

The Site of Biological and Ecological Interest (SBEI) of Ain Asmama: 20 Years Later, What Are Changes?

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ABSTRACT

Concerning this big SBEI (West of Morocco), its bioecological qualities especially its very specific and original flora has attracted naturalists for a long time. This region seems to be relatively preserved still despite the erosion and anthropogenic advanced threats. The most effective method to evaluate the degree of environmental's change caused by anthropogenic activity and climatic conditions is the multi-date study of land cover. For this, the purpose of this work is to analyze the land cover's changes evolution in this SBEI from remote sensing technics. Concerning that, we did a tri-achronical approach on data from 1988 to 2000 and from 2000 to 2010 (LANDSAT imagery). The land cover's maps that we got were produced from a supervised classification. The analysis of time series of LANDSAT images has shown that, during the period 1988-2000, the forests area decreased to the benefit of cultural practices (period before the creation of the SBEI), while the shrub strata distribution area has clearly increased during the period 2000-2010.

Keywords: SBEI; Ain Asmama; LANDSAT; Supervised Classification; Land Cover; Morocco

1. Introduction

Between 9.03° and 9.33° Longitude West and between 30.74° and 31° Latitude North, the Site of Biological and ecological Interest (SBEI) of Ain Asmama is localized in the South-West of Morocco, its area is approximately 23 564 ha (**Figure 1**). This is a unique environment with forest areas still wild and well preserved. This site had already been noted for its' biological and ecological qualities, its' original flora which earned him his proposal, in the early 70 s, to be erected into a National Park, the project soon forgotten. The SBEI of Ain Asmama is an important site of biological values, landscape, aesthetic and cultural. Its rugged environments, reliefs and powerful varied vegetation, dense, continuous and well preserved, offering a wide variety of habitats and ecosystems important for maintaining wildlife communities against desertification.

Studies on land cover change are of great importance because they can know the current trends in the process of deforestation, degradation, desertification and biodiversity loss in a specific region [1]. To map and quantify changes in land cover, multi-date assessment from LANDSAT images becomes an effective means for measuring the degree of change. Several past studies have highlighted the different strata vegetation types that dominate in this site [2,3].

The objective of this study is to map the land cover

change in the SBEI of Ain Asmama (Morocco) using multi-date LANDSAT images. The method used in terms of distinction of dominant plant species is the supervised classification.

To access difficult and painful penetration, the western High Atlas consists mainly of trays stacked in tiers where the altitude gradually diminishes westward and northward. This massif contains deep valleys and canyons and steep cliffs that give a relief appearance eventful and picturesque. The corridor of Argana depression bordering the Ain Asmama's SIBE with NNE-SSW aspect, it is a valley considered a depression printed Issène River, the only Whitewater River in the region. The SBEI is located on the upper parts of the right side of the Ait Moussa River, his relief is short-cut ravines overlooking the whole site look hilly, rugged, very rugged and steep in places. The altitude varies between 780 m and 1744 m.

The site's geology is dominated by Jurassic and Permo-Triassic formations, with presence of Quaternary terraces from the phenomena of alluvial and colluvium recent.

Given its great altitudinal variation, the Ain Asmama's SBEI is characterized by terraced important bioclimate ranging from arid to subhumid. However, most of the Site is under the influence of the Mediterranean bioclimate floor Thermo semiarid temperate. Annual average rainfall show high spatial irregularity of rainfall. As is generally the rule in Morocco, the amount of precipita-

