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The Use of Remote Sensing and GIS to Map Unstable Sand dunes
-A Case Study in the Oudia Area of Tunisia-

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Abstract: Desertification constitutes a major concern of countries in the Sahelian region of North Africa. This phenomenon is responsible for the degradation of the natural habitat and for the arable land disappearance. With the development of remote sensing techniques, it became possible to study this phenomenon at spatial and temporal scales and to analyze the interaction between the various elements of the environment in relation to soil dynamics and human activity. This study was an attempt to use high-resolution satellite data, specifically Quick Bird, to thematically map the geomorphology of the study area, particularly active dunes. Visual interpretation combined with supervised classification using training site tests allowed us to perform a precise identification and led us to an accurate mapping desertification sensibility. As a result, it appears that Oudia may be threatened by the encroachment of sand dunes and significant wind activity. In conclusion this study strongly recommends the use of these new techniques of remote sensing in assessment and mapping of desertification.

Keywords: Desertification, Quick Bird, Remote sensing, Tozeur

1 Introduction

Mapping of desertification serves to define the current limits of zones affected by the desertification and as source data to the decision-makers for the implementation of means to effectively fight against desertification.

The south of Tunisia, particularly the Chott El-Garssa depression, is strongly threatened by desertification amplified by population activities and overgrazing. Presently, the area of the zones affected by the desertification is in progression. In fact, many factors of desertification (Wind, Rain, overgrazing, types of sols, etc.) are implicated in the increase of the infected area. The study area, Oudia, in spite of the apparent state of stable sand dunes, is threatened by the formation of barkhanic dunes that constitute the most mobile shape of dunes (Ben Zaied *et al*., 2006). Our approach was to use Quick Bird satellite data to map the landscapes' geomorphology, plant formations, and use GIS to predict susceptibility to desertification.

2. Materials and Methods

2.1. Study area

The study area represented in **Figure 1** is located in the Southwest of Tunisia at Latitude and Longitude. It is about 400 km from the capital Tunis. It is a depression that is surrounded by important geological formations (Quaternary formations). The annual precipitation ranges between 50 mm to 100 mm (Talbi *et al*., 2006). The mean annual temperature is about 22 ˚C (Talbi *et al*., 2006). The region has high evapotranspiration that is combined

Fig.1. Location of study area (Ben Zaied, 2007).

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with low precipitation causing a strong annual deficit in the water balance. The zone of study is subjected to important flows of wind drained by a vast network of wind corridors through a bordering west-east axis mountain chain. Need the soil type, vegetation, and geology. The zone of study is characterized by very extended and localized soils Types (Sand, silt and limon). The scarcity of soils in this region finds its explanation in the revealed aridity, the very scattered plant cover, moreover to the influence on the quality of the soils by the depressions closed during the Quaternary (Talbi *et al.*, 2006). The study area is distinguished by sparse low vegetation, mainly tamarix. (Ben Zaied *et al.*, 2006). The study area is used mainly for camel grazing.

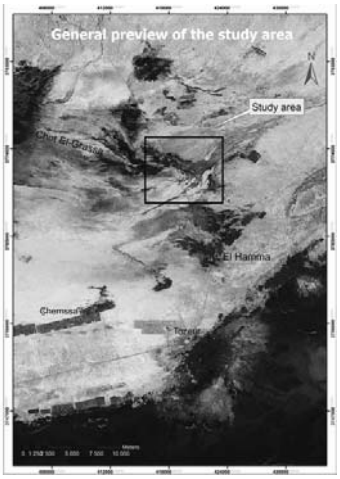

Fig. 2. Survey map of the study area.

2.2. Methods of Data Collection

2.2.1 Remote sensing data resources

The data used for this study are collected from:

- A scene of Quickbird with panchromatic and multispectral layers acquired in February 2006 (panchromatic with 60cm resolution and multispectral of 4 m resolution containing 4 bands)[A].

- A Landsat image ETM+ with 8 bands (panchromatic with 15m of resolution)[B].

2.2.2. Field Work

Prior to field work we produced a survey map of the area using a Landsat image where we added the main localities (**Fig. 2**). Also produced a via interpretation land cover map that allowed comparison between the reality of ground and the satellite images. During a period of three days, fieldwork consisted of using car 4×4, a Global Positioning System (GPS) and a digital camera to identify16 representative training sites of Sabkha, sand dune, barkhan and salt crust on the satellite imagery based on texture, pattern and tone (**Fig. 3**).

