Mapping of the space change of Oued Ali Mountains (Mascara, Algeria) by Landsat optical imagery

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Abstract:

Analyzing and understanding the dynamics of physical environments, due to quarrying, is a fundamental issue in detecting change, in semi-arid natural environments. The mountains of Ouled Ali (Beni Chougrane Mountains) contain highly unstable areas that make the region of Sig (wilaya of Mascara) vulnerable. Observation and qualification of landscape changes is the easiest way for career monitoring. This exploitation has a direct and indirect impact on the ecosystem and the surrounding environment.

The slopes of Aoud Asma Mountain (Ouled Ali Mountains) affected by the exploitation of quarries are the subject of our study whose purpose is to characterize their kinematics. To do this, the means are many and varied; each of them has specific properties as regards the type of use, the quantity measured and its scope and accuracy. The change of space mapping by a correlation of optical images is one of these methods.

The work methodology adopted is based on the application of Principal Component Analysis (PCA), Intensity, Hue and Saturation of rock (IHS) and Normalized Difference Vegetation Index (NDVI). Two Landsat images were used: Landsat5 image (25th September, 1999) and Landsat7 image (02nd September, 2011). It is followed by a comparison with the ground truth and a mapping of physical space dynamics of the study area.

The PCA, IHS and NDVI results allowed us to highlight the bare soils, and the degradation of forest cover and halophyte vegetation. Moreover, the quarrying contributed largely, in some places, to the change of space of Aoud Asma Mountain of Ouled Ali Mountains.

Key words : *Quarrying; Monts de Ouled Ali (Beni Chougrane); Satellite Imagery; Mapping of change*

1. Introduction:

Our work concerns the application of mapping of change using transformation methods on two Landsat optical images of our region, the mountains of Ouled Ali (Beni Chougrane, West of Algeria). However, given large surface area, this approach can be cumbersome if we do not limit the region of our pilot zone, for example a well-defined area of average size that would represent the change in natural areas. This is the case of Djebel Aoud Asma (mountains of Ouled Ali) where the extracted materials (limestone and clay) are used for feeding the cement plant of LAFARGE for the manufacture of cement.

In this context, three methods of detecting changes are proposed in order to allow a temporal follow-up of the changes of this natural environment. That is why, for the environment preservation and to allow a prolonged use of the territory, we should, in one hand, to deep our knowledge on the process of change due to quarrying and in other hand, to represent degrees of change of this landscape. In this framework, this study is based on Principal Component Analysis (PCA) and the application of Intensity, Intensity, Hue and Saturation of rock (IHS) transformation and the Normalized Difference Vegetation Index (NDVI).

2. Geographical presentation of the zone of study, Djebel Aoud Asma:

Djebel Aoud Asma belongs to the Mounts of Beni Chougrane, it is located at 3 km approximately South-West of Oggaz city and approximately 5 km West of Sig city (Wilaya of Mascara), figure (1.a). It is characterized by an extreme density of thalwegs, figures (1.b, 1.c). The limestone is the dominating facies at Aoud Asma Mountain. This area is subjected globally to a semi-arid regime with cold winter [1].

The quarrying in Aoud Asma Mountain started from 2006 which motivate us to study the change of this natural environment by optical imagery, using transformation methods: PCA, IHS and NDVI. This is for the first time to apply these methods for changes of detection due to quarrying in the mounts of Beni Chougrane, case of Dj. Aoud Asma.

