

# Beach surface lost historically: The case of the eastern coast of Las Palmas de Gran Canaria (Canary Islands, Spain)

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## ABSTRACT

Land use changes cause significant loss of natural and cultural elements. This is the case of the eastern coast of Las Palmas de Gran Canaria (LPGC) (Canary Islands), which was heavily transformed between the late XIX century and the 1960s by increased urban sprawl. Most of the beaches were covered by the city and, therefore, disappeared. The aim of the study is to identify and describe the natural characteristics of the beaches lost between 1879 and 2017 along the eastern coastline of LPGC, as well as to quantify the lost surface area. The changes in land uses that have taken place around these beaches are also addressed. For these purposes, historical sources (documentary, graphic, cartographic and oral) and geographic information systems (GIS) have been used. The results show that, since 1879, eleven beaches, with an extension of 13.19 ha, have disappeared and, with them, their natural and cultural features. Eight land uses were identified: fishing, defensive, agriculture, port, industrial, commercial, residential and recreational. It was also found that beaches from the northern and central sectors had more varied uses than those of the southern sector, which tended to be mainly used for fishing. The results are analyzed at both global and local scale. At global scale, different effects of globalization on coastal urban areas are discussed. At local scale, a discussion is undertaken on how the knowledge acquired can be used to improve future urban planning and to rebuild the memory of the city's coast for its inhabitants and visitors.

## 1. Introduction

Coastal lands are areas with numerous natural and strategic values that have long attracted human populations, especially since the mid-XX century (Martínez et al., 2007; Ariza, 2011). Currently, 50–70% of the global population is concentrated in such areas (Mimura et al., 2007) and nearly 30% of coastal land has been altered as the result of human activities (Martínez et al., 2007; Ferrer Valero et al., 2017). Land use development and human activities have triggered an important littoralisation process, leading to significant changes to the coast (Lin, 1996; Bajocco et al., 2012) and, in some cases, to the disappearance of previous land cover over entire coastal stretches (Santana Cordero et al., 2014). Coasts are dynamic, complex systems and their features are constantly changing because of both natural and human factors (Kurt

et al., 2010; Ponte Lira et al. (2016)). The natural processes that induce such changes include, amongst others, sea level variations due to global warming, wave climate alterations and coastal drift (Schnack et al., 2002; Caires et al., 2006; Stanica and Ungureanu, 2010; Hemer et al., 2013; IPCC, 2014; Dabrio and Polo, 2015; Johnson et al., 2015; Preston et al., 2018; Glavovic et al., 2019). The transformations to them that human activities can result in are, in many cases, irreparable. One of the most damaging activities for these areas has been urban expansion and, since the mid-XX century, the growth of tourism (Nordstrom, 1994; Gormsen, 1997; El Banna and Frihy, 2009; Kiss et al., 2009; Dawson and Smithers, 2010; Kurt et al., 2010; Bochev van der Burgh et al., 2011; Jackson and Nordstrom, 2011; Bajocco et al., 2012; Hepcan et al., 2013; Flor-Blanco et al., 2013; Malavasi et al., 2013). Residential use, port and tourist infrastructures, and recreational activities place great pressure

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on the natural processes (e.g. aeolian transport, sea currents, wind flows) that form the coastal landscape (Faggi and Dadon, 2011). These processes are aggravated in islands, which are especially vulnerable areas due to their more limited and scarce resources (Mimura et al., 2007; Hay, 2013; Santana Cordero et al., 2016; Ferrer Valero et al., 2017).

A clear example of these changes induced by human activities can be found on the eastern coast of Las Palmas de Gran Canaria (LPGC) city (Canary Islands, Spain). The evolution experienced by this city has had important consequences for land use and land cover, with major alterations to the shoreline. This particular stretch of coast has experienced several transformations since the late XIX century, especially in the 1960s, as a consequence of socioeconomic changes (Martín Galán, 1980, 2001; 2007, 2008; 2009; Santana Cordero et al., 2017). Occupation of this zone increased in this latter period due to expansion of the port and road infrastructures, as well as the desire to acquire new land for the construction of buildings. Population growth can be added to the constant modernization of buildings and infrastructures as causes of the transformation of most of this coast. In this process, many natural features were eliminated and, to a large extent, virtually forgotten about.

In view of all the above, in this research work we consider the following questions: How was this coast before its transformation? What were the uses and functions of the beaches? How much of the original beach area has been lost?

To answer these questions, we undertook a historical reconstruction of the changes that have taken place, defining what this coastal area was like in terms of its natural features and determining its previous uses and functions. Research studies of this type has been taking place for roughly four decades for various kinds of environment which have experienced historical changes due to the development of human activities (Bürgi and Gimmi, 2007; Grossinger et al., 2007; Hoffman and Rohde, 2007; Ouzts, 2007; McAllister, 2008; Stäuble et al., 2008; Bator, 2009; Gautreau, 2010; McLeman et al., 2010; Stein et al., 2010; Jackson and Nordstrom, 2011; Bajocco et al., 2012; Roig Munar et al., 2012; Ponte Lira et al. (2016); Santana Cordero et al., 2016).

In this kind of research, historic sources, in addition to others, geographic and bibliographic, are of primary importance to enable an accurate reconstruction of the processes that have taken place. Precisely because this type of research works with historic sources, these studies are frequently faced with the difficulty of finding detailed information as, in many cases, there are no written or graphic records of the elements or events that are of interest for the study. For these reasons, oral sources can be essential for the reconstruction of recent events (to around 50 years ago), enabling information obtained from other sources to be contrasted as well as providing new data (Sloan, 2008; Hernández Calvento et al., 2013).

Given these observations and in accordance with the aforementioned research questions, the general aim of this paper is to identify and

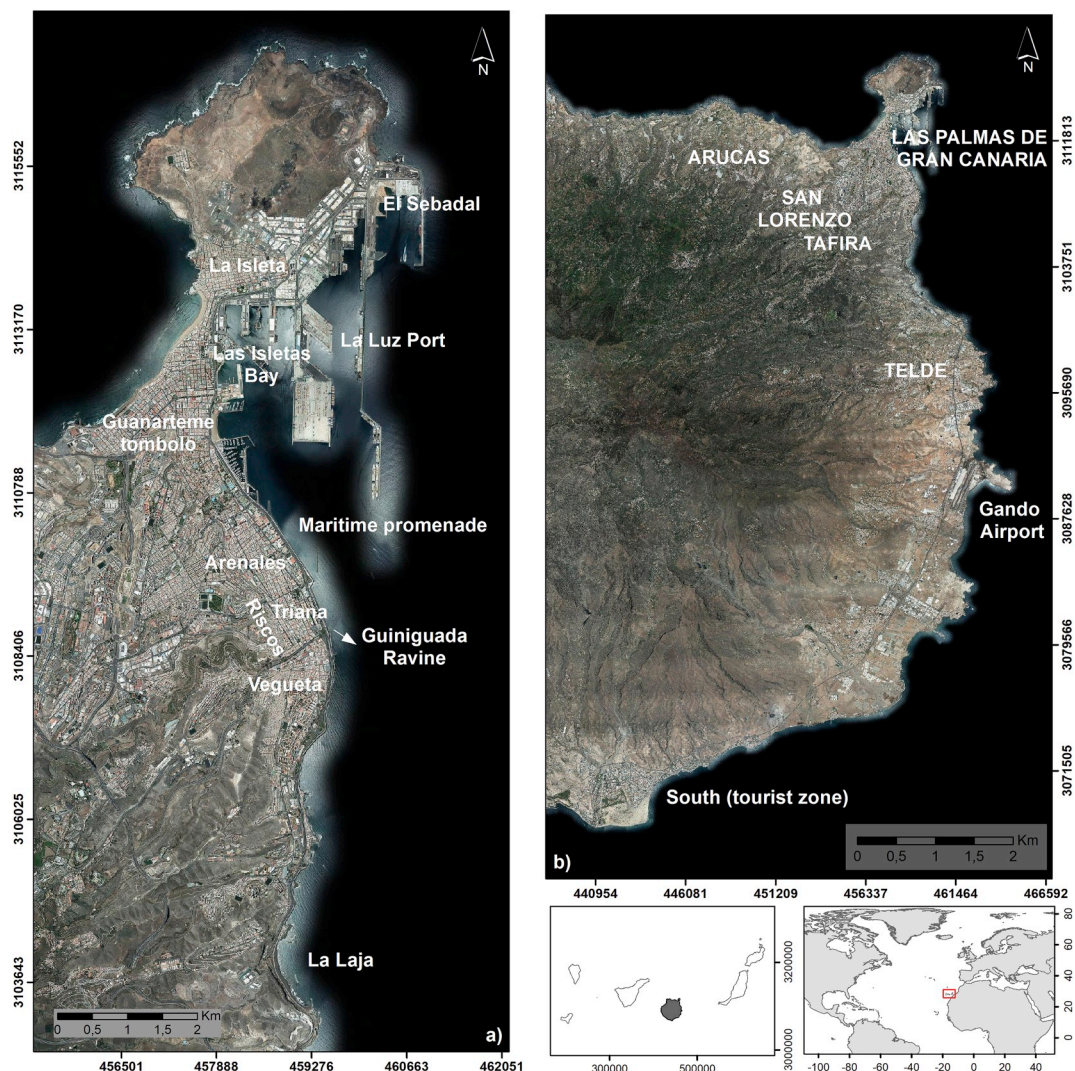


Fig. 1. a) Study area; b) Partial maps of Gran Canaria with main place names cited in the historic context.

describe the natural beaches that existed along the eastern coast of LPGC before the expansion of the city over this stretch of coast. In line with this general aim, the specific objectives of this study are: (1) to identify and characterise the nature, land uses, functions and cultural traits of the natural beaches of the eastern coast and their changes over time; and (2) to quantify the lost beach area and now-disappeared land cover.

