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DIACHRONIC ANALYSIS OF SOIL OCCUPANCY USING REMOTE DETECTION TOOLS IN TLEMCEN PROVINCE SOUTHERN (WESTERN ALGERIA)

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ABSTRACT

The diachronic land use analysis, performed by processing the sensor data, is based on the 10- and 30-year change maps. The dynamics of the vegetation is followed by the application of the NDVI. The gradual and regressive changes in the components of land use reached the rates of 44.78% and -29.21% respectively. The most reduced surfaces are the forest massifs, the steppe area and to a lesser extent the waters of the saline surfaces (dayet). Cereal crops, urban and mineral areas, on the other hand, have increased in area to the detriment of the natural plant cover. The stability of the studied area recorded only a rate of 26.01%. This rate represented only ¼ of the area of the south of Tlemcen region.

Keywords: forest; steppe; NDVI; sensor data; changement; Tlemcen.

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1. INTRODUCTION

The forest environment and the western steppe of Algeria have undergone very significant spatial transformations in recent decades. These transformations are mainly ecological and

climatic (drought), resulting from inappropriate agro-pastoral activities [1,2]. This situation has greatly contributed to the instability of the soil very often eroded by strong winds and to the rise of steppe flora towards forest environments. The phenomenon of desertification and the silting up in the south has greatly reduced the vegetation cover and prevented all measures to combat the advance of the desert [2]. In other words, the semi-arid and arid zones undergone important modifications by the intensification of agriculture, the regression of the surface of forest and steppe and the aggressiveness of means leading to soil degradation and desertification [3]. Availability of digital data archive since 1987 makes it possible to quantitatively and qualitatively assess land use patterns. Dynamics of degradation is followed by application of normalized difference vegetation index, also called NDVI. Data used for design of land cover change maps are « Landsat 5-TM and 8-OLi » sensor data obtained in the spring season of 1987, 1997, 2007 and 2017. They will thus make it possible to establish a more complete diagnosis of the evolution of the area in the south of t Tlemcen region for a period of 30 years spread over three decades.

2. STUDY AREA

Studied area (Figure 1) is located between the two Atlas including the Tellian in the North and the Saharian in the South of Western Algeria. It is located between 34°10’ and 34°50’ in the North 1°40’and 0°50’ in the West. It is limited to the east by the province of Sidi bel Abbes, to the south by Naama region and to the west by Morocco. It covers an area of 4,794.9885 km² or 50.16% of the area of the province of Tlemcen [4].

The western steppe zone belongs to the cool lower semi-arid bioclimatic stage to the cool upper per-arid. This steppe area experiences a contrasting thermal regime, continental type with annual thermal amplitude between 20 and 22 ° C [5,6]. The dry period can reach 09 months on the plateau, and less, on the mountains. Annual rainfall did not exceed 25% of the average. The effects of exothermic summer are mitigated by the relative humidity, especially when a forest or pre-forest cover exists [7].