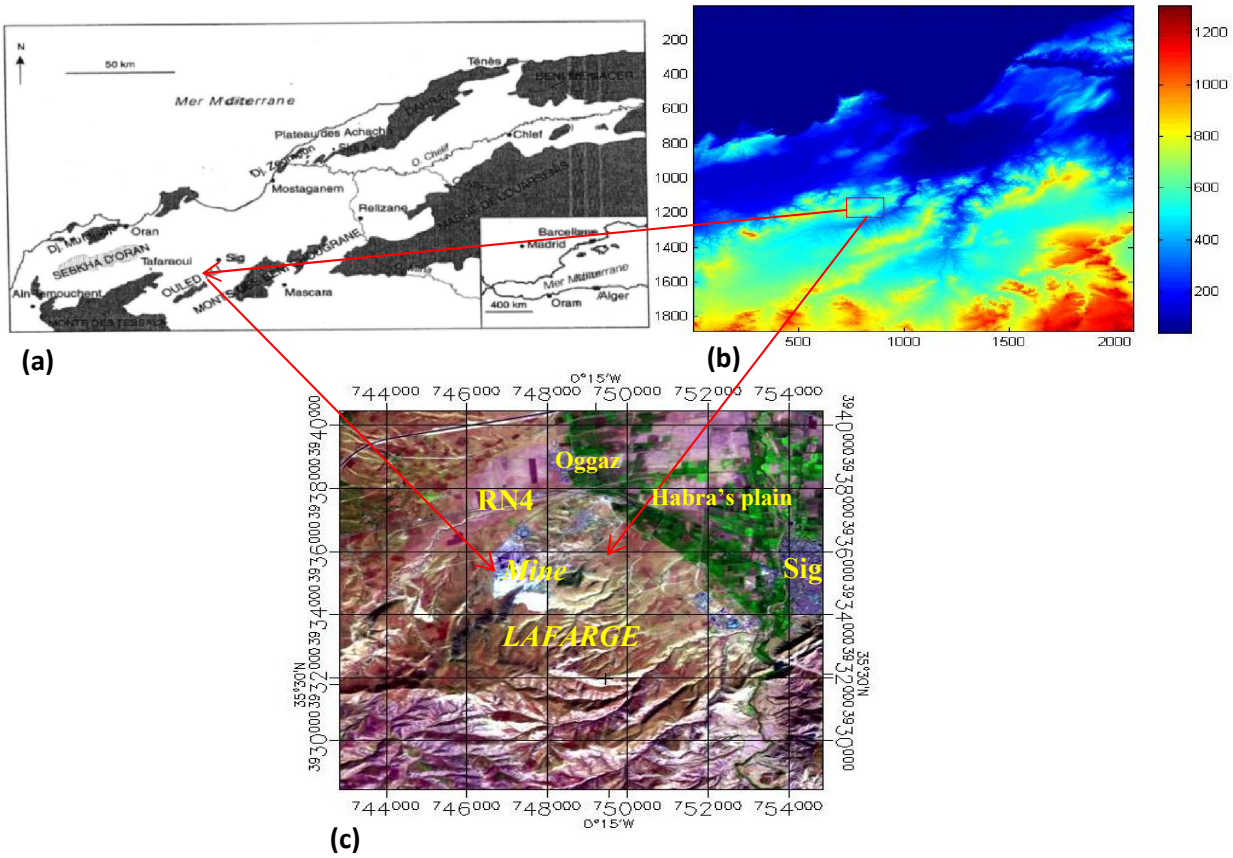

Fig.1: Geographical location of Dj. Aoud Asma: Mine and cement factory of LAFARGE. (a) Diagram of the basin of Bas Chelif [5]. (b) SRTM 30x30 of the area. (c) Landsat7 image of Dj. Aoud Asma.

3. Methodology and data used:

The methodology of changes detection is based on mathematical transformations developed to represent the complexity of multidimensional data set [2].The optical images used, in this work, are from Landsat5 at September 25th, 1999 and Landsat7 at September 2nd, 2011.

The Principal Component Analysis (PCA) is used in remote sensing for images zip, by reducing the dimension of the data while their variability is preserved. In this study, the PCA is applied as normalization method of data used, followed by a transformation of the Intensity, Hue and Saturation (IHS). The purpose of this method is to represent as well as the points cloud [8]. These points correspond to pixels distribution within the space of spectral channels (5-4-2: infra-red, close infra-red and visible, respectively), by a change of reference frame (centered on the cloud centroid), in the axes of maximum lengthening of the cloud.

3.1. Application of the PCA analysis:

The figure (2) represents the results of the application of PCA on both Landsat images (1999 and 2011), where one can clearly distinguish the roadway systems, the hydrographic network, the limits of the quarrying and the space occupied by vegetal cover.