## 2. Study area

The city of LPGC is located in the NE of Gran Canaria island (Canary Islands, Spain). This study focuses on the eastern coastline of LPGC, from the beach of El Sebadal (in the north) to that of La Laja (in the south). The length of the studied shoreline is 19.74 km and the total area is 16.35 ha (Fig. 1).

From a geological point of view, the northern sector overlies Cycle III lava flows (less than 2 Ma) and a geological layer called *Terraza Baja de Las Palmas* (Lower Terrace of Las Palmas), a narrow sedimentary coastal platform that has fossiliferous marine deposits containing *Strombus bubonius* and *Thais haemastoma* (Linné), typically found today in warmer climate zones of equatorial Africa (IGME, 1990). This sector of the eastern coast of LPGC was characterized by organic sand beaches of the dune system located on the Guanarteme isthmus. Further south, the geological setting changes: lava flows appear, one from the first volcanic period (14–8 Ma) and another, further south again, from the second one (about 5 Ma). Consequently, towards the south, the coast was mainly formed by rolling stone beaches with abundant beachrock. At low tide, wide surfaces of dark sand (due to the dominance of volcanic materials) would be revealed (Pérez Hernández and Hernández Calvento, 2017). From an ecological point of view, the vegetation in the study area is disperse and scarce. The species found include *Traganum moquinii*, *Zygophyllum fontanesii*, *Lotus kunkelii* (endemic species), *Euphorbia paralias*, *Cyperus laevigatus*, *Polycarpha nivea*, *Schizogyne sericea* and *Astydammia latifolia* (Banco de Datos de Biodiversidad de Canarias, 2016; GEVIC, 2016). Additionally, in the sea were abundant algae and *Cymodocea nodosa*, among others (Banco de Datos de Biodiversidad de Canarias, 2016; GEVIC, 2016). Avifauna, including Alcaraván (*Burhinus oediacnemus distinctus*) and other migratory birds, and marine fauna associated with no longer existing reefs were also found in this area.

The city of LPGC was founded by Spanish conquerors in 1478 in the area now known as Vegueta. The city gradually began to spread in the direction of the Guiniguada ravine. A commercial district named Triana became established as the result of slow but continuous growth which continued to the late XVI century (Martín Galán, 1980). In this phase, the city was walled, forming the historical perimeter of the city which was then comprised of the areas or districts of Vegueta and Triana. In the following two centuries, there were no important changes to the urban fabric of the city, except for the emergence of the first suburbs, called 'riscos' (this term, "cliffs" in English, refers to neighborhoods built on the slopes of the ravines and the high marine terrace), inhabited by the most disadvantaged classes.

Towards the end of the XVIII century, with the expansion of foreign trade and a modernizing impulse in line with the ideas of the Enlightenment, the city partly changed its physiognomy, although it continued to be comprised of the same districts.

In the XIX century, an expansion of the city took place following access routes that connected the city with other inland towns: to the south with Telde, to the west with Tafira and San Lorenzo, and to the northwest with Arucas (Martín Galán, 1980). This stage concluded in 1883 when construction of the port of Las Palmas, Puerto de (Refugio de) La Luz, began. In the mid-XIX century, the collapse of the northern walls took place in the direction of the future port, with a new district emerging (Arenales) from 1858 onwards. The construction of the port saw the city experience a major transformation (Santana Cordero et al., 2016). The resulting significant changes to its physiognomy saw the appearance of Guanarteme district on the tombolo between the city and La Isleta (Martín Galán, 1980). Conurbation between the original city

and the port thus began to take place. In the period 1877–1930, the city population grew from 20,756 to 78,214 inhabitants (Noreña Salto and Pérez García (1992)) as people from the inland regions of the island, and from Lanzarote and Fuerteventura, came to the new city neighborhoods. This rise in population resulted in increased urban functionality and a growth in port activity.

For the Canary Islands as a whole, the 1960s saw the commencement of the mass-tourism industry, especially in Gran Canaria and Tenerife. Tourism became the economic growth engine of these islands, triggering a transformation from an agriculture-based to a tourism-based socio-economic system (Santana Cordero et al., 2017). Construction, transport, and tourism with its associated services were the main lines of development of the Canary Island economy. In Gran Canaria, tourism was developed mainly in the south of the island, exploiting its exceptional climate and the presence of sandy beaches. In this context, the rapid growth in airline connections with different European cities made Gran Canaria airport and the roads that connected it the main development axes of the island.

In this context, port extensions developed eastwards, occupying the south coast of La Isleta and leaving free almost all the coastal front, except for a marina constructed beside *Las Alcaravanas* (Martín Galán, 2008). The city continued to grow. In the 1960s and 1970s, the most notable urban interventions were the spread of Triana district towards the coast (CIDELMAR project drawn up by Secundino Zuazo in 1962), the "Plan Parcial del Paseo Marítimo" from 1964, and the development of the highway to the south of the island (Machín Gil and Ruiz-Sánchez (2006)) which also involved construction of a 7 km long coastal road in Las Palmas. Through these projects, some 250 m were gained in the direction of the sea, using the former harbor of *Las Palmas* as a limit of the expansion towards the north.

In short, the fact that space had to be gained from the sea along the eastern coast was due to the need to build a new, wide-gauge road that would facilitate the transport of goods and passengers along the eastern axis of the island, joining the main port (La Luz, in LPGC), the airport and the new tourist areas in the south of the island (Martín Galán, 2008). However, this new road could not cross the tombolo of Guanarteme which, along with its dune system, had disappeared by this time and had been fully built over (Santana Cordero et al., 2014, 2016). The option of building this new highway along the west coast, after circling the city, was not an option either due to the economic interests of the concentrated urban-tourism development that had taken place in the area, with the construction of numerous hotels, apartments and residences, as well as the presence of Las Canteras, one of the island's longest and most impressive sand beaches (Di Paola et al., 2018).

## 3. Materials and methods

Bibliographic references from scientific articles and local publications on the study area - particularly those of Martín Galán (2001, 2007, 2008, 2009) - were an important resource for this work. Also important were various historical maps, most notably the 1879 *Plano de la Bahía de Las Palmas* (Map of the Bay of Las Palmas) which shows the coastline before the rapid growth of urban expansion, and 3 maps of different dates (*Plano de la ciudad de Las Palmas* and *Plano del ensanche del Puerto de la Luz* by Fernando Navarro and *Plano de Las Palmas* by Benito Chías Carbó) (details in Table 1), contained in the map collection of Tous and Herrera (1995). These cartographic documents enabled the identification of natural coastal heritage sites (beaches) as well as the toponymical names used at the beginning of the XX century. Current maps were also used, including the geologic map consulted using the SDI (spatial data infrastructure) of the Canary Islands (Grafcan, S.A. – Government of the Canary Islands), the geologic map of LPGC and Santa Brígida (scale: 1: 25,000), from the *Instituto Tecnológico Geominero de España* (Geological and Mining Institute of Spain) and *Google Earth*.

Aerial photographs from 1954, acquired from the *Centro Cartográfico y Fotográfico del Ejército del Aire de España* (Cartography and



**Table 1**  
Characteristics of historic maps and other cartographic documents.

Date	Document type/title	Scale/ resolution	Producer	References
1879	<i>Plano de la bahía de Las Palmas</i>	1:20000	Directorate of Hydrography	Tous and Herrera (1995)
1910	<i>Plano de la ciudad de Las Palmas</i>	1:5000	Fernando Navarro	Tous and Herrera (1995)
1910	<i>Plano del ensanche del Puerto de la Luz</i>	1:5000	Fernando Navarro	Tous and Herrera (1995)
1914	Plano de Las Palmas	1:13000	Benito Chías Carbó	Tous and Herrera (1995)
1990	Geologic map (Las Palmas de Gran Canaria and Santa Brígida)	1:50000	Geological and Mining Institute of Spain	IGME (1990)
2010	Geologic map	1:50000	SDI of the Canary Islands	IDECanarias (2018)
1954	Aerial photographs	1:2650	CECAF	CECAF (1954)
1966	Orthophoto	1:7000	SDI of the Canary Islands	IDECanarias (2018)
2017	Orthophoto	25 cm/pixel	SDI of the Canary Islands	IDECanarias (2018)

Photography Centre of the Air Force of Spain) (CECAF, 1954), were used to enable identification and mapping of the areas of interest, as well as two orthophotos from 1966 to 2017.

