included practising sports, going for a walk, playing with the family, etc., although the most commonly cited reasons were to enjoy the scenery and nature (30.58%) and to sunbathe and swim (29.14%).

4.3.2. *Social preferences*

Table 3 shows the existing relationships between four variables associated to the profile of those surveyed (island of residence, age, accompanying people and educational level) and the variables related to beach attributes importance (of beach length, material and colour) and preferences (of beach length: short, medium or long; material or grain size: sandy, mixed or pebble/cobble; colour: white, golden or black/dark brown). The results show some significant or highly significant correlations between island of residence and beach attributes. Residents in the older islands, where beach surface area is greater and the predominant beach colour is golden or white, give greater importance to beach length and material (sig. = 0.000 and 0.024, respectively). A correlation was found between the natural colour of beaches on the different islands and the preferences of the surveyed local residents. That is, preferences for beaches with lighter tone colours were identified for the older islands, whereas darker tones were preferred for the newer islands (sig. = 0.000). A similar importance trend was observed for beach length (sig. = 0.001) and grain size (sig. = 0.001) matching island age-related coastal exposure and erosive processes. As for the *age* variable, the only correlation found was with *material* (sig. = 0.017), with respondents older in age considering beach material to be important, with a preference for sandy beaches. It was also found that a greater importance is given to beach material type as the number of people accompanying the survey respondent on beach visits (family or friends) rises, though without any specific preferences. This may be due to the diversified age range and recreational preferences of those accompanying the survey respondents. With respect to beach colour, preferences for clearer tones are found but without this being significantly important (sig. = 0.000 and 0.005, respectively). Finally, the importance given to beach material type also rises with the educational level of the survey respondents, though with no clear pattern on the preferred material type (sig. = 0.014 and 0.862, respectively). In this case, the specific preferences for beach material type may depend on the educational and professional narratives acquired in the training formation of each survey respondent.

In relation to beach services, preferences vary by age, educational level and accompanying persons, Age and educational level show a positive importance correlation with the presence of toilet facilities, hammocks, locker rentals, watersports, children's areas and sports areas (Table 4). This pattern has also been seen in other studies in which both these social profile variables are determining factors for environmental awareness (Lukoseviciute and Pereira, 2021; Srihadi et al., 2016).

In addition to the above mentioned services, the importance of others, such as showers, parking facilities or the surrounding environment increases with the number of people accompanying the survey respondent on beach visits (Table 4). These are beach services and attributes which condition the comfort of beach visits by groups of people of different ages and needs, as is the case of visits with family or friends.

5. Discussion

5.1. *Conflicts arising from urban-tourist development in beach environments*

5.1.1. *Conflicts between development and natural geoheritage conservation*

The anthropogenic transformation of the beaches of the Canary Islands, based on urbanisation and the construction of infrastructures, is generating serious alterations to their natural geoheritage (Bru and Alonso, 2013; Marrero-Rodríguez and Dóniz-Páez, 2022). Since the mid-1960s, the Canarian economy has been mainly based on the service sector, especially tourism. The predominant type of tourism is 'sun and beach', so most of the infrastructure is coastal and normally associated with sandy areas such as those occupied by beaches. Not only are these changes affecting their immediate environment and landscape and potentially altering the natural dynamics of the beaches, making them unsustainable (Marrero-Rodríguez et al., 2024), but in the short or long term they could also affect the economic activity that takes place there (García-Romero et al., 2023a). In this sense, it is paradoxical, and at the same time incongruous, that no management measures are being taken to guarantee the long-term sustainable maintenance of beaches (a fundamental resource of 'sun and beach' tourism), not only so as not to compromise the resource but also to sustain the economic sector that feeds off them (tourism).

Anthropic pressure is also endangering the conservation of their natural geological, geomorphological, floral and faunal values, and in general, their geoheritage, although in many cases they are under environmental protection (Biosphere Reserves, Special Areas of Conservation (SACs), Special Protection Areas for birds (SPA system), National and Nature Parks designated by international (UNESCO, European Union), national and regional bodies). However, numerous authors speak of erosion processes in the beaches of the Canary Islands associated with current and historical beach mismanagement (Marrero-Rodríguez et al., 2021), coastal squeeze processes

Table 3
Spearman test between variables of the beach user profile and variables related to importance and preferences regarding natural attributes of beaches.