In both results “a” and “b”, the blue color shows the bare areas or the limestone outcrop and the site of the mine confirms it. The red in the results of 2011 image “b” indicates the irrigated cultures.

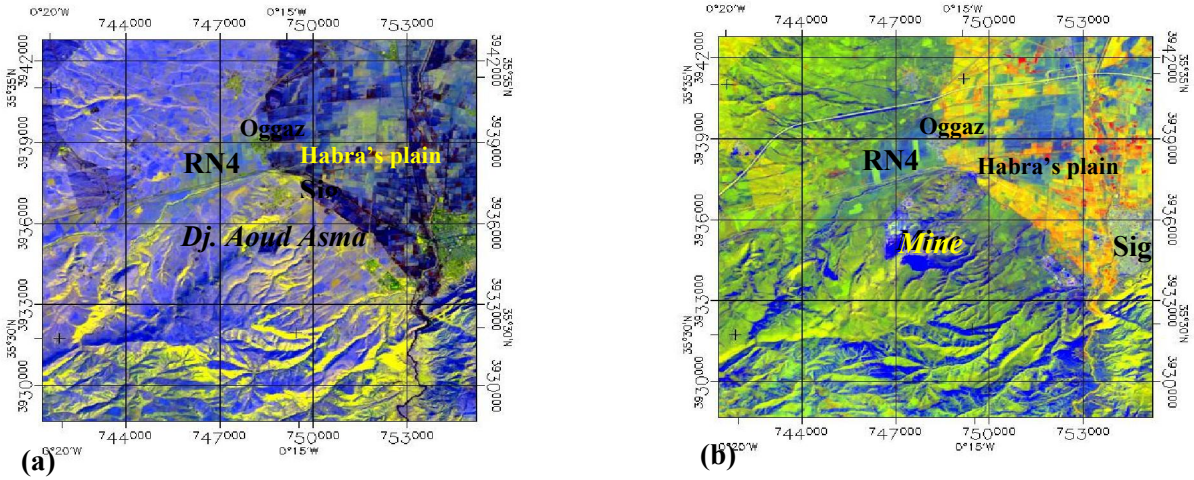

Fig.2: Color composition of the PCA applied to: (a): image MT 9/25/1999, (b): image ETM+ 9/2/2011.

3.2. Application of system IHS of Munsel

Figure (3) represents the results of the transformation of PCA color composition into HIS (Red, Green and Blue: RGB→IHS) which permits to separate space information (intensity) from spectral information (hue and saturation). This transformation highlighted the fault (*cf.* fig.n°4), located in perimeter of the mine, which is monitored by geophysicists at time of using of the explosives for the exploitation) with green color on the images of 1999 and 2011. This color indicates also the outcrops of limestone, in the zone of quarrying and on the Chaabats slopes.

In the figure 4.b, the green color in the Habra's plain indicates the increase of salt, considering the climate changes in this semi-arid area, where the rainy season takes five months in the year: from November until March. The remaining months represent the dry season which is spread out from April until October (07 months) during the old period of 1913 to 1938 [4] and of 1976 to 1996 [1].

Dj. Aoud Asma is characterized by a Mediterranean climate, semi-arid bioclimatic stage with cold winter. The type of climate of the area is a limiting factor for the setting of agriculture or the installation of vegetation, which needs to make complements of irrigations. Pluviometry is another significant factor of the climate. According to [6], this area is in a semi-arid climate (near to arid), and presents average annual pluviometry which ranges between 300 and 500 mm/an. Moreover these precipitations are concentrated in a restricted number of days and in winter period, they are more important (they are often torrential rains). The summer is characterized by very high temperatures [6].

