SPATIO-TEMPORAL DYNAMICS OF STEPPIC LANDSCAPES: DJEBEL YOUSSEF - SETIF (ALGERIA)

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Abstract.- *Djebel Youssef, who possesses particular characteristics in terms of geographical isolation in the high Setifian plains, contains a very important floristic diversity. Currently, its plant formations were entering a phase of intense and continuous degradation, causing great distruption of the plant cover with the regression and disappearance of vulnerable and endemic species. This degradation is mainly due to anthropic action and climatic conditions, particularly recurrent periods of drought. In order to the preserve and protect this ecosystem, spatio-temporel monitoring of vegetation evolution was applied by using of landat satellite images (TM 5 and OLI 8), forming several study scenes. Knowledge of vegetation distribution and dynamics allows detecting changes in the state of vegetation cover over a 10-years period, using remote sensing and geographic information system (SIG) data. The recorded regression was estimated at 2,21 %.*

Key words*: Djebel Youssef, spatio-temporal dynamics, regression, NDVI.*

DYNAMIQUE SPATIO-TEMPOREL DES PAYSAGES STEPPIQUES: DJEBEL YOUSSEF-SETIF (ALGERIE)

Résumé.- *Djebel Youssef, qui possède des caractéristiques particulières en matière d'isolement géographique dans les Hautes Plaines Sétifiennes, renferme une diversité floristique très importante. Actuellement ses formations végétales entraient dans une phase de dégradation intense et continue, entraînant une grande perturbation du tapis végétal avec la régression et la disparition des espèces vulnérables et endémiques. Cette dégradation est due essentiellement à l'action anthropique et les conditions climatiques, notamment des périodes de sécheresse récurrentes. Afin de préserver et protéger cet écosystème, des suivies spatio-temporelle de l'évolution de la végétation ont été appliqué par l'utilisation des images satellites de type Landsat (TM 5 et OLI8), formant plusieurs scènes d'étude. La connaissance de la répartition et de la dynamique de végétation a permis de détecter les changements du couvert végétal sur une période de 10 ans, à l'aide des données de la télédétection et de système d'information géographique (SIG). La régression enregistrée a été estimée à 2,21%.*

Mots clés : *djebel Youssef, dynamique spatio-temporelle, régression, NDVI*

Introduction

The phenomenon of degradation is already perceived in Algeria, according to CHERMAT *et al.* (2016) [1], the mountain ranges of the Setifian High Plains face problems of degradation and loss of their biological resources, including the results of the diachronic study of the last decade, show a trend towards a significant qualitative and quantitative decline in vegetation cover.

In djebel Youssef the steppic vegetation, under the effect of the strong anthropogenic pressure and climatic hazards, knows a notorious modification of its floristic composition.

Anthropogenic disturbances are largely responsible for the current state of vegetation structures in the Maghreb [2]. The natural vegetation cover is permanently subjected to a double impact, that of the soils (too dry and light) and the climate (low precipitation) and that of the actions of man and his animals [3].

Important mapping works on vegetation degradation in Algeria: mountains of Tessala [4], Telagh [5], massif El Ouahch [6], massif of Aures [7], mountains of Beni-Chougrane [8], the high plains of Oran [9].

The Algerian steppe is an arid ecosystem characterized by limited natural resources, poor soil, low and open plant formations and severe climatic conditions [10].

The phenomenon of degradation of steppic ecosystems is not recent and has been reported by several authors in North-Western Algeria by AIDOUD *et al.,* (2006); AIDOUD and TOUFFET (1996); BENABADJI *et al.* (2009) and BENSLIMANE *et al.*, (2008) [11-14]. In north- eastern Algeria and during the last two decades, the only study conducted so far on the vegetation of djebel Youssef and carried out by CHERMAT (2013) [15] by determining the levels of degradation of the vegetation cover and reporting particularly rapid and intense changes in this ecosystem. To complete this phytodynamic study, we suggested studying, for the first time, the vegetation by the cartographic method.

The degradation of the vegetation in this massif is mainly due to anthropic action and very constraining climatic conditions, especially the recurrent periods of drought lasting more than5months.