Several pictures were consulted from the FEDAC catalogue (*Fundación para la Etnografía y el Desarrollo de la Artesanía Canaria* - Foundation for Ethnography and the Development of Canarian Crafts, 2015), as well as the websites *Las Palmas Ayer y Hoy* (2018), *Recuerdos de Gran Canaria* (2018) and *Gran Canaria. imágenes del ayer* (2018) (unpublished images). These were used to identify specific elements in the territory from the late XIX century to the 1970s.

Fieldwork was also performed to collect oral sources. A total of nine

interviews were conducted with a group of people who were born between 1919 and 1953. The selection of the people who were interviewed was based on two criteria: (1) people who lived close to the city coast before its transformation; and (2) distribution over the three sectors of the coast which formed the area of study in this work (3 in the northern sector; 5 in the central sector and 1 in the southern sector). The interviews, carried out in 2015 between March and May, allowed information gaps to be filled and information obtained from other sources to be contrasted. The interview comprised a semi-structured conversation between two people (interviewer and narrator) (Fogerty, 2005) in which different resources were used to correctly identify the natural heritage, including a guide with a series of open and closed questions (Fig. 2), a tape recorder and historic photographs.

The information obtained was integrated into a GIS, which allowed us to locate all elements of interest on the aerial photograph from 1954 and the current orthophoto (2017). In doing so, it was necessary to geometrically correct the 1954 aerial photographs. This allowed us to detect and show the coastal changes between 1954 and 2017, using the wet mark to digitalize the shorelines (Ojeda Zújar (2000)) and calculate the dry beach areas. The two documents were compared to determine which of the studied places no longer existed. Finally, this process enabled a calculation of the so-called lost heritage.

Notwithstanding the above, it should be acknowledged that the two documents contained a series of errors due to both the geometric adjustment and digitalization processes. These errors (Table 2) were calculated following Robinson et al. (1987) and García Romero et al. (2016). It should also be noted that there may be some temporal variation in the coastline, because the tidal range in the study area is about

**Table 2**  
Geometric adjustment and delineation errors.

Document type	RMS (m)	Error delineation (m)
Orthophoto (2017)	<1.5 m	1 m
Aerial photographs (1954)	3 m (max.)	0.54 m



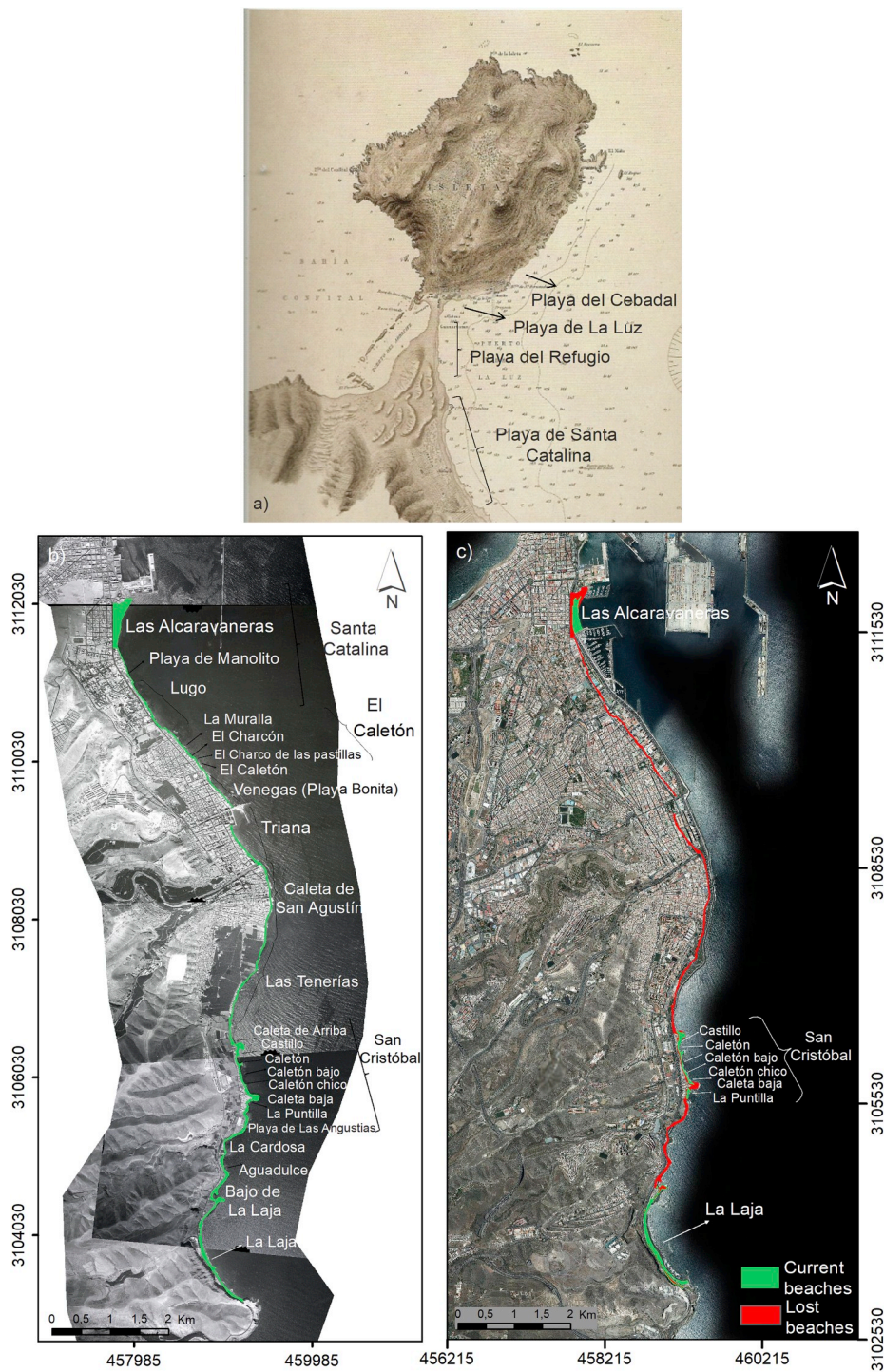
**Fig. 2.** Type of question asked during the interviews.

3 m maximum. However, the fact that, in general, the coast in the study area is reflective and presents a rocky basement minimizes the effect of the tidal range. In any case, the accumulated values of these errors are lower than the changes produced in the coastline by urban expansion, some 250 m, as previously mentioned in the Study Area section.

## 4. Results

### 4.1. Beach identification

The reconstruction made using the historic sources allowed us to identify the existence in 1879 of 14 natural beaches along the eastern coastline of LPGC, and in 1954 of 12. Of these, only three remain (Fig. 3; Table 3). According to their location and considering the type of geological material, the beaches can be divided into three sectors:



**Fig. 3.** a) Location of beaches on the 1879 map; b) Location of beaches in 1954; and c) in 2016. From the 1879 map, the first beaches to disappear were due to construction of Puerto de La Luz and the urban growth of the city towards the east. For these reasons, in map b), from the 1954 aerial photograph, the port zone has been excluded since no beach existed there.

**Table 3**

Toponymy according to the historical moment (late XIX century, beginning and mid-XX century and current times), and following a north-south direction.

	End of the XIX century	Beginning of the XX century	Middle of the XX century	Current
Northern sector	Playa del Sebadal Playa de La Luz/Playa de Las Isletas Playa del Refugio	– – –	– – –	– – –
Central sector	Playa Santa Catalina	Playa Santa Catalina Playa Las Alcaravaneras Playa de Lugo	Playa Las Alcaravaneras Playa de Manolito Playa de Lugo	Playa Las Alcaravaneras – –
	El Caletón	El Caletón Aguadulce La Muralla El Charco de las Pastillas El Charcón El Caletón	El Caletón Aguadulce La Muralla El Charco de las Pastillas El Charcón El Caletón	– – – – – –
	San Sebastián/Charcón de Arenales Playa de Triana/San Telmo Playa de San Agustín/Caleta de San Agustín	Playa Bonita/Venegas Playa de Triana Playa de San Agustín	Playa Bonita/Venegas Playa de Triana/La Marina Playa de San Agustín	– – –
Southern sector	Playa de las Tenerías San Cristóbal Caleta de Arriba Castillo Caletón Caletón Chico	Playa de las Tenerías San Cristóbal Caleta de Arriba Castillo Caletón Caletón Chico	Playa de las Tenerías San Cristóbal Caleta de Arriba Castillo Caletón Caletón Chico	– San Cristóbal – Castillo Caletón Caletón Chico Caletón Bajo Caleta Baja Puntilla Playa de Las Angustias –
	La Cardosa or El Cardoso Aguadulce Bajo de La Laja La Laja/Caleta de San Sebastián or Laxa	La Cardosa or El Cardoso Aguadulce Bajo de La Laja La Laja	La Cardosa or El Cardoso Aguadulce Bajo de La Laja La Laja	– – – La Laja

northern (*Sebadal*, *La Luz* and *El Refugio*); central (*Santa Catalina*, *Alcaravaneras*, *Lugo*, *El Caletón*, *Venegas*, *Triana* and *San Agustín*) and southern (*Las Tenerías*, *San Cristóbal*, *La Cardosa*, *Aguadulce*, *Bajo de La Laja* and *La Laja*) (Fig. 3; Table 3).

