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Research article

USING SATELLITE IMAGERY TO ESTIMATE THE RATE OF VEGETATION COVER IN THE WATERSHED OF CHOTT CHERGUI -WILAYA OF EL BAYADH (HIGH STEPPE PLAINS OF ALGERIA)

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ABSTRACT: Several factors influence the extent of water erosion: the length and the gradient of the slope, soil texture, the extent of vegetation cover. However it is the soil cover that remains the dominant issue on the effective response against erosion by protective the surface facing the erosive forces of raindrops and runoff. Our work aims to estimate the rate of vegetation recovery using satellite imagery in a semiarid region of the watershed of the Chott Chergui within the wilaya of El Bayadh. It is estimated the overall rate of recovery of vegetation on the site and its linking with the values of the normalized difference vegetation index (NDVI) corresponding to the image. The result has developed a map of three classes of vegetation cover, the first is completely denuded of vegetation, it is sandy areas, with rocky outcrops, or areas of buildings. The second vegetation with a less than 10 %, which corresponds to natural vegetation growing at altitudes moderately important to mountainsides. The third class has a recovery rate above 10% representing the agricultural parcels along the banks of the wadis, or reforested areas (that cover more than 30 %).

Keywords: water erosion, watershed, vegetation cover, vegetation index, GIS and remote sensing

INTRODUCTION

In recent decades, the term high steppe plains of Algeria were marked by intense degradation. One of the major causes is water erosion that occurs when rainwater, no longer able to infiltrate, runs off the land, carrying soil particles; the refusal of the soil to absorb water. Soil refusal to absorb excess water appears either when the rain intensity exceeds the infiltrability of the ground surface or when the rain enters a surface partially or totally saturated with the web [1]. The erosive process depends on a variety of factors interact with each other; these are soil, occupation, topography and climate [2]. When addressing the topic of soil erosion and land degradation, it is important therefore to consider the four basic physical factors determine the erosive regime, namely: rainfall erosivity, erodibility soils, topography, nature and density of the canopy because it is a major factor that protects the surface against water erosion.

In this work, the methodological approach of estimating the rate of vegetation cover is based on the satellite image processing.

The Study Area

The geographical location

The wilaya of El Bayadh occupies an area of 7,169,670 ha, it is part of the high steppe plateaus. This area is in three successive physical arrays from North to South:

- In the north the high steppe plains are a huge closed endorheic basin in which rainwater flows to the Chott Chergui,
- In the center of the mountainous area of the Saharan Atlas,
- In the southern Saharan desert area which forms the southern foothills of the Saharan Atlas (Fig. 1).

