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Change detection and spatial dynamics of forest degradation in the South East Aurès, Algeria.

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The East Aurès presents an undeniable diversity of flora and fauna, however weather conditions and actual adverse anthropogenic, caused degradation of the physical environment, which have the form of a regression in the natural forest cover. The present work presents the results of a study concerning land use mapping and its spatial change detection using remote sensed images of Landsat (MSS 1972, TM 1987, TM 2002 and OLI 2015). The objective of this study is to determine the contribution of the satellite images in the detection of ground occupation changes and to pursuit in forms of forest degradation between the four dates in the area East Aurés in Algerian. Our methodology is based on data analysis of fieldwork observation in the Southeast of Aurès, thematic maps information allowed to identify four principle types of land use (Forests, Steppes, Cereal culture and Sandy soil).The obtained results show a high degradation of forest cover and the disappearance of sand formations in the study area.This study is a multi-temporal diagnosis, which has allowed us to identify at a time the degradation affecting vast semi-arid areas, causing regression of plant cover, and the pace of its development. The results of treatment of satellite images show that the forest cover, rangelands and soil are being the object of advance degradation. As part of this study, emphasis was placed on the processing of remotely sensed data over diachronic to monitor the evolution of the degradation in semi-arid zones.

Keywords: Change detection, Land Cover, Degradation, Southeast of Aurès

INTRODUCTION

Forest ecosystems progressive destruction and the continuing processes of land degradation of the Algerian steppe are related to anthropic factors (overgrazing and inadequate agriculture) in addition of natural factors (Benderradji, 2006; Khaldi, 2014). Antropic degradation in the presaharian regions accentuates the deterioration of vegetal cover and the extention of sand (Melzi, 1993). In arid zones, soil evolution is related to climate fluctuations on one-side and exploitation habits of agricultural lands in on another. The south of Aurès by its direct contact with the Sahara is strongly exposed to degradation phenomena, which is amplified with the time because of the environment vulnerability, rainfall irregularity and the socioeconomic pressures (Abdessemed,1984: Benmessaoud et al. 2009). The change detection in arid and semi-arid zones is one of the challenges raised by spatial remote sensing researchers in order to obtain actualized and repeated information of the ground surface states evolution (Jauffret, 2001). The change detection is the process which consists to identify the difference in the state of an object or a phenomenon that we observe in different dates

(Singh, 1989). It is an important procedure of assessing the environment, the principal factors of changing that we find on a global scale emanate human activities are intensification of agriculture, deforestation and urbanization, these changes are more often known as an explicative element of climatic changes. In this study, the applied processing on the satellite data of Landsat; allowed to develop thematic maps of changes in our study area, these documents made in evidence the successive states of land cover during the years 1972, 1987, 2002 and 2015. as well as the detection of land cover changes, these used multi-dates cards has permitted to analyses the dynamics of land cover between the different dates.

Description of the study area

The study area belongs to the massive of Aurès mountains, it is located in the Northeast of Algeria, it is far by 120 Km on Southeast of Constantine and covers an area of 101. 584,89 ha, with accident topography where the altitudes vary between 1956 m to 84 m, this area is administratively attached to three communes M'Sara, El Ouledja and Khenguet Sidi Nadji, it is characterized by three different landscapes: Forest landscape of Beni Imloul, it containes 43. 000 ha and covered by Aleppo pine and low degraded formations of Holm oak (Delartigue,1904), a steppe landscape mainly covered by the Alfa groupings (*Stipa Tenacissima*) and the grouping of wormwood (*Artemisia Herba alba*) and A pre-Saharan landscape in the South, which gives the study area an Agro-sylvo-pastoral vocation.The study area is a transition zone between the atlas domains, which is characterized by a conflict between the influences of Mediterranean climate of Tellian Atlas in the North and the Saharan influences by the Saharan Atlas in the South. The climate going from the type semi-arid in the North to the arid in the South, and sub-humid climate in the summits to semi-arid in the valleys (Côte, 1974). The distribution of annual precipitations confirms a good rainfall on the North Slope because it is exposed to wet winds and decreases in the South; this is due to the decrease of the relief (orographic effect) and on another part because of the high Saharan pressures in south (Seltzer, 1946; Meharzi, 1994).