The objective is to show the potential of using remote sensing to know the state of the vegetation cover and its spatio-temporal evolution from a diachronic study of Landsat images from 2010 to 2019.

To cover this study our methodological approach consists in: i) classifying the NDVI (supervised classification) of the acquired images, ii) detect changes in vegetation cover over the three periods: 2010-2013, 2013-2017 and 2017-2019.

All the data obtained during this work will be organized in a geographic database. This database will provide decision-makers and managers with complete and accurate information for the management and protection of the natural resources of the high plains. [16].

1.- Material and methods

1.1.- Presentation of the study area

To the North-East Algerian, the sector studied is between latitude North 36° - 36°27′ and longitude East 5°23′- 5°29′. It belongs administratively to the daïra of Ain - Oulmene, (Setif wilaya). It stretches about 10 km from east to west. It rises to about 1440 m (fig. 1). To the north, it is bordered by a vast plain traversed, by the oued Guedjel and the oued Ben diab. To the east, it is limited by the Gueta djebel and sebkhet Bazer, to the south are the saline depressions of sebkhet El hamiet and chott El Fraïn as well as the Sekrine djebel, to the west it is limited by sebkhet Melloul. They belong to the South-Setian allochthonous group. All the formations are of different ages: Barrémian, Jurassic and Lower Cretaceous [15]. This Tertiary era massif is geologically homogeneous with poorly evolved, skeletal soils that are very poor in nutrients. It is mostly brown calcareous soils [17].

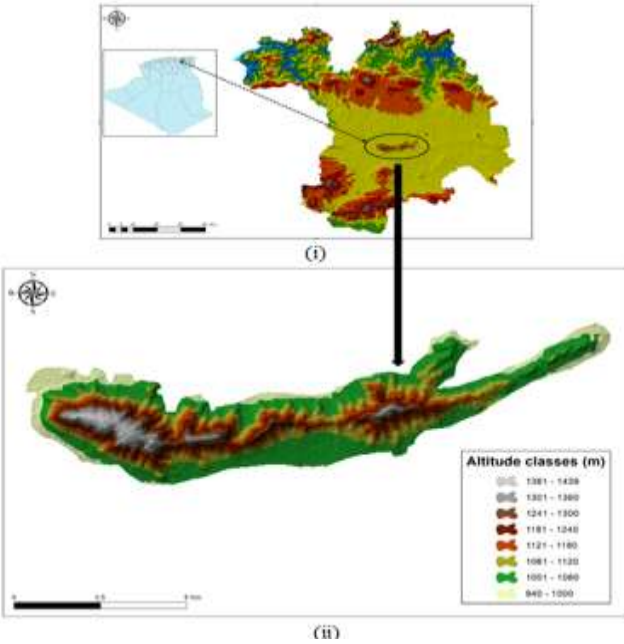

Figure 1.- (i)- Location of the site operated in the semi-arid steppe of djebel Youssef. (ii) -The altitude classes of djebel Youssef

1.2.- Methodology

Among the different types of sensors available, we have chosen LANDSAT for the acquisition of satellite images since it is the oldest and has a large archive of images over a long period (more than 34 years).

In order to carry out a diachronic study of the vegetation in any region, it is necessary to choose the date of the image taking, because of the variation of the ground conditions during the seasons of the year. For the choice of the optimal date of the image it is necessary to obtain a cloud-free and overlapping image and to recognize all the elements of the terrain avoiding confusion between vegetation due to annual herbaceous plants that can cause confusion with woody plants during the growing season. We opted for the period from March to June [16].

Lighting and atmospheric attenuation conditions are highly variable in time and space. The images therefore necessarily require atmospheric corrections in order to homogenize the multispectral data [18]. The principle of atmospheric correction of an image is to convert the numerical values (in gray level) of the scene into luminance values and then to extract the atmospheric disturbing effects which give a physical measure of the reflectance at the level of the targeted surface [19].

The atmospheric correction is followed by the application of the mask which consists in hiding a part of the image which has no interest and that could affect the results of final classifications. A mask may be radiometric or geometric. In a geometric mask, a geographical space on the image is eliminated. To do this, a geometric cut-out has been performed on the image by digitizing the geographical boundaries of the study area. It’s the geographical masking [7].

