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DETECTION OF THE MULTI-TEMPORAL DYNAMICS OF THE VEGETATION COVERS IN THE ALGERIAN STEPPE BY REMOTE SENSING CASE OF THE KESDIRE ZONE (NAAMA WILAYA)

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Abstract

The Algerian steppe is very affected by the ecological and climatic imbalance; the degradation of the natural environment is currently a serious problem following silting, wind erosion, overgrazing and clearing.
The extent of degradation in the semi-arid zone (commune of Kesdire in Naama wilaya) has led to a significant regression of the vegetation cover, requires a better understanding in order to see how to fight against this plague and propose adequate facilities.
Through this work, we have tried to show, on the one hand, the potential of using remote sensing for the detection of the dynamics of the steppe cover and its spatiotemporal evolution from the treatments carried out on Landsat 5 satellite images and 8 (March 1987 and March 2015). On the other hand, to provide decision-makers with information on the state of the vegetation cover in this area.
The method used is based on the interpretation of the treatments (calculations of MSAVI vegetation indices and soil brightness IB) on Landsat satellite images, these digital treatments made it possible to analyze the multi-temporal dynamics of the vegetation cover and identifying areas of degradation within 28 years.
The results of our study show that the state of the vegetation cover and its evolution seem alarming, our study area lost 22.22 % of its natural vegetation during the last quarter of the century. This change informs about the different changes that the municipality of Kesdire has experienced.

Key words: Remote sensing, dynamic vegetation cover, MSAVI, soil gloss index, change maps.

INTRODUCTION

The degradation of semi-arid ecosystems in Algeria has become a palpable fact that hinders progress and rural development. In these exceptionally fragile environments, the decline in vegetation is an alarming progression. The ecosystem is subject to a long, hot, dry season and low average annual rainfall. The combination of climatic and edaphic conditions makes the steppe a fragile environment exposed to a regression of natural vegetation. We are witnessing a profound change in the steppe ecosystem where the wind equipment (sand) replaces the steppe vegetation (alfa).
In front of this situation, however, it is essential to be able to analyze the vegetation cover in order to identify problem areas (degradation). This analysis involves the manipulation of a considerable amount of information to describe the vegetation of the steppe zone of Kesdire commune. The use of remote sensing is then essential.
Thanks to satellite images, it is possible to map vegetation cover at timescales. For a better understanding of the physical and biological processes that govern the dynamics of plant ecosystems, remote sensing data can also be used to learn about the consequences of possible changes in the distribution of plant cover, so as to establish more sustainable management solutions. For this purpose, a diachronic study of the images acquired in March 1987 (Landsat 5) was carried out in March 2015 (Landsat 8).

STUDY ZONE

The area concerned by this study is the southwestern part of the high plains of Oran. It is administratively attached to the wilaya of Naâma, it is the commune of Kesdire. It is located about 150 km north-west of the city of Naâma, it occupies an area of 6,378 km^2, it is characterized by a population density is 1.2 inhabitant/km^2. A commune is victim of its geography and a vast steppe country degraded by intensive and reflective grazing.

The natural vegetation of the study area is characterized by a steppe physiognomy saved in the mountains where the remains of primeval man-made forests of Pinus Halepensis and juniperus phoenicea remain. Apart from these forest species, the aspect of the steppe changes with the rainfall gradient and the nature of the soil. The southern steppe Oran is dominated by the following plant formations:

- Alfa (Stipa tenacissima) steppe ;
- White sagebrush steppe (Artemisia herba Alba);
- Spartan Steppe (Lygeum spartum);
- Halophyte steppe;
- Psamophyte steppe.