MATERIALS AND METHODS

To realize our works, we have chosen a chronological time series of images Landsat including one MSS, two TM and one OLI dated respectively in 1972, 1987, 2002 and 2015 (Table 1). Those images are all taken in dry season because we have been careful to not compare images of different seasons, which can give a place to incomparable results. Processing methods and analyze comprises three main steps: preprocessing of images, digital classification and the detection of land cover.

Pre-processing satellite imagery

First, we have geo referenced the images using the WGS84 system with the projection UTM 32 North, and we realized a mask of images out of the administrative boundaries of the study area,

The resampling of pixels made after the radiometric improvement had permitted to bring the pixels MSS (60 m of resolution) on the resolution of pixels TM (30 m), to make correct overlays and change detection, after these operations we have created colored composition on a colorimetric order: RGB (red, green, bleu).

Digital classification of images

Every image was classified using supervised Maximum Likelihood Classification applied on the colored composition; this type is considered as a powerful thematic of classification, the decision rule of this method is based on the probability of a pixel of belonging to a particular valid class by the field surveys. The determination of classes number is founded on the matching of remotely sensed data with the field information, gathered in May 2015; the classification of colored composites permitted to obtain for classes: Forest, Steppe, cereal and Sandy soil.

Change detection

Change detection by remotely sensed data is useful to monitor the difference of land cover at different times (Singh, 1989), the methodology of change detection has been the "Post-classification comparison" (Mas, 2000); this method offers to allow the quantitative and spatial detection of the dynamic change in each type of land cover between 1972/1987, 2002/2015 and 1972/2015.

RESULTS AND DISCUSSION

Dynamics of land cover change between 1972 and 1987

By comparing the land cover classes between 1972 and 1987, we recorded the following results: of 61743, 30 ha, of original forests, only 53490, 04 ha remained, other lands