#### 4.2. Land uses and cultural traits

The sources consulted revealed that the land uses of this coast were various and evolved progressively in accordance with the growth and

modernization of the city (Fig. 4). Before the XIX century, the coast was an uninhabited, marginal and undervalued zone, considered unsafe and unhealthy (Martín Galán, 2008). As such, this zone was configured as an area for defense where agriculture and fishing activities were also undertaken. After work began on the construction of *Puerto de la Luz* (1883) and with the gradual incorporation of the customs of foreign people who came to visit and live in the islands, this situation began to evolve, the coast started to be revalued and new land uses appeared.

Thus, in this coast we can find eight different land uses (Table 4).

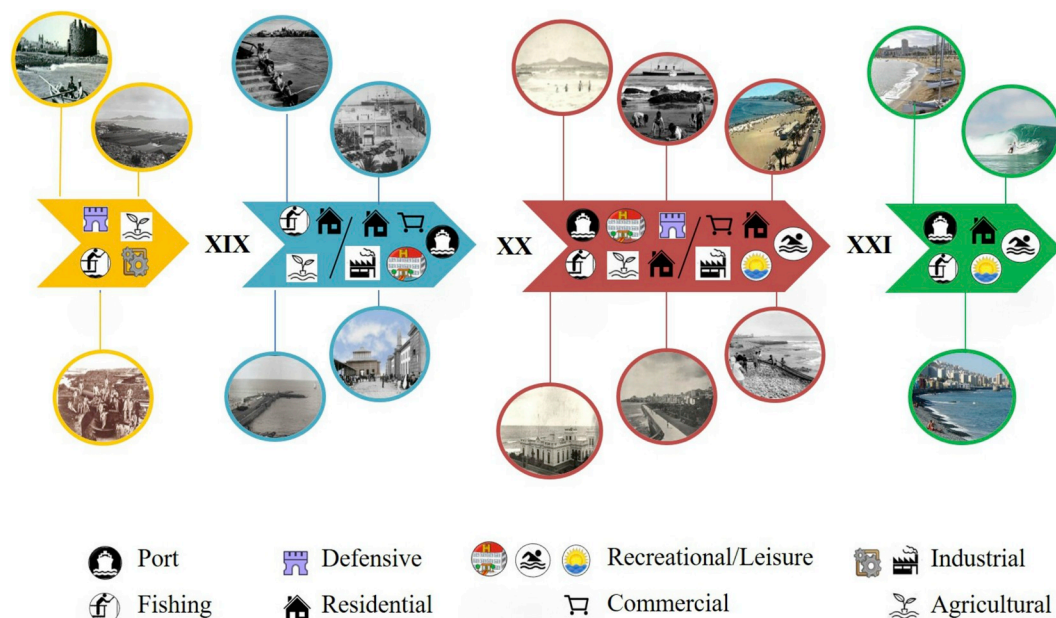


Fig. 4. Evolution of land use along the eastern coast of LPGC (photos: *Las Palmas Ayer y Hoy*, *Recuerdos de Gran Canaria* and FEDAC, 2015).



**Table 4**  
Description of the land uses identified.

L.U	Main features	Further data
<b>Fishing</b>	Fishing played a fundamental role in this sector of the city. It was most commonly practised by family groups.	Northern S. Commonly practiced by family groups in the port area.
		Central S. Commonly practiced by family groups in this sector. In Las Alcaravaneras, the fishing technique was practiced known as <i>el chinchorro</i> (type of trawler fishing with nets which lines of fishermen would haul to shore).
		Southern S. San Cristóbal and La Laja were 'professional family' beaches, contributing to the family economy in these neighborhoods. One of the most important practices was <i>el chinchorro</i> .
<b>Defensive</b>	After the Spanish conquest of the islands (XV century), and as a result of their growing strategic importance, numerous fortifications were constructed along the coast to protect the city against external attack. These defenses were reinforced with the incorporation, during the Second World War (1939–1945) of a set of machine gun nests.	Northern S. Batteries: <i>San Fernando</i> and <i>La Esfinge</i> were located in <i>El Sebadal</i> and <i>La Isleta</i> , respectively. Fortification: Castillo de La Luz in La Luz beach.
		Central S. Fortifications: in Santa Catalina the Castillo de Santa Catalina, in Triana and San Agustín the Cubelo de Santa Ana and Santa Isabel (both from the XVI century). Machine gun nests: In Las Alcaraveneras beach.
		Southern S. Fortifications: Castillo de <i>San Pedro Mártir</i> in <i>San Cristóbal</i> . Machine gun nests: on San Cristóbal and La Laja beaches.
<b>Agriculture</b>	Agricultural activity (local farming) also took place along two stretches of this coast (central and southern).	Northern S. –
		Central S. The banana crop was cultivated between the former Guanarteme dune field and <i>Vegueta</i> (pre-XX century).
		Southern S. In <i>Las Tenerías</i> , <i>San Cristóbal</i> and <i>La Cardosa</i> , was located the San José valley: Local farming included bananas and tomatoes, potatoes, corn, coriander, parsley, lettuce, cabbage, beans, radish, etc. An experimental farm was also set up in this area by the Regional Government: its purpose was to support other farmers and perform agriculture experiments to determine which crops were best adapted to the local environmental conditions (climate, soil, water) ( <i>Alcaraz Abellán</i> (1993)).
<b>Port</b>	Two places: northern and central sectors.	Northern S. <i>Puerto de La Luz</i> was constructed on the

**Table 4 (continued)**

L.U	Main features	Further data
<b>Industrial</b>	Several industrial activities were also developed along this stretch of coast, in 7 areas in particular.	Puerto de La Luz, which gave rise to La Isleta neighborhood, the development of the shoreline from Las Palmas to Santa Catalina and the establishment of a new population ( <i>Martín Galán</i> , 2001).
		Central S. beaches of La Luz and El Refugio in 1883. Numerous charcoal companies, shipyards and shipping agencies were set up. Most were foreign-owned (Elder, Miller, Grand Canary Coaling, Cory Brothers, Wilson, Blandy Brothers Woermann etc.)
		Southern S. <i>Puerto de Las Palmas</i> (the first city port) was established at Triana beach (carpentries, warehouses, shipyards, caulking workshops and dry docks).
<b>Commercial</b>	Commercial activity was concentrated in stores situated at ground level of the buildings, and involved mainly the supply of food, recreational and textile products.	Northern S. La Luz and Refugio beach: factories and industries related to coal companies. At El Caletón and Venegas: carpentries, workshops, warehouses, factories and small food industries (windmills, bakeries, ice cream, etc. (Florida, 1998)).
		Central S. Las Tenerías was devoted to tanning and carpentry activities. Two plants were established in Bajo de La Laja and La Laja in the middle of the XX century. One extracted rock from the hillside for the manufacture of bricks and blocks. The other made pieces of artificial granite for pavements.
		Southern S. Barter that took place here between the local population and the crews of the ships was a recognized practice known as <i>cambullón</i> . Local shops which mainly sold food, recreational and textile products (especially in Triana). In Caleta de San Agustín there was a market (since the 18th century), butcher's and fishmonger's (1876).
<b>Residential</b>	After construction of Puerto de La Luz, the shoreline between La Isleta and Vegueta gradually came to be occupied by buildings. <i>San Cristóbal</i> is the only neighborhood that still exists today, with a	Northern S. San Cristóbal beach: fish factory (1940s and 1950s) that exported its products to the UK, a tomato packing factory and a bottled water distribution company.
		Central S. The dwellings were low-rise constructions with a maximum of three floors. The dwellings were low-rise constructions with a maximum of three floors. Access to them was generally landward-facing. Access to the
		(continued on next page)

Table 4 (continued)

L.U	Main features	Further data
	morphology similar to its original one.	beach was possible through a back door or via small passageways that separated the buildings.
		Southern S. The dwellings were self-constructed with local materials (soil, loose material, sand and stone blocks) (Machín Gil (2006)). Further south were relatively unpopulated sectors.
Recreational	The first recreational use was for health tourism (the first tourist activity in the island) at the end of the XIX century. From this time onwards and with the introduction of foreign customs, sea bathing began to acquire some popularity among the local population and the value of this environment became more appreciated (Martín Galán, 2009). In the mid-XX century the coast became a recreational area for walks, contemplation of the maritime landscape, sports, games etc. The children of the poorest families would construct their own toys from waste materials that arrived at the beaches.	Northern S. Near to the port the departure and arrivals of the ships constituted an attraction for the local population.
		Central S. Santa Catalina beach (Las Alcaravaneras): different hotels and other tourist facilities were concentrated here at the end of the XIX century. In the 1950s, it was one of the best prepared beaches for family activities. A spa, restaurant, bar and small boats for short sea trips could be found here. Another attraction of this beach was the sight of hydroplanes landing on the sea (Cossío, 2014). Triana beach had a promenade and San Telmo park was nearby (Martín Galán, 2008).
		Southern S. Playa de Las Angustias: Camping with tents often made by the locals from old blankets, sheets or flour and sugar bags. La Laja beach: people went there to rest and snack. Summer houses of families from Triana and Vegueta could be found there.