There are different indices associated with the intensity of green allow the study and observation of changes in vegetation cover using satellite images. Among all these indices, the normalized vegetation index NDVI was chosen for the calculation of the NDVI [20]. The value of this indicator of the chlorophyll activity of the vegetation is between -1 and +1 and is calculated from two spectral bands, the infrared IR and the red R according to the following expression:

$$NDVI = (IR - R)/ (IR + R). \quad (1)$$

Generally, an open water surface (ocean, lake,) takes NDVI values close to 0, bare soil takes values from 0.1 to 0.2, while dense vegetation takes values from 0.5 to 0.8. [16].

The NDVI classification allows the image to be classified, according to the NDVI value, into two distinct thematic classes: vegetation and non-vegetation. There are two methods of classifying images: unsupervised and supervised classification. In our case, we chose the supervised classification, which is based on the identification of fairly homogeneous samples of the image that are representative of both types of surfaces (vegetation and non-vegetated). These samples form a set of test data. The selection of these test data is based on the knowledge of the djebel Youssef region and the types of surfaces present in the image. We therefore supervise the classification of a specific set of classes. Numerical information for each band and for each pixel of these sets is used to define classes and then recognize regions with similar properties to each class. Classification remains the most critical and complex step to be carried out, as the accuracy of the results depends on it. The greatest difficulty consists in choosing the test data that are samples of each thematic class. For this reason, at each step of the classification process a preview of the result is analyzed, allowing a follow-up throughout the classification process [6]. In the supervised classification of NDVI, three classes were selected: Clear vegetation; dense vegetation; Non-vegetated.

After classification, the change between the selected dates is detected. This process makes it possible to detect the slightest change in class, between two images classified at different dates. The images obtained illustrate, both spatially and quantitatively, the significant changes in vegetation over time in the study region [6]. Possible changes can be a progression, regression, stability of the vegetation cover or an increase or decrease in density.

The final phase consists in making synthesis maps of vegetation changes over the 10 years.

1.3.- Material used

1.3.1.- Satellite images

Scenes from Landsat 5 TM and Landsat OLI 8 (Operational Land Imager) images with 30m spatial resolution, downloaded from earthexplorer.usgs.gov, were used [21].

1.3.2.- Processing software

- Remote Sensing Software (ENVI 5.1) for Image Processing.
-Geographic information system (ArcGIS 10.1) for the mapping part and creation of the geographic database.

-The Google Earth software for the confirmation of the results.

2.- Results and discussions

2.1.- Type and date of satellite images used for the diachronic study of vegetation

Between 2010 and 2019, for the djebel Youssef, we counted 182 LANDSAT scenes. After consultation of the images and elimination of those containing cloud cover, only 59 have shooting dates during the period from March to June. Out of the 59 available dates, we have chosen the earliest date of 22/06/2010 and the most recent of 15/06/2019. For more precision in monitoring the evolution of the vegetation over time, intermediate dates have been chosen. Depending on the availability of the scenes, two intermediate dates have been chosen, 14/06/2013 and 23/03/2017 [16].

2.2.- Evolution of the vegetation of djebel Youssef between 2010 and 2019

The study period was subdivided into three periods: 2010-2013, 2013-2017 and 2017-2019 For a detailed follow-up of the evolution of the vegetation of djebel Youssef.

2.3.- Evolution of vegetation between 2010 and 2013

From 2010 to 2013, djebel Youssef showed a negative balance with a loss of area equivalent to 48.39 ha or 1.23% of vegetation, this regression concerns primarily the north-western, western and southern parts of the northern slope with some spots in the southern slope and the center. During the same period, the areas of progression represent an estimated area of 5.94 ha (fig. 2). The areas where an increase in vegetation density has been recorded are in the majority, they occupy an area of 284.64 ha (7.24%). On the other hand, the decrease in density concerns only 5.05 ha.

