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Contribution of Remote Sensing and GIS for the Study of the Evolution of the Spatial and Temporal of Land Use in the ZIZ Middle, Errachidia Region (Morroco)

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Abstract: In Morocco, the scarcity and randomness of rainfall, desertification increasingly disturbing siltation resulting from the degradation of natural resources under the human action and threaten harsh climatic conditions, in addition settlements, agricultural land and irrigation infrastructure. Errachidia region is located in the southern Atlas of Morocco, is facing enormous difficulties combining scarcity and poor quality of water then long periods of severe drought that have affected recent decades, whose ecological consequences are considerable, as evidenced by the decline in the area irrigated under the action of desertification and rising saline soils. Remote sensing, combined with Geographic Information Systems (GIS), today brings a decisive contribution to the various issues that arise in environmental, health, land use, exploitation of natural resources or prevention against natural disasters. The implementation of these technologies independently and continuously depends on a sustained information, education, capacity building and adaptation to local conditions. In this context, their application to sustainable development in the region becomes a necessity. The use of remote sensing and GIS has to understand the dynamics of the land. Five images at various dates ranging from 1972 to 2011, were used for a diachronic study, to assess and monitor the change of the palms in the Middle Ziz. We are able to show the levels of development in terms of differential use of space, soil degradation, regeneration and resilience of the environment, and finally segmentation of the territory. This study shows a global trend to widespread degradation of plant resources (palm) under the combined effect of anthropic action (urbanization) and climatic conditions.

Key words: Morocco · Ziz watershed · Remote sensing · GIS · Landsat · Dynamic · NDVI · Land use

INTRODUCTION

In Morocco, the scarcity and randomness of rainfall and desertification increasingly worrying threaten farmland and irrigation infrastructure. Errachidia region, located in the southern Atlas of Morocco, is facing enormous difficulties combining scarcity and poor quality of water then long periods of severe drought that have affected recent decades and whose ecological consequences are considerable, as evidenced by the decline in the area irrigated under the action of desertification and rising saline soils [1].

The region has, moreover, a desertification process which manifests itself in the form of silt, vegetation degradation, soil salinization, groundwater depletion and water and wind erosion. Environmental challenges imposed by recurrent drought and population pressure, it is necessary to monitor the natural resources available for their rational and sustainable management. In this context, remote sensing is a powerful tool for acquiring information necessary for the monitoring and management of natural resources, large temporal and spatial scale. Hence the need, to monitor and understand the dynamics of land units to assist in decision making for the sustainable management of these resources.

Objectives of the Study: The overall objective referred in this study is to know and map the evolution of the land use in the Errachidia region. A diachronic analysis combining the Digital Elevation Model (DEM) and satellite images used for the production of cartographic materials useful for the study of spatial dynamics.

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The specific objectives can be summarized as follows:

- Mapping the state of natural resources for the reference years: 1972, 1987, 2001, 2006.2011. The choice of these years is guided by the availability of satellite images and the avoidance of any follow too close.
- The diachronic study of the dynamics of land use in the analysis of maps produced.
- Analysis of changes to produce elements for decision-making.

Presentation of the Study Area

Geographical Location: Tafilalet region at large is located in the south-east region of Morocco and covers an area of 77,500 km2. This vast territory encompasses four major watersheds: the Ziz, the Guir the Maider the Rheris basin and oriented in the north-south direction. These basins are all limited to the north by the High Atlas. In the South, they are open to the Sahara (Fig. 1). Occupying an intermediate position between the watershed Guir to the east and the west of Rheris, the watershed of Ziz, more important than the other three, extends from the High Atlas Mountains, at an altitude greater than 1500 m, to the plain of Tafilalet whose altitude is less than 1000 m [2].

The Middle Ziz that relates the present study. It is located between 4°50 and 4°20 W and 31°60 and 32°00 N. it's an area along the Ziz valley whose center is occupied by the palm of Kheng Medaghera, Aoufous and Erteb.

Characteristics of the Biophysical

Geological Setting: Three morpho-structural units form the landscape of the region from north to south: Upper basin that corresponds to the High Atlas, the middle basin or furrow pre-African (Errachidia basin Cretaceous), which includes the study area and the little Atlas [3].