Depending on its characteristics and localization, each beach had a different function (Figs. 5–7) for which various land uses were developed.

It can be seen how the northern and central beaches had more varied uses than those of the southern sector which tended to focus on fishing. Land uses were (high to low frequency): fishing, residential, recreational, agriculture, industrial, commercial, defensive and port. Some of these uses were no longer functional over time. Such is the case of the defensive elements located in San Cristóbal and Triana (*Torreón de San Pedro Mártir* and *Cubelo de Santa Ana*, respectively), which lost their use after the beginning of the 19th century.

#### 4.3. Lost surface area

In terms of surface area, 13.19 ha of beaches have been lost. Currently, the only beaches that remain are *Las Alcaravaneras*, *San Cristóbal*, *La Laja* and *Bajo de La Laja* (Pérez Hernández and Hernández Calvento, 2017) (Table 5).

Of these, *Las Alcaravaneras* has been the most affected, losing 3.78 ha due to the development of port infrastructures. Currently, this beach is located within the port area. The beach of *San Cristóbal* has lost 2.06 ha as the result of construction of the promenade and the small port area in this neighborhood. *Bajo de La Laja* has almost completely disappeared (0.69 ha lost), whereas *La Laja* has not experienced major loss (only 0.18 ha). Although *San Cristóbal* and *La Laja* have experienced changes, their morphologies have remained more or less unaltered.

The rest of the coast (including the beaches that formed it) disappeared in the mid-XX century due to the extension of the city towards the sea (Fig. 8) and the need to acquire more land for the population. Thus, 100% of the territory of these beaches was lost.

#### 4.4. Overview

In terms of land use, the occupation of the eastern coast of LPGC generally speaking followed three pathways depending on the sector: (1) buildings and infrastructures were located near to the shoreline, but did not significantly affect its characteristics: this was the case in *San Cristóbal* and *La Laja*; (2) port infrastructures and buildings altered the morphology of the original shoreline: this was the case in *Las Alcaravaneras*; and (3) the infrastructures and buildings totally changed the coast: this was the case in *El Sebadal*, *La Luz*, *El Refugio*, *Lugo*, *El Caletón*, *Venegas*, *Triana*, *San Agustín*, *Las Tenerías*, *La Cardosa*, *Aguadulce* and *Bajo de La Laja*.

In general, the northern beaches were occupied by port, commercial and industrial facilities. The growth of the city of LPGC occupied the central sector of this coastal stretch, from *Las Alcaravaneras* to *Vegueta*, invading the former Guanarteme dune system (Santana Cordero et al.,

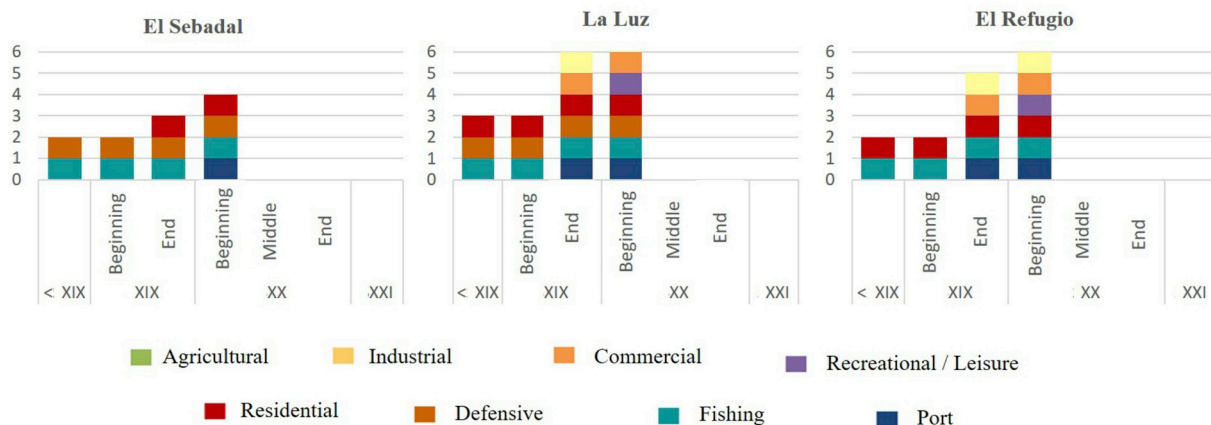


Fig. 5. Distribution of land use by century (pre-XIX century, XIX century, XX century and XXI century) in the northern sector.



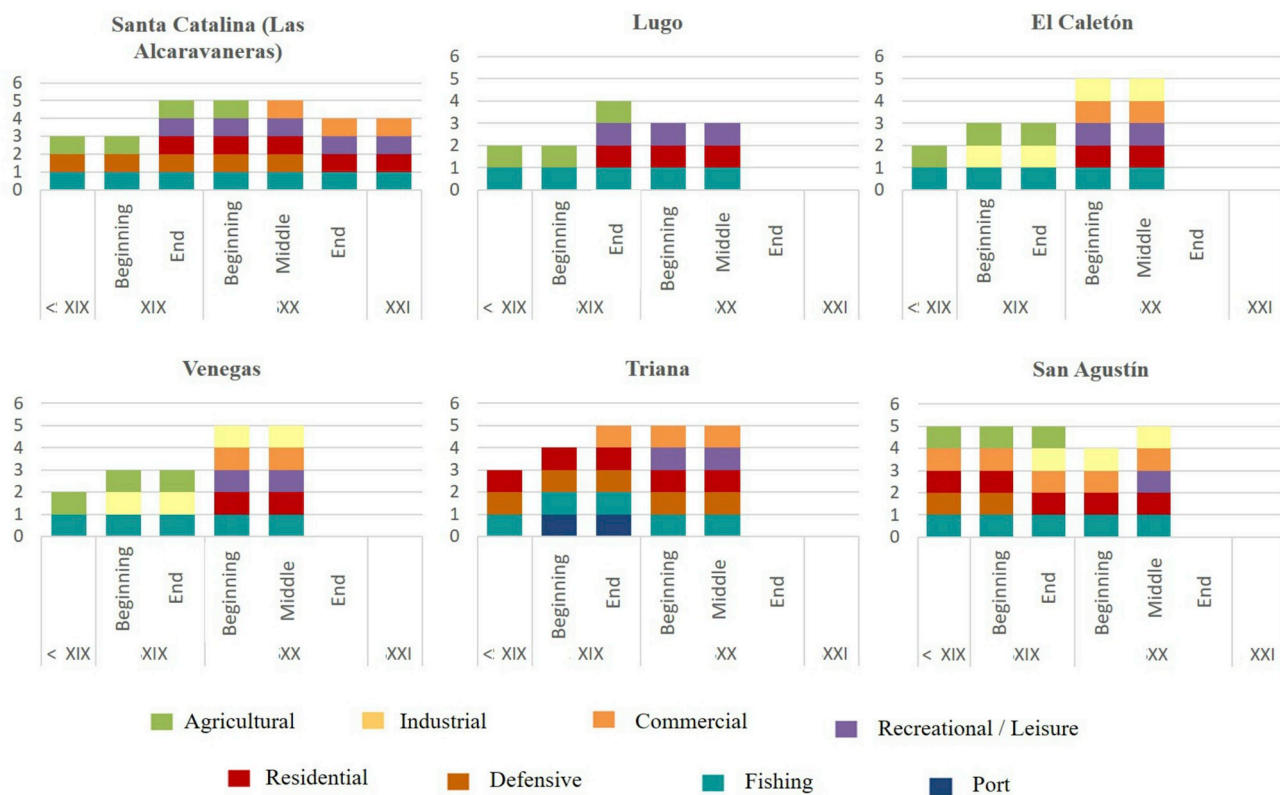


Fig. 6. Distribution of land use by century (pre-XIX century, XIX century, XX century and XXI century) in the central sector.