Variables		importance_length	preference_beach_length	importance_material	preference_material	importance_colour	preference_colour
residence_island	S	−0.127[a]	0.200[a]	−0.080[b]	-,161[a]	−0.032	−0.426[a]
	Sig.	0.000	0.001	0.024	0.001	0.375	0.000
age	S	−0.033	0.052	−0.085[b]	−0.018	−0.005	−0.084
	Sig.	0.356	0.406	0.017	0.709	0.884	0.182
who_visit	S	−0.034	0.082	−0.131[a]	−0.007	−0.008	−0.182[a]
	Sig.	0.351	0.200	0.000	0.892	0.826	0.005
study_level	S	−0.029	−0.107	−0.087[b]	−0.008	0.062	−0.081
	Sig.	0.424	0.083	0.014	0.862	0.082	0.200

S: Spearman correlation. Sig.: Significance level.
[a] The correlation is significant at the 0.01 level (bilateral).
[b] The correlation is significant at the 0.05 level (bilateral).

Table 4
Spearman test between variables of the beach user profile and variables related to preference and importance of the beach services.

Variables		environment	carparking	toilet	shower	hammock	locker	watersports	children_areas	sport_areas
residence_island	S	−0.043	0.008	−0.009	−0.023	0.027	0.041	0.007	−0.021	0.037
	Si	0.231	0.825	0.801	0.527	0.443	0.257	0.837	0.564	0.300
age	S	−0.060	0.026	0.096[a]	0.060	0.214[a]	0.179[a]	0.136[a]	0.180[a]	0.088[b]
	Si	0.091	0.460	0.007	0.095	0.000	0.000	0.000	0.000	0.014
who_visit	S	−0.154[a]	0.140[a]	0.160[a]	0.190[a]	0.158[a]	0.143[a]	0.121[a]	0.164[a]	0.096[a]
	Si	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.009
study_level	S	−0.024	0.004	−0.091[b]	−0.067	−0.108[a]	−0.095[a]	−0.101[a]	−0.128[a]	−0.107[a]
	Si	0.498	0.912	0.011	0.059	0.003	0.008	0.005	0.000	0.003

S: Spearman correlation. Si: Significance level.
[a] The correlation is significant at 0.01 level (bilateral).
[b] The correlation is significant at 0.05 level (bilateral).

(García-Romero et al., 2023a; Marrero-Rodríguez et al., 2024), or even the total disappearance of beaches due to urbanisation processes or the development of coastal infrastructure (Ferrer-Valero et al., 2019; Pérez-Hernández et al., 2020). In addition, coastline characteristics are being altered through the creation of artificial beaches, which are difficult to maintain and whose synergistic effects can generate problems in other nearby areas (Alonso et al., 2019). Beach management should take into account the geological characteristics of the islands' beaches when making decisions, understanding their dynamics from an evolutionary point of view (historical and current). To date, management has been based on the creation of tourism products through the transformation of beaches and not on the promotion of the existing geoheritage values that are characteristic of the archipelago.

According to García-Romero et al. (2023b), islands could promote natural beaches in a sustainable way and thus decongest the high pressure on urban and semi-urban beaches. For this purpose, an island zoning was carried out based on the density of natural beaches on each island studied (Fig. 6, top), and a characterization highlighting the geological values, which would help tourism managers and promoters, always in coordination with environmental managers, to promote the natural beaches of these areas of the islands through geotourism. The island with the greatest percentage of natural beaches and with the largest surface area occupied by natural beaches is La Palma (74.13%), followed by Fuerteventura (61.25%) and, lastly, Tenerife (44.44%). In general, the beaches of La Palma and Tenerife are characterised by being in environments practically untransformed by human activities, with basaltic lava flows, pyroclastic cones and crossed by intense dike meshes. In Fuerteventura, however, they are made up of loose aeolian sands and, in some cases, are naturally protected by reefs of volcanic material (Fig. 6.