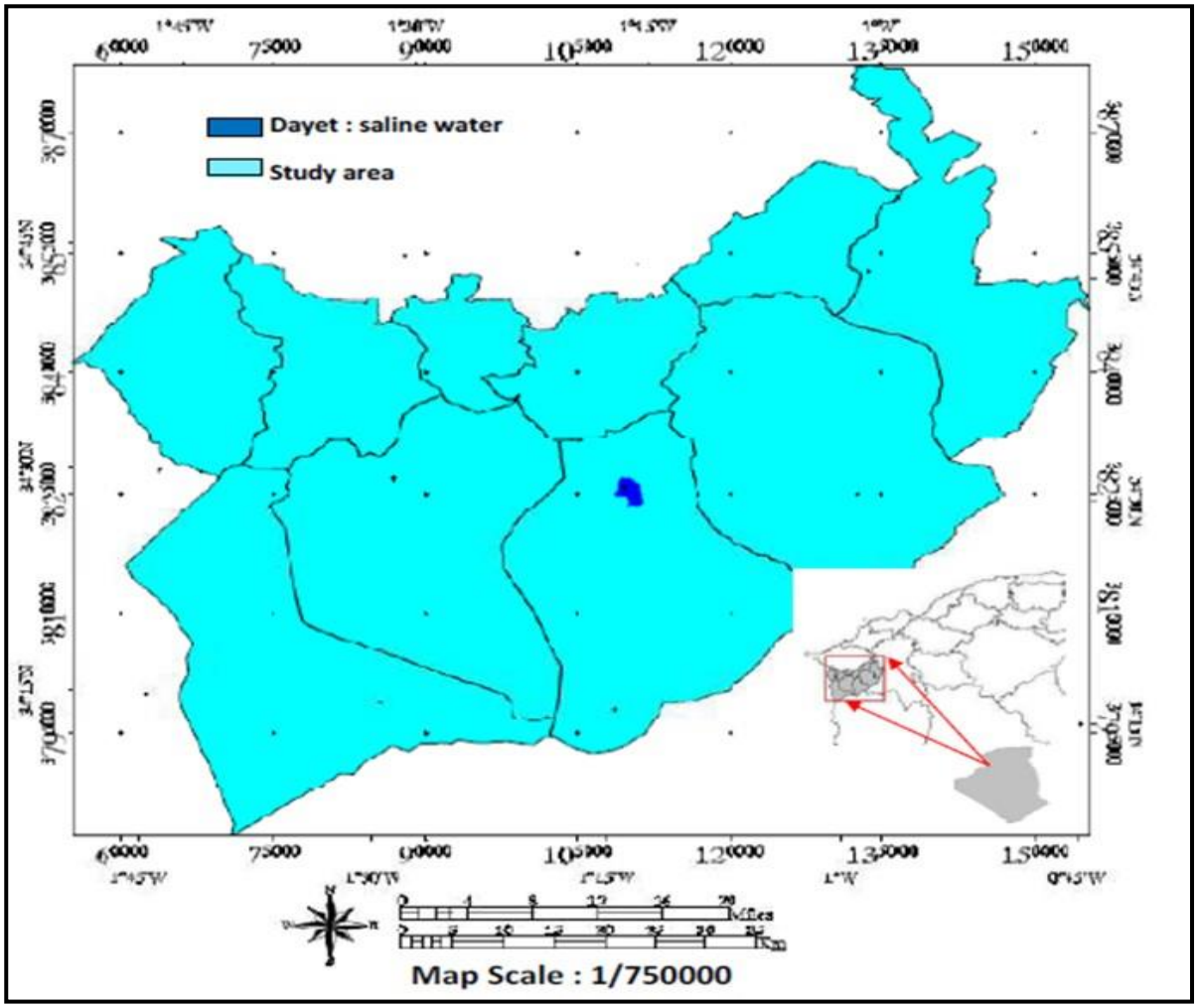

Fig.1. Location of the studied area

The geomorphology of the steppes of southern Tlemcen appears as a belt in the endorheic basins or on the edge of the ouadis in the form of large flat areas. The morpho-pedological unity is considered as a consequence of the determinism of the environment according to the specific characteristics of the soil (texture, stability or instability). The steppe soils are characterized by the presence of limestone accumulation at a shallow sandy-clay texture, the low organic matter content and a high sensitivity to erosion and degradation [8].

The natural vegetation of the study area is characterized by a steppe physiognomy except in the mountains where the remains of the primitive forests felled by man made from *Pinus halepensis* and *juniperus phoenicea*. A scrub composed of Phoenicie juniper and alfa (*Stipa tenacissima)* or steppe vegetation with a simplified structure, mono-stratum and very open, dominated by remth (*Arthrophytum scoparium*) on the reliefs [9-13]. The south-west steppe of

Oranaise is dominated by low and clear formations with woody and herbaceous perennial species following: Steppe with alfa; White sagebrush steppe *(Artemisia herba alba* Asso*)*; arid or Saharan steppe, psammophilic steppe colonizing sandy substrates, or halophilic steppe with Salsolaceae colonizing soils with high salt content; Sparte steppe *(Lygeum spartum)*; Steppe halophytic; Steppe psammophytic [14-17].

3. METHODOLOGY

3.1. Data of remote sensing

The study was based on four sensor data, in digital format, acquired by the multi-spectral sensor Landsat 5-TM and Landsat 8-OLi. They are geo-referenced and projected in the system WGS84. The size of the pixels in these photographs is 30 m. The sensor data underwent digital preprocessing and processing using software « *ENvironment for Visualizing Images ENVI, version 5.1*». The radiometric (*atmospheric*) corrections, based on the physical model of radiative transfer, made it possible to correct the wavelengths in the visible through the near infrared and the short waves of the infrared up to 3 μm [18]. They made sensor data of different dates directly comparable. The geo-referencing of data, thus carried out, made mapping operations possible [19].

3.2. Generation of NDVI index and change detection

The normalized difference vegetation index, also called NDVI, is constructed from the channels: red (R) and near infrared (PIR). It highlights the difference between the visible band of red and that of the near infrared according to the following formula:

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

Legend: PIR: near infrared channel, R: red channel [20].