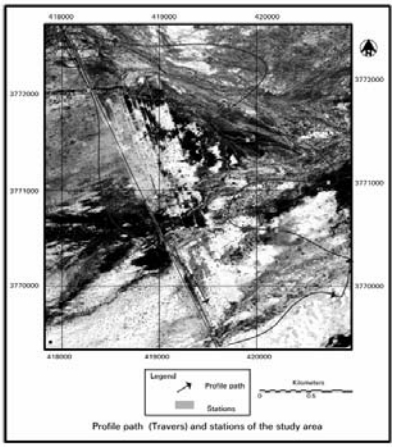

Fig. 3. Profile path and stations.

2.2.3. Data processing

We used ERDAS Imagine (Version 8.6) for thematic land classification (ERDAS Imagine Manuel). We carried out texture analysis/radiometric enhancement of contrast and unsupervised and supervised classification (the maximum likelihood method and visual interpretation of different classes of imagery within landscape). The validity of the training data was evaluated both from visual examination and from quantitative characterization. The spectral signatures of the main features such as sand dune, sabkha and barkhan were evaluated. The dynamic vision of the desertification process is important for the identification of the zones already affected as those which in the future risk being it.

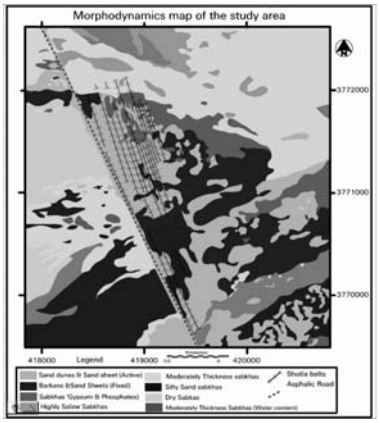

Fig. 4. Geomorphology map.

3. Results and discussion

3.1. Geomorphology map

The multiple projects that were established to fight against the sand encroachment also contributed to landscape change (Ben Zaied *et al.*, 2006).

El-Oudia region corresponds to the eastern part of chott El-Gharssa altitude between -5 m and -25 m.

These areas made decisions-makers about a channel as Suez from Gabès to the Algerian Sahara. In this area we have a lot of salt, so this means that the sea was be there. It is located in the catchment area of Wadi El-Maleh, this unit is characterized by a wind action.

Therefore many deposits come from the deposit of phosphate factory of Gafsa in upstream. The **Figure 4** represent the different morphology forms, such us: Sand dunes, Barkhans, Sabkhas Gypsum and Phostphates, Highly Saline Sabkhas, Moderately Thickness Sabkhas, Silty Sand sabkha, Dry Sabkha and wet Moderately thikness sabkha

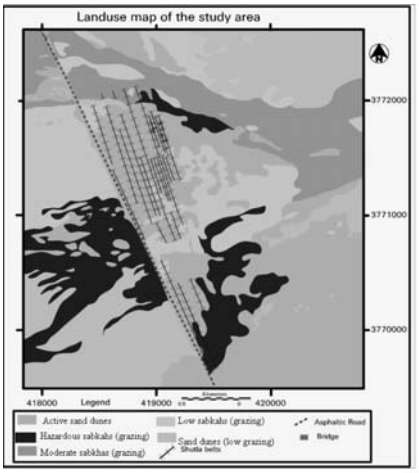

Fig. 5. The land cover map.

3.2. Land Cover map

Land cover map is one of key parameters in environmental studies.

The study area is distinguished by the weak depth and weak content in organic matter. It is dominated by a pseudo steppe with psamophiles and gypsophiles species, characterized by three states (50 to 200cm, 15 to 50cm and 0 to 20cm). This steppe assures a soil covering of about 20% in the best situations. But we can generally distinguish three plant groupings, in relation with the type of soil:

- Grouping on the salty formations: *Haloconemum Strobiloceum, Arthrocnemum indicum, Salsola Siberico, Salsola tetrandra, Sueda mollis*;
- Grouping on the sandy formations: (*Stipagrostis pungens*), *Retama raetam*, *Calligomum* spp., *Aristida pungens* is indicating of mobile sand. The presence of this species indicates that sand moves.
- Grouping on the gypseous formations: *Astragalus armatus, Zygophyllum album, Erodium glaucophyllum*.

The offered pasture is in poor because of the over grazing and constitutes only a summer supplement in particular for the dromedary. In **Figure 5**, we can see the different classes of soils and their use for grazing. Land use types mapped in this study are: Active sand dunes, Hazardous sabkhas, Moderately sabkhas, Low sabkhas, and Sand dunes.