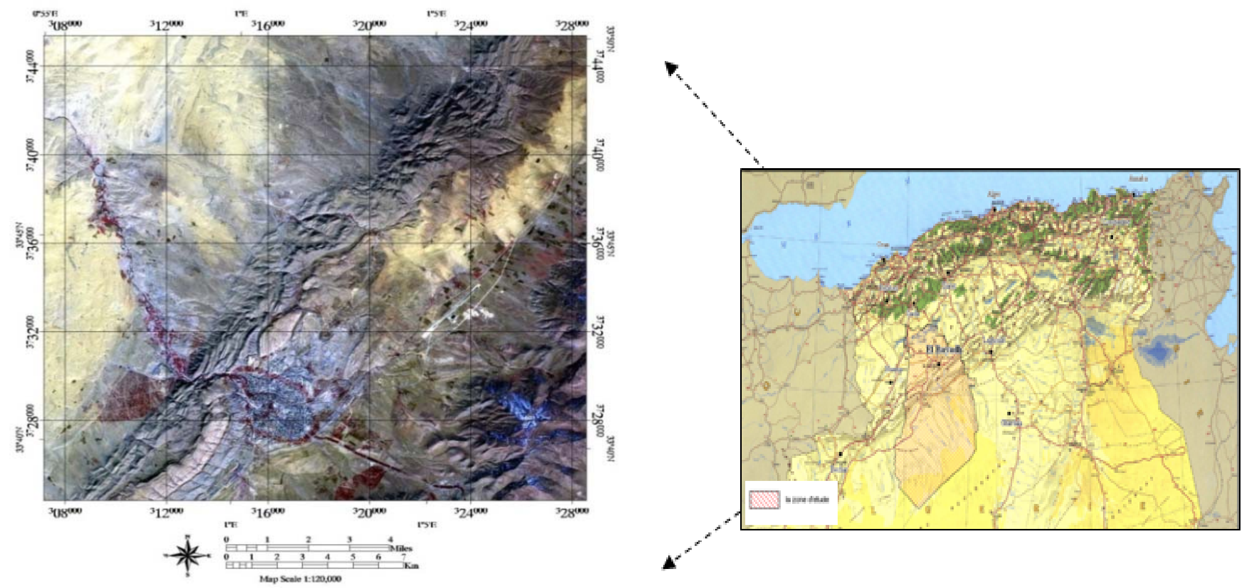


Fig.1. The location of the study area

Climate
In recent decades, the study area has undergone a remarkable decrease in rainfall where the average annual rainfall is 247.5 mm, the mean minimum temperature of the coldest month is 1.2 ° C (January), while the maximum of the hottest month is 38.8 ° C (July). The dry period extends over a period of 08 months with a dry cold winter bioclimatic.

Soil
Soil types and their distribution are closely related to geomorphological units in the region. A considerable area is occupied by shallow soils such as raw mineral soils, unsophisticated erosion on outcrops of bedrock geology and soils Calcimagnesian slab, crust or crusting limestone glaze encrusted ancient Quaternary. A relatively small area is occupied by shallow soils on the terraces of Late Quaternary (wadi channels, dayas) such as isohumic soils and salt-affected soils.

Hydrographic
Formed a series of closed basins and reliefs few defendants whose direction is West, is very imprecise. The largest number of these wads is located in the North

They originate in the peaks of the Tell Atlas in the north and flow into the Chott Chergui South. The regime of rivers is very irregular and low flow is zero or insignificant throughout the dry period. Runoff is quite low due to terrain mitigated land lows (or Chott) in each basin.

The vegetation of the area
Herbaceous steppe type, it is dominated by perennial grasses such as alfa (*Stipa tenacissima L*), esparto (*Lygeum spartum*) and mugwort (*Artemisia vulgaris*) plus a steppe floristic with a recovery rate of less than 30% often.

MATERIALS AND METHODS
This work aims to develop a map of the rate of vegetation cover from satellite image. For this, the following approach was adopted:

-Ranking of the area into homogeneous spatial units

-Visual assessment of the recovery rate of each homogeneous unit (on the ground)

-Statistical treatment of data to draw correlations between the recovery rates estimated visually and vegetation index derived from satellite image values.

Study Material
Monitoring of vegetation cover requires the signal images are calibrated to ensure comparability of data between them (Dehbi, 2007) [3]. To this end, various corrections (radiometric, geometric and atmospheric) are applied to all images used.

We worked on: - The image ALSAT1 March 2007 which covers the northern part of the region of El Bayadh . The time taken to this picture is very suitable since in March chlorophyll activity is very strong which is easily detectable bands in the visible and near infrared, this will allow us to better discriminate and map areas with different plant densities.

- The image in high resolution (2.5m) satellite SPOT5 (April 2006) covering the joint chief town of El Bayadh.
- Geological map of the North Algerian 1: 500,000, to delineate the major geological structures in the study area, and then to integrate it as a decision criterion in the creation of homogeneous spatial units.
- The topographic map of Geryville, the Scale of 1:200,000

METHODOLOGY

Extraction of homogeneous spatial units

According Delpoux (1972), while landscape is divided into two basic units: the physical medium and vegetation, the first is related to geological and geomorphological features, while the second is essentially linked to biological variation. However, knowledge of the natural environment requires a review of all its components [4].
It is advisable to define the components of the homogeneous units studied area, which has achieved first time the following layers:

• The layer of the geological map: - Scanning from the geological map (Geological map of the region of El Bayadh s
- The rasterisation of this layer
- The consideration of three geological structures characterizing the bedrock of the area (Jurassic facies sandstone, Miocene limestone-marl and clayey sandstone, post - Miocene Limestone Lake).
• The layer of the slope map: obtained from the SRTM (Shuttle Radar Topography Mission) of the El Bayadh area, with four defined classes (<5%, 5-15%, 15-30 %,> 30 %).
• The layer of the land use map produced from NDVI considering two main themes: Vegetation, No vegetation (bare soil).
cale 1:500,000)

Based on the image of the colored composition and NDVI was able, by the method of histogram and visual analysis, determine the value of zero (0) as a threshold boundary between the two selected classes (vegetation and non vegetation).

Note: the three images are in raster format (same spatial resolution) and include the same geo -referential characteristics (same projection).
The classification decision tree was the best method for making selected maps units the homogeneous extraction decision classes (Ricco, 2005) [5].