The NDVI values are between (-1) and (+1) where the negatives correspond to areas other than the plant cover. The plant formations have positive values in the range of 0.1 to 0.7. The normalized vegetation index (NDVI) is linked to the activity of the plant cover where the leaf pigments, depending on the phases of the plant cycle, strongly absorb the radiation in red (R) while the lacunous parenchyma reflects a large part of radiation near infrared (PIR) [20,21].

The highest values of the NDVI correspond to the densest covers. This index used to generate an image displaying the plant cover (relative biomass). It is designed to monitor drought, control and forecast agricultural production, help prevent fires and map desertification [20,21]. In more particular; The NDVI index is preferred for the overall observation of vegetation because it compensates for changes in lighting conditions, surface slope, exposure and other exogenous factors [22]. The differential reflection in the red and infrared (IR) channels makes it possible to control the density and intensity of plant growth using the spectral reflectivity of solar radiation. Green leaves frequently display better reflection in the near infrared wavelength range than in visible wavelength ranges [22]. The NDVI maps generated for the entire study area are the basic information for *pixel-to-pixel comparison*. This pixel change detection method allows in particular discerning the changes that have occurred in the shaded areas and provides interesting results in the areas of significant change [23,24]. The principal component analysis on the data produced and the investigation in the field is necessary to produce the data of changes. For this, during field trips; nineteen verification points were chosen for the validation of our classification of changement. These check points had to be representative of a land use class and have a sufficient area to be clearly identified in the data. This mission consists in verifying and validating the cartographic results with the reality on the ground (figure 2).

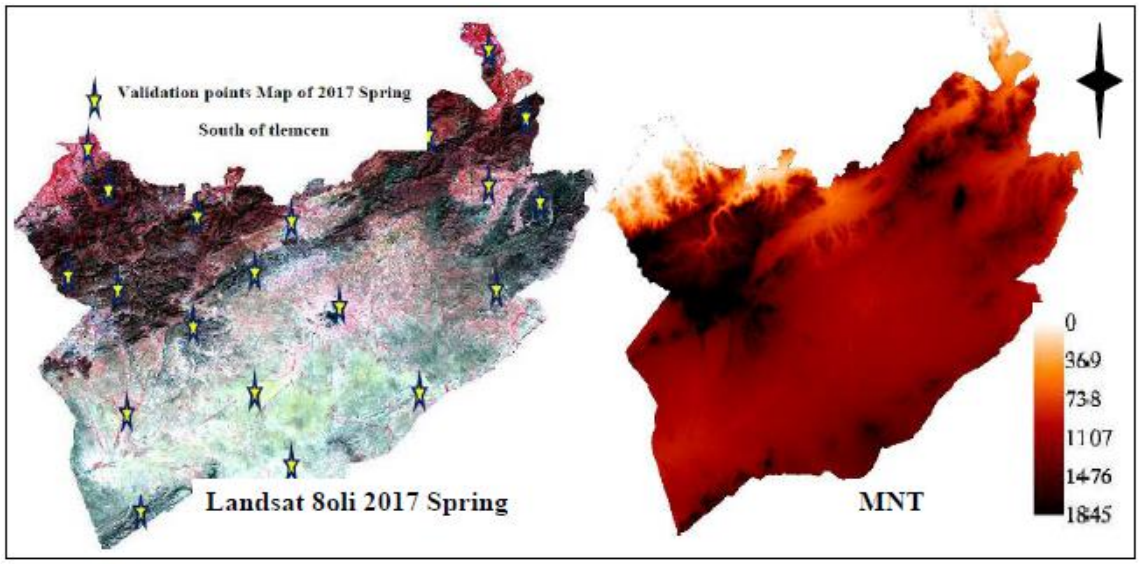

Fig.2. Checking points and numerical model of the terrain of the study area

This allows us to estimate the accuracy of the maps produced and also to correct the characteristics of the different classes. The changement method adopted made it possible to produce four change maps of the study area. The first three change cards have a ten-year step, while the fourth spans 30 years.

4. RESULTS

4. 1. NDVI maps

The results of the change in the normalized vegetation index (NDVI); calculated for the four years 1987, 1997, 2007 and 2017 on our study area are organized in Figure 3. The NDVI maps established show strong values of this index which are located in the northern part, it indicates the presence of forested areas at significant altitudes while the presence of market gardening on the outskirts of built-up areas. The maximum value of NDVI is around 0.89. The more we head towards the southern party; there is a gradual decrease in NDVI, hence the presence of the steppe plant cover. The latter is marked by the existence of steppe species with low recovery. Note here that the NDVI values range between 0.45 and -0.5.

