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STUDY OF THE TEMPORAL EVOLUTION OF LAND USE IN THE STEPPE SOUTH OF TLEMCEN PROVINCE FOR THE PERIOD 1987 AND 2010 USING REMOTE SENSING AND GIS THECHNIQUE (WESTERN ALGERIA)

Ayache.A[1*], Ayad.N[1], Hellal.B[1], Benhanifia.K[2], Gacemi.M[2]
Laboratory of plant biology: conservation & recovery. The environmental science department, Faculty of Life and Natural Sciences. Djillali Liabès University of Algeria
Email: **Ayache.abbassia@yahoo.fr**

ABSTRACT

Steppe southwest high steppe plains of western Algeria is an open space mainly due to changing climatic conditions and anthropogenic pressures. Land use changes in the arid depending on the mode of operation. The study of the dynamics of the land has to understand the effect of the main operating modes, the causes of degradation of vegetation and landscape fragmentation. The data, such as Landsat-5 TM two images *(Tematic Mapper)*, were used to analyze the changes between 1987 and 2010 by using the normalized difference vegetation index *(NDVI)*. The study of change shows an increase of clearings (55%) and cultivated (49%) and a remarkable reduction of the areas of steppe (31%) in the space-time of 23 years. The medium resolution remote sensing is therefore, in the light of these statistics, a relevant and effective management tool of the steppe area, which, in addition, allows enriching the area in view of an appropriate accommodation plan for the fight against desertification.

Key words: remote sensing, change, land cover, satellite scenes, atmospheric correction, NDVI

INTRODUCTION

The last few decades have witnessed considerable evolutions in the use of remote sensing satellite as a means to follow-up and scrutinize the changes imposed on our natural environment including the semi-arid steppe regions. The detailed track of these changes relies on the longue series of remote sensing imagery from the Landsat satellites, which measure variations in the reflection of solar radiation by ground surfaces. Such use is based on the relations between these measurements and the ground surface composition that results in the elucidation of the state of the target environment. Today, the steppe area of Tlemcen province (Western Algeria) reflects very important spatial transformations. These transformations are, in large parts, of ecological and climatic order (drought), resulting from the improper agricultural activities, the illicit ploughing practised by some farmers, despite their prohibition by the local authorities, the nomadic population settlement in the sparse zone with its livestock as well as from the spread of agricultural valorisation operations. Hence, this situation has contributed to the instability of the soil often eroded by the violent winds of the region. The result was the eventual outbreak of the desertification phenomenon which continues to expand and reach several areas of the steppe space [25]. In other words, this study area, namely the arid zones, undergo significant changes reflected mainly in the agricultural intensification, the regression of the forest and steppe vegetation cover and the aggressiveness of means leading to land degradation or even its desertification [12],[14]. Accordingly, different studies have been carried aiming to detect the changes affecting the steppe vegetation cover by exploiting the spatial data supplied by remote sensing technology which is a constantly evolving area. In the same context, this research work endeavours to provide a quantitative and an objective evaluation of these modes of land occupation. Taking into consideration the benefits of multispectral imagery, such as the repetition of the data, their synoptic view and their digital format suitable for computer processing, they become a source of relevant information for the determination of the nature and the status of land cover. Besides, the normalized difference vegetation index (NDVI) [30] , used as indicator of degradation, allows the assessment of the degradation dynamics of the steppe vegetation cover in response to human activities, in particular the agricultural practices. As such, this study is based on a supervised classification NDVI values *(normalized difference vegetation index)* using images of remote sensing of medium spatial resolution of Landsat-TM type 5 of the south steppe of Tlemcen province.

Study area

The study area stretches from the locality of the Ras elma to that of El Aricha. It occupies respectively the southern provinces of Sidi bel abbes and Tlemcen (Western Algeria). The surface area is about 168885 hectares. It is elongated from north-west to south-west for a distance of 90km and from north to south over a distance of 50km (figure 1).

