

Decadal Environmental Changes on the Dune Field of Maspalomas (Canary Islands): Evidences of an Erosive Tendency

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Abstract

This paper shows the environmental changes that have taken place in a dune area since the 60s decade until present time by means of aerial photographs and satellite images. The selected study area is the Maspalomas dune field, located in the southern margin of Gran Canaria. This area is the only dune field in the island and was declared Special Natural Reserve in 1994 according to coastal conservation and management policy. The evolution of this system is closely related with tourist activities around the area, where the urban development since the 60s decade seems to be related with the modification of the lower wind field, which contributed to the stabilization of the inner dune sector. Another aspects related to the sedimentary evolution of the area includes the general decrease of the dune field height, the formation of wide deflation surfaces and wet sandy areas, the lower dune mobility due to the increase of vegetation, and the shoreward retreat of the foredune. All this facts can only be explained due to decrease in the input of sediments.

1. INTRODUCTION

Coastal dune fields are very complex environments due to diversity of physical and ecological processes affecting their dynamics.

Characteristics of the wind field and sediment properties mostly determine their sedimentary dynamics. Wind field is determined by atmospheric conditions, but strongly modified close to bed by the local topography (Gomes *et al.*, 2002). Grain size and density of sediments, their humidity content, presence of salt crust and other factors (Sherman & Hotta, 1990) also determine the evolution of dune fields. Moreover, the input of sediments to coastal dunes is normally determined by the marine dynamics on the beaches associated to these areas.

Characteristics of dune ecosystem are strongly conditioned by the sedimentary dynamics. Therefore, vegetation in coastal dunes presents a landward gradient associated to the degree of dune mobility. The continuous transport of sediments in the active area close to the shoreline restricts the growth of vegetation, although it is generally accepted that the initiation of the foredune can be traced to the influence of vegetation (Bauer and Sherman, 1999) while the inland zones normally had a lower mobility of sediments that permits a higher vegetal cover. A feedback process have been described between growth of vegetation and dune stabilisation (Tsoar & Moller 1986).

Human uses of dune fields are generating a drastic modification on evolution of these systems (Nordstrom 1994, 2002).

Unfortunately, massive tourist use of many beaches has been followed by the destruction of many coastal dune areas during the last decades all along the world (Paskoff, 1998). Reconstruction of destroyed dunes is nearly impossible because these zones have become occupied in many cases by resorts, or in some other cases, the new dunes are smaller and more linear than the natural dunes they replaced (Nordstrom, 1994).

In medium term, destruction of coastal dunes usually generates problems of coastal erosion, since the coast become more vulnerable to storm surges and issues related to sea level rise (Thomas, 1999).

The study of coastal dune evolution in tourist areas needs a different methodology compared to natural areas due to the diversity of human actions and effects involved. However, appropriate monitoring of the dune area is necessary in order to prevent their degradation, since the consequences will not be only environmentally adverse, but also economically catastrophic.

Therefore, the aim of this work is to analyse the roles that geomorphologic parameters and human uses play in the evolution of a particular coastal dune area.

2. STUDY AREA

The dune field of Maspalomas is located in the southern margin of Gran Canaria, in Canary Islands (Figure 1). This is the only dune field in the island, with a total extension of 4 km².

Several dune areas are also in some other islands of the archipelago, but this is the most important one of interest to tourists. Geomorphologic characteristics are also unique, due to presence of paleobarrriers of pebbles, a lagoon related to alluvial and marine dynamics, and active beach-dune interactions. The main aeolian feature of the dune field is the presence of barchan and transverse dunes, but a partially vegetated foredune is also present.

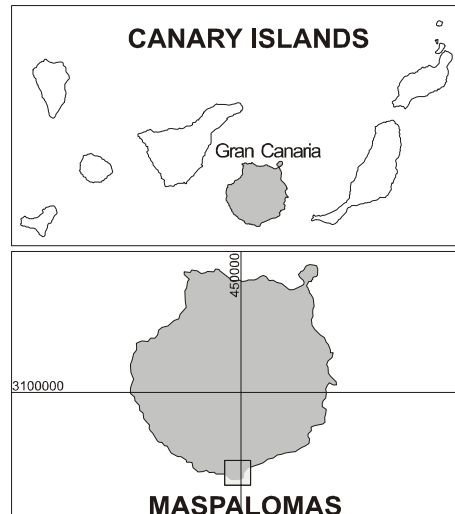


Figure 1: Location of the study area.

The study area is limited by two exposed beaches, El Inglés and Maspalomas, facing East and South respectively, while tourist resorts currently occupy rests of the border (Figure 2).

Sediments of this dune field are marine sands, with average size of 0,18 mm and 48% calcium carbonate (Martínez *et al.*, 1986). This materials have been accumulated into the former delta of the ravine of Maspalomas. This delta is fossilized at present time by sand deposits that overlay it with an average height of 5-10 m. (Nadal and Guitián 1983).