Finally, it is important to preserve beaches that still have a natural environment because previous works on Canary Islands beaches predicts that the fusion between sea level rise (SLR) and the increased frequency of SW marine storms associated with Climate Change could make them disappear. Especially since the combination of the loss of sediments from the beaches, the SLR and the complete urbanisation that is taking place around these systems makes the retreat of the beaches inland impossible and their disappearance likely in contrast to natural beaches (de Santiago et al., 2021; García-Romero et al., 2023a; Marrero-Rodríguez et al., 2024).

5.1.2. Social conflicts

Studies that address the perception of beach users often do not discriminate between tourists and local residents or natives (Pranzini et al., 2010; Botero et al., 2013). In this sense, no direct attention is paid to the perception resulting from the rootedness and sense of belonging of the residents, who live in the immediate surroundings of these systems and in some cases before they were finally used as an economic resource and not treated as a socio-ecological system (Peña-Alonso et al., 2017; Pérez-Hernández et al., 2021).

Despite the fact that a significant number of users prefer natural beaches, some studies refer to this type not being the most frequented (Peña-Alonso et al., 2018). In this sense, it should be noted that beaches that have maintained their natural characteristics are generally less accessible (no road access or public transport) and lack basic services and security. This lower intensity of use also seems to be directly related to the 'who with' variable, as people accompanied by children or people with reduced mobility probably prefer beaches with services that facilitate their use. In this context, we cannot affirm that the uses of the beaches have changed with their transformation. Instead, it seems that users have adapted to using transformed beaches because of their accessibility and comfort. With respect to preferences related to the type of sediment, it does not seem that beach colour is key for local users. Although correlation was found between local residents' preferences for beaches with lighter tone colours were identified for the older islands, whereas darker tones were preferred for the newer islands. This contrasts with the affirmation of Pranzini et al. (2016) that tourists are often disappointed when they come across beaches of dark-coloured or completely black sand, and with the results obtained by Williams and Micallef (2009) or Pranzini and Vitale (2011) that tourists prefer white and golden beaches and show a progressive dislike for the beach as the sand becomes darker in colour. However, in Tenerife there are many artificial beaches with white or golden-coloured sand, even though they are costlier to build because of the origin of the material, as in the case of Las Teresitas beach (Fig. 7). On this island, most of the artificially created beaches before 2000 were made with golden or white sand. These beaches were located in tourist areas or areas where large hotel complexes were planned were created with golden sand, mainly imported from other regions such as Laayoune in Morocco. These beaches were designed to fit the ideal of paradisiacal Caribbean or Western Canary Islands beaches. This preference has been studied in other parts of the world (Pranzini et al., 2010; Pranzini and Vitale, 2011). However, due to current environmental restrictions and the rising cost of sand, the usual source of sediment is now crushed gravel. Additionally, as a large number of beaches are experiencing erosion processes, external sand supplies have become economically unsustainable. As to the importance of grain size, resident users in the Canary Islands generally prefer sand to pebble-cobble beaches. In this regard, a closer examination needs to be made of the beach landscape preferences of local users and tourists, as this seems to be a decisive factor in their recreational experience. According to Palmer et al. (1998), the type of preference depends directly on personal experience with nature in childhood and the education received.

In addition, in recent years, the Canary Islands have experienced a significant process which has been defined by numerous authors as tourismphobia (Milano et al., 2019; Veríssimo et al., 2020; Almeida-García et al., 2021) and rejection of the transformation of the archipelago's natural and cultural values to cater to the needs and preferences of tourists as it happened in other parts of Spain (Egio-Rubio and Fernández-Toledo, 2020). This has been evident in the protests that took place in May 2023 and April 2024, as well as other planned actions. In this sense, in 2023, the Canary Islands received over 16 million tourists