Errachidia basin in the center, generally designated by the cretaceous basin consists mainly of horizontal layers of Cretaceous limestones [4]. This basin forms an asymmetrical synclinorium, consists of carbonate deposits of the Turonian, sandstone sand intercalated with gypsum of the Infra-Cenomanian and sand and clay with evaporite deposits of gypsiferous formations of the Senonian [3] and [5].

Climate Framework: Errachidia region-Tafilalet is marked by varying altitudes from 1200 to 800m which decrease from north to south. It is characterized by large variations in temperature and seasonal rainfall distribution are scarce and very irregular, from 270 mm on the reliefs of the High Atlas to 130 mm in the area of Errachidia dropped to less than 70 mm level plain Tafilalet (Fig. 2).

The Nicholson index or rainfall index:

$$X_i = \frac{P_i - M}{\sigma}$$

with:

Xi: Nicholson Index;

Pi: Total Rainfall (i mm a year)

M: is the average height of the annual rainfall series of years used;

σ: Standard deviation of rainfall annual series of years.

To be representative, Nicholson index (Fig. 3) requires data on at least 30 years after the World Meteorological Organization.

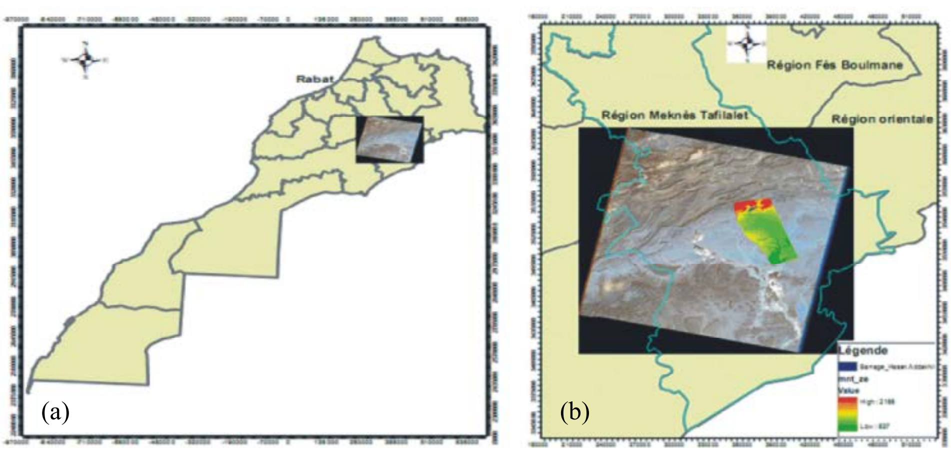

Fig. 1: Location of the study area (Middle Ziz) (a) across Morocco, (b) at the regional level

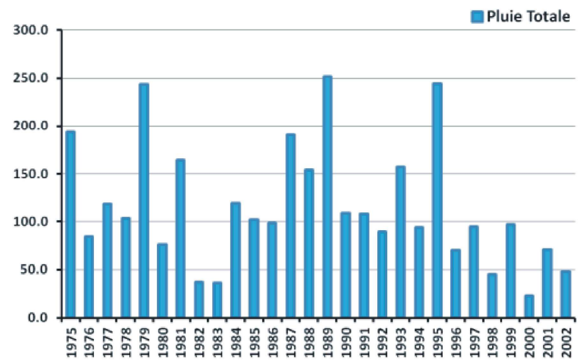

Fig. 2: Annual Total Precipitation (mm) Barrage Hassan Addakhil station during water years 1975-2002

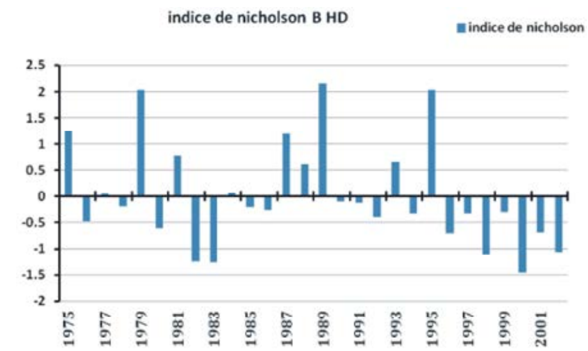

Fig. 3: Index Nicholson Station Dam Hassan Addakhil during water years 1975-2002

The rainfall regime is dependent on orographic disturbances responsible if the stormy summer and ocean disturbances cause rainy winter and spring. The scarcity of rainfall is mainly due to Atlasiques reliefs that constitute a barrier to oceanic influences.