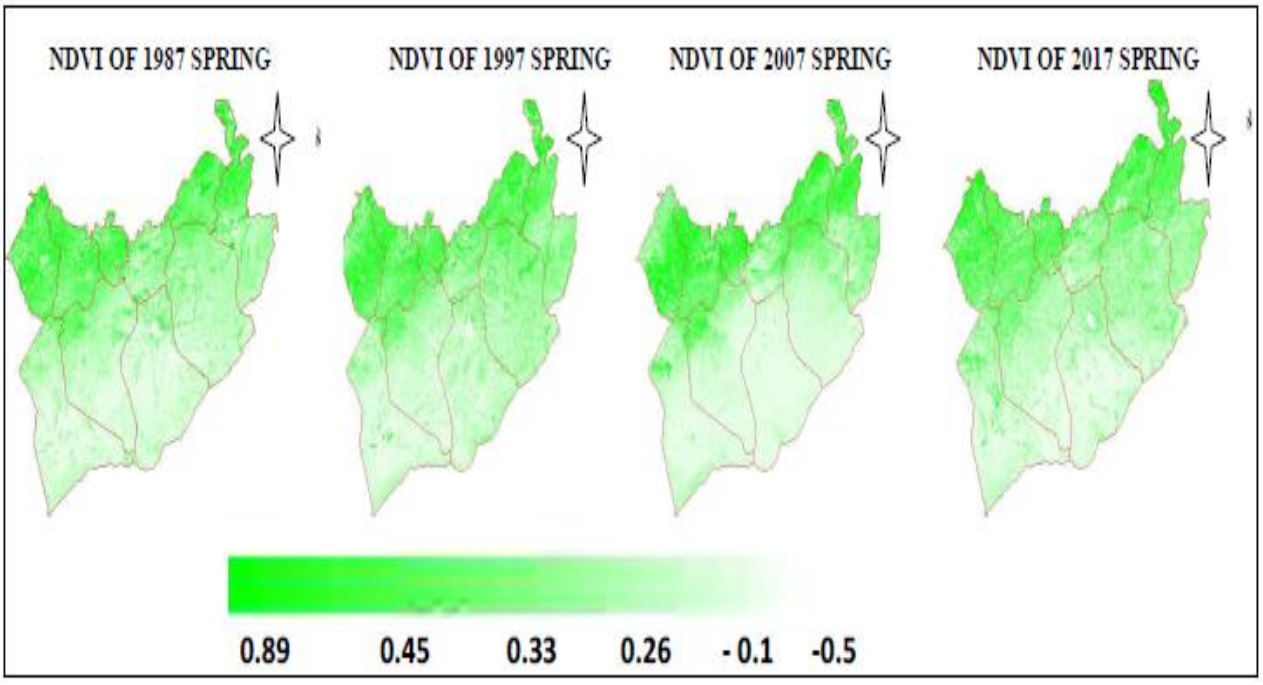

Fig.3. NDVI maps of southern Tlemcen province (western Algeria)

4.2. Changements maps

The land use change maps, as a whole, made it possible to highlight a regression of -29.21% in plant cover and a clear increase of + 46.33% expressed by the increase in cereal crops, the decrease in the area of the forest massifs to the north and the steppe rangeland to the south of the study area (figure 4).