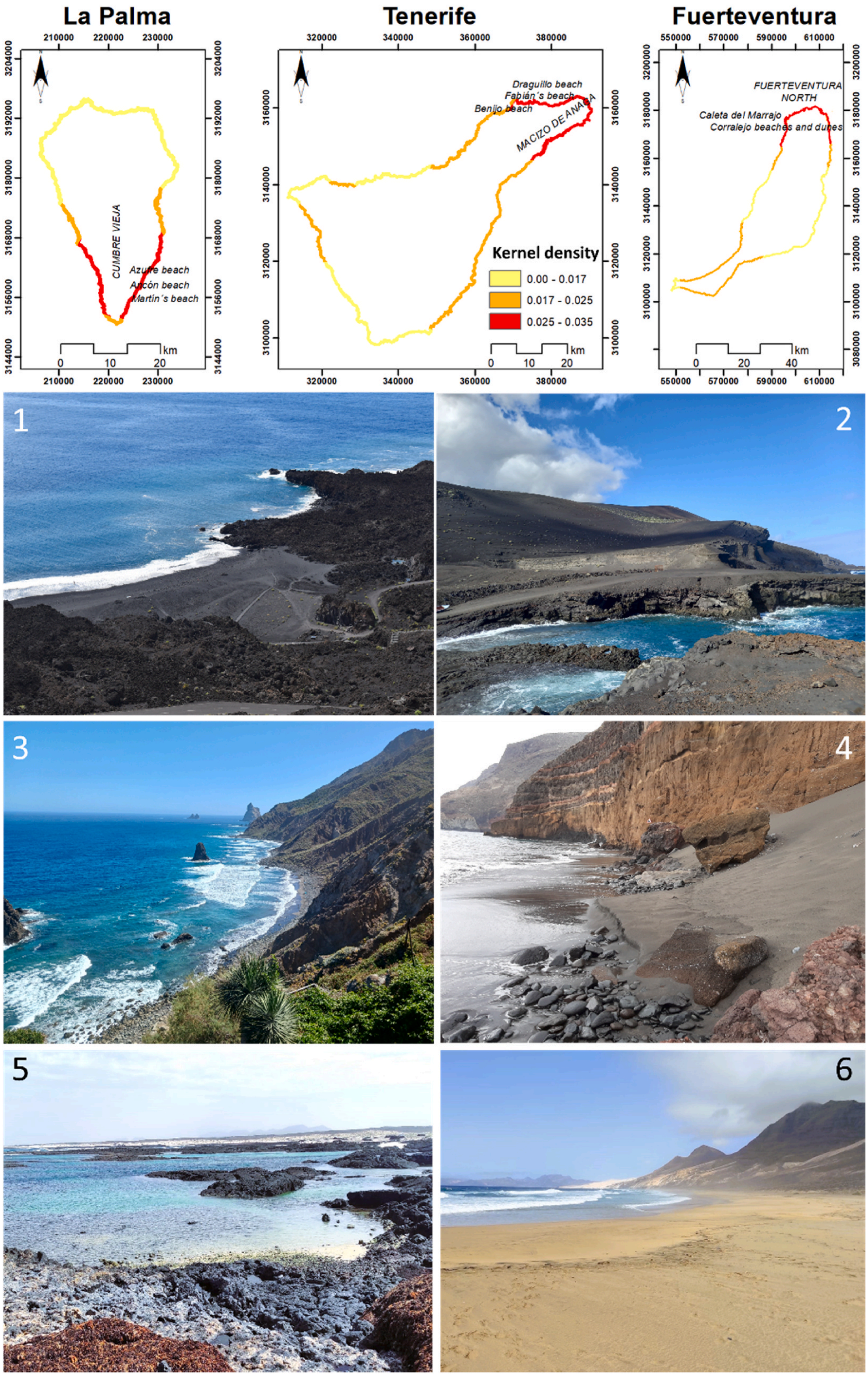

Fig. 6. Island mapping for geotourism associated with natural beaches. The colours show the kernel density of natural beaches detected on each island studied, from yellow (low density) to red (high density). Echentive beach and La Cabras beach in the south of La Palma (located in Cumbre Vieja, 1 and 2 respectively). Benijo beach and Antequera beach in Tenerife (located in Anaga, 2 and 3 respectively). Punta de la Ballena beach and Cofete beach in Fuerteventura (located in the north, 5 and 6 respectively).