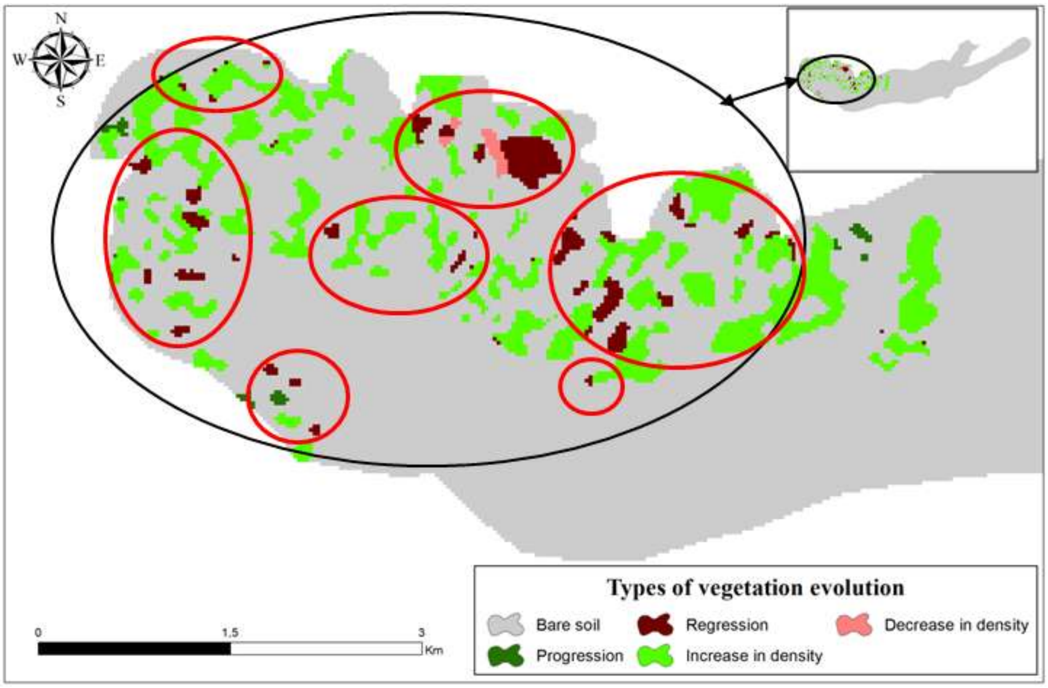

Figure 2.- Stages in the study of the evolution of vegetation at djebel Youssef

2.3.- Evolution of vegetation between 2013 and 2017

During the 3 years, 169.68 ha (4.31%) underwent a decrease in density. This decrease was observed in the northern, western, southern and south-western parts of the northern slopes of the massif (fig. 3). At the same time, 21.81ha recorded a loss of vegetation especially in the southern part of the northern slope and in the center, while the areas of progression represent only a negligible value estimated at 5.68 ha or 0.14%.