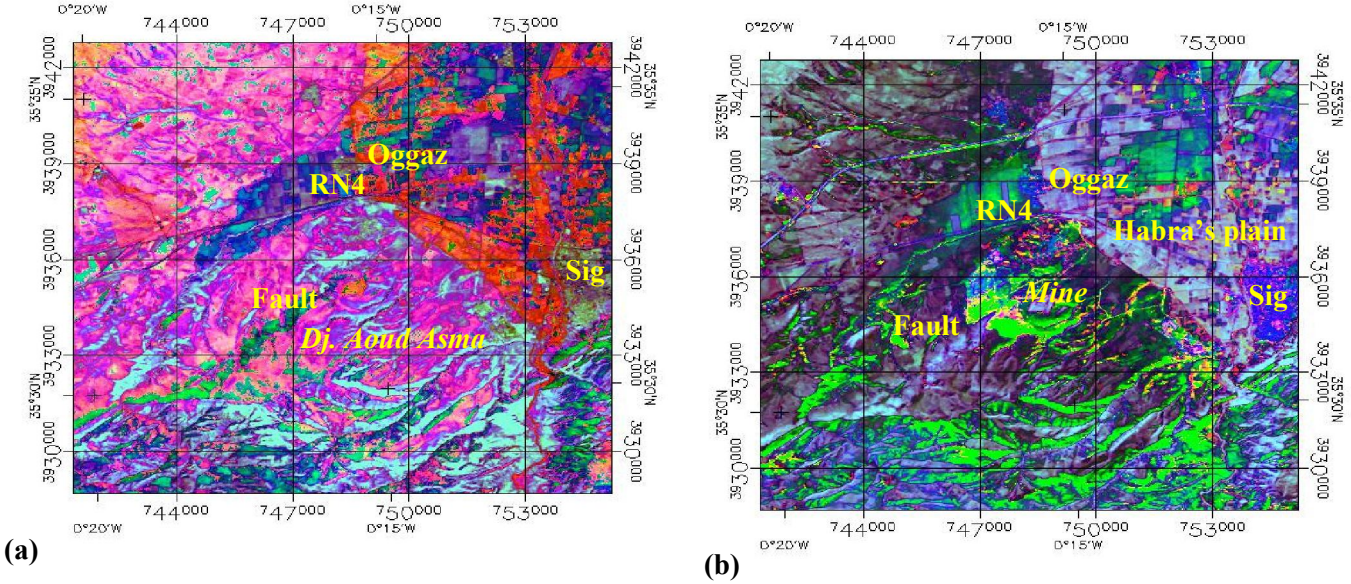

Fig.3: Color composition of the channels Intensity (I), Hue (H) and Saturation (S) applied to: (a): image MT 9/25/1999, (b): image ETM+ 9/2/2011.

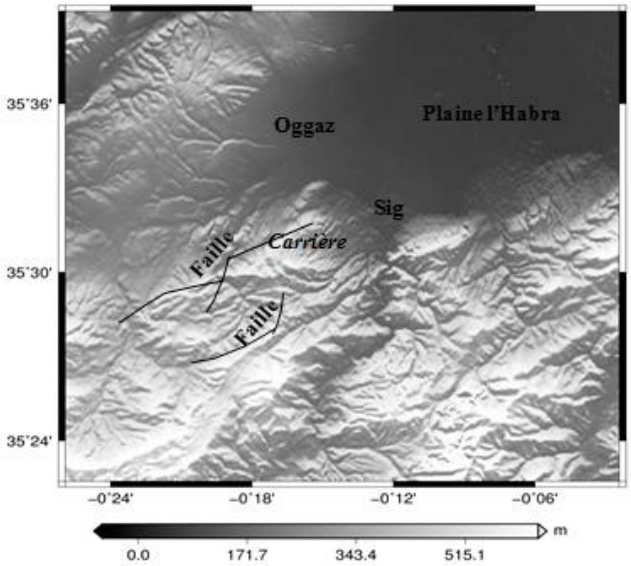

Fig. 4: Topography of Dj. Aoud Asma and localization of the faults.