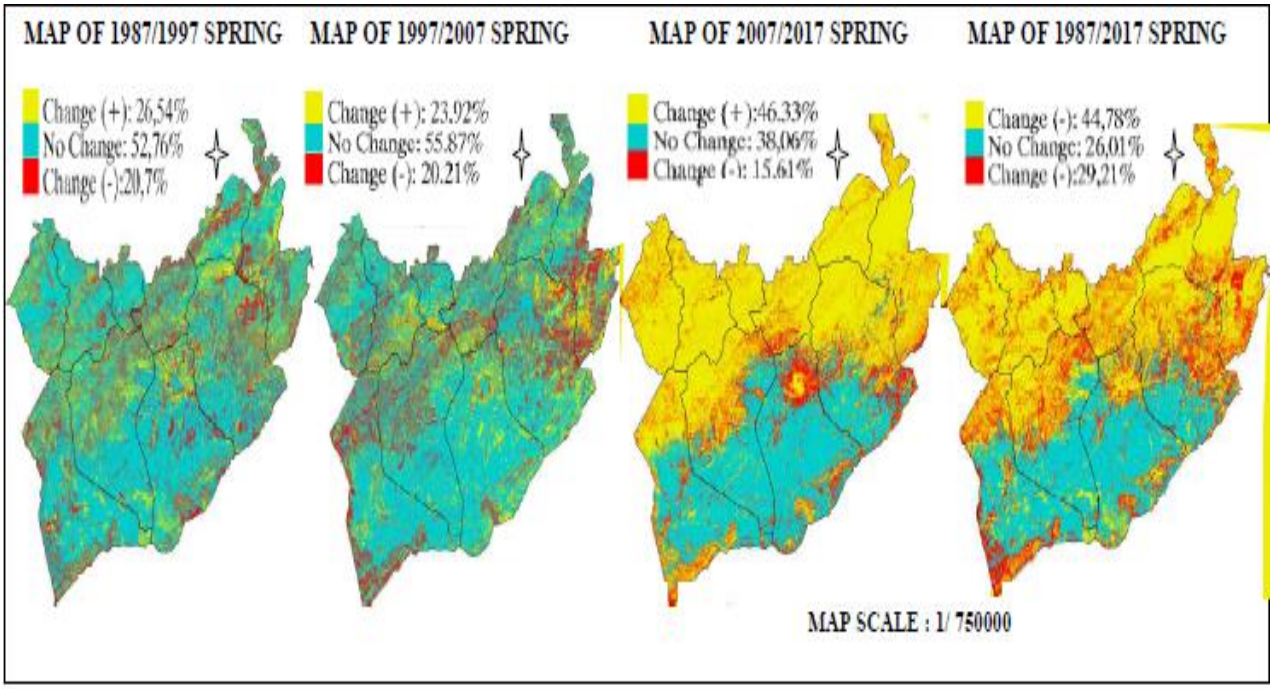

Fig.4. Changement maps of the south of Tlemcen province (western Algeria)

The first decade (1987/1997) was marked by a stability of around 52.76% homogeneously across the study area. The regression, of the order of 20.7% concerned the surfaces of the relics of the forest massifs and the steppe rangelands. Sporadic cereal crops, reservoirs of rainwater (dayet), urban and mineral areas on the other hand increased by 26.54%. The second decade (1997/2007) saw a slight increase in the stability (55.87%) of the spaces in the study area. The regressive changes (20.21%) affected the relics of the forest massifs and barely the steppe rangelands. The gradual changes reached 23.92% where the area cleared for cereal crops doubled compared to the first decade (1987/1997). The urban and mineral surfaces have this time decreased in favor of cereal crops. The third decade change map (2007/2017) revealed that the gradual changes covered the northern half of the studied area with a rate of 46.33%. During this third decade, the stability rate (38.06%) of the

environments in the study area decreased significantly compared to the previous ones (52.76% and 55.87%). The areas of cereal crops are affected by these gradual changes despite a clear decrease between the second decade (30.32%) and the latter (4.23%).

Table 1. Rate of deviations and changes; by decade and over 30 years; of the study area south of the Tlemcen province (western Algeria)

Land Cover	Ecarts (%) 1987/97	Rate of Change (%) 1987/97	Ecarts (%) 1997/07	Rate of Change (%) 1997/07	Ecarts (%) 2007/17	Rate of Change (%) 2007/17	Ecarts (%) 1987/17	Rate of Change (%) 1987/17
Forest Massif	-2,97	-12,42	-5,63	-26,82	-8,72	-56,80	-17,33	-72,31
Croplands	+3,01	+11,44	+11,47	+30,32	+1,67	+4,23	+16,16	+40,91
Dayet	+0,006	+30,04	-0,001	-0,33	-0,086	-44,02	-0,03	-20,24
Urban	+1,11	+8,55	-5,053	-38,84	+11,49	+59,09	+7,55	+38,83
Steppe	-1,21	-2,97	-0,78	-1,99	-4,35	-11,26	-6,35	-15,62

The urban and mineral surfaces increased from -38.84% to + 59.09%. The regressive changes affected 15.61% of the area of the study area. The relics of the forest massifs, the steppe area and the surfaces of saline waters (dayet) are subject to a marked decline.