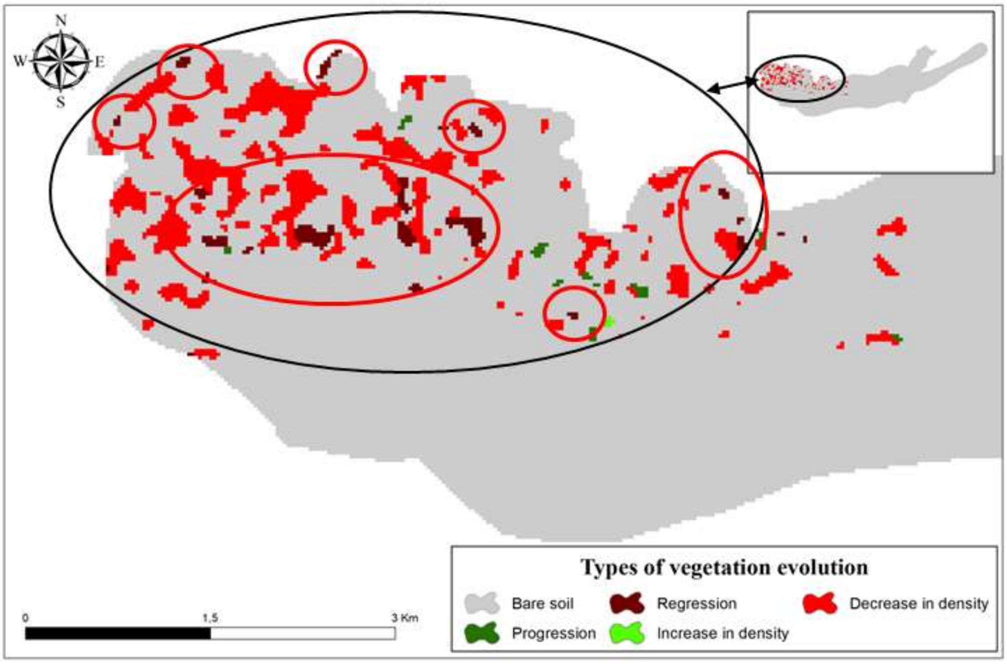

Figure 3.- Regressive evolution of vegetation between 2010 and 2013.

2.4.- Evolution of vegetation between 2017 and 2019

After analysis of figure 4, it can be seen that between 2017 and 2019, djebel Youssef shows a rather negative balance with an estimated lost surface area of 44.21 ha or 1.12%, particularly in the western part of the northern slope and spreading towards the south-western part of the southern slope of djebel Youssef. This regression is essentially due to human action, especially the grazing of livestock that consume the wooded steppes on the southern slope, such as mugwort and esparto grass. An increase equivalent to 13.53 ha was recorded, mainly due to reforestation.

In terms of vegetation density, the increase concerned an area of 48.21 ha, while the loss concerned 0.81% or 81.8 ha.

2.5.- Evolution of vegetation between 2010 and 2019

Figure 5 shows the changes in vegetation in djebel Youssef between 2010 and 2019. During this period, vegetation increased by 5.04 ha (0.13%) and recorded a loss of 91.88 ha or 2.34%. This loss was observed in the northwestern, western and southwestern part of the North Slope and in the southwestern part of the South Slope with a few spots in the center. The overall balance of vegetation regression between 2010 and 2019 is 86.84 ha of the total area of the massif.

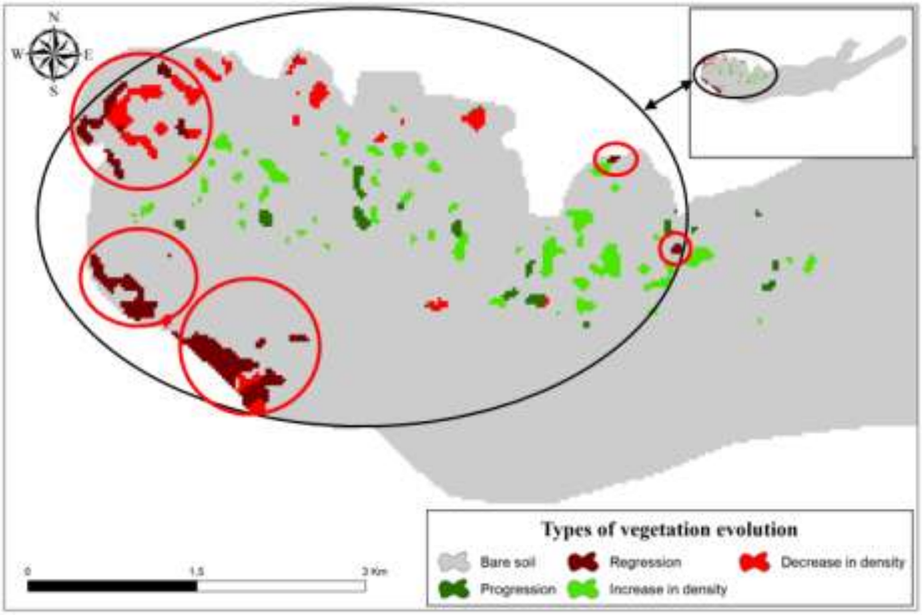

Figure 4.- Regressive evolution of vegetation between 2013 and 2017.

Concerning the evolution of vegetation density, an increase in density of 157.66 ha (4.01%) was observed, while the decrease represents only 0.69% or 27 ha of the total area.