3.3. Application of the Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is a transformation very much used to supervise the vegetation state, we used the channels: close infra-red and infra-red. It is between the red bands and near infra-reds that one observes more large variations of reflectance between the vegetation and the grounds [7]:

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

The application of the NDVI within the space of Dj. Aoud Asma, represented by figure (5), shows the changes in the vegetal cover, during 12 years. The white color in the images indicates the absence of vegetation. The image 2011 presents more white color than in 1999. This regression of vegetal cover is not due to the climatic conditions (the year 2011 is rainy compared to 1999) but it is the impact of the urban extension of Oggaz and Sig cities and especially the quarrying of LAFARGE. Indeed, the table (1), which illustrates the statistics and the histograms of the NDVI, enable us to follow the chlorophyllian activity of the area. The maximum values of the NDVI according to 1999 and 2011 images are, repressively, 0.4 and 0.3 which express dense vegetation. The minimal values of the NDVI are about -0.30 and -0.46 and express the absence of vegetal cover, in particular in 2011, due to the exploitation of the mine of LAFARGE and to the urban extension of the Sig town. Indeed, the median values of the NDVI in 2011 confirms it (- 0.28) compared to 1999 (- 0.16).

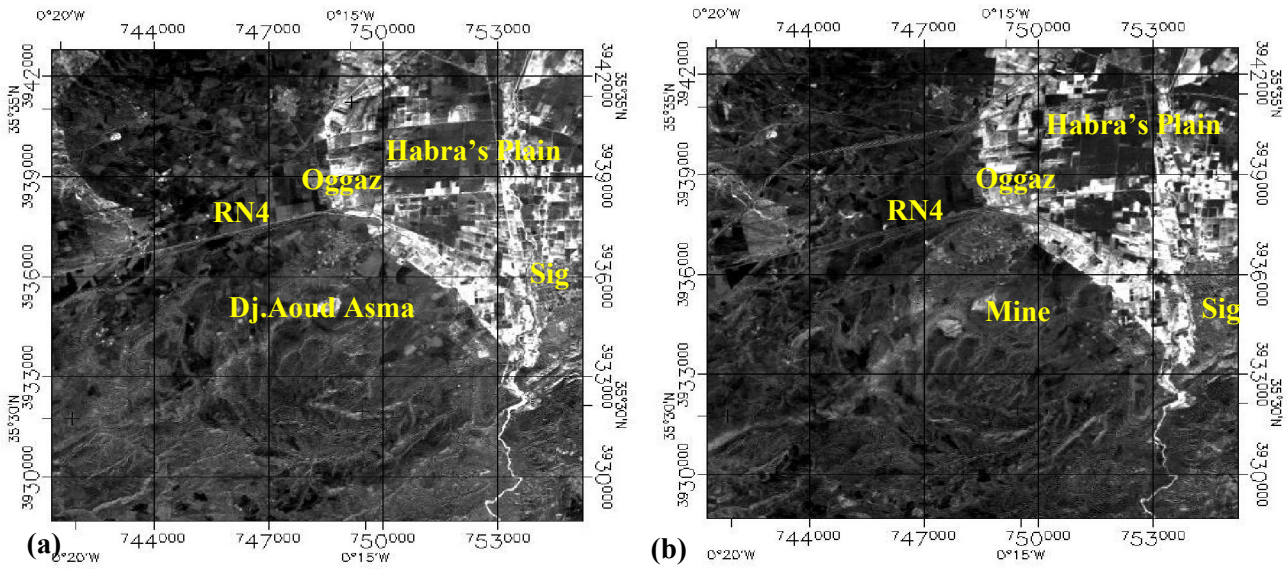

Fig.5: NDVI of (a) image MT 9/25/1999,(b) image ETM+ 9/2/2011.

Statistics of NDVI	Minimum	Maximum	Average	RMS
Image 1999	-0.304348	0.442623	-0.160165	0.061461
Image 2001	-0.462687	0.333333	-0.286931	0.083289

Table n°1: Statistics of the NDVI of Dj. Aoud Asma: 1999 and 2011.