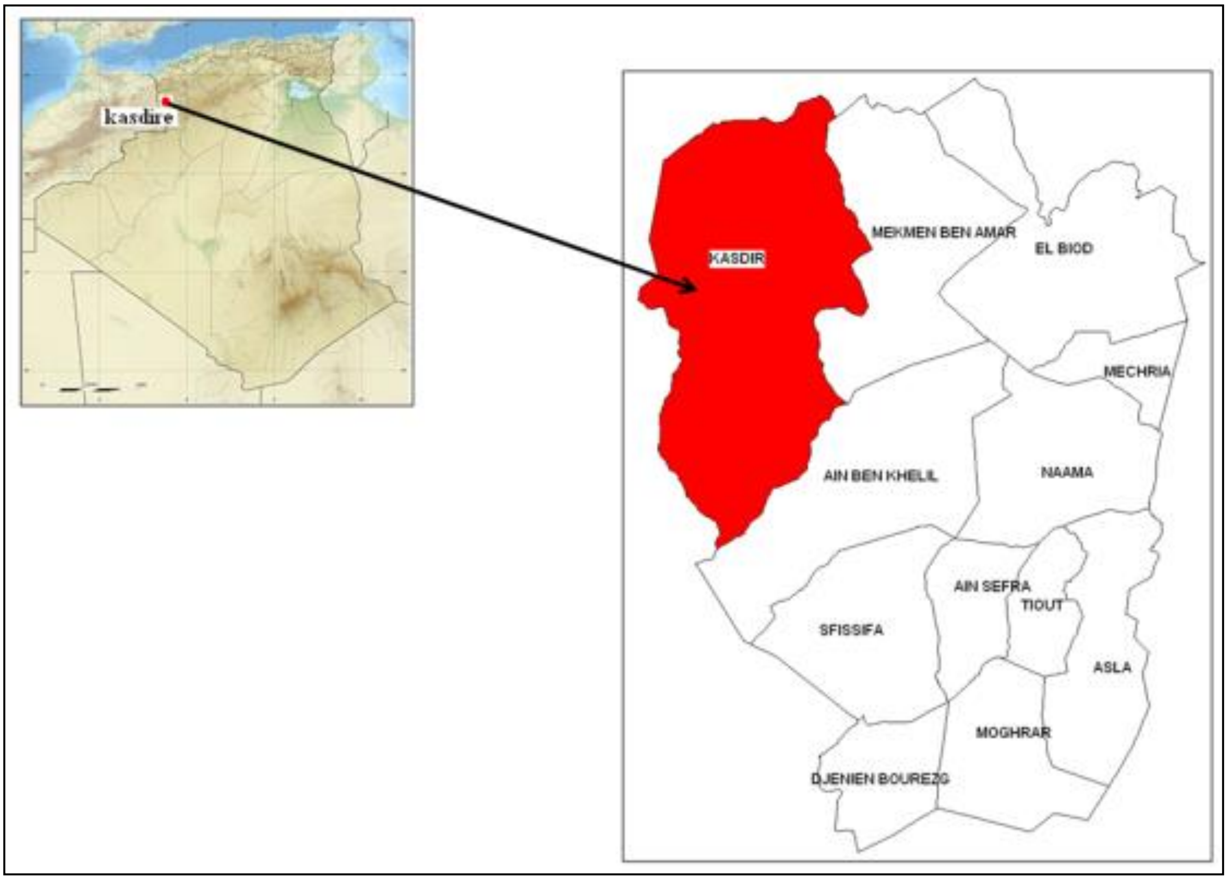

Figure 1. Location of the study area

METHOD OF WORK AND DATA USED

The site chosen for this work is the commune of Kesdire, this zone presents the characteristics of the semi-arid environments subjected to the processes of degradation of the natural environments. To characterize the state of degradation of vegetation cover and soils in this region, we have the following satellite images:

- Image of LANDSAT 5 satellites taken in March 1987 with a resolution of 30m.
- Image of LANDSAT 8 satellites taken in March 2015 with a resolution of 30m.

They were taken during the months of March, the period when seasonal chlorophyll vegetation is present.

We applied the trichromatic three channels (4, 3 and 1) for the Landsat 5 satellite image and (5.4 and 2) for the Landsat satellite image.