The dry period often lasts up to eight months with temperatures obtained during the months of June, July and August. The relatively wet winter and very cold with minimum temperatures in December and January.

The ombrothermic diagram (Fig. 4) shows that during the dry season occupies the entire year because we always (P <= 2 * T);

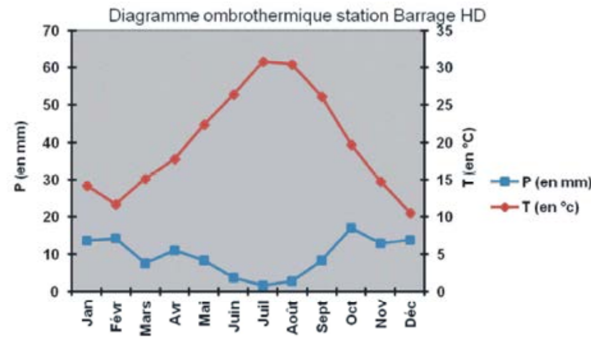

Fig. 4: Ombrothermic Diagram at the Hassan Addakhil Dam Station during hydrologic years 1975-2003

MATERIALS AND METHODS

Materials and Data Bases Used

Materials Used: The different materials used in this study are:

- Five multitemporal Landsat and multispectral images (Table 1): MSS (1972), TM (1987), ETM + (2001.2006 and 2011);
- Google Maps Satellite Image 2011
- Topographic map of ORMVAT 1/100 000;
- Topographic Map Sheet Errachidia 1/50 000;
- Topographic Map Sheet Aoufous 1/50 000;
- Topographic Map Sheet Tiydrine 1/50 000;
- MNT Ziz;
- Master Plan Urban Ziz (SDAU 2007).

The software image processing and GIS such as:

- Erdas imagine 9.1 software for processing digital images. This software allows you to perform a variety of tasks related to import, compile and mosaicking of satellite images. It was also used for contrast enhancement, color composition, extraction of the area of interest, but also for the timing, correction, classification and analysis of digital images... etc.

Table 1: Summary of satellite images used

Images satellitaires utilisées	WRS: P/R	Capteur (Dataset)	Date d'acquisition	Résolution Spatiale (m)
1	P 115 R 38	Landsat MSS	20/08/1972	57,0
2	P 200 R 38	Landsat TM	07/10/ 1987	28,5
3	P 200 R 38	Landsat ETM+	11 /03/2001	28,5
4	P 200 R 38	Landsat ETM+	09/03/2006	30
5	P 200 R 38	Landsat ETM+	27/10/2011	30

- ArcGIS 9.3 was used for the interpretation and digitization of images, from which the mapping can be performed. It also served to make the layering, calculating the areas of the different units, the crossing of information to detect changes, finalizing output cards, handling vector layers imported... etc..
- Excel for graphing statistics extracted results mapping, conversion and import or export data to other formats compatible with other computer programs.

Five Landsat satellite images are used in our study. They range from 1972 to 2011 (Table 1).

Methodology: In this methodology, it's necessary to calculate indices that measure chlorophyll activity. Among these indices are cited NDVI, SAVI and MSAVI.

Evaluation of Chlorophyll Activity by Calculating NDVI: The Normalized Difference Vegetation Index (NDVI) is a good indicator of the density of the vegetation [6] and [7]. It is an index derived from a satellite image and adapted to the study of vegetation cover. This index uses the behavior of chlorophyll to highlight vegetation because the latter absorbs the maximum in the red and reflects heavily in the near infrared. It is calculated on the basis of the spectral characteristics of the vegetation.

$$NDVI = \frac{PIR - R}{PIR + R}$$

With:
PIR: reflectance in the Near Infra Red
R: reflectance in the red.

NDVI can express the force of the status of the vegetation at the time of observation. It also allows you to check the dynamics of land use in relation to density of vegetation cover.

The SAVI (Soil Adjusted Vegetation Index) ([8]): SAVI is a hybrid index between NDVI and PVI. In this vegetation index adjusted for soil (SAVI), the soil adjustment factor "L" is added.

$$\text{SAVI}=\frac{(\text{PRI-R})}{(\text{PIR+R+L})}\times(1+\text{L})$$

with:
PIR: average reflectance in the near infrared channel
R: average reflectance in the red channel
L: constant to reduce the effect of the soil.
"L" is a correction factor. its value depends on vegetation cover.