Climate is warm and dry (Marzol 1987), with an average temperature of 23°C and low diurnal fluctuations. The rainfall is rare (100 mm) with an irregular monthly distribution. Trade winds are the dominant ones, blowing from the NE with an average velocity ranging from 24 to 28 km/h (Naranjo 1999).

Vegetation is composed by psammophile and halophile species. They present different rates of coverage depending on the presence of water, salt and dunes. The only specie near the beaches is *Traganum moquinii*, which specimens show significant sizes at the north of El Inglés Beach.

In the interdune areas inside the dune field it is possible to find *Cyperus laevigatus*, while in the crest of the dunes sand is fixed by *Tamarix canariensis*. Finally, in the inner sector, where dunes are completely stabilized, the most significant species are *Launaea arborescens*, *Juncus acutus* and, occasionally, *Phoenix canariensis*.



Figure 2: General view of the dunar system.

Tourism is the main economic activity of Canary Islands, and Maspalomas is probably the largest tourist area in the whole archipelago. This area has changed a lot since the early sixties due to the fast increase of tourism activities. Most of these activities are associated to the intense use of the beaches and the dune filed itself. The results are a compact urban development all around the dune field and a permanent presence of kiosks and numerous zones of hammocks on the beaches.

Conservation of Maspalomas dune field has been carried out by different legal figures since 1982. Finally, the area was declared a Natural Special Reserve in 1994. The coastal strip where are located the beaches is outside this protected area, but it is classified as Ecological Sensitivity Area. Recently, the Director Plan for management of the Special Natural Reserve of Maspalomas (B.O.C. 051/1999) has established the necessity to study the dynamics and morphological processes in the dune field.

3. METHODOLOGY

Different techniques have been used to determine the main environmental changes on the study area since 1959 to 2000, *i.e.* from the beginning of the tourist development in the area to until present situation.

These techniques include analysis of aerial photographs and satellite images, generation of ortho-photographs, photo-interpretation, monitoring of topographic profiles and calculation volume changes of sand.

The aerial photographs from all the decades (60', 70', 80' and 90') with a similar nominal scale have been digitized and corrected to avoid distortions due to geometry, differences in real scale and tilting (Moore, 2000). The multispectral image of October 1993 was obtained by an Advanced Thematic Mapper (ATM) sensor of the Instituto Nacional de Técnica Aeroespacial (INTA), while the IKONOS panchromatic image was taken in June 2000.

Landscape evolution has been obtained by means of the comparison of all these images. Therefore, any changes in the different geomorphological units have been detected. These units include the aeolian deflation surfaces, the length of the shadow corridors located at the leeward side of the kiosks, the surface of interdune areas covered by wet sand, and the distance between the coastline and the foredune at El Inglés Beach.

Several topographic profiles across the dune field were carried out from two cartographic documents 1:5000, dated in 1962 and 1996, which were very detailed in relation with the topographic data.

4. RESULTS AND DISCUSSION

The analysis of the multispectral image of 1993 shows the presence of the underlying substratum, composed of alluvial sandy clays and the expansion of the vegetation communities. Both facts have been related to the shortage of aeolian sediments in some areas inside the dune field (Suárez & Hernández 1998). Moreover, it has been also possible to detect some darker lines close to El Inglés Beach following a ENE-WSW orientation. These lines correspond to areas uncovered by aeolian sediments, due to the interaction of the kiosks with the aeolian sediment transport.

El Inglés Beach is the most important source area of sediments towards the dune field (Martínez, 1990). However, the mobile dunes close to the beach have disappeared during the last decades (Figure 3). In this area, dunes have been replaced by stony and wet sands surfaces where the only aeolian bedforms are very small occasional barjanoid dunes (less than 1 m height) and sand sheets. These surfaces are clearly a consequence of deflation processes, and indicate a sedimentary deficit on the input of sediments to the system.

In the inner sector of the dune field has been observed the increase of these wet sand surfaces. Associated to these surfaces, has been also detected an increase in vegetation cover from 1959 to 1998 (Figure 4).

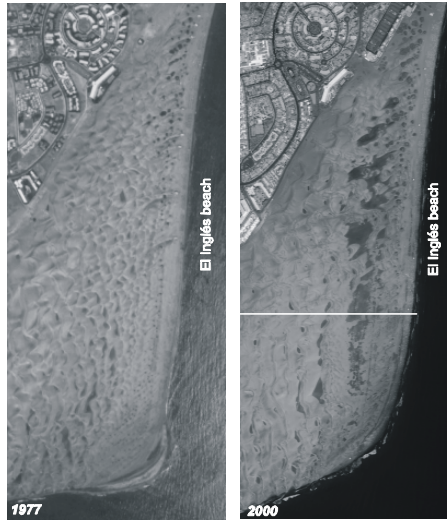


Figure 3: El Inglés Beach. 1977 aerial photograph (left) and 2000 IKONOS image (right)