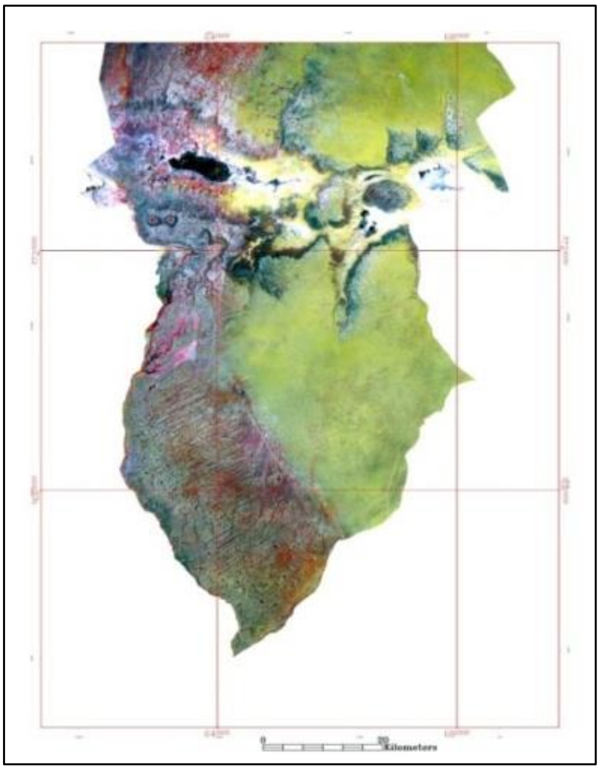

Figure 2. Trichromatic (4,3,1) image 1987

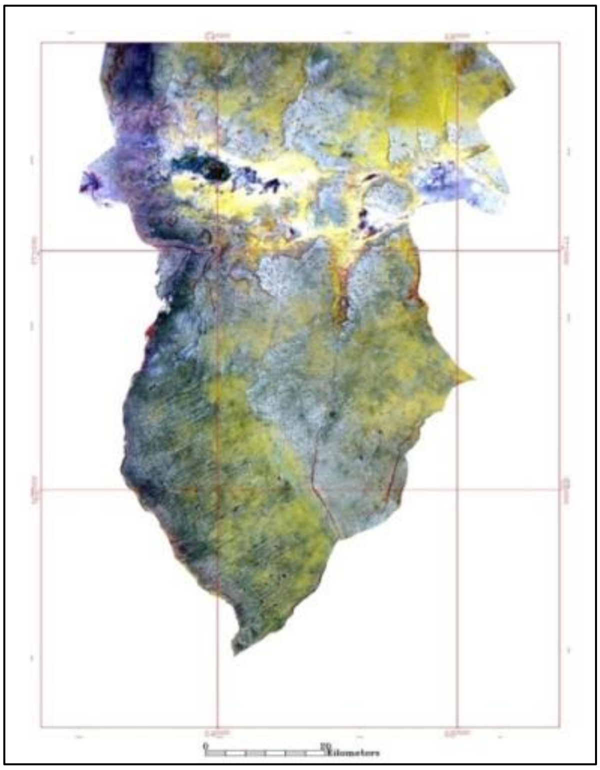

Figure 3. Trichromatic (5.4.2) image 2015

Satellite images have been transformed following the conventional image processing chain; namely: the correction of geometric distortions. The correction of the geometric distortions of the image taken in 1987 was made compared to the 2015 image. It is an image-to-image correction using the closest neighbor polynomial approach of degree 1. Then, as shown Figure 4 is a flowchart of a variety of different treatments according to arranged steps.