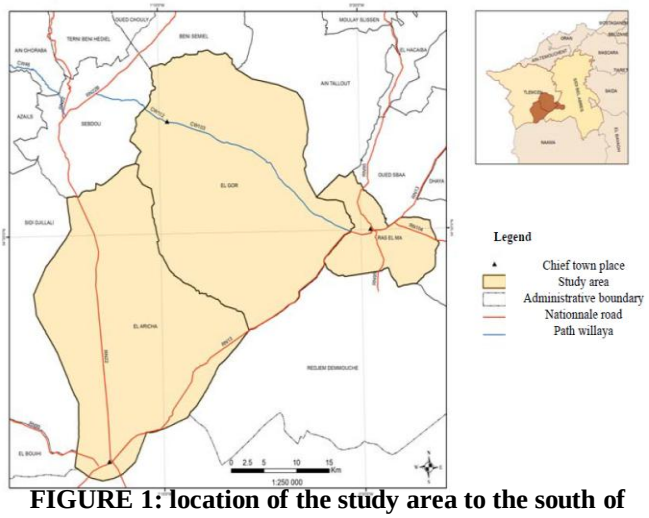

FIGURE 1: location of the study area to the south of Tlemcen province

The steppes of southern Tlemcen are characterized by a disproportion between the amount of water received and the intensity of evaporation. They shall be determined by a sparse plant cover can survive in this arid climate through the presence of plants bearing long periods of drought.

Dataset and Method

The study is based on two satellite images Landsat-TM 5 of March 1987 and March 2010, geo-referenced and projected in the conical Lambert system (geographic coordinated system applied in Algeria).The pixels size in these photographs is 30 m.

Image selection criteria

One of the main reasons favouring the choice of TM images *(Tematic Mapper)* «Landsat-5 » is their usefulness in monitoring land-use change processes. It was necessary to define a selection procedure based on the assessment of the following elements:

- The spatial resolution of the image: the spatial resolution is chosen according to the scale of the design of the final thematic maps, and depending on the level of detail necessary for the analysis of the environment.
- The phenological season is the basic parameter to analyze the evolution of vegetation, we must respect the most suitable period for the assessment of the latter [19].

In the present study, two scenes in digital format related to the study area, obtained by two multi-spectral sensors (Landsat-5), are used for the production of thematic maps of different types of land cover of the observed territory on a scale of (1 / 200 000).

Image pre-treatment

The selected scenes must undergo digital pretreatments by using appropriate software (ENVI, *version 4.7*) containing geometric and atmospheric corrections for the improvement of the coloured composition of the three selected channels TM1 (blue channel), TM3 (red channel) and TM4 (near infrared channel) for Landsat image TM-5 and TM2 (blue channel), TM4 (red channel) and TM5 (near infrared channel) for the Landsat image TM-8. The purpose of this step is to minimize insofar as possible the artifacts related to the shooting conditions.

Atmospheric correction

Radiometric corrections (atmospheric) were made on the two satellite scenes of 1987 and 2010. Each pixel of the time series is radio-metrically corrected by the use of physical models, given that the applied atmospheric correction model involves the use of the topographic features of the pixel so as to make the two images from different date's directly comparable [11],[15] . The physical model used for atmospheric corrections of the satellite scenes is radiative transfer-based (MODTRAN) contained in the ENVI software. This model of atmospheric correction based on radiative transfer calculations is the most adopted. It allows correcting the wavelengths in the visible through the near-infrared and short-wave infrared up to 3 μm [15] and [18] .

Geometric corrections

The geo-referencing of satellite images of 1987 and 2013 consists in correcting, in a raw image, the geometric distortions caused by the orientation variations of the observation platform .This correction allows reducing the raw image geometry to a cartographic geometry [15],[28] . The geometric correction is applied to both images obtained using support points located on the topographic map of the Military Staff (scale 1:50000) taking into consideration the projection system of this latter (Lambert conic, geographic coordinate system applied in Algeria) and the digital terrain model (DTM).

Treatment by the normalized difference vegetation index (NDVI)

The NDVI is given by the following formula [30]

$$NDVI = (PIR - R)/(PIR + R)$$

Normalized difference vegetation index (NDVI) is based on prior determination from sensor spectral bands. It uses the following data:

(PIR): near-infrared channel; (**R**): red channel; the values vary between (-1 and +1) for the absence and presence of the vegetation, respectively.

Supervised classification of NDVI

The supervised classification involves the definition of the land cover classes on a thematic basis prior to classification. Comparison of the results is carried on the test areas or

the validation dependent of the training areas using confusion matrix [15],[26]. The validity of the final result can be assessed using control areas that have not served to the prior definition of classes. The preliminary segmentation of the image in homogeneous geographical areas may frequently be necessary, to subsequently allow a consistent classification. The land cover classes are determined from the different values of the NDVI calculated on the two scenes 1987 and 2010.

Results and discussion

Slopes

Figure 2 shows four categories of scopes according to the inclination of the area. We note mountains areas, foothills area and lowlands areas.