For a maximum vegetation cover, "L" is equal to 0 and the SAVI is then equivalent to NDVI.

For a vegetation cover very low, "L" is equal to 1. Huete (1988) suggested that the value of 0.5 is used when the vegetation type was unknown. the value 0.5 represents an average vegetation cover.

The MSAVI (Modified Soil Adjusted Vegetaion Index): For the MSAVI, the adjustment factor "L" is not a constant but rather a function that varies inversely with the presence of vegetation in order to minimize the effect of nude soil on the SAVI index.

$$\text{MSAVI}=\frac{2\text{PIR}+1-\sqrt{(2\text{PIR}+1)^2-8(\text{PIR-R})}}{2}$$

with:

PIR: average reflectance in the near infrared channel
R: average reflectance in the red channel
L: constant to reduce the effect of the soil.

This index is more efficient than the SAVI in some cases.

RESULTS AND DISCUSSION

Qualitative Analysis (Visual Interpretation)
Interpretation of Single-Channel Image: It is possible to obtain geographic information from the single channel image interpretation. These are displayed in grayscale (black and white). Fig. 5 shows the image of the red band (band 3) of Landsat image taken in the year 2011.

Knowing that water and vegetation, in general, absorb this band. So, they will be characterized by the lowest reflectances (black areas at the dam hassane Eddakhil and along the valley of the Oued Ziz. By cons, Soils, in General, have an average reflectance in the red band. They have grayish or whitish color.

Combination of Bands: The colored compositions are used to produce color images, taking into account the spectral signature of the objects. They are often used to highlight the different types of surface multispectral images or highlight certain environmental phenomena such as forest fires, sandstorms, etc.

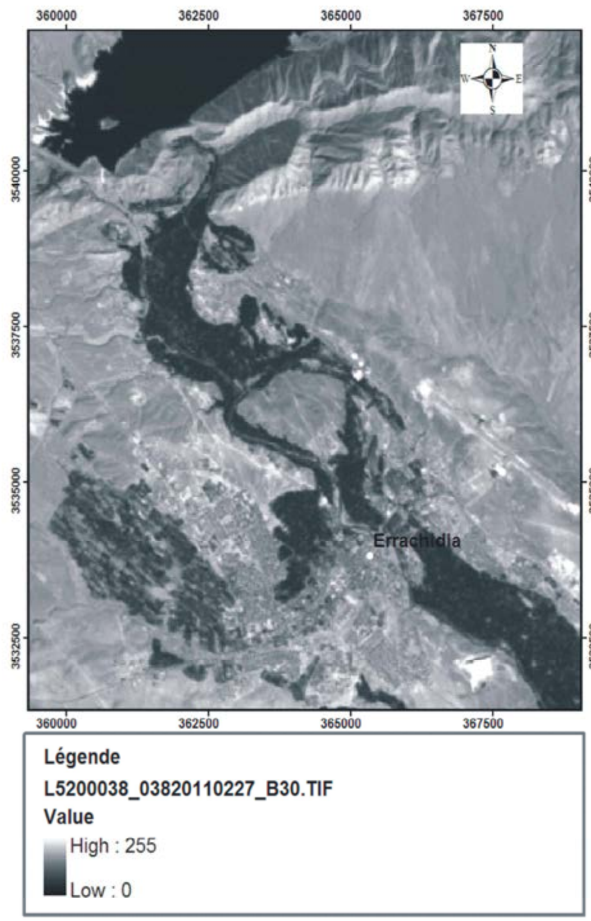

Fig. 5: Extract from the band red of the single channel image (grayscale) Enhanced thematic mapper (year 2011).

The color composition is the most widely used composition 453. It includes three spectral bands sensitive to vegetation, which makes the image contrast and rich in information.

The image below (Fig. 6) shows the band 4 (NIR) in the red channel, band 5 (MIR) in the green channel and band 3 (red) in the blue channel. This figure is an extract image at the city of Errachidia.

It is quite easy to identify a number of elements in this image:

- The Vegetation: it appears a shade of red for this class. They consist mainly of palm trees and appear dark red.
- The bare soil and urban area: mainly identifiable by a mixture of gray, light blue.
- The Water: in the studied area, the dam appears black.