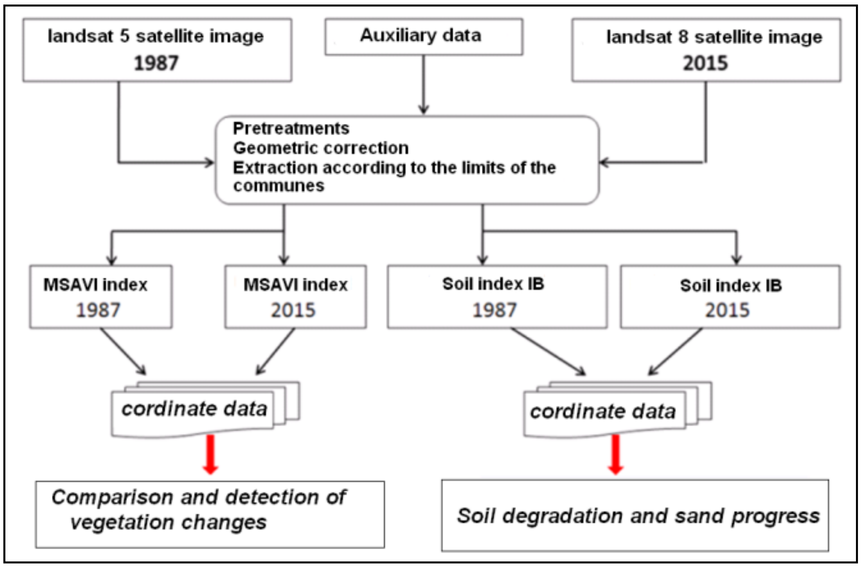

Figure 4 Flowchart of the method of work.

WORK RESULTS

Spatio-temporal monitoring of soil cover in semi-arid regions of Algeria such as Kesdire using satellite imagery is of paramount importance for a regional inventory of this vegetation cover, as well as that its spatial variation. The consequences that result from this variation can be irreversible on the state of soil degradation (Defries et al., 2000, Bannari et al., 1995).

We try to use satellite images in order to extract a key parameter in the monitoring and mapping of vegetation cover, we studied statistically over a period of 28 years by applying the index that takes into account soil influence Modified Soil-Adjusted Vegetation Index MSAVI, Qi et al. (1994) propose an improvement in the vegetation index adjusted for SAVI soil. In their MSAVI Modified Soil Vegetation Index, the L-shaped adjustment parameter that characterizes the soil and its rate of vegetation cover, L is no longer a constant, but is automatically adjusted to local conditions. The expression of the MSAVI index is the same as that of the SAVI index. The difference is in the L factor, which depends on the soil right, the NDVI and the weighted difference vegetation index. It was created to minimize the effect of bare floors. The MSAVI index is widely used in the low vegetation zone as the case of the steppe. The MSAVI is calculated by the following formula and by the two channels the red (R) and the near infrared (PIR).

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

It is therefore through this index that we have chosen to compare the diagnoses relating to the state of vegetation in the Kesdire area. High values of MSAVI represent chlorophyllian activity and low values show bare soils.
The crossing of the image of the 1987 MSAVI index and the 2015 MSAVI index makes it possible to carry out the two-year vegetation cover change chart (Figure 7), the MSAVI 2015 index and coded by the red color, MSAVI 1987 and coded by the yellow color.
The interpretation of the map of the changes makes it possible to detect the regressions in green, the evolution in red and no change in yellow, the western part of the zone has experienced significant degradation and a decline in vegetation.