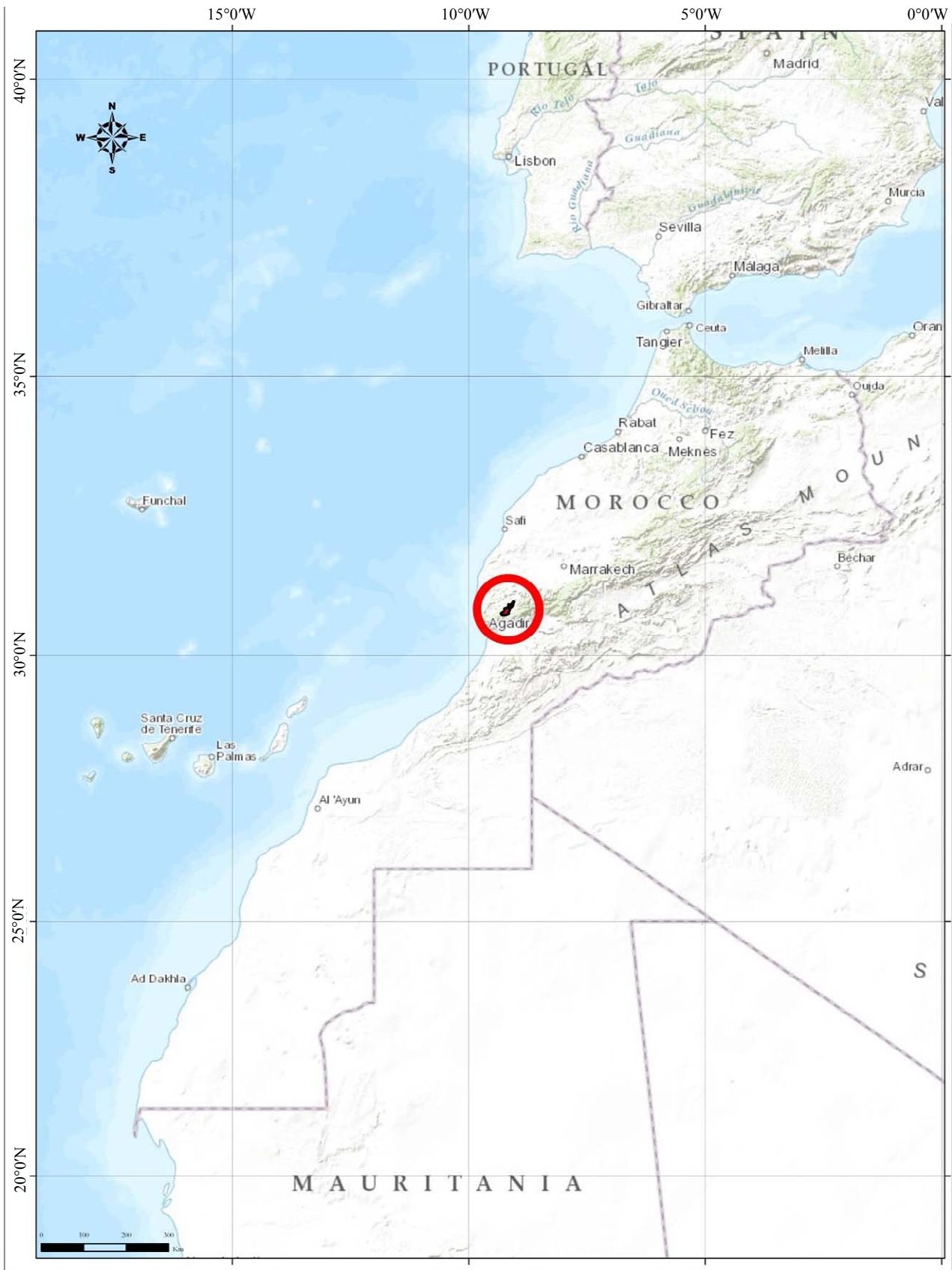


Figure 1. Location map of Ain Asmama's SBEL.

tion increases with altitude. The average annual rainfall varies between 220 mm and 548 mm. The maximum rainfall is recorded in the period from November to February. The driest period occurs during the months from June to September. Given the importance of altitudinal range in the region of SBEI, reliefs high altitudes are cool and well watered, including disturbances of Atlantic origin (from Northwest). The sides exposed to the southeast are largely immune to these disturbances, although they are strongly influenced by the hot dry winds from the South and Southeast (Chergui).