Integration conditions making (NDVI ≥ 0, the four classes of slopes and three geological classes) in the decision algorithm must give 24 new classes to the maximum by the proliferation of information layers. After visual analysis and application of smoothing filters on images yielded six core classes taken as a homogeneous unit (Table I) , the application of the median filter has allowed us to neglect the smaller classes that have no spatial meaning.

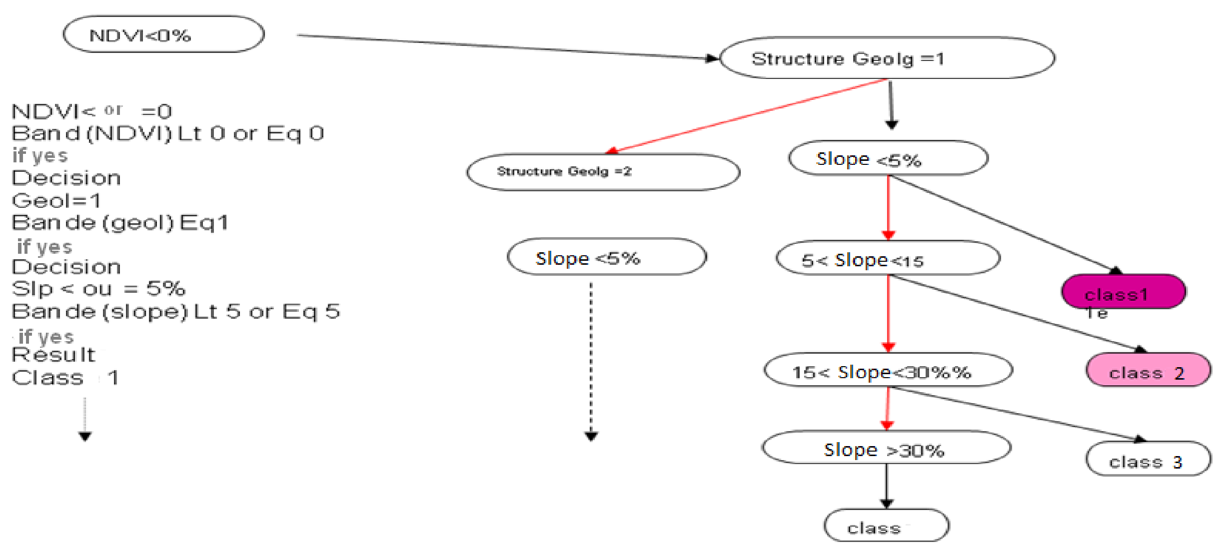


Fig. 2. Example of the classification algorithm adopted by decision tree for the extraction of homogeneous spatial units

Table.1. Classes of homogeneous spatial units extracted

	Classes	NDVI	Geology	Slope
Unit1	1	<0	G1	<5%
Unit 2	2	<0	G1	5-15%
Unit 3	5	<0	G2	<5%
Unit 4	9	<0	G3	<5%
Unit 5	14	>0	G1	5-15%
Unit 6	17	>0	G2	<5%

Visual estimate of vegetation cover on the ground

This step was carried out in the month of April (spring 2008). It allowed us to make contact with the ground, to see the complexity and choose the route to be followed in our study. And six stations were defined (according to the number of homogeneous units determined) to visually estimate the rate of vegetation cover in each spatial unit. Indeed, the period of field investigations in the same season shooting the satellite image (ALSAT1 picture taken in spring 2007).

Sampling

Because the vegetation is sparse, the sampling plots approach was adopted. The number of plots is selected according to the heterogeneity of the study site. The latter was assessed from the values of the NDVI image. Among the ten plots sampled and visually estimated on the ground, eight have been correlation test (recovery rate - NDVI), and the other two for validation. The plot sampling technique is used and applied by several authors (Godard, 1996 in the south- western Mauritania, which is a semi -arid region with sparse vegetation that is similar to our case) [6]. Plot size of inquiry should not be less than (9 x 9 pixels) because of the level of location accuracy (Tidiane, 2006) [7]; from equation (1):

$$A = L(1 + 2n) \qquad \text{.......(1)}$$

Where A is the smallest plot, L is the pixel size (20m here) and N is the precision error in pixels (here 4).