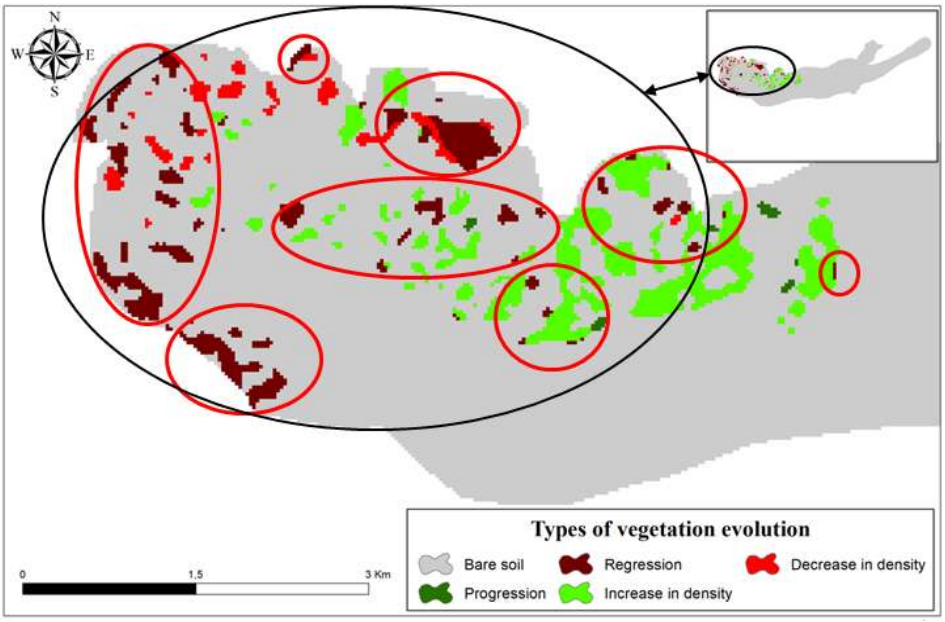

Figure 5.- Regressive evolution of vegetation between 2017 and 2019.

2.6.- Global synthesis of the evolution of vegetation in djebel Youssef

After analyzing the maps, we see that the largest regression concerns the period 2010-2013. During the same period, the greatest increase in density is recorded then there is a slowdown between 2013-2017, which records the lowest average regression and the largest decrease in density. The largest increase was recorded between 2017 and 2019.

The regression of the vegetation is mainly due to anthropic action, particularly grazing, fires and the presence of quarries, which lead to an increase in dust content which, in turn, covers the leaves of the trees and prevents them from breathing. This anthropogenic action is aggravated by very constraining climatic conditions, particularly recurring periods of drought, wind action, especially sirocco, water erosion and parasitic attacks such as the pine processionary caterpillar.

Conclusion

The diachronic study of the evolution of vegetation in djebel Youssef shows that during the period from 2010 to 2019, the vegetation cover increased by 5.04 ha in the northern and central part of the northern slope. In return for this increase, losses amounted to 91.88 ha, particularly in the northwest, west and southwest parts of the north slope and in the southwest part of the south slope. The overall result for this period is alarming in accordance with the results of CHERMAT (2013) [15], highlighting the impact of human action and climate change.

The cartographic base set up constitutes a management tool for the conservation units and for monitoring the evolution of plant cover and land use. Coupled with geographic information systems (GIS), remote sensing appears to be an effective tool to be made available to managers. The work carried out constitutes a first approach; its objective is to monitor the evolution of the plant cover. This study has shown the possibilities of analysis of the dynamics of the vegetation cover in the djebel Youssef . We hope, through this work, to have shown the state of the regressive evolution of the vegetation, from the point of view of extent and density, in the massif and to have emphasized the main factors responsible for it, for a better management of these problems [16].

In terms of perspectives, it would be better to use very high-resolution satellite images for a more detailed monitoring of the regression of the vegetation cover of djebel Youssef.

To protect this fragile and threatened steppe ecosystem, it is urgent to establish an adequate management plan to better control the antropozoic action, to finance and increase reforestation operations, in particular with species better adapted to climatic conditions, in particular to the impact of the dry season.

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