The 30-year changement map (1987/2017) summarizes the dynamics of the physical component of the study area (Figure 4). The gradual and regressive changes in the natural environment reached the rates of 44.78% and -29.21% respectively. The most reduced surfaces are the forest massifs, the steppe rangelands and to a lesser extent the surfaces of saline waters (dayet). The other components such as cereal crops, urban and mineral areas, on the other hand, have increased in area to the detriment of the natural plant cover. The stability of the study area recorded only a rate of 26.01%. This rate represented only ¼ of the area of the south of Tlemcen region.

5. DISCUSSION

The use of data from sensor data, obtained in the spring season of 1987, 1997, 2007 and 2017, made it possible to monitor the spatio-temporal evolution of the dynamics of land use in the south of Tlemcen province. The pixel-to-pixel comparison of the variation of the Normalized Vegetation Difference Index (NDVI) highlighted changes in the composition of the physical environment in the study area. The changements are imposed among others by climate change, land clearing for agricultural purposes, overgrazing and fires [25]. The forest formations consist mainly of holm oak groups (*Quercus ilex* L.) and Aleppo pine (*Pinus halepensis* Mill.). The undergrowth is formed in lentisk *(Pistacia lentiscus* L.*)*, the rosemary (*Rosmarinus officinalis* L.) and the calycotome *(Calycotome villosa* LINK.*)*. The forest vegetation is in the form of clear scrub where holm oak (*Quercus ilex* L.) dominates over the juniper oxycedre (*Juniperus oxycedrus* L.) [13].

The forest formations, still in place, have greatly diminished given the impact of anthropozoogenic action and the climatic conditions characterized by successive droughts. They are exploited by a rural population whose lifestyle is based on mountain agriculture and animal husbandry (arboriculture, cereal farming and sheep, cattle and goat livestock). The commensal plant species, spared from forest fires, have not escaped of domestic ruminants. The samples are taken by the livestock from perennial leafy species as well as woody herbaceous plants, palatable therophytes colonizing the clearings and whose production is estimated at 140 UF/ha [26]. The area of cereal crops has increased significantly at the expense of the decline in forest formations (-72.31%) and steppe rangelands (-15.62%). This situation is mainly due to the high demand for livestock for feed supplement. The steppe areas, long devoted to pastoralism, are subject to cereal cultivation which has spread at the expense of the steppe. The establishment of private property in the steppe areas has resulted in the emergence of various agricultural production systems and the loss of natural resources very often aggravated by successive droughts. The high use of steppe soils in crops, during periods of drought, has resulted in a decrease in the rate of organic matter in the surface horizon, thus offering a particulate structure favorable to the processes of water and wind erosion [27]. The western steppe of Algeria is the area most affected by the phenomenon of desertification (40%

of its surface) [28]. The degradation of the steppe with alfa (*Stipa tenacissima* L.) and sagebrush (*Artemisia herba-alba* Asso.) is favored by the permanent frequentation of the herd [29]. The latter, by its increasing number, has not stopped accentuating overgrazing and consequently desertification. This situation has become irreversible in the face of an imbalance between supply and demand on the steppe routes. Certain facies of alfa and sagebrush are replaced by others based on *Salsola vermiculata*, *Noaea mucronata*, *Peganum harmala*, *Stipa parviflora*, *Atractylis serratuloïdes* and *Circium syriacum* [30]. The species Atriplex halimus, sought after by the herd, is present in the surfaces of salt water. Other facies, badly degraded, are cleared for the installation of cereal crops. Climate change, in the south of Tlemcen prefecture, has been well manifested by a marked decrease in precipitation and an increase in temperatures [31]. These climatic conditions directly influenced the dynamics of the vegetation in a regressive direction. The maintenance of cereal crops, in steppe areas on fragile soils, has attracted a lot of attention from decision-makers and management researchers [32].

Thus, intervention of the State and private owners in this steppe area is undoubtedly conditioned by its specificities to ensure the success of development operations. Climate change, characterized by a marked decrease in precipitation and an increase in temperatures, has only increased the areas strongly affected by desertification and the delignification of forest areas still in place.

6. CONCLUSION

The mapping of changement the states of land use in the south of the Tlemcen province (western Algeria), from sensor data, revealed various modifications of the plant cover. It appears that the different land use classes recorded cases of progression and regression during this period. Indeed, the changements are mainly due to land clearing for the benefit of the agricultural sector and overgrazing supported by the sedentarization of livestock. The steppe area is confronted in terms of exploitation and preservation, with various desertification problems. Arid climate, extensive livestock farming and cereal crops, along with other social factors, are all determining factors in the evolution of land use. The deforestation of existing

forest, by illegal logging and fires caused, by local residents, contributed to their decline.

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