3.3. Vulnerability map to the desertification

The conservation of natural resources and the protection of the public infrastructures constitute the best means of fighting against the desertification. The objective to establish the desertification sensitivity map is to provide support for the local decision-makers for better understanding the processes in progress and planning the interventions of attenuation of the desertification and direct the follow-up of their efficiency. The establishment of this map was an important step in this work. By visual photo interpretation, desertification units were recognized. The personal knowledge of the same land use, similar physical conditions (climate, soil, vegetation) and common characteristics of land degradation (types and class of desertification) are very important to achieve this work.

Adopted methodologies are based on the analysis of the dynamics of the landscape. The **Figure 6** which represent the result of images

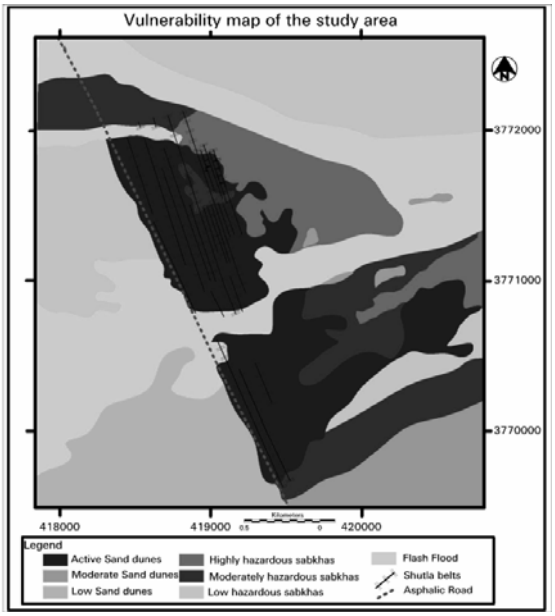

Fig. 6. The sand cover map.

processings and the field work shows the vulnerabily map of desertification. This map represents the result of superposition of many information layers (Land use, Geeomorphology, climat data).

The wind represents the primary mechanical agent of desertification. It was the cause of sand deposits were made in dunes. In the process of elaboration of desertification sensitivity map, the sand chart constitutes an important element. This map elaborated from Quick Bird data shows the big types of dunes which are discriminated in step with their reflectance: The final result was an image map of vulnerability of desertification, which gives good indication of areas affected by desertification and those under risk of desertification. The areas were divided into seven classes including high, Moderate and low hazardous: Active sand dunes, moderate sand dunes, low sand dunes, highly hazardous sabkhas, moderately hazardous sabkhas, low hazardous sabkha and flash flood. On the ground, we saw fences, and lineaments which are used for the fight against the desertification. But the barriers were built in perpendicular with the dominant wind direction. In this zone, there are two dominant sectors of the wind: the West during the winter and the east during summer but 65 % of wind come from the east. It appears that the fences amplify the trapping of a lot of sand. The question is if these fences embarrass the existing plantation? We have to study the zone between two fences and verify if the sand is going to become a plateau of sand. In our opinion, it is necessary to define the situation before to know if the intervention was justified or not? To look for the alternative, it is necessary to make a comparison between the natural sector and the anthropological sector.

4. Conclusion

This paper shows the application of remote sensing to map land cover (vegetation) and geomorphology in an arid region. Application of the remote sensing and geographic information systems constitute good tools for investigation to help decision-makers fight against desertification and provide reasoned management of natural resources. Reliable and constantly updated information constitutes a need and a guarantee of sustainable development of natural resources. These techniques allow us to measure the impact of the phenomenon on the people as well as on the natural environment. As regards the elaboration of the Vulnerability map to the desertification we insist on the need of harmonizing and to standardize the approaches and the methods used everywhere in Africa.

It is necessary to revise the current models concerning the physical, ecological and socioeconomic aspects of the degradation of lands, for their integration in a framework of dynamic modelling and instruments of support for the decision. The visual interpretation combined with the digital processing of the satellite data with high resolution Quick bird and Landsat permitted to classify the territory studied in its various components on the geomorphological level.

This study shows that the use of the satellite data with high resolution allows the elaboration of a cartography which reports the state of degradation of the ground under the influence of the desertification . These documents are essential for the rehabilitation of the sector Oudia, today strongly threatened by the desertification.

Annotations

A) Laboratorio TELEGIS, Dipartimento Scienze della Terra, Università di Cagliari

B) Global Land Cover Facility: ftp://ftp.glcf.umiacs.umd.edu/glcf/Mosaic_Landsat/N-32/N-32-30.ETM-EarthSat-MrSID/

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