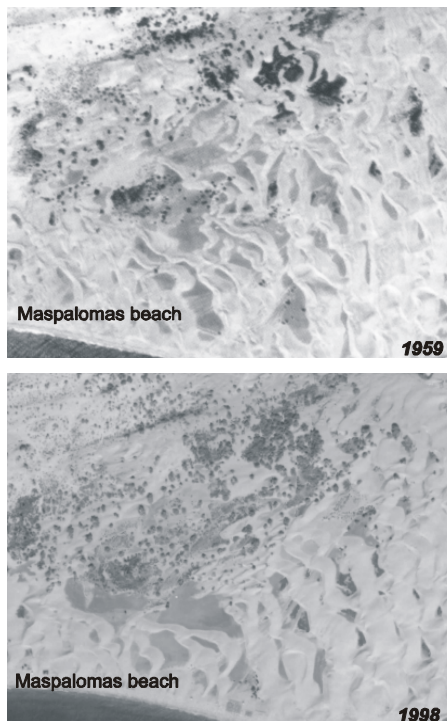


Figure 4: Increase of the vegetation communities between 1959 (up) and 1998 (down)

These changes are related to the building of tourist resorts on the sedimentary terrace located northward the dune field. These resorts are related with the modification of the lower wind field, and therefore the aeolian sediment transport across this sedimentary terrace is completely interrupted. On the other hand, the modified wind field contributes to stabilize the dunes in the inner sector of the dune field.

The analysis of aerial photographs also shows that the distance between the foredune and the shoreline along El Inglés Beach has exponentially increased by a factor of 3,5 since the early sixties (Figure 5). This exponential behaviour can not be explained due to sea level rise, since the shoreline changes does not show any trend neither in the landward nor the seaward direction. (Alonso et al, 2001). Therefore, this pattern again confirms a progressively lower input of sediments to the aeolian system.

Finally, topographical profiles allowed us to detect the decrease on the dune field height between 1962 and 1996. An average decrease of 1.0 m has been calculated for the whole study area, although changes in some sectors are nearly 4 meters height. Figure 6 shows the profiles obtained accross El Inglés beach and the nearby inside area (see Figure. 3 for profile location). An average decrease of 1.5 meters has been detected. These topographic measurements indicate that the loss of sediments is a generalised process that affects all the aeolian system.

5. CONCLUSIONS

Maspalomas dune field has shown intense modifications during the last forty years. These changes include the formation of deflation surfaces, the increase of wet interdune sandy areas, the growth of vegetated areas, the stabilization of the dunes in the inner sector, the shoreward displacement of the foredune and the general decrease of the dune field height.

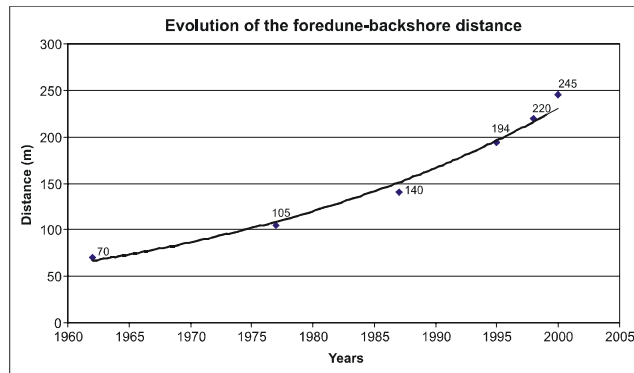


Figure 5: Evolution of the foredune-backshore distance

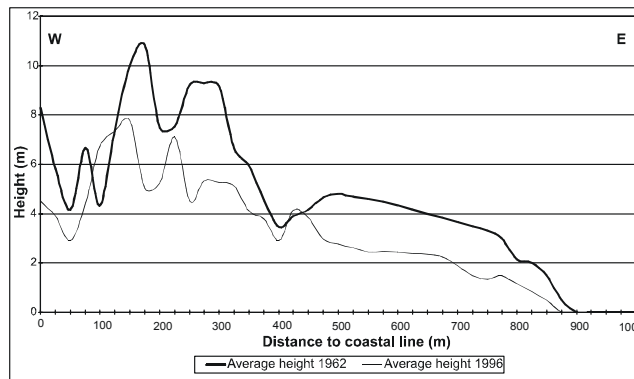


Figure 6: Topographic profiles across El Inglés Beach and eastern dune sector in 1962 and 1996.

In summary, all these changes indicate severe erosion of the Maspalomas dune field, which could finally disappear during the next decades.

The reasons for this situation are the changes induced in the natural aeolian fluxes, which in certain areas have been completely interrupted due to the tourist development, and the decrease of sediment inputs from El Inglés Beach.

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