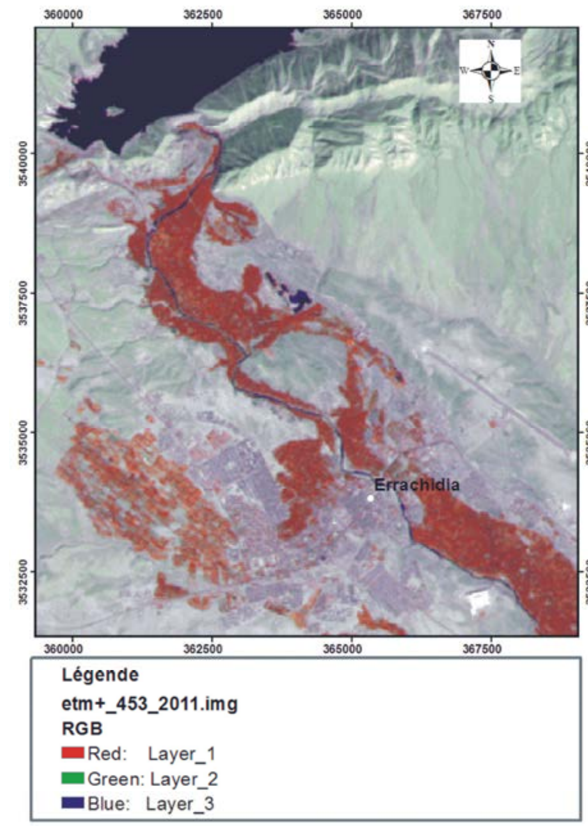

Fig. 6: Image ETM + (year 2011) in false colors (453)

Indices and New Channels

Vegetation Index NDVI: This index is correlated with chlorophyll activity sheets. In fact, chlorophyll pigments absorb strongly in the red and leaves by reflecting against strongly in the near infrared.

NDVI is used for the detection of active vegetation. Therefore, the NDVI gives, easily, information on the vegetation in the spring when natural species are developing.

These maps (Fig. 7) show the spatio-temporal evolution of vegetation cover from 1972 to 2011. From these cards, especially from average NDVI values, we were able to calculate the vegetation area percentage in the study area (Table 2).

The evaluation of chlorophyll activity was obtained by calculating the average NDVI of each scene and validated by SAVI and MSAVI indices.

The Inter-annual variation in NDVI average (Fig. 8) is strongly linked to climatic conditions (rainfall) (2001 driest year and 2011 wettest year).

