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Gis Technique Applied to Goggle-Earth Image for Automated Extraction of Dunes: Case Study: Laâyoune City, South of Morocco

KEYWORDS: GIS, Google-Earth Image, dunes, Laâyoune City, Morocco, morphometric analysis.

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ABSTRACT *In a deserted environment, the sandy dunes are considered as a threat for all human activities. Studying dunes at a large scale requires intensive fieldwork and a huge dataset. But this task is not always easy because of the high cost and the limited availability of data. In this paper, we present a technique based on the process of Google-Earth image for automated extraction of dunes of the Laayoune city in the south of Morocco. To extract dunes from such images, a subset of Google-Earth image scene of the study location, a pre-processing and enhancement images were used. The Google-Earth image has been georeferenced and integrated in a GIS. Extraction of dunes from this image was performed using spatial analyst tools in ArcGIS. The technique allowed us not only to extract the dunes but also to extend our study to the morphometric analysis.*

1. Introduction

Nowadays, living and growing in a desert environment where the sandy encroachment effects are daily, it is essential to know the various factors controlling this area. However, the wealth of these arid lands in natural resources has been accompanied by the creation of new urban and rural areas that continue to grow and are constantly threatened by the sandy encroachment caused by the movements of dunes. Only the vastness of the area of these territories and climatic conditions make the study of these lands very difficult (Bagnold, 1941).

In this context, many scientific studies have been undertaken in these desert environments (Clos-Arceduc, 1967). The descriptive study of these environments has qualified extensive sands located between Tarfaya in Morocco and Mauritania as Sand River. Some authors have focused on the morphological study of dunes (Finkel et al., 1959). Others have shown the relationship between wind velocity and dune dynamics (Bagnold et al., 1941).

To learn more about these vast and inaccessible areas, remote sensing has been widely used. Thus, satellite images and aerial photographs were used to study the dune morphodynamics of the Moroccan Sahara (Elbelghiti, 2010). These satellite images are also often used to study and monitor desertification (Mainguet et al., 2001, Elhadi et al., 2009).

Given the free accessibility of Landsat images, several researches have been focused on the potential of these data. So they were used to discriminate different classes of dunes in China (Liu, Haijiang et al., 2008). The Landsat Thematic Mapper (TM) and the Enhanced Thematic Mapper (ETM+) were also examined to understand the movement of the dunes (Parker 1999, Wang et al., 2007).

The capabilities of ASTER, Quick bird and Lidar images have been tested to study sand source, transport, and pathways, morphology and migration of sand dunes (Bourke, M. C et al., 2009, Bubenzer, O., & Bolten, A. 2008, Bullard, J. E et al., 2011, Hesse, R, 2009, Hugenholtz, C. H., & Barchyn, T. E 2010, M., Leprince, S et al., 1999, Vermeesch, P., & Drake, N., 2008).

Multi-temporal Landsat TM images have been also explored to analyze dune dynamics at the dune-field scale (Ihab N.L. Mohamed, Gert Verstraeten 2012). This study showed that the techniques used to estimate the dune migration are very simple and don't require sophisticated algorithms of image processing.

From all these researches using low spatial resolution to analyze sandy dunes, there are few studies at high spatial resolution, some attempts started to map dunes of cap Juby Morocco using SPOT images (Mering C., Oulehri T.1994). SPOT images were also used for automated extraction of sand dune encroachment (Ghadiry M et al 2012). Despite the high spatial resolution of these images, their cost is very high, which has led some authors to exploit the potential of Google Earth images. Such images often used for visualization, have undergone a process of mathematical morphology in order to extract olive trees covered by small sand dunes (Venard C et al., 2010).

In this paper, we present a GIS technique based on the process of Google-Earth image for automated extraction of dunes of Laâyoune city in the south of Morocco.

2. Study site

Laâyoune city is considered one of the largest city in the southern provinces of Morocco (Fig. 1). The region, presents a remarkable physical homogeneity, with a large desert area, characterized by the presence of the vast plateau of the hammada, showing no major accidents reliefs, except dug by wadis, depressions in sebkhats and some

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sand dunes. The "bedrock is formed by limestone and sandstone of Upper Cretaceous very low dip to the West, it's covered of about fifteen kilometres from the shore by discordant strong Oligocene and Miocene beds.

The climate of the region is a Saharan climate, cold in winter, hot and dry in summer, marked by the scarcity of rainfall (60 mm/year). On the coastal strip, the temperatures are moderate and influenced by the proximity of the Atlantic Ocean. Winds are generally wet, resulting in low temperature differences. The dunes in the study area consist mainly by barchans (Sauermann, G et al., 2000, Elbelrhiti, H et al., 2008)

Ocean currents bring the sand on the beach; the winds (blowing from the north-east to south-southwest) outweigh the sand and form fields barchans along the coast.