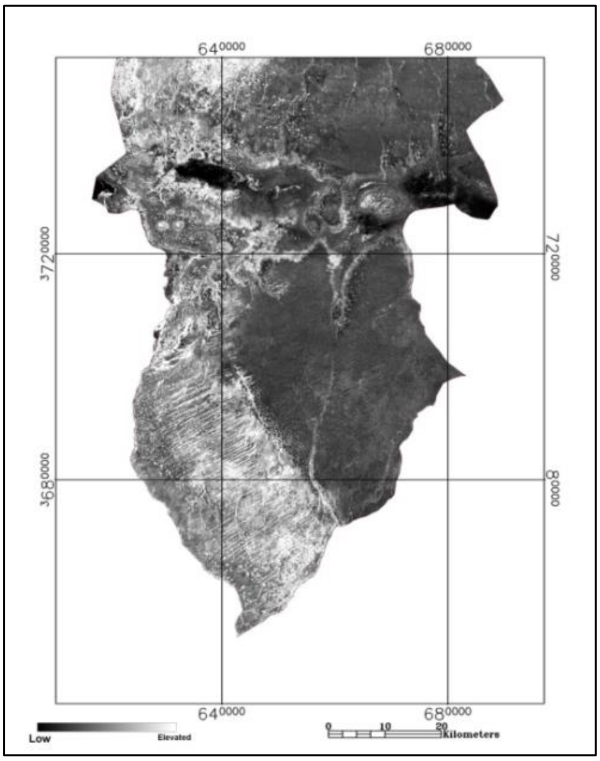

Figure 5. Image of the 1987 MSAVI index

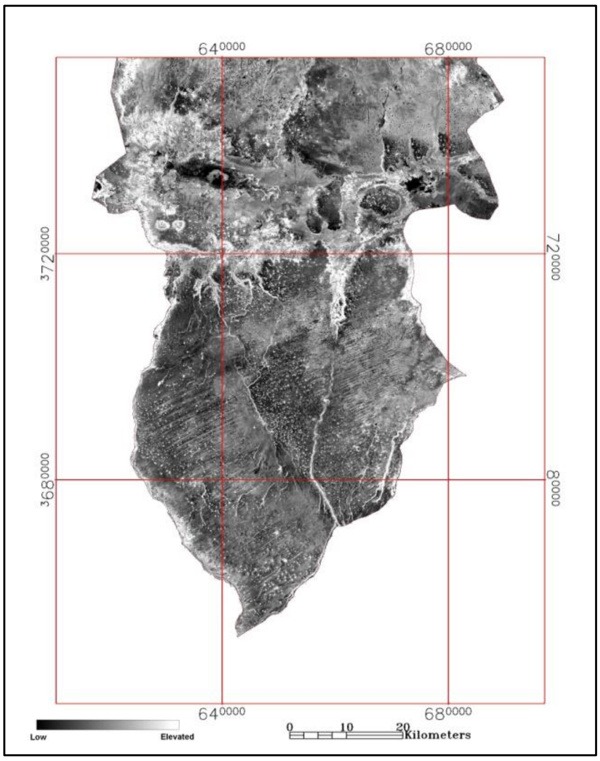

Figure 6. Image of the MSAVI 2015 index

The MSAVI indices (Figure 5 & Figure6) by their crossing (Figure7) have clearly shown that there has been a very significant regression during the last 28 years (1987-2015), this is due to the degradation of the vegetation cover caused, in particular, by the problem of overgrazing and excessive exploitation and the problem of drought and the advancement of sand. The green color of the index of change shows the degradation of the steppe vegetation cover.
Thresholding has been applied to the MSAVI of the 2015 image to find the different intervals of the values of this index, respectively corresponding to the two classes selected (Table 1). By a simple application model these same inte rvals were found on the MSAVI of the 1987 image.

Table 1. Coverage rate of vegetation cover between 1987 and 2015

	Year **1987**		Year **2015**	
	Ha	%	Ha	%
Absence of chlorophyllous activity (bare soil) MSAVI values: -5 to 0.05	353721.24	70.37	465445.17	92.59
Chlorophyllous activity (vegetal cover) MSAVI values: 0.05 to 1	148922.64	29.62	37198.71	7.4
Total	502643.88	100	502643.88	100

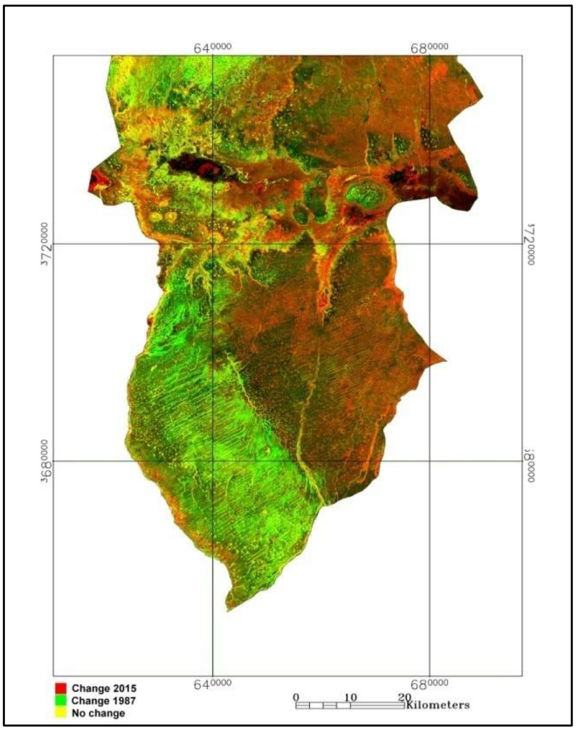

Figure 7 Map of changes in vegetation cover between 1987 and 2015

The reading of Table 1 and the interpretation of the two MSAVI threshold maps (Figures 8 and 9) clearly show the degradation of the environment. The "bare soil" class increased considerably in 2015 compared with 1987, while the other "vegetative cover" class experienced a reverse scenario to the detriment of the former.