Spatial variations of temperature are influenced by two main factors:

- **Continentality:** the amplitude of thermal variations is milder on the coast (Tamri: $M = 11^{\circ}\text{C}$), while the contrasts between the means of maxima and minima are increasing progressively as we advance towards inside (Argana $M = 22^{\circ}\text{C}$). Indeed, the Atlantic Ocean exerts a soothing effect on extreme temperatures in summer by reducing: $M = 27^{\circ}\text{C}$ in Agadir; Tamri at 28°C and 41°C to Argana.
- **Terrain:** given the available mountains and highlands of Ida Outanane Haha, summer temperatures decrease with altitude which would result in attenuation of the effect of continentality and softens the heat of the was ($M = \text{Argana } 41^{\circ}\text{C}$; Or Ida ou Tanane $M = 34^{\circ}\text{C}$).

2. Methods

2.1. Determining the Scenes Making Changes to the Mapping of Land

For this analysis, the choice of images is based on four parameters: coverage, spatial resolution, years and seasons of shooting. LANDSAT imagery acquired in 1988, 2000 and 2010 were selected for carrying out this work. Cover 2000 and 2010 consists of scenes LANDSAT 7 (ETM+) while that of 1988 consists of LANDSAT TM5.

From the geographical point of view, images are projected in UTM (Universal Transverse Mercator) Zone 29. The datum and reference ellipsoid used is the World Geodetic System (WGS84).

Before using the image in the different treatments that are needed, it is necessary to prepare and it is improving radiometric and geometric correction. Among the work on the study of changing land use by remote sensing, there are three sets of detection methods. The first method is to perform an unsupervised classification that separates the pixels of the image in as many classes as we have defined a priori surface states [4-6].

This method is inappropriate when referring to nomenclature that is not defined in terms of spectral signatures of surface states but according to thematic classes of land whose spectral signatures are not always sufficiently homogeneous nor inherently contrasting one class

to another to be recognized automatically.

The second method, known as supervised classification, involves the use of control areas based on the precise location of a large number of "ground-realities" [7, 8].

The third method is to use unsupervised classification [9] by separating the pixels in a number of clusters large enough to proceed with the development of the map by grouping these classes [10-12].

2.2. Supervised Classification for LANDSAT Images

The images of the three dates were first georeferenced and coregistrées until an error less than 1 pixel. Then bands TM1, TM2, TM3, TM4, TM5 and TM7 are extracted for each image. The images of the three dates are being combined into a single image composed of six bands each (**Figure 2-4**). The band TM6 and the panchromatic band were not used because they do not take much to distinguish the forest and have a resolution different from other bands.

The classification of an image of different date has the advantage of reducing errors due to differences in vegetation phenology, illumination conditions and differences in interpretation.

By viewing all three dates on the computer screen, the reference areas are identified for learning the computer. We create classes and subclasses for the entities on the images. Simultaneous viewing of images of different dates also allows the creation of classes and subclasses for static states without any changes (e.g. argan tree in 1988, 2000 and argan argan tree in 2010) and change (e.g. argan tree in 1988, field of culture in 2000 and field cultivation in 2010).

To develop these maps, it was useful to first collect all the data and study reports in relation to the existing area of interest. Similarly, in 1994, it was created a map of phytocological Argana corridor that encompasses the entire study area. In 2002 [13-15], for the purposes of a study on desertification in the Souss basin, a land use map of soil was carried out by the consulting firm ADI on behalf of the Secretary of State for the Environment. Another study conducted on behalf of the Regional Directorate of Forestry and Desertification Control Southwest (SW-DREFLCD) on land use of part of the plain of Souss has allowed have data for land use that were used to support the classification.

Initially, it was appropriate to establish the legend and to identify classes and land use for images of 1988, 2000 and 2010. Then step of the overall process of supervised classification was followed.