Category I (0-6%): represents slopes reaching up to 6% (lowlands and spreading zones);

Category II (6-12%): represents gentle slopes rather moderate (lowlands et low foothills) ;

Category III (12-25%): includes steep slopes (hills and foothills of mountains);

Category IV (>25%): represents steep slopes (djebels, mountain summits and hilly areas).

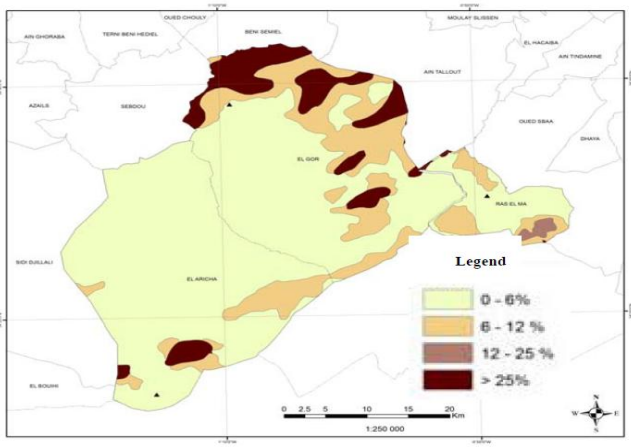

FIGURE 2: Slopes category of the studied area

Reliefs

Three sets of very clear relief can be distinguished. In the north, the distinguished mountain range on the study area has a south-west and north-east direction, it is much more rugged in the west compared to the east (Figure 3).

The topography drops gradually from west to east from "1300 meters to 900 meters", which represents a vertical rise of "400 meters". This mountainous area is a barrier which opposes the humid climatic influences from the north and northwest, the southern slopes end in more or less gentle slopes forming small alluvial cones at the El Kaudit Mkam and the foothills of Jebel Raourii. We note the presence of small hills and basins « Dayet El Ferd, Dayet Mekahil » as well as, nicks caused by a non-hierarchical water system that give a fleecy appearance relief where the average altitude is about "1000 meters".

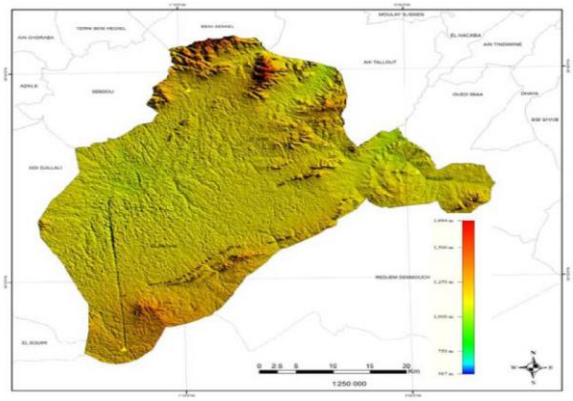

FIGURE 3: Reliefs category of the studied area

Hydrographic networks and watersheds

The basins are fed from a number of wadis coming from all directions which know each other during flooding of "El Ferd Dayet" at the center of these watersheds (Figure 4). It is a reservoir of rainwater ensuring flood control, sediment retention, nutrients, and recharge groundwater.
According to figure 6, we could distinguish the following six watersheds:

- Watershed Dayet El Ferd;
- Watershed Oued Mekkera Upstream;
- Watershed of Medium Oued Mekkera;
- Watershed Meskhskha;
- Upstream Watershed Tafna;
- Watershed of Yssed Cedra.

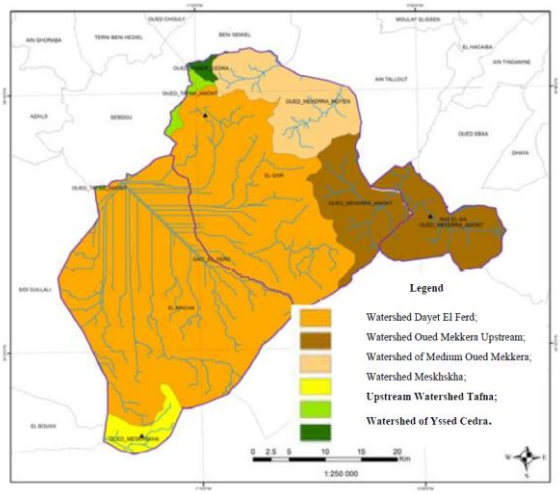

FIGURE 4 : Hydrographic networks and watersheds of the studied area

Land use in 1987 and 2010

The classification led by the normalized difference vegetation index made possible the identification of major vegetation types and observation of astonishing vitality of woody and herbaceous formations that sometimes seem to progress and regress. The NDVI is widely used to monitor the state of the vegetation and production in different environmental situations. Thus, the physical values of this index range from "0.1 to 0.92", where the highest values indicate a more dense and healthy vegetation. The NDVI values of 0.6 to 0.7 are related to broadleaf species and those of 0.4 to 0.5 correspond to softwood [29] ,[7],[17]et [16].
The land cover map from 1987 shows:

a. A low representation of dayas and cultivated depressions (0.6%);

b. A predominance of natural grasslands and pastures in the study area (Figure 5 and 6).