The population of the Laâyoune province has evolved significantly over the past two decades, it has grown from 113,411 inhabitants in 1982 to 153,978 inhabitants in 1994. It reaches 210,023 people in 2004. On the other hand, the average annual growth rate showed a slight increase between the two periods, it increased by 2.6% from 1982 and 1994 to 3.2% from 1994 to 2004. Note that the great challenge of this city is the struggle against the movement of sand dunes. This phenomenon results from the transport of sand by strong winds. The constant threat of this movement of sand towards basic infrastructure inevitably leads to harmful consequences in economic, social and environmental terms of the city.

Figure1. Location of the study area.

3. Methodology

The scene covering the study area was obtained by screenshot of Google Earth image. Since Google Earth has provided us with an archive of multi-date images, the one acquired in 2007 was chosen because of its quality. This image has a spatial resolution of about 10 m and is composed of a matrix of 4753 columns and 3306 lines.

The image has undergone a number of treatments using spatial analysis tools provided by ArcGIS.

The figure below summarizes all processing and analysis that were made for the automatic extraction of dunes.

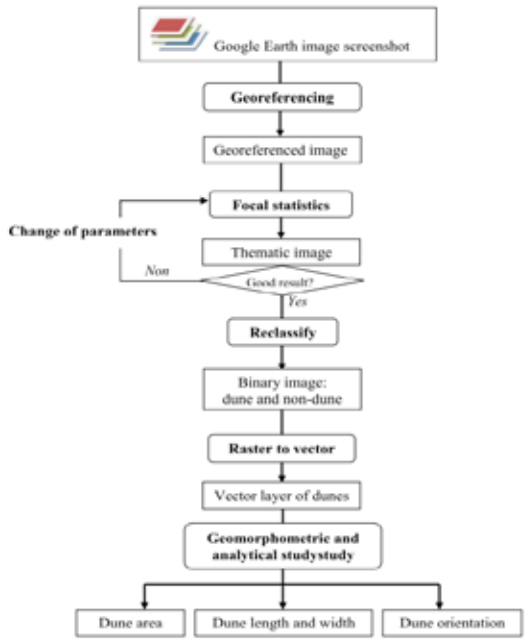

Figure2. Methodological flow chart.

3.1 Georeferencing

In this study, the georeferencing was carried out for the screenshot Google earth image using 20 ground control points (GCP) obtained with a GPS Garmin Dakota device with accuracy up to 3 meters. The GPS data were collected during the site visit conducted in January 2013. The RMSE was less than 0.5 pixels. The obtained image was projected in UTM projection.

Figure3. A sample area representing the most active sand dunes

3.2 Focal statistics

The operation performed by the Focal Statistics tool computes an output raster using the neighbourhood of each pixel. The value for each output cell is calculated from the values of all the input cells located in a specified neighbourhood around that cell of interest. A statistical function such as the maximum, average, or sum is performed on the input cell value and all values of cells in its neighbourhood. The neighbourhood can be defined as circle, rectangle, annulus or wedge with the number of cells to include. For our image, a 3x3 rectangular neighbourhood and average function were used to classify the image.

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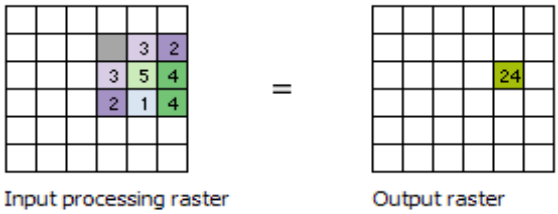

Figure 4: Focal statistics principle

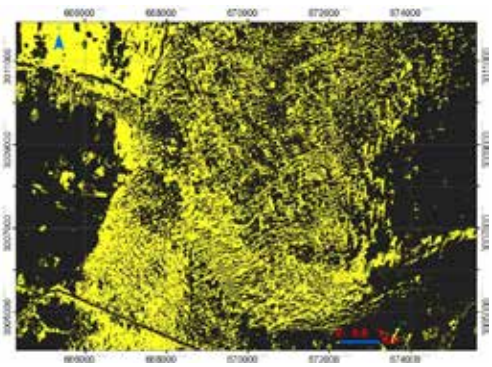

Figure5. Result of focal statistics followed by the reclassify processing

3.3 Reclassify

The focal statistics results in a raster of 15 classes where the dune shape is discerned and each class presented in a gray level. During this step, each class is affected either to a dune or to a non-dune area using first the photo interpretation, and secondly our knowledge of the study area. The reclassify tool under spatial analyst in ArcGIS allows obtaining from these 15 classes only 2 classes: sand dune was given the value 1 and the other classes were given the value 0.