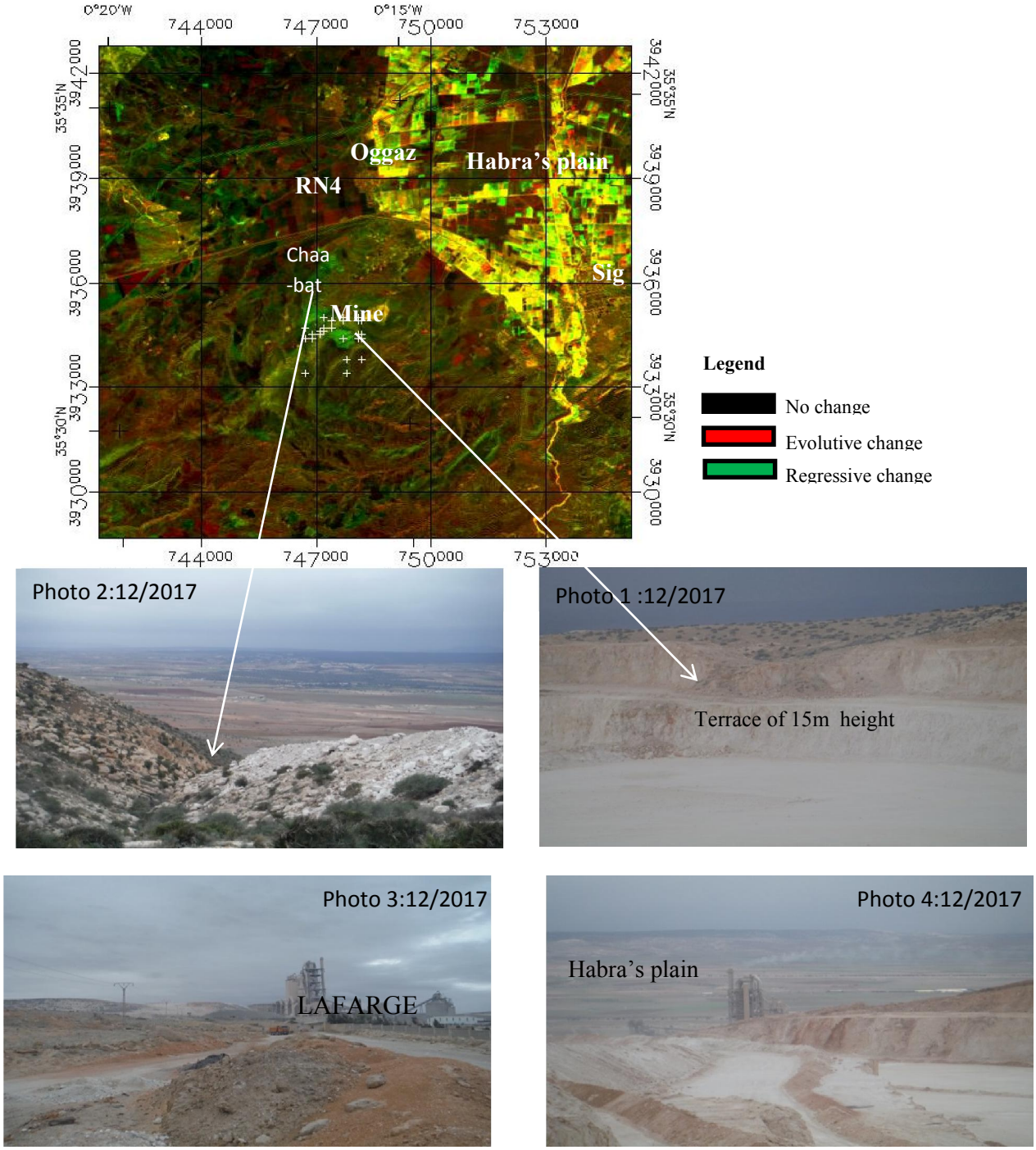

Fig.6: Map of space change of Dj. Aoud Asma for the period 1999 to 2011, according to site photos of December 2017.

The red indicates an evolutionary change; it is the case of the grounds of agriculture and part of the Habra's plain, also some zones of soil restoration by the foresters. The green color indicates a regressive change due to disappearance of vegetal cover in the zone of thee mine and to the urban expansion of Oggaz and Sig cities.