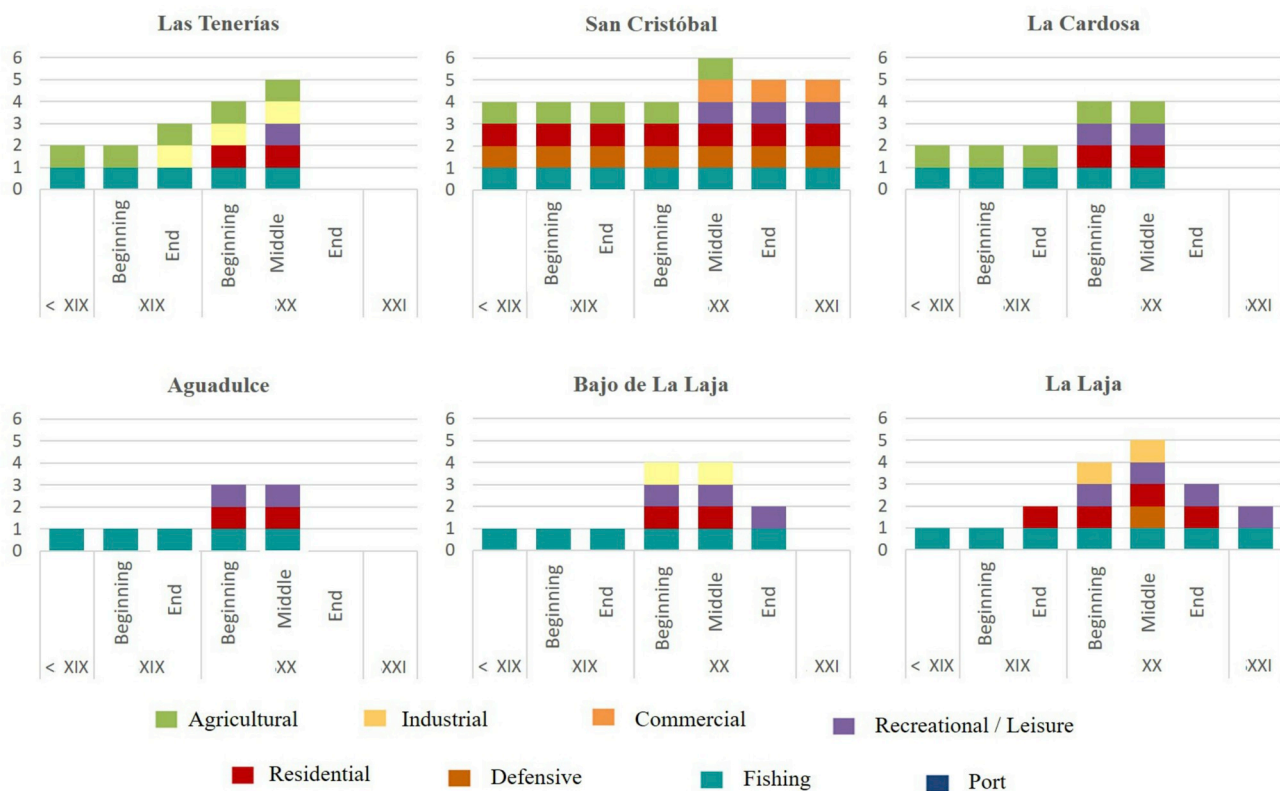


Fig. 7. Distribution of land use by century (pre-XIX century, XIX century, XX century and XXI century) in the southern sector.

**Table 5**

Beaches and their surface area (ha).

Beaches	Area (ha) 1954	Area (ha) today
El Sebadal	Unknown <sup>a</sup>	0
La Luz	Unknown <sup>a</sup>	0
El Refugio	Unknown <sup>a</sup>	0
Santa Catalina (Las Alcaravaneras and Lugo)	6.85	3.07
El Caletón	0.77	0
Venegas (Playa Bonita)	0.42	0
Triana	0.91	0
San Agustín	1.13	0
Las Tenerías	1.59	0
San Cristóbal	3.83	1.77
La Cardoso (El Cardoso)	0.68	0
Aguadulce	0.97	0
Bajo de La Laja	0.71	0.02
La Laja	3.57	3.39

<sup>a</sup> Note that El Sebadal, La Luz and El Refugio beaches cannot be mapped (nor therefore their areas measured) from the 1954 aerial photograph, because at the time they did not exist. These beaches were identified from historical maps and oral sources.

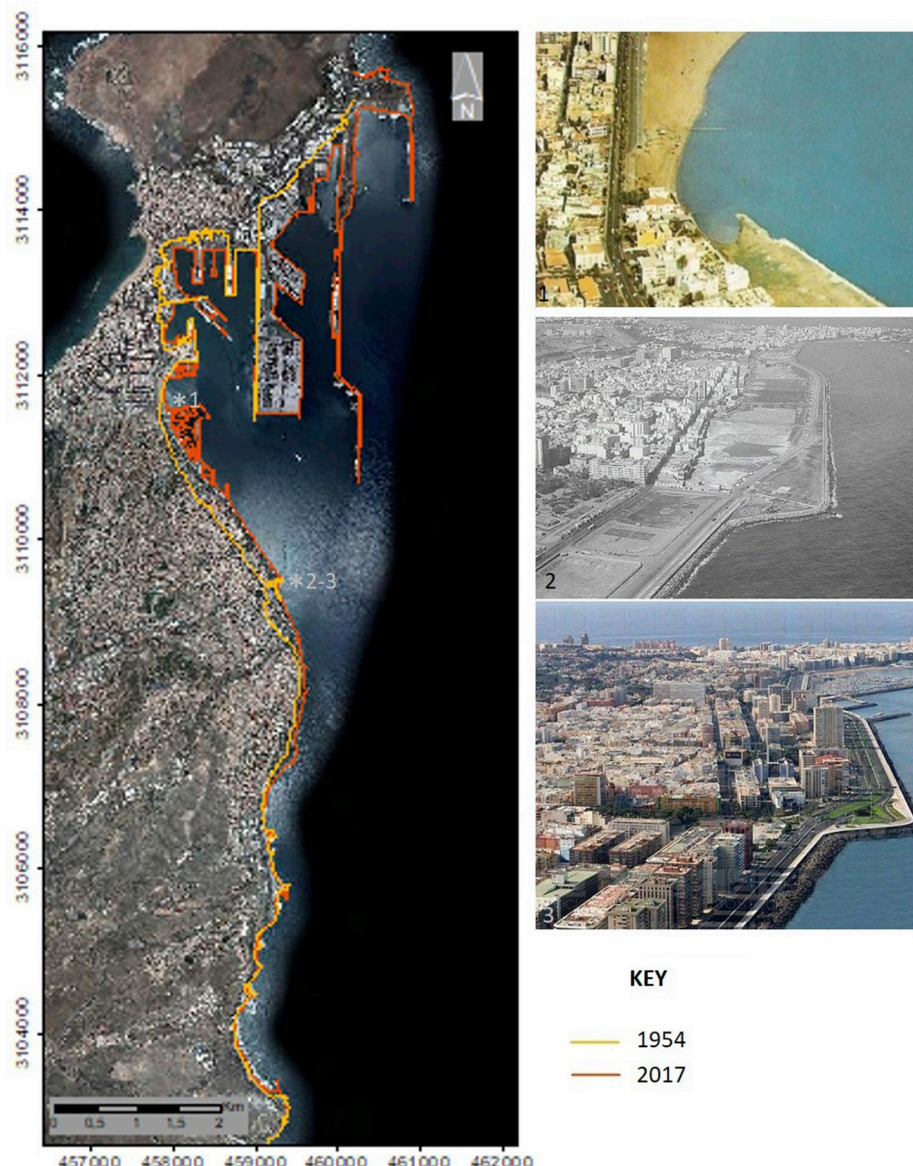
2014, 2016, 2017). The southern coast was occupied by road and health infrastructures, residential zones and green spaces.

Bearing in mind these three modalities of occupation, the characteristics of each stretch of the coast are presented in Tables 6–8.

## 5. Discussion

Coastal areas have become places of growing interest in the scientific literature (Gormsen, 1997; Martínez et al., 2007). As has been demonstrated, they are areas which are highly susceptible to change in terms of their morphological dynamics, with significant natural losses occurring as a result of human activities (Jackson and Nordstrom, 2011; García Romero et al., 2016). It is widely accepted that such consequences can derive from the processes involved in changes to land use. This has been the case of our study area. The present work has shown not only the evolution and transformations experienced by this coast, but also the territorial and functional losses that it has undergone by linking disappeared beaches with those existing in the present. Additionally, this research provides quantitative data with which the natural losses can be calculated.






The study area has undergone major changes, especially in relation



**Fig. 8.** Comparison of the shoreline in 1954 and in 2017. Photos: IDECanarias, Las Palmas Ayer y Hoy and Recuerdos de GC.

**Table 6**

Natural and cultural characteristics, land use and lost area of the beaches of the northern sector of the eastern coast of LPGC.