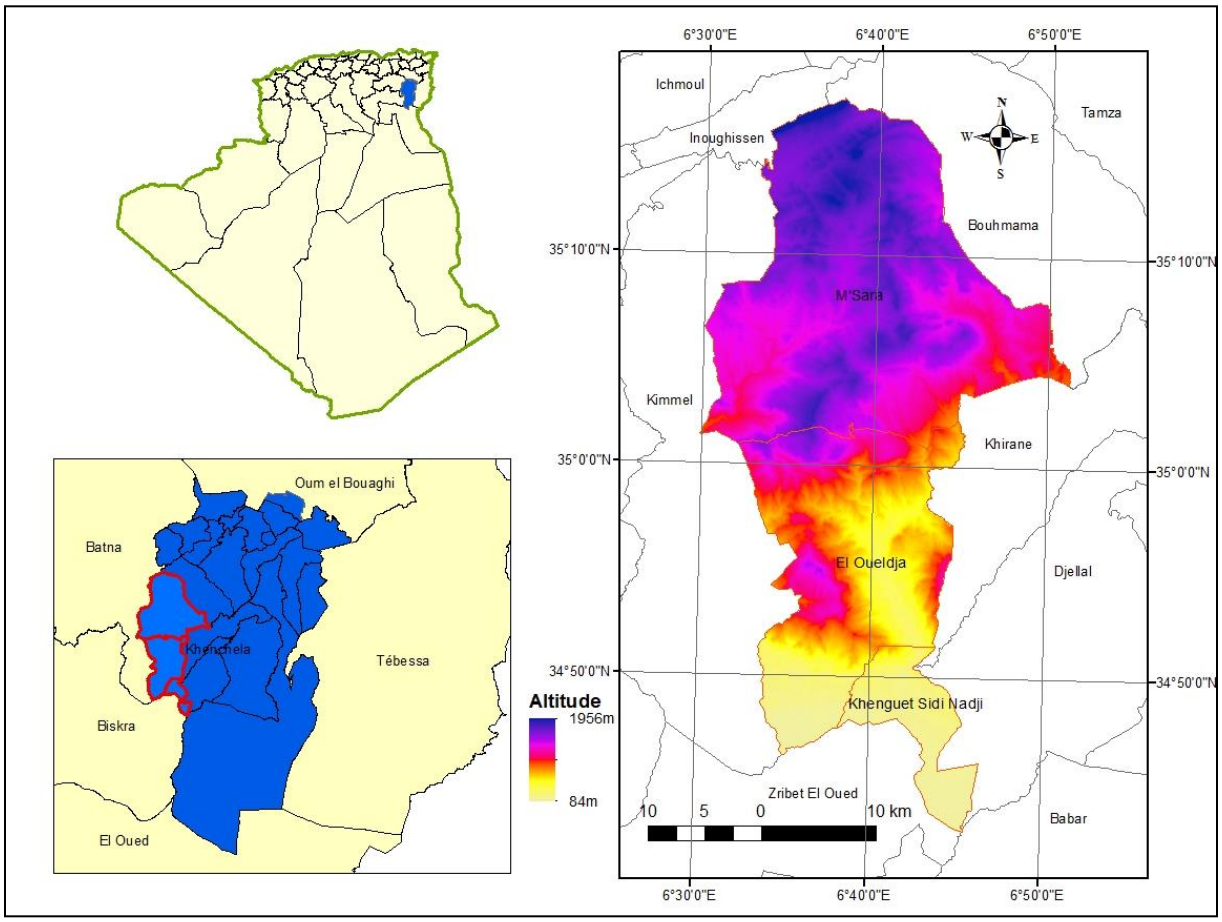

Figure 1: Geographic location of the study area

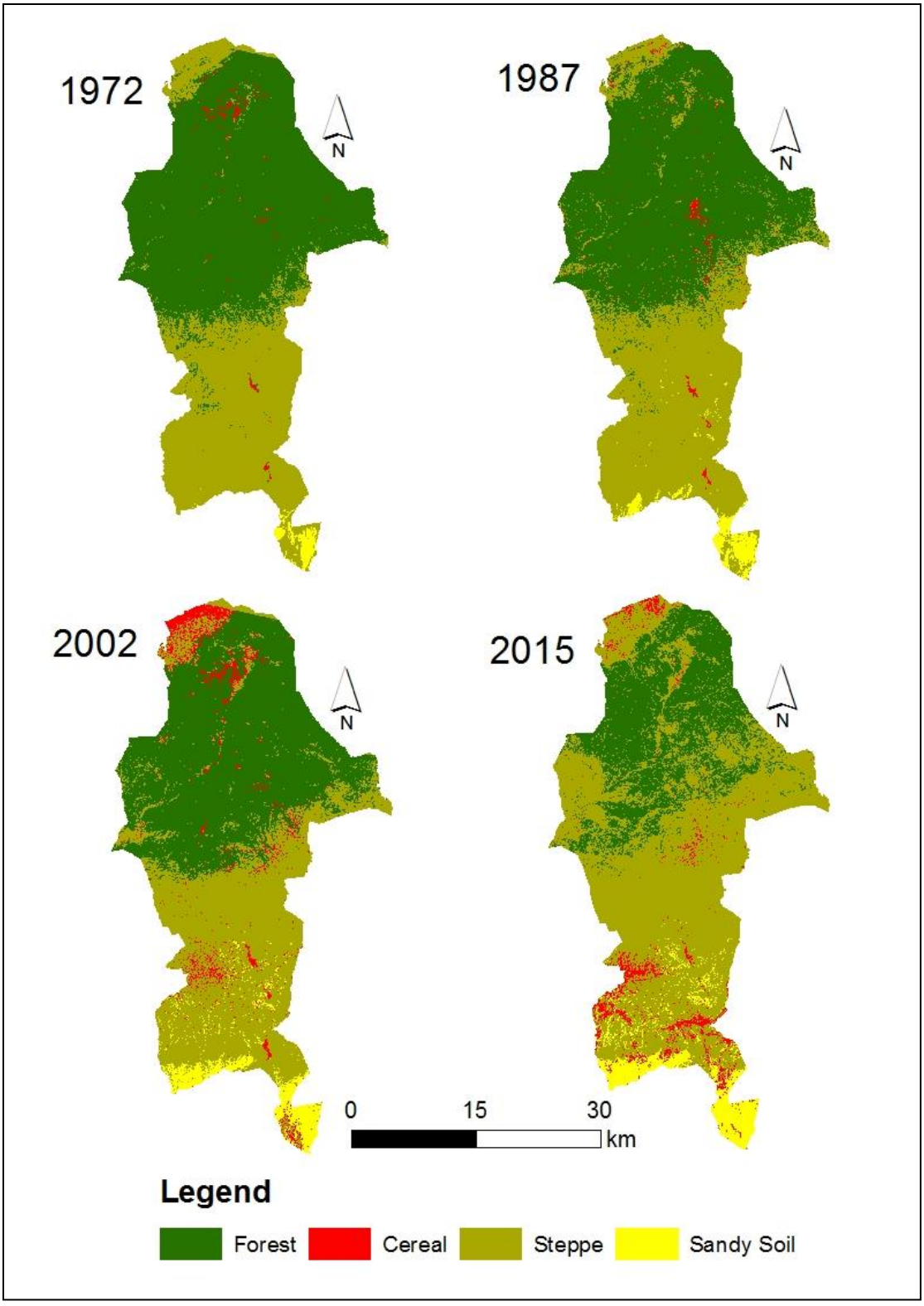

Figure 2. Land cover maps for the four defined periods

Table 1. List of satellite images collected for the study area

WRS	Path	Row	Acquisition date	Sensor	Spatial Resolution
1	208	036	1972/08/13	Landsat MSS	60 m
2	193	036	1987/06/16	Landsat TM	30 m
2	193	036	2002/06/25	Landsat TM	30 m
2	193	036	2015/06/13	Landsat OLI-TIRS	30 m

Table 2. Percentage and Area of Land Use Units

	Area in 1972		Area in 1987		Area in 2000		Area in 2015	
	ha	%	ha	%	ha	%	ha	%
Forest	61743,30	60,78	55038,69	54,18	48466,15	47,71	28078,06	27,64
Steppe	37992,75	37,40	42797,71	42,13	43336,11	42,66	62627,08	61,65
Cereal	731,41	0,72	1219,02	1,2	5038,61	4,96	4124,35	4,06
Sandy Soil	1117,43	1,10	2529,46	2,49	4744,01	4,67	6755,39	6,65
	101584.89	100	101584.89	100	101584.89		101584.89	100

Table 3. The changes in land use units between 1972 and 1987

	Forest	Steppe	Cereal	Sandy Soil	
Forest	53490,04	7581,63	671,63	0,00	61743,30
Steppe	987,81	35173,07	243,77	1588,10	37992,75
Cereal	560,84	43,01	127,56	0,00	731,41
Sandy Soil	0,00	0,00	176,07	941,36	1117,43
	55038,69	42797,71	1219,02	2529,46	101584.89

Table 4. Transformations of land-use units between 2002 and 2015

	Forest	Steppe	Cereal	Sandy Soil	
Forest	27291,29	21019,76	154,04	1,06	48466,15
Steppe	444,65	38190,64	2826,9	1873,92	43336,11
Cereal	342,12	3416,68	829,36	450,45	5038,61
Sandy Soil	0,00	0,00	314,05	4429,96	4744,01
	28078,06	62627,08	4124,35	6755,39	101584.89