The thresholding of the two MSAVI (1987 image and 2015 image) revealed significant changes in vegetation cover. Formerly with a good recovery rate (map of vegetation cover in 1987), this vegetation has disappeared and given way to the extension of bare soil and sandy accumulations.

The rate of recovery by the steppe vegetation cover has experienced a very strong regression it went from 29.62% to 7.4%, a decline of 111723.93 (22.22% of the vegetation cover) this is the obvious sign of the problem of silting in the region from Kesdire.

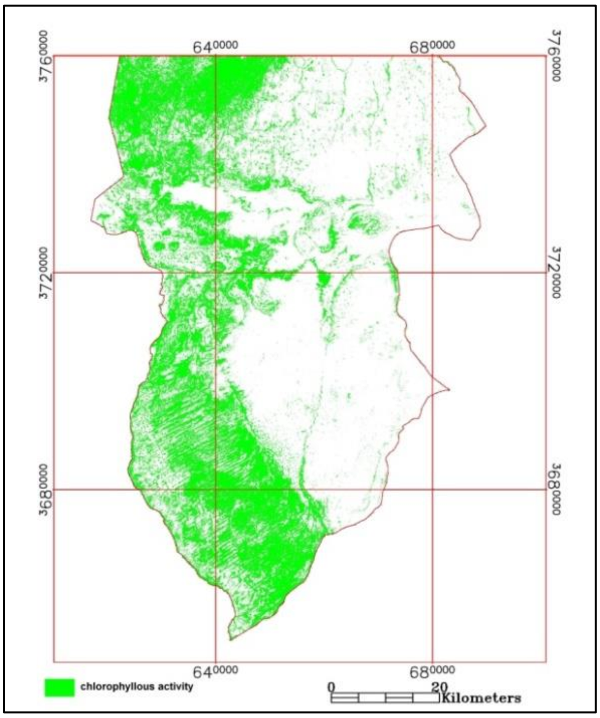

Figure 8 Map of vegetation cover in 1987

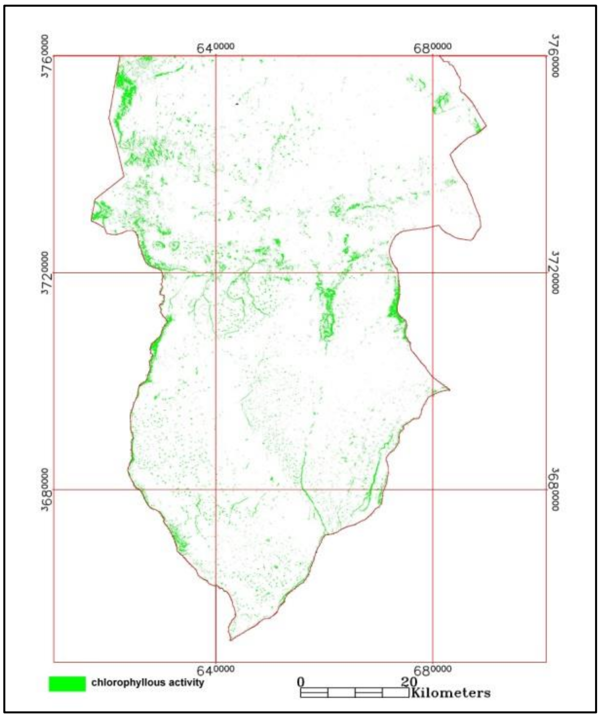

Figure 9 Map of vegetation cover in 2015

In order to detect the evolution of bare soils and sandy accumulations we applied the index of gloss of the soil on the two images 1987 and 2015.

This is calculated from the red and near-infrared bands according to the expression:

$$\boldsymbol{IB = \sqrt{PIR^2 + R^2}}$$

It makes it possible to clearly distinguish between vegetated surfaces and bare floors, The IB highlights:

Dissociates mineral surfaces from vegetable blanket

- Mineral surfaces - strong value, reflective surfaces.
- Vegetation - average value of IB.
- Very wet soil water - low value, absorbent surfaces.