	DESCRIPTION				GEOLOGY	ECOLOGY	CULTURE	LAND USES	LOST AREA
EL SEBADAL	Location	Coordinates	Length	Beach	Basanite lava platform of the post-Roque Nublo lower cycle (2.8 Ma.)	Sparse and scarce vegetation, with the most significant being <i>Cymodocea nodosa</i>  Varied and rich in marine fauna species	Area practically uninhabited with some fishermen's houses and military buildings nearby	Fishing Defensive Residential Port	100%
	Northeast coast	28°09'06.08"N 15°25'01.25"W	2.7 km approx.	Pebble					
		28°09'53.43"N 15°24'11.57"W							
									
LA LUZ	Location	Coordinates	Length	Beach	Basanite lava platform of the post-Roque Nublo lower cycle (2.8 Ma.)	Scarce or minimal value due to construction of the port	Port area of Puerto de La Luz (at the end of the 19th century)  Coal companies, ship repair and shipping agencies  "cambullón" (unregulated barter)	Fishing Defensive Residential Port Industrial Commercial Recreational	100%
	Northeast coast	28°08'50.50"N 15°25'43.18"W	790 m approx.	Mixed					
		28°08'57.19"N 15°25'12.59"W							
									
EL REFUGIO	Location	Coordinates	Length	Beach	Part of the seaward outlet of the extinct dune fields of Guanarteme  Mixed composition (organogenic-volcanic) and fine grain size	Scarce or minimal value due to construction of the port	Port area of Puerto de La Luz (at the end of the 19th century)  Coal companies, ship repair and shipping agencies  "cambullón" (unregulated barter)	Fishing Residential Port Commercial Industrial Recreational	100%
	Northeast coast	28°08'51.50"N 15°25'43.18"W	795 m approx.	Sand					
		28°08'25.65"N 15°25'45.77"W							
									

to land use and the natural landscape. The results show that most of the eastern coast of LPGC has been lost, with only some sections of three beaches remaining intact: Las Alcaravaneras, San Cristóbal and La Laja. We consider that exogenous socio-economic factors (Lambin and Meyfroidt, 2010), above all with respect to the influence of the port and the investments it has attracted, are the main cause of land change and transformation in this general area. Other factors include the rush to 'modernize' the city, urbanistic/political motives driven by the needs of a growing population, and the substantially lower environmental awareness that existed in the past. By way of example, a City Project document from 1894 (Archivo Histórico Nacional, 1894) explains how the plan to gain land from the sea along the Santa Catalina beaches was a viable and cheap option given that other land was being used at the time for crops and, as the document claims, "the coast has no value for society". Consequently, important resources, from a social and land use point of view, have been lost to the city. The local establishment of a given land use is usually linked to cultural traits that characterizes the area. In this line, traditional human practices, such as *el chinchorro* (land-based trawler fishing practice) and *el cambullón* (commercial exchange between small local boats and foreign ships) can be considered intangible human goods. Thus, the beaches studied represented a connection between land and culture for centuries. The loss of a large part of the coastal features has thus resulted in part of the natural history of the island also being lost.

The idea of gaining land from the sea has been put into practice in numerous places and in many countries, including the Netherlands, Monaco, Dubai (Dubai Marina or Palm Island), Japan, New Zealand, Gibraltar, Chile (Valparaíso), Turkey (Istanbul), Indonesia and Singapore, among others. Similar studies to the present one have been conducted on some of these places in terms of quantifying urban growth in their coastal areas (Marfai et al., 2008; Smit et al., 2008; Kurt et al.,

2010; Nassar et al., 2014). Zhang et al. (2019) found that in Ningbo (a coastal city in China) construction land, i.e. urban/rural residential land, industrial and commercial areas, as well as other facilities, dominated in the period 1990–2005. However, this trend changed for 2005–2016, when agricultural use became dominant. Comber et al. (2016) analyzed land use changes on the coasts of England, Wales and Northern Ireland between 1965 and 2014, detecting a decline in defense land uses and an increase in urban and leisure land use, as well as woodland. On the other hand, Thanh Thoi and Dang (2019) studied the evolution over a 20 year period (1990–2010) of a coastline in the south of Vietnam. During this period, 2206 ha of coastal zone were lost to erosion, in which both natural and human factors intervened. Erosive losses were also observed by Aymara and Benseny (2016) in Miramar (Argentina) from 1888 to 2015 associated with urban-tourism development. In Spain, other similar investigations have been carried out, such as the work of Sanjosé et al. (2016) on the coastal evolution of the Cantabrian coast (northern Spain) in the period 1988–2014, in which they observed the retreat of the coastline. Manno et al. (2016) studied the evolution of coastline armoring along Spain's Andalusian coast during the period 1956–2010 when ports and coastal defense infrastructures (breakwaters, etc.) were created to avoid erosive losses and to expand the dry beach to benefit tourist and urban development at the expense of natural sedimentary transport. A general view of all these studies proves that changes in land use are dynamic in terms of adopting different trends.

The historical reconstruction of coastal areas can be used to understand their spatial variation over time and can provide keys to understand their function and current state (Douglas and Crowell, 2000; Botequilha Leita and Ahern (2002)). Studies of this type should be considered when management, protection or regional planning projects are being undertaken in order to develop a more sustainable urban fabric. In this regard, it should be taken into account that, in the period



Table 7

Natural and cultural characteristics, land use and lost area of the central sector of the eastern coast of LPGC.




















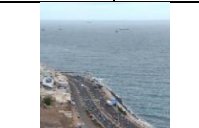
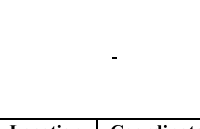



	DESCRIPTION				GEOLOGY	ECOLOGY	CULTURE	LAND USES	LOST AREA
SANTA CATALINA (LAS ALCARAVANERAS)	Location	Coordinates	Length	Beach	Part of the seaward outlet of the extinct dune fields of Guanarteme  Mixed composition (organogenic-volcanic) and fine grain size	Sparse and scarce vegetation (halophile, psammophile and xerophile species), with the most significant being <i>Traganum moquinii</i>  Varied and rich in marine fauna species	Health tourism due to the beneficial properties of the water and climatic and environmental qualities  Hotels (Santa Catalina, Metropol, British Club)	Agricultural Defensive Fishing Residential Commercial Recreational	55.2%
	East coast	28°08'09.12"N 15°25'44.40"W	1.9 km approx..	Sand					
		28°07'07.77"N 15°25'27.38"W							
									
LUGO	Location	Coordinates	Length	Beach	Phonolite base with fossil marine deposits from the Pleistocene  <i>Strombus bubonius</i> and <i>Thais haemastoma</i> (Linné) fossils  Conglomerates of rounded basaltic pebbles (upper level)	Sparse and scarce vegetation (halophile, psammophile and xerophile species), with the most significant being <i>Traganum moquinii</i>  Varied and rich in marine fauna species	Residential and commercial area	Fishing Agricultural Residential Recreational	100%
	East coast	28°07'25.27"N 15°25'39.26"W	700 m approx.	Mixed					
		28°07'07.61"N 15°25'25.35"W							
									
EL CALETÓN	Location	Coordinates	Length	Beach	Phonolite base with fossil marine deposits from the Pleistocene. <i>Strombus bubonius</i> and <i>Thais haemastoma</i> (Linné) fossils  Conglomerates of rounded basaltic pebbles (upper level)	Sparse and scarce vegetation (halophile, psammophile and xerophile species), with the most significant being <i>Traganum moquinii</i>  Varied and rich in marine fauna species	Carpentries, warehouses and food industries  Windmills for the production of breadmaking flour and gofio (toasted cornmeal)	Fishing Agricultural Industrial Residential Commercial Recreational	100%
	East coast	28°07'07.77"N 15°25'27.38"W	600 m approx.	Mixed					
		28°07'07.77"N 15°25'27.38"W							
									
VENEGAS	Location	Coordinates	Length	Beach	Phonolite base with fossil marine deposits from Pleistocene  <i>Strombus bubonius</i> and <i>Thais haemastoma</i> (Linné) fossils  Conglomerates of rounded basaltic pebbles (upper level)	Sparse and scarce vegetation (halophile, psammophile and xerophile species), with the most significant being <i>Traganum moquinii</i>  Varied and rich in marine fauna species	Carpentries, warehouses and food industries  Buildings for recreational and social use	Fishing Agricultural Industrial Residential Commercial Recreational	100%
	East coast	28°07'07.77"N 15°25'27.38"W	600 m approx.	Mixed					
		28°07'07.77"N 15°25'27.38"W							
									
TRIANA	Location	Coordinates	Length	Beach	Phonolite base with fossil marine deposits from Pleistocene  <i>Strombus bubonius</i> and <i>Thais haemastoma</i> (Linné) fossils  Conglomerates of rounded basaltic pebbles (upper level)	Sparse and scarce vegetation (halophile, psammophile and xerophile species)  Varied and rich in marine fauna species	The first port of the city (1811)  Santa Ana tower (1574) located at the end of the Las Palmas wall at the northern end of the city	Fishing Port Defensive Residential Commercial Recreational	100%
	East coast	28°06'35.13"N 15°24'59.92"W	740 m approx..	Mixed					
		28°06'12.19"N 15°24'47.96"W							
									
SAN AGUSTÍN	Location	Coordinates	Length	Beach	Phonolite base with fossil marine deposits from Pleistocene  <i>Strombus bubonius</i> and <i>Thais haemastoma</i> (Linné) fossils  Conglomerates of rounded basaltic pebbles (upper level)	Sparse and scarce vegetation (halophile, psammophile and xerophile species)  Varied and rich in marine fauna species	Commercial facilities including a market, fishmonger's, butcher's, etc., and public buildings	Fishing Defensive Residential Commercial Industrial Agricultural	100%
	East coast	28°06'10.34"N 15°24'47.39"W	963 m approx.	Pebbles					
		28°05'40.65"N 15°24'45.09"W							
									

Table 8

Natural and cultural characteristics, land use and lost area of the southern sector of the eastern coast of LPGC.