So: A = 20 [1 + (2 x 4)] = 9 pixels = 180m

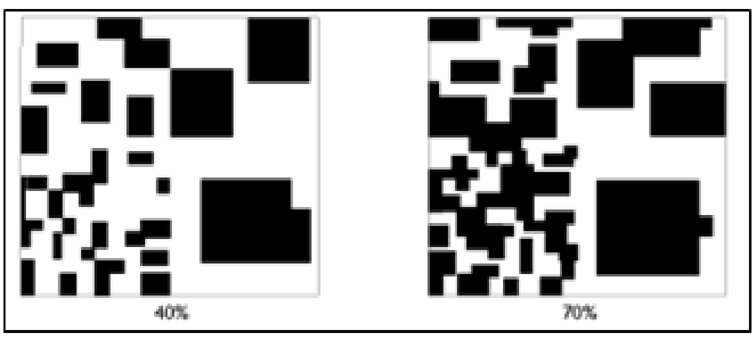


Fig. 3: Visual estimate of the percentage coverage of a given area, indicated by the black colored area.

Estimation of vegetation covers by the method of vegetation indices

Vegetation indices derived from satellite images allow to have an idea of the vegetation occupying the study area. A large number of indices is provided in the literature that the properties and sensitivity to external factors vary considerably. The relationship between the rate of vegetation cover and vegetation indices can be identified using several methods. For this reason, many studies have found a linear relationship between vegetation indices and biophysical characteristics of vegetation (Purevdorj et al., 1998) [8]. The NDVI (Equation 2) is the most used reasons of simplicity of calculation, the normalized character and its lower sensitivity (compared to reflectance) with respect to external factors such as the optical properties of the soil, geometry of the illumination or atmospheric effects (Cayrol , 2000) [9] .

PIR: channel infrared, **R:** the red channel

$$NDVI = \frac{PIR - R}{PIR + R} \quad ....(2)$$

To estimate the overall rate of recovery, the calculations are performed with the mean values of recovery rates taken on the ground and the vegetation index.

The following equations (3) and (4) respectively give the general form of linear and polynomial functions of the second order, they are used to connect the plant recovery rate (R) with the normalized difference vegetation index (NDVI).

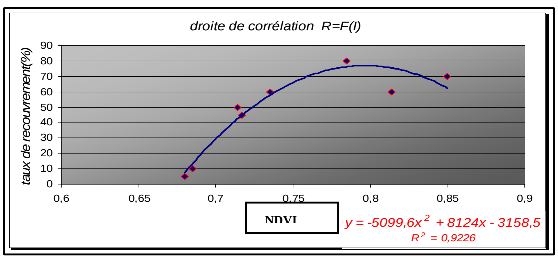
$$R = a.NDVI + b \quad ....(3)$$

$$R = a.(NDVI)^2 + b(NDVI) + c \quad ....(4)$$

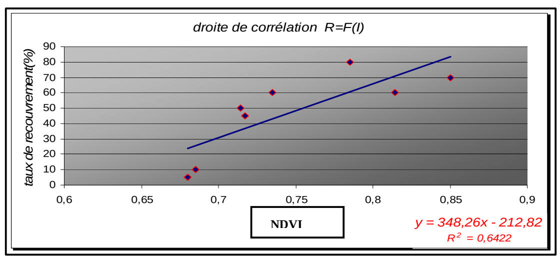
Where a, b and c are regression coefficients (real numbers)

RESULTS AND DISCUSSION

To determine the function that best represents a good relationship between NDVI is the recovery rate in the study area, it is based on the value of the correlation coefficient (the threshold for a good correlation r2 ≥ 0.6). We therefore have two relationships that give the best recovery rate based on the NDVI. From the graph (a) , we notice that there's a strong correlation between NDVI and recovery rates (r2 = 0.92) , but the application of this relationship on the NDVI values for calculating the percentage recovery rate gave us a result that does not represent the reality on the ground , usually values that exceed standards (upper to100 %).



Graph (a): relation-NDVI recovery rate in a 2nd order polynomial function



Graph (b): Relationship recovery rate-NDVI in a simple linear function

The second graph (b) is the simple linear relationship between NDVI and the recovery rate , the correlation is acceptable since the correlation coefficient is equal to (r2 = 0.64) , the application of this relationship on the values NDVI has given us very good results and that better represents the reality on the ground . Why our choice is fixed on the relationship of the simple linear function, the equation R = F (NDVI) is established as follows (Equation 4):

$$Rate(\%) = 348.26(ndvi) - 212.82 \quad ....(5)$$

The two remaining samples values (visually estimated to plots) are replaced in equation (5) for validation , which gave us very good results (recovery rates calculated automatically in the reality field) , it clearly explains the good correlation expressed by the relationship (see table 2) .