A threshold has been applied to the IB of the 2015 image to find the different intervals of the values of this index, corresponding respectively to the three classes selected (Table 2). By a simple application model these same intervals were found on the IB of the 1987 image, we detected three classes, very wet waters and soils, vegetation cover and mineral surfaces (bare soils and sandy accumulations).

The reading of Table 2 and the interpretation of the two IB thresholding maps (Figs 12 and 13) clearly show the degradation of the environment. The "mineral surfaces" class increased considerably in 2015 compared to 1987, while the other "vegetative cover" class experienced a reverse scenario to the detriment of the former.

The analysis of the two threshold maps makes it possible to describe the following mutations:

- A regression of the vegetation cover by a percentage of 14.55%.
- An evolution of the mineral surfaces by a percentage of 14.79%.

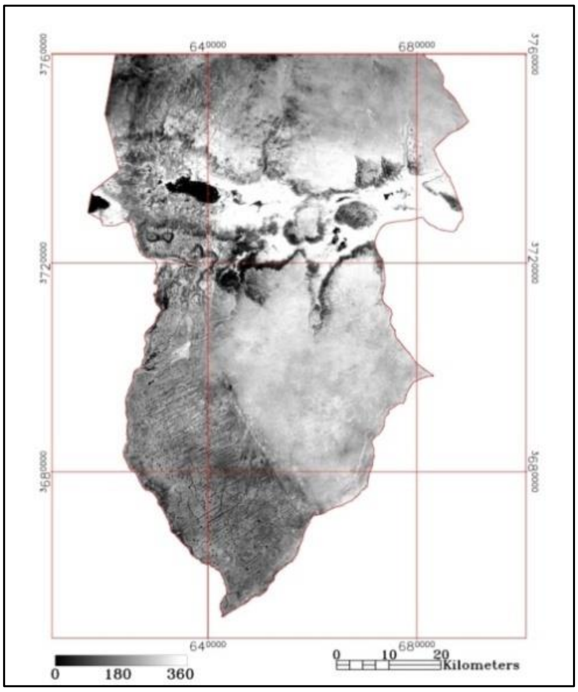

Figure 10. Index of brightness of the ground in 1987

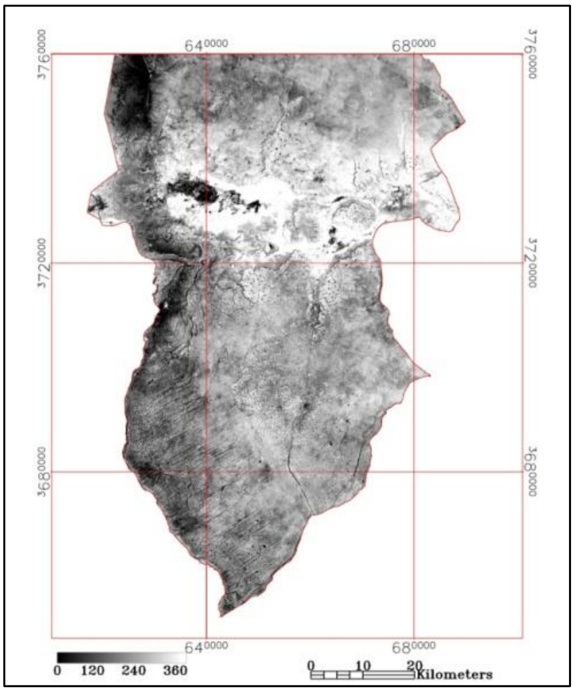

Figure 11. Soil gloss index in 2015

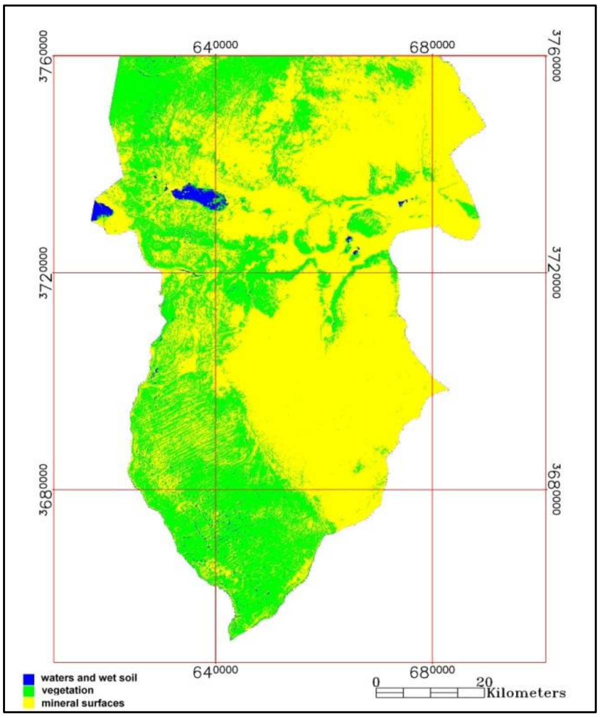

Figure 12. Thresholding of the index of gloss of the ground in 1987

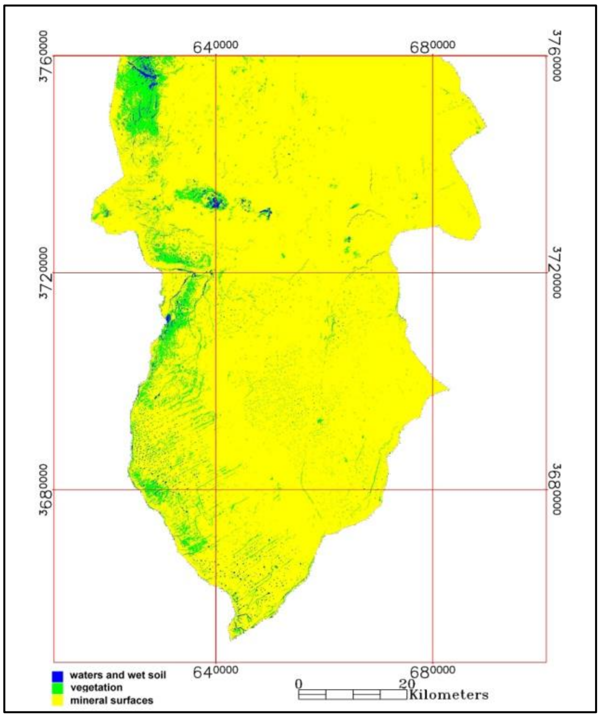

Figure 13. Thresholding of the index of gloss of the ground in 2015

Table 2. Statistics of the threshold of the index of brightness of soil (IB) of 1987 and 2015

	Yers 1987		**Yers 2015**	
	Ha	%	Ha	%
Water and very wet soil	5665.96	0.92	3503.88	0.69
Vegetable cutlery	104062	20.7	30910.95	6.14
Mineral surfaces	393917	78.36	468234.48	93.15

CONCLUSION

Along this work we have tried, using remote sensing data, to understand the degradation of plant cover and steppe soils in Kesdire commune.

The use of multi-date (1987 & 2015) Landsat 5 and 8 satellite data-based approaches allowed us to obtain a set of interpretative photo maps of MSAVI indices and soil gloss that, in turn, helped us to see the changes in the environment, copiously regressive and progressive.

From these images we were able to establish vegetation cover maps of both dates. These images have been processed and analyzed. We based on the calculation of the indices and the classification of these indices to highlight the characteristics of the soil surface in a semi-arid environment.

The use of remote sensing data allowed us to follow at a regional scale the spatiotemporal evolution of the dynamics of the vegetation cover and the nature of the soil over a period of 28 years. At the end of this study, it appears that LANDSAT's numerical data processing methods provide a very efficient contribution to the mapping of vegetation cover in this area.

According to our estimates using satellite image index calculations, between 1987 and 2015, 22.22% of the canopy area is currently silted. This figure is alarming and shows the extent of the phenomenon in the steppe region of southwestern Algeria.

The maps obtained are cartographic documents intended to enlighten decision-makers and planners on the problems of regression of vegetation. Faced with this document, decision-makers, local elected representatives, developers, pastorals and ecologists can define in the short term priority intervention actions, and in the long term sector-wide planning and management with a view to combating climate change.

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