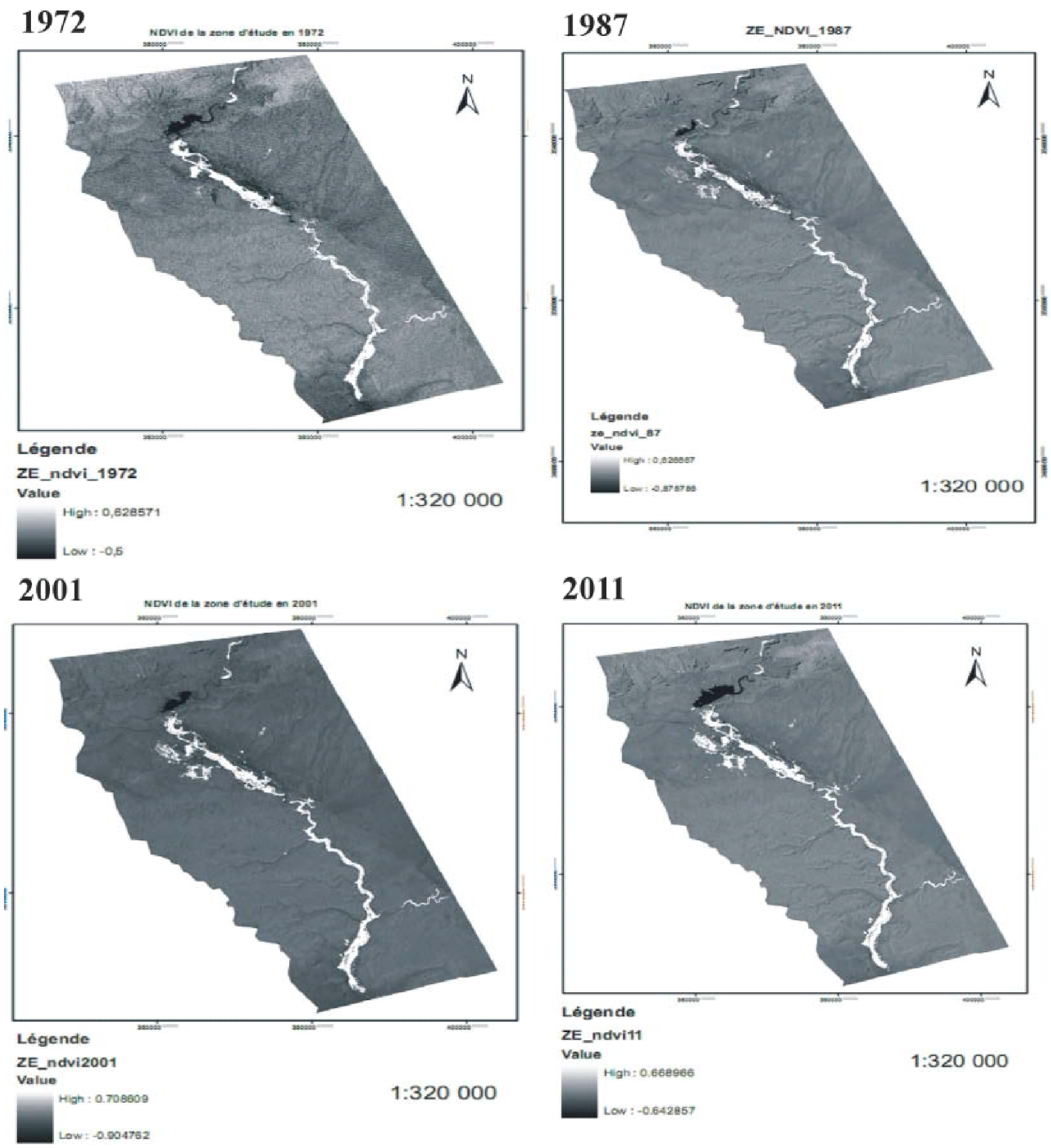

Fig. 7: Calculating the vegetation index NDVI for different years (from 1971 to 2011)

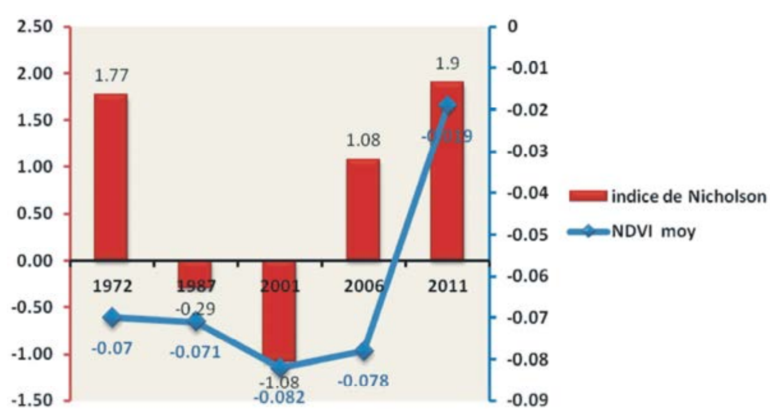

Fig. 8: Evolution of average NDVI index and Nicholson in the study area

Table 2: Changes in land use between 1972 and 2011

Landsat satellite images used	NDVI Average In the studued Zone	% of the total vegetation cover in the study area
P 115 R 38 _MSS_ 20/08/1972	- 0,07	1,7
P 200 R 38_TM_ 07/10/ 1987	-0,071	2,39
P 200 R 38_ETM$^+$_ 11 /03/2001	-0,082	2,97
P 200 R 38_ETM$^+$_ 09/03/2006	-0,078	3,07
P 200 R 38_ETM$^+$_ 27/10/2011	-0,019	3,44

CONCLUSIONS

Remote sensing, combined with Geographic Information Systems (GIS), today brings a decisive contribution to the various issues that arise in the general environment and the impact of desertification in arid zones in the Sahara particular.

This study showed the undeniable contribution of GIS and remote sensing for monitoring spatio-temporal couvet plant oasis in an area very sensitive to the effects of climate change.

The evaluation of chlorophyll activity was obtained by calculating the average NDVI of each scene (From 1972 to 2011) and validated by SAVI and MSAVI indices. In additional, we were able to calculate the vegetation area percentage in the study area.

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