In the year 2010, we notice that:

a. An increase in the surface of heterogeneous cultures (24.68%) and cultured depressions (1.83%) with predominance of clearing (29.91%).

b. The forest stands and shrub vegetation are very poorly represented in 2010 compared to 1987 (Figure 7 and 8).

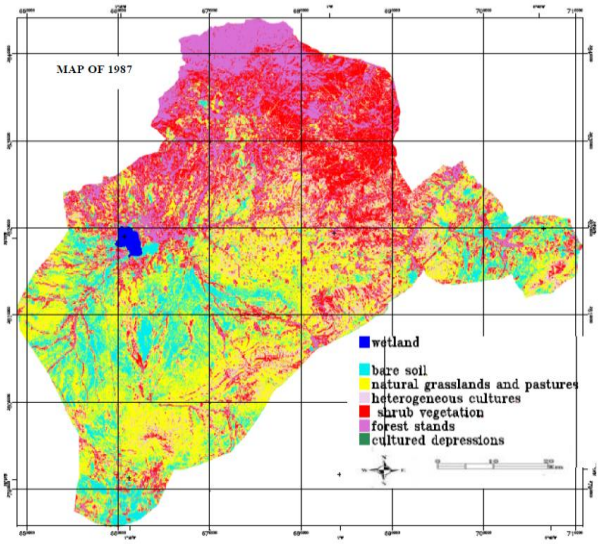

FIGURE 5: Map of land use in 1987 of the studied area

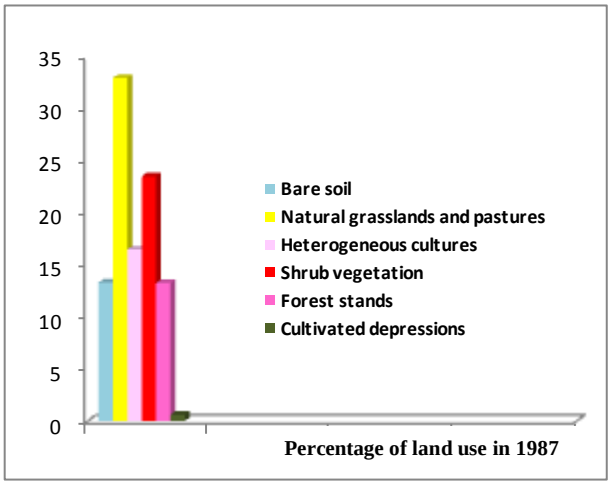

FIGURE 6: Percentage of land use in 1987 of the studied area

The forest stands in southern Tlemcen are subject to severe degradation caused by fires, overgrazing and clearing. Reducing the size of matorrals is strongly illustrated in the satellite image of 2010. El 'Ghor town sees its forest stands regress considerably between 1987 and 2010. In the south, on the northern slopes of Jebel mékaidou (El Aricha) remain some of Aleppo pine (*Pinus halepensis)* feet, from 1300 m of altitude. The shrub layer, light, consists of oak *(Quercus ilex)* and juniper *(Juniperus oxycedrus).*