Table 2. Validation results (correlation recovery rate - NDVI)

	NDVI	Rate (field)%	Rate (calculate) %
Sample 1	0.756	50	50.4
Sample 2	0.650	15	13.54

One distinguishes three classes on the card recovery plant (Fig. 5), the first is completely stripped of vegetation, it corresponds to silted areas, rocky outcrops or areas housing (common head held naked around the common land). The second vegetation with a less than 10 %, which corresponds to natural vegetation growing at moderately important to mountainsides altitudes. The third class is one that has a recovery rate of more than 10% of agricultural plots shown following the banks of wadis, or reforested reaching a recovery that exceeds the 30% areas.

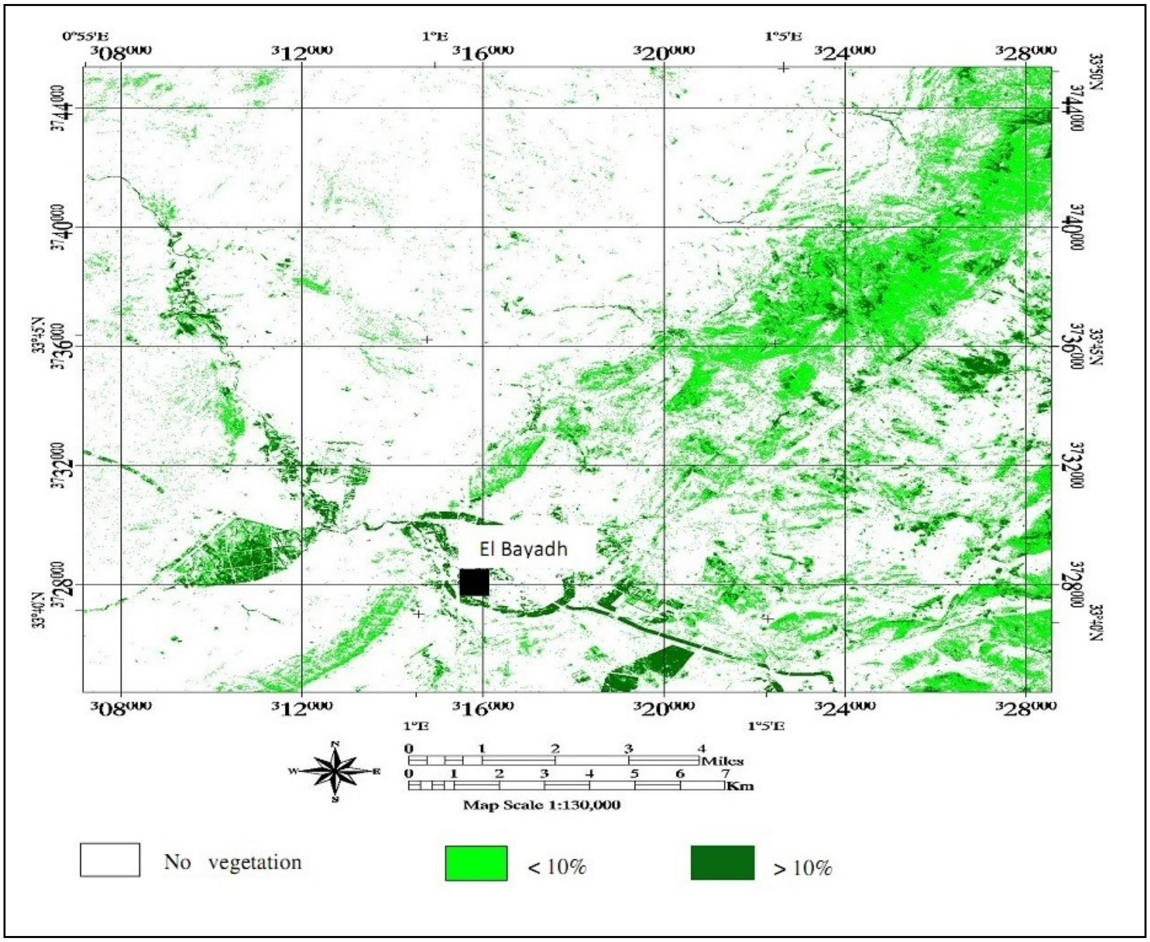


Fig.5. The recovery rate percentage

CONCLUSION

This work aims to achieve a map of vegetation cover in the watershed Chott Echergui (W. El Bayed), which is characterized by low vegetation cover , this rate can be explained by the semi -arid climate known for its low rainfall. The method of vegetation indices gave us interesting results , which seems adequate to estimate the plant recovery rate close to the reality on the ground , it is characterized by its simplicity and reliability ; it requires to integrate real data sampled terrain without needing a heavy or expensive equipment. The resulting map shows a briefing on the degraded state of the canopy layer, which is indeed one of the limiting factors that reacts effectively against water erosion.

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