The photos (1,2,3 and 4) were taken on December 2017, they show the change of the space of Dj. Aoud Asma. Photo (1) represents the Chaabat which limits the mine and pours out directly on the Habra's plain. It is an old zone restored by the foresters.

Photo (2) illustrates the terraces of the limestone exploitation to detriment of the natural vegetation. Photos (3 and 4) show the site of LAFARGE's cement factory with respect to the mine and the Habra's plain. The impact of the cement factory is major on the ecosystem; it affects the site by the emission of dust and the noise, particularly the neighboring urban area of Ahl El Ouennen village. The cement factory uses raw materials extracted close to surface of the ground which explains the degradations of vegetal cover. For national road RN4, the network of circulation and the volume of the traffic increased. Thus we must intervene to save this space and to prevent this accelerated degradation of ground and vegetation. If the intervention is not done by adequate techniques, one will obtain irreversible effects on this natural environment.

4. Conclusion

The occupation of the natural environment by plants follows narrowly the cycle of seasons. The annual plants, die each year by leaving seeds which will germinate next spring, example: the poppy. The hardy perennials persist throughout the year, but change aspect, such as the trees. However, the creation of mine exploitation has fatal consequences on the natural environment and represents a burden for the environment rehabilitation. Through this article, we introduced the methodology of change detection of the natural environment using optical imagery of Landsat, due to LAFARGE quarrying in Dj. Aoud Asma. It based on transformation techniques (PCA, IHS and NDVI), which were applied successfully to highlight the changes caused by quarrying in this zone during a given period. The important surface of the regressive change at Dj. Aoud Asma slopes implies need for repairing which aims to return to the balance of the ecosystem, by taking in account the climate, the nature of the mineral substrate and the new topography. In this optics, biological installations in-situ must be undertaken by LAFARGE enterprise, in order to preserve the natural environment of Dj. Aoud Asma after the end of quarrying.

References :

[1] Bachir Belmehdi.F, 1998 : Etude comparative de l'érosion hydrique dans les Beni Chougrane, cas de Djebel Aoud Asma à exposition Nord et Djebel Sidi Ali Cherif à exposition Sud. Engineer thesis (in French), Option: Geography. University of Oran, Sénia, Algeria.

[2] Bachir Belmehdi.F, 2002 : L'apport de l'imagerie radar et optique a la caractérisation de la morphologie des dunes et l'état du voile sableux : application au cordon d'El Mesrane et Zaafrane (wilaya Djelfa). Magister thesis in space tehniques (in French), option : Remote sensing, CNTS, Arzew, Algeria.

[3] Boudy.P, 1948 : Economie forestière nord-africaine. T.1: Milieu physique et milieu humain.

[4] Meddi. M. , Hubert. P, 2003 : Impact de la modification du régime pluviométrique sur les ressources en eau du Nord-Ouest de l'Algérie. In :Hydrology of the mediterranean and semiarid regions, IAHS publication, n°278, pp. 229-235.

[5] Perrodon.A, 1957 : Étude géologique des bassins néogènes sublittoraux de l'Algérie occidentale. paper (in French) Bulletin of Algeria geological mapping n° 12, pp. 62-82.

[6] Remil. R, 2006 : Utilisation de l'imagerie satellitaire et des SIG dans l'analyse phytoécologique et l'aménagement, application a la région de Beni Chougrane. Magister thesis (in French), option Eco-biology. Biology Institute, University of Mustapha Stamboul, Mascara, Algeria.

[7] Rouse, J.W., R.H. Haas, J.A. Schell, and D.W. Deering, 1973: Monitoring Vegetation Systems in the Great Plains with ERTS. Third ERTS Symposium, NASA SP-351 I: 309-317.

[8] Smara.Y, 1997 : Contribution au système L.A.T.I.S. Evaluation de correspondance terrain-image classée et intégration d'images multi-sources optique et radar SAR. PhD thesis (in French). University of technology sciences Houari Boumediene, Algiers, Algeria.