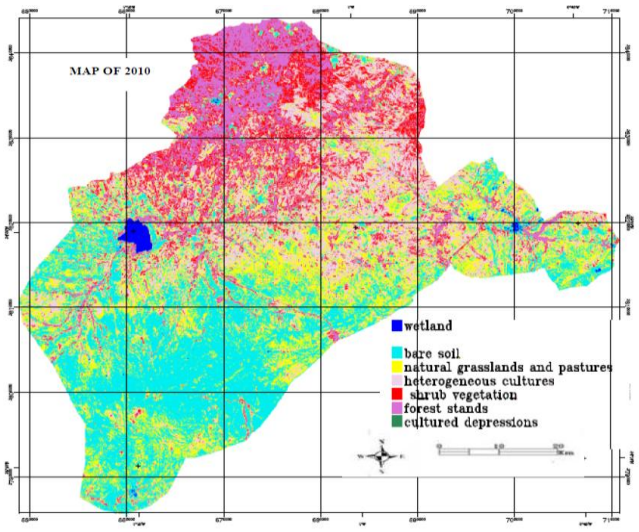

FIGURE 7: Map of land use in 2010 of the studied area

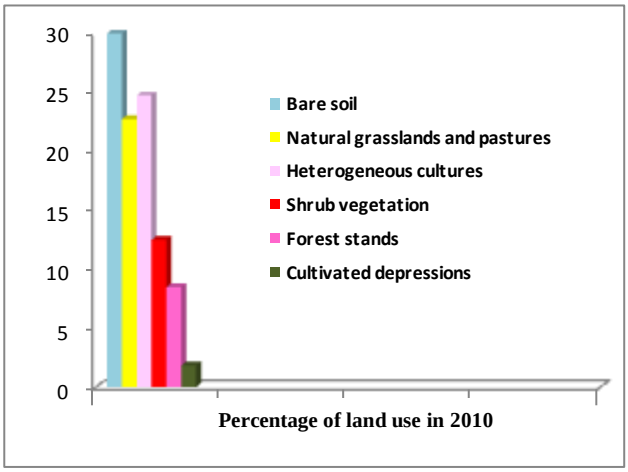

FIGURE 8: Percentage of land use in 2010 of the studied area

The shrub layer is made from rosemary *(Rosmarinus officinalis)* and alfa (*Stipa tenacissima)*. The forest stands of El 'Aricha and Ras Elma areas, despite very sparse and low collection rates, have undergone significant reductions. Their regression over a period of 23 years, can be explained by the impact of the fires and the high human pressure. The impact of fires, particularly during the decade "1986-1996" has resulted in the degradation of plant cover [8],[13],[22]. Deforested areas, through repeated demonstration of fires, favored clearing for agriculture and increasing livestock grazing in matorrals [3], [6],[23] ,[24] .

Table 1 shows according to the importance, the classes of land clearing (53.02%), natural grasslands and pastures (24.34%) very strongly represented in the municipality of El 'Ghor in 2010 compared to 1987; The same trend was observed for the municipality of El 'Aricha concerning the classes of heterogeneous cultures (33.81%) and forest stands (20,17%). Ras Elma region was distinguished by class areas with or without vegetation (27.26%), natural grasslands and pastures (35.73%) and heterogeneous agricultural areas (26.94%).

TABLE 1: **Percentage of land use in 1987 and 2010**

Thematic classes	Land use 1987 (%)	Land use 2010 (%)	Observations
Bare soil	**13,30**	**29,91**	**55%**
Natural grasslands and pastures	**32,92**	**22,68**	**-33%**
Heterogeneous cultures	**16,47**	**24,68**	**49%**
Shrub vegetation	**23,47**	**12,45**	**-46%**
Forest stands	**13,25**	**8,45**	**-36%**
Cultivated depressions	**0,60**	**1,83**	**67%**
Total	**100%**	**100%**	

Spatio-temporal changes

The land cover map enabled to highlight a 23.88% regression of vegetation cover and a marked increase of 43.33%, expressed by the increase in cereal crops. On the other hand, it shows a stability of rate zones course 32.79%. The landscape changes are mainly due to overgrazing, fire and clearing of natural pastures populated by sagebrush (*Artemisia herba-alba* Asso.), alfa (*Stipa tenacissima*), and esparto (*Lygeum spartum*).

The practice of cereal production, widespread on shallow soil and sagebrush term alfa has caused irreparable harm to the steppe and promoted Desertification [1],[5],[14],[27] The cultivation of cereals, in depressions and wadi beds where performance is significant, seems to encourage agro-pastoralists to expand cultivated areas [29]. The areas of cereal crops are mainly located in southern El 'Ghor region where they occupy very large areas. These areas occupy the dayas in the municipality of El 'Aricha. The cereal production is always uncertain and continues to encroach on the land route [2],[8] Alfa grass are under heavy degradation in the study area and are being replaced by the sagebrush stands [4] ,[11],[20], [21],[23].

CONCLUSION

Using data from satellite scenes from 1987 and 2010 allowed us to follow the spatiotemporal evolution of the land cover dynamics of the steppe of southern prefecture of Tlemcen, over a period of 23 years. The mapping of statements of changes in land use in the southern steppe of Tlemcen (Western Algeria), from the satellite scenes of 1987 and 2010, revealed various modifications of the vegetation cover of the study area. It is clear that the different classes of land cover recorded cases of progression and regression during this period. Indeed, the changes are mainly due to clearing for the agricultural sector, and supported by the overgrazing of livestock settlement. This space is facing in terms of exploitation and preservation, various problems of desertification.

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