After defining the classes, the ground truth was collected by using GPS and fed into the computer to create

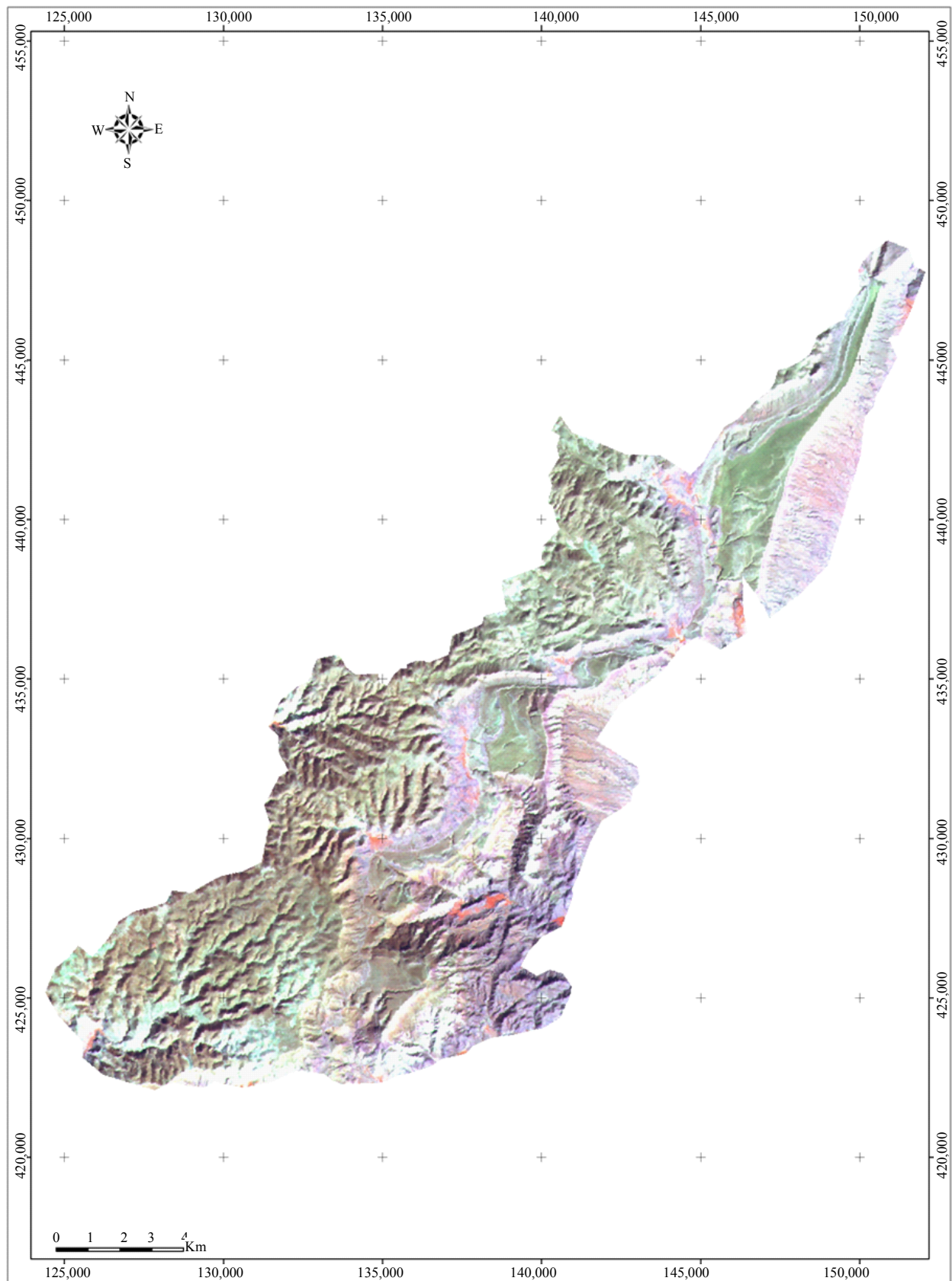


Figure 2. LANDSAT imagery TM5 acquired in 1988 (Bands 4, 5 and 3).