3.4 Converting raster to vector

In order to obtain a sand dune vector file from the raster sand map, the conversion tool "Raster to Polygon" was involved. To improve aesthetic or cartographic quality of the vector map obtained, Smooth tool was used to sharp angles in polygon outlines. In order to obtain sand dune close to the reality, the small polygons are attached to great ones using Aggregate polygon tool. The aggregation distance of 10 m was used.

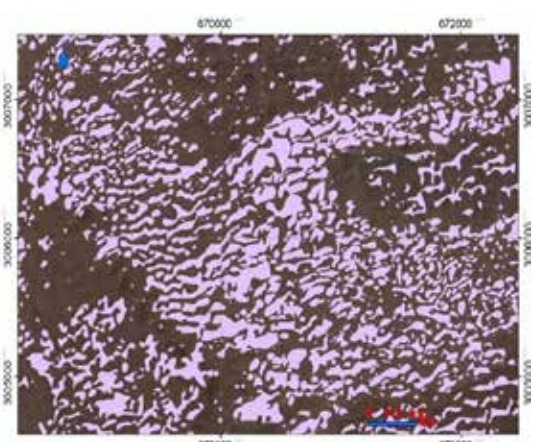

Figure6. Sand dunes after raster to polygon and smooth geoprocessing.

3.5 Dune orientation

To determine the sand dune orientation in the study area, a Calculate Polygon Main angle tool was used. The calculated angle is stored as attribute

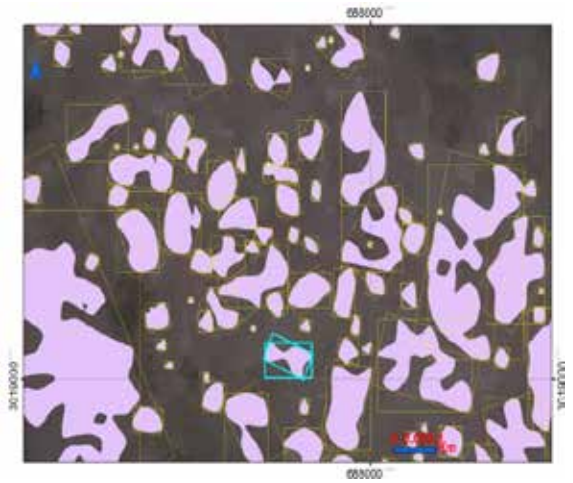

Figure7. Image the cyan rectangles indicate the result of the Polygon Main Angle calculus.

4. Results and discussion

Our study focused on the automatic extraction of dunes from the images of the archive of Google Earth based on technical GIS spatial analysis provided by the image processing software. The results of this new approach were subsequently used to conduct further morphometric study.

The identification and mapping of dunes have enabled us to deduce their spatial distribution in the study area and to distinguish them from other existing geographic objects such as vegetation, water, bare soil and sand.

If we were able to exploit the advantage of having high spatial resolution of Google Earth images, the presence of clouds or discoloration on certain areas remains an obstacle during treatment. Faced with these constraints, the picture may be blurred. Hence the need to focus on choosing archive representing the best quality, except that Google Earth does not offer much of the acquisition dates of images for the study area.

Also for our study area, images have low spectral resolution seeing the captured image is composed of three primary colors (red, green and blue) may and contain strong dominant colors. The different processing steps then consisted in overcoming these constraints by reducing at most the error that they can generate.

This approach allowed us to clearly identify the contours of the dunes leading to the recognition of different dune shapes and geometrical characteristics such as width and length.

In our area of interest, the most dominant dune forms are barchans. The results of this study were compared to previous studies based on the manual extraction and were found satisfactory according to our expectations.

The results of all these geoprocessing applied to the Goggle-Earth image are summarized in figure 4.

5. Conclusion

This study was able to demonstrate a methodology con-

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sisting in automatic extraction of dunes, highlighting the exploitable potential of Google Earth images. This automated mapping has led to conduct an analytical study on the characterization of these dunes in the study area.

The potential of Google Earth in terms of geographic information system makes it a tool that is essential among other existing programs in this domain. The use of Google Earth imagery for the automatic extraction of dunes was accompanied by a great saving of time and efforts.

These results will be used to identify local issues faced by the region of Laayoune-Boujdour-Sakia El Hamra in Morocco and identify appropriate tools to address the study of such environments.

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