Table 5. Transformations of land-cover units between 1972 and 2015

	Forest	Steppe	Cereal	Sandy Soil	
Forest	27635,52	33724,19	382,53	1,06	61743,30
Steppe	167,17	28531,04	3618,03	5676,51	37992,75
Cereal	275,37	371,85	83,55	0,73	731,41
Sandy Soil	0,00	0,00	40,34	1077,09	1117,43
	28078,06	62627,08	4124,35	6755,39	101584.89

Figure 3: Steppe of degraded alfa and scattered individuals of *Pinus halepensis.*

are divided between 7581, 63 ha of steppe and 641, 63 ha of cereal farming.
As regards the steppe area very few changes have been recorded, in fact of the initial 37992,75 ha, only 987,81 ha has involved in forests 243,77 ha in cereal farming and 1588,1 ha in bare soil.

Dynamics of land cover change between 2002 and 2015

Table 4 shows the degradation of large areas of vegetation and soils, in the period 2002 to 2015. Compared to the previous studied period forest formations recorded a new type of change in this period towards sandy soils by an area of 1, 06 ha, and the transformation of an area of 21019, 79 ha of these forest formations to steppe vegetation and 154, 04 ha was modified in cereal farming. But the transformation of the steppe area is more remarkable than the class of forests where 1873,92 ha was transformed into sand formation and an area of 2 826,9 ha was colonized by cereals, during this time the cereal farming class was intensified in an area of 3416, 68 ha and 342, 12 ha in the steppes and forests respectively. In addition, 450, 45 ha were changed to sandy soil in the last 13 years, however, sandy soils lost only 314, 05 ha were modified in cereal farming.

Dynamics of land cover changes between 1972 and 2015

The major change in land cover in the study area from 1987 to 2015 is the 54, 52 % decrease in forest area from 61 743, 30 ha (60, 78 % of total area). To 28 078, 06 ha (27, 64 %of the area), which is exposed to successive fires, from 25 000 to 50 000 ha between 1962 and 1967 (Sari 1977). Which affects the most degraded forest cover (Ansar, 2002). This regression was located at the level of the Aleppo pine in Beni Meloul forest which spread out on the southern side of the Aurès.The Aleppo pine forest corresponds to the semi-arid stage (Quezel, 1957). Which was characterized by less precipitation than the northern mountainside down to 200 mm/year (Ansar, 1998 ; Cote 1973). Retained only 27,635.52 ha, and lost an area of 33724.19 ha in the steppes, 382.52 ha in cereal farming and 1.06 ha in sandy soils respectively, despite being gained an area of 442.54 ha through the implementation of forestation reforestation programs. The steppe area areas have increased from 37992.75 ha in 1972 to 62627.08 in 2015 with 24634.33 ha; this increase is due to the removal of the areas formerly occupied by The Aleppo pine forest. This increase is justified by the development of steppe plant formations (Alfa, wormwood) from a forest vegetation by degradation (Bouzekri and Benmessaoud, 2014).
The converted steppe area represents 9461.71 ha, is 24.90% of the area of the steppe zones and is distributed as follows: 5676.51 ha in sandy areas, 3618.03 ha of cereals and 167.17 ha of forest cover.
In the open range, the impact of overgrazing is the determining factor, in this situation the vegetation cover decreased dramatically to reach a level that seemed irreversible (Melzi S 1991, Aidoud et al. 1998). Because they are subjected alternately to plowing and during fallows, to the winter pasture of herds of livestock descended from the massif (Despois et al. 1967; E.B et Ballais, 1989).
The widespread exploitation of alfa since the colonial era until the 1970s for the manufacture of paper (Nedjraoui and Bédrani, 2008) opens the access to the extension of the cereal farming, which colonizes the steppe zones.
Over the past forty-three years, the increase in cultivable area has been linked to population growth and the development of mechanized farming. Which have led to an increase in cultivable area at the expense of the forest and steppe area, which was gained an area of 382.53 ha of the forest area, 3,618.03 ha of the steppe area and 40.34 ha of the sandy surface.
During the four analyzed decades, the transformation of the sandy soil class into another pattern of land cover concerns only the cereal farming class by an area of 40, 34 ha.
The sanded areas have increased from 1117.43 ha in 1987 to 6755.39 ha in 2015; the extension of sandy areas is strongly linked to steppe zone by an area of 5676.51 ha where 99.96% of the sand formation has been formed in the steppe.