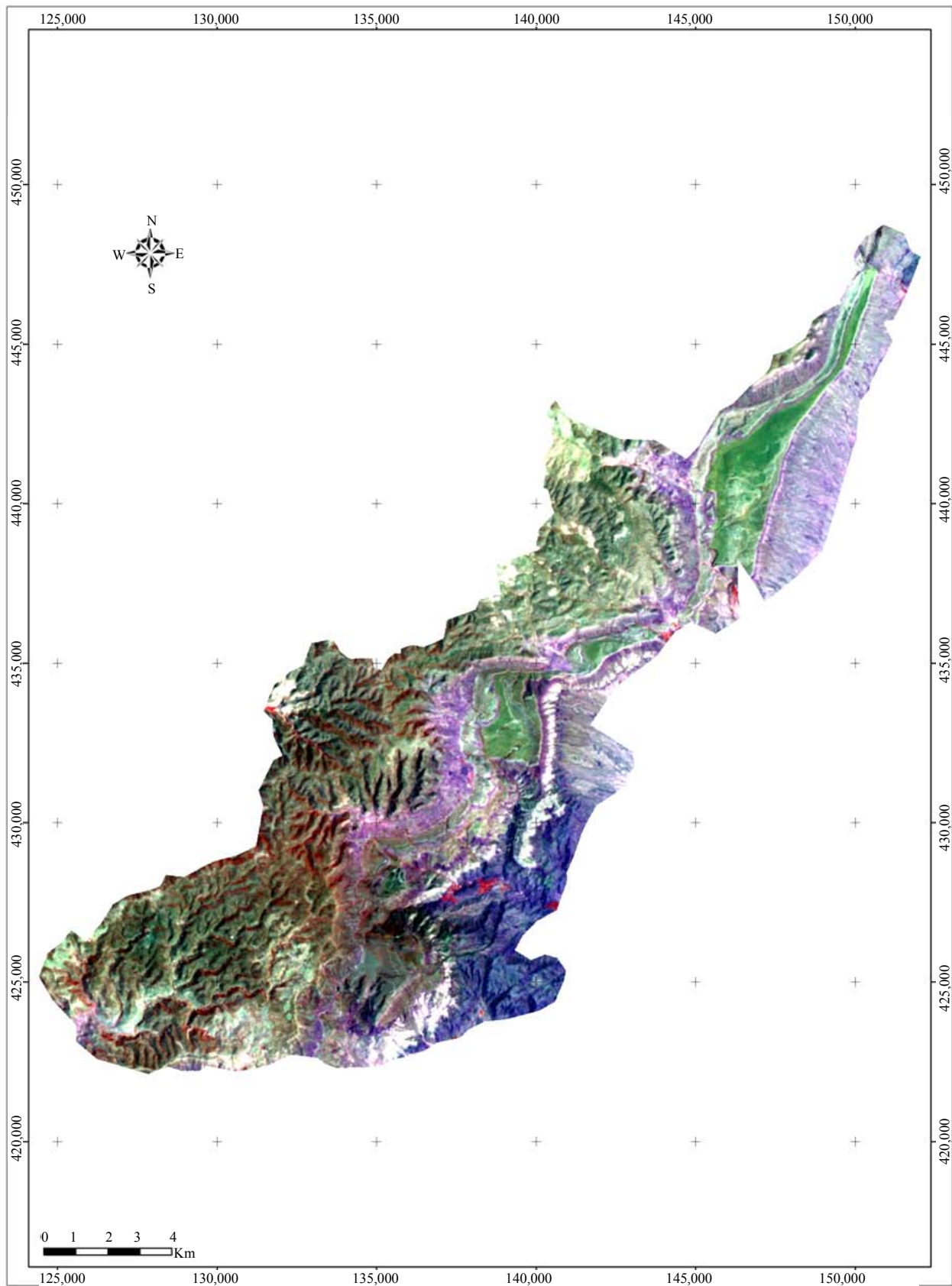


Figure 3. LANDSAT imagery ETM+ acquired in 2000 (Bands 4, 5 and 3).