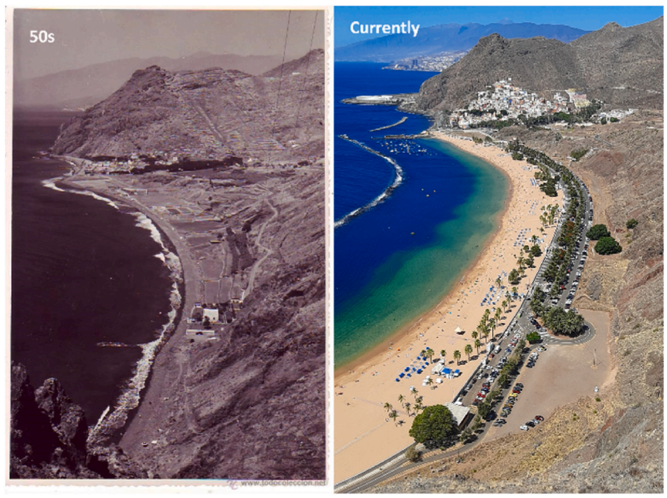

Fig. 7. Las Teresitas beach (Tenerife). Example of the transformation of a beach associated to a ravine mouth using infrastructures and changes to the vegetation and sediment type and colour. Source: unknown author for the 1950s photo on the left and taken by the authors on the right.

(ISTAC, 2024), setting an occupancy record. However, as demonstrated in this work, the most transformed beaches are located in tourist areas such as the municipality of Adeje (Tenerife), where only this municipality received approximately 2.5 million tourists in 2023 (ISTAC, 2024). Therefore, it could be argued that the tourism industry has relied on altering the natural values of the beaches to build urban-touristic infrastructures, while areas further from tourist spots have been able to preserve their values. However, the current tourism growth threatens the last virgin beaches in the south of Tenerife (Marrero-Rodríguez et al., 2020) and those in Fuerteventura (Marrero-Rodríguez et al., 2021).

In relation to this research strand, future research should aim at a thorough analysis of beach landscape expectations based on underlying standards and the sense of belonging to a place, as this could be decisive in understanding the transformation of beaches in different geographical regions. Furthermore, an analysis of beach transformations and how they are perceived by users could be of interest in order to make management recommendations that integrate user perception into decision-making and the conservation of natural values. Finally, a study to clarify whether, due to the transformation of beaches, there has been a change not only in the users of these beaches but also in the actual use of the beach itself could help to explain certain preferences or the displacements of residents to use particular beaches.

6. Conclusions

The following are the main findings of this research, sequenced according to the questions posed at the beginning of this paper:

1) The beach resource has greater significance the younger the island, with Tenerife having 207 beaches, followed by Fuerteventura (80) and, finally, La Palma (58). However, Fuerteventura has the largest beach surface area in relation to the total area of the island. On the younger islands studied (Tenerife and La Palma), pebble-cobble beaches predominate, followed by mixed beaches and darker-coloured beaches. On Fuerteventura, the oldest island, golden or white sand beaches are the most significant.
2) In terms of the use made of the immediate surroundings of the beaches, Tenerife is the island with the highest number of urban and transformed beaches.
3) In terms of urban-tourist development, there is a certain tendency towards the use of sandy beaches followed by the mixed (sandy and pebble-cobble) type, but mainly of golden or dark-coloured sand associated with terrigenous materials of volcanic origin.
4) Around 58% of the urban beaches located in La Palma, Tenerife and Fuerteventura have been transformed, producing alterations and changes in the substrate and colour of the sediment with respect to that apparent in natural conditions, or at least prior to the transformation detected in the last 65 years.
5) A correlation was found between the preferences of the residents of each island analysed for beaches with characteristics associated with their geological origin and their natural environment.

CRediT authorship contribution statement

Leví García-Romero: Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Néstor Marrero-Rodríguez:** Writing – original draft, Supervision, Investigation, Conceptualization. **Javier Dóniz-Páez:** Writing – original draft, Visualization, Supervision, Funding acquisition. **Carolina Peña-Alonso:** Writing – original draft, Validation, Supervision, Investigation. **Emma Pérez-Chacón Espino:** Visualization, Supervision. **Carlos Pereira Da Silva:** Visualization, Supervision.

Declaration of competing interest

No conflict of interest exists.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2024.107378.

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