	DESCRIPTION				GEOLOGY	ECOLOGY	CULTURE	USES	LOST AREA
LAS TENERÍAS	Location	Coordinates	Length	Beach	Phonolite base with fossil marine deposits from Pleistocene <i>Strombus bubonius</i> and <i>Thais haemastoma</i> (Linné) fossils Conglomerates of rounded basaltic pebbles (upper level)	Sparse and scarce vegetation (halophile, psammophile and xerophile species), with the most significant being <i>Cymodocea nodosa</i> Varied and rich in marine fauna species	A large fertile plain near the beach (locally called "Vega de San José")  Industrial activities, such as leather tanning or carpentry	Fishing Agricultural Industrial Residential Recreational	100%
	Southeast coast	28°05'40.65"N 15°24'45.09"W 28°05'01.33"N 15°24'59.38"W	1.22 km approx.	Pebble					
									
SAN CRISTÓBAL	Location	Coordinates	Length	Beach	Phonolite base with fossil marine deposits from Pleistocene <i>Strombus bubonius</i> and <i>Thais haemastoma</i> (Linné) fossils Conglomerates of rounded basaltic pebbles (upper level)	Sparse and scarce vegetation (halophile, psammophile and xerophile species)  Varied and rich in marine fauna species	Traditional fishing activities, including local technique of "chinchorro" (trawl fishing from the shore)  A large fertile plain near the beach (locally called "Vega de San José")	Fishing Defensive Residential Agricultural Recreational Commercial	53.8%
	Southeast coast	28°05'01.33"N 15°24'59.38"W 28°04'26.19"N 15°24'53.12"W	1.3 km approx.	Pebble					
									
LA CARDOSA	Location	Coordinates	Length	Beach	Phonolite formation (Cycle I, Upper Miocene)	Sparse and scarce vegetation (halophile, psammophile and xerophile species)  Varied and rich in marine fauna species	Traditional fishing activities, including local technique of "chinchorro" (trawl fishing from the shore)  Agricultural facilities	Fishing Residential Agricultural Recreational	100%
	Southeast coast	28°04'26.19"N 15°24'53.12"W 28°04'12.52"N 15°25'01.01"W	468 m approx.	Pebble					
									
AGUADULCE	Location	Coordinates	Length	Beach	Phonolite formation (Cycle I, Upper Miocene)	Sparse and scarce vegetation (halophile, psammophile and xerophile species)  Varied and rich in marine fauna species	Traditional fishing activities	Fishing Residential Recreational	100%
	Southeast coast	28°04'12.52"N 15°25'01.01"W 28°04'02.40"N 15°25'01.81"W	350 m approx.	Pebbles					
									
BAJO DE LA LAJA	Location	Coordinates	Length	Beach	Phonolite formation (Cycle I, Upper Miocene)	Sparse and scarce vegetation (halophile, psammophile and xerophile species)  Varied and rich in marine fauna species	Traditional fishing activities	Fishing Industrial Residential Recreational	98.6%
	Southeast coast	28°04'02.40"N 15°25'01.81"W 28°03'52.87"N 15°25'05.97"W	374 m approx.	Pebbles					
									
LA LAJA	Location	Coordinates	Length	Beach	Two magmatic cycles: Phonolite formation (Cycle I, Upper Miocene)  Basaltic and tetric lavas belonging to the 2nd volcanic cycle of the island ("Roque Nublo", Pliocene)	Sparse and scarce vegetation (halophile, psammophile and xerophile species), with the most important being <i>Cymodocea nodosa</i> and <i>Lotus kunkelii</i>  Varied and rich in marine fauna species	Traditional fishing activities, including local technique of "chinchorro" (trawl fishing from the shore)  Mining industries  Summer residences	Fishing Recreational Residential Industrial Defensive	5%
	Southeast coast	28°03'52.87"N 15°25'05.97"W 28°03'12.92"N 15°24'51.67"W	1600 m approx.	Mixed					
									

in which the transformation of the eastern coast of LPGC city took place (1960), the regulation of the coastal areas in Spain depended on the Port Laws (from 1880 to 1928), whose main objective was to meet the needs of navigation and shelter conditions for vessels and which paid no

attention to non-port coastal areas (Torres, 2010). Spain's Law on Centers and Areas of National Tourist Interest of 1963 promoted tourism development on the Spanish coasts (Ariza et al., 2016), but had no impact on our area of study, since it was not an area of tourist attraction.

It is only since promulgation of the Coastal Law of 1969 (and more directly the Coastal Law of 1988) that these spaces are considered areas to be preserved, through conservation of their ecosystems and stabilization of the coastlines (Ariza, 2011). Thus, prior to enactment of the first Coastal Law of 1969, there were no legal limits to urban plans that promoted the seaward urban growth of the city of LPGC. The three remaining beaches at that time (Alcaravaneras, San Cristóbal and La Laja) have been protected since then by that and later Coastal Laws and by municipal regulations based on that legislation. In accordance with these and the current [municipal regulations on coasts and beaches \(in force since 2013\)](#), in these three remaining beaches, conservation and improvement work has been carried out for public use and to guarantee the rational use of public space. Previously in this regard, in the 1990s, the Ministry of Environment carried out a regeneration action on La Laja beach, building a submerged dike and providing sand from nearby seabed (Ministry of Agriculture and Fisheries. Food and Environment, 2019). At present, through the City Council's 'Pacto por el Mar' (Ciudad de Mar 2014) initiative for the sustainable development of the LPGC coast, actions are underway aimed at sustainable coastline development ('Territorios Azules' project), promotion of the city's southernmost coastal area ('Cono Sur' project) and regeneration of the port isthmus area ('Sanapú-Istmo' project). The general goals of this wide-ranging initiative include improving water quality, reducing waste discharges at sea, and promoting sea-based renewable energies as well as marine and nautical sports tourism.

While many coastal areas of the planet have been considerably transformed and some may even have disappeared (as in our study area), it is clear that their restoration is, today, unfeasible, especially from the socio-economic point of view. Nonetheless, they retain an importance in their ability to sensitize society, hopefully making it more aware of the need to preserve and limit the damage that can be done and, especially, to avoid further negative environmental impacts in the future.

Likewise, this kind of study can be used to retrieve the environmental memory of a place enabling a knowledge and understanding of the relationship between the people that inhabited that place and its natural area (Hughes, 2006), as well as of the characteristics of the natural system (Santana Cordero et al., 2014).

Finally, this line of study can be the basis for the undertaking of new projects in which cultural activities are developed to help promote interest in natural heritage. Studies of this type can continuously be enriched with newly found materials and data.

## 6. Conclusions

This work is concerned with the reconstruction of the natural characteristics, cover and use of coastal land, and the rediscovery of traditions intrinsically associated with the territory in spaces that have disappeared as the result of recent human intervention. To achieve these objectives, a methodology was used which was based on historical, geographic and bibliographic sources.

The results of the study show that the vast majority of the natural and manmade elements which used to characterise the eastern coastline of Las Palmas de Gran Canaria city have progressively disappeared over the last 70 years. The analysis of the sources revealed the extension and previous use of lost beaches along the eastern coast of the city Las Palmas de Gran Canaria. In addition, the changes that have happened in recent decades were quantified.

Land use change has many implications, some of them related to the loss of human and natural assets. Such losses can disconnect a place from its past. Knowing an area's past by retrieving its historical characteristics is essential for planning its future development in a sustainable way. The integration of historical (natural and cultural) features can be extremely useful for future land change planning.

Working on the concept of lost natural heritage can open up new perspectives in historic reconstruction research, development and

strategies. Through these, lessons from the past can be learned and applied to land management issues today. The results obtained from this type of study can also be used to develop original cultural strategies, educate new generations and provide visitors to the area with interesting and relevant information.

## Acknowledgements

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