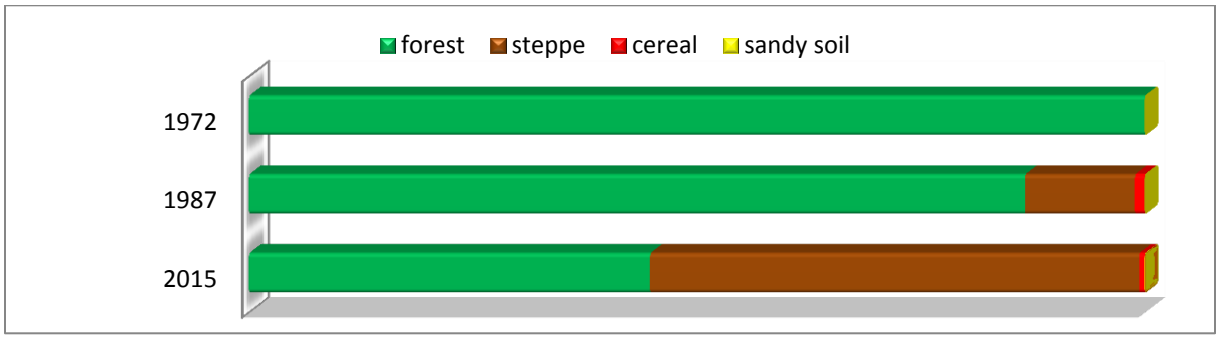

Figure 4: Change dynamics of the forest unit

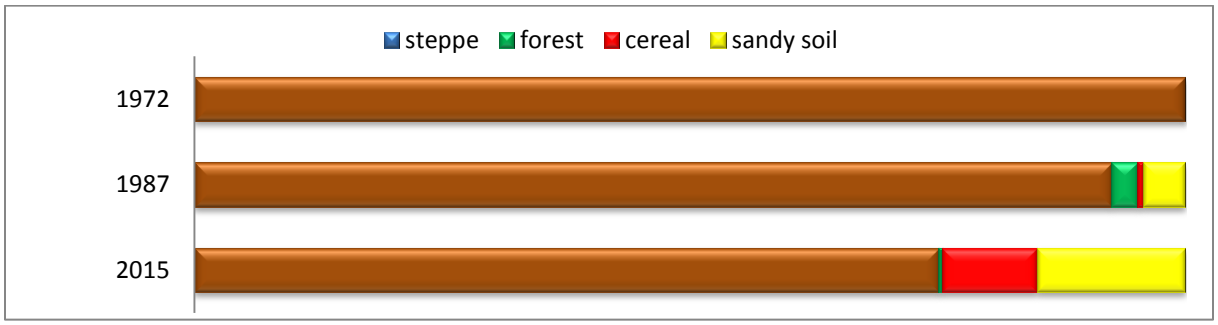

Figure 5: Dynamics of change of the steppe unit

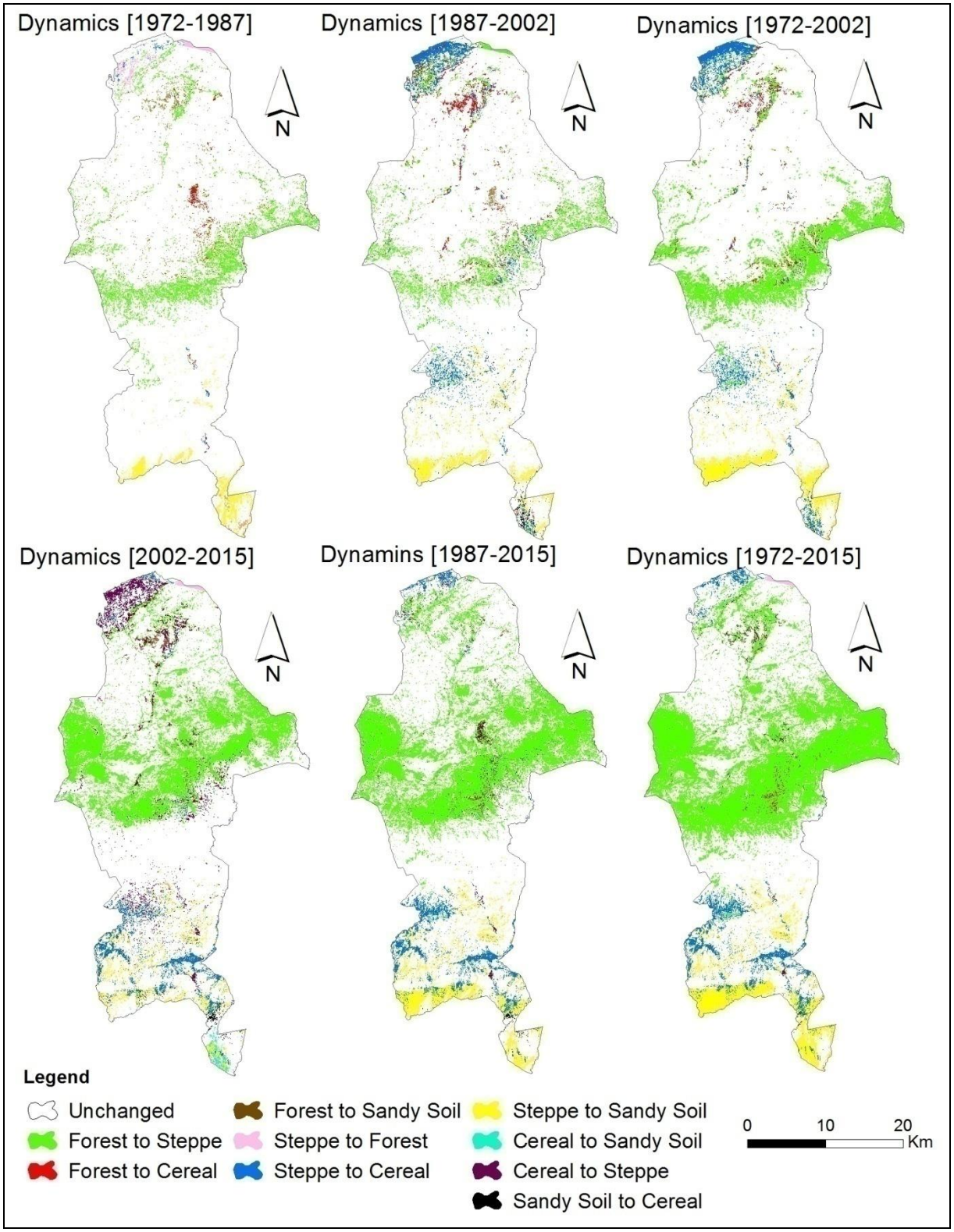

Figure 6. Map of changes and dynamics of land use in the study area for: 1972/1987, 1987/2002, 1972/2002, 2002/2015, 1987/2015 and 1972/2015

The length of the dry season of the Algerian steppe recorded an increase over time (Pierre R 1996), Where the sanding dynamics were particularly intense during this period (Melzi, 1994).

CONCLUSION

The geographical and socioeconomic characteristics of the southeastern part of the Aures are domain a large part of the steppe zone, characterized by the extent of desertification phenomena. Land cover mapping and their mutations between the different dates in the study area highlights the alteration of natural environment and the analysis of these mutations revealed some modifications and the appearance of new phenomena like deforestation in the forest of Beni Mloul, which has lost half of its surface area. The regression of the Alfa aquifer in the ElOuldja municipality. And the sanding that colonizes the majority of the municipality of Khenguet Sidi Nadji, all these processes of desertification are amplified in space and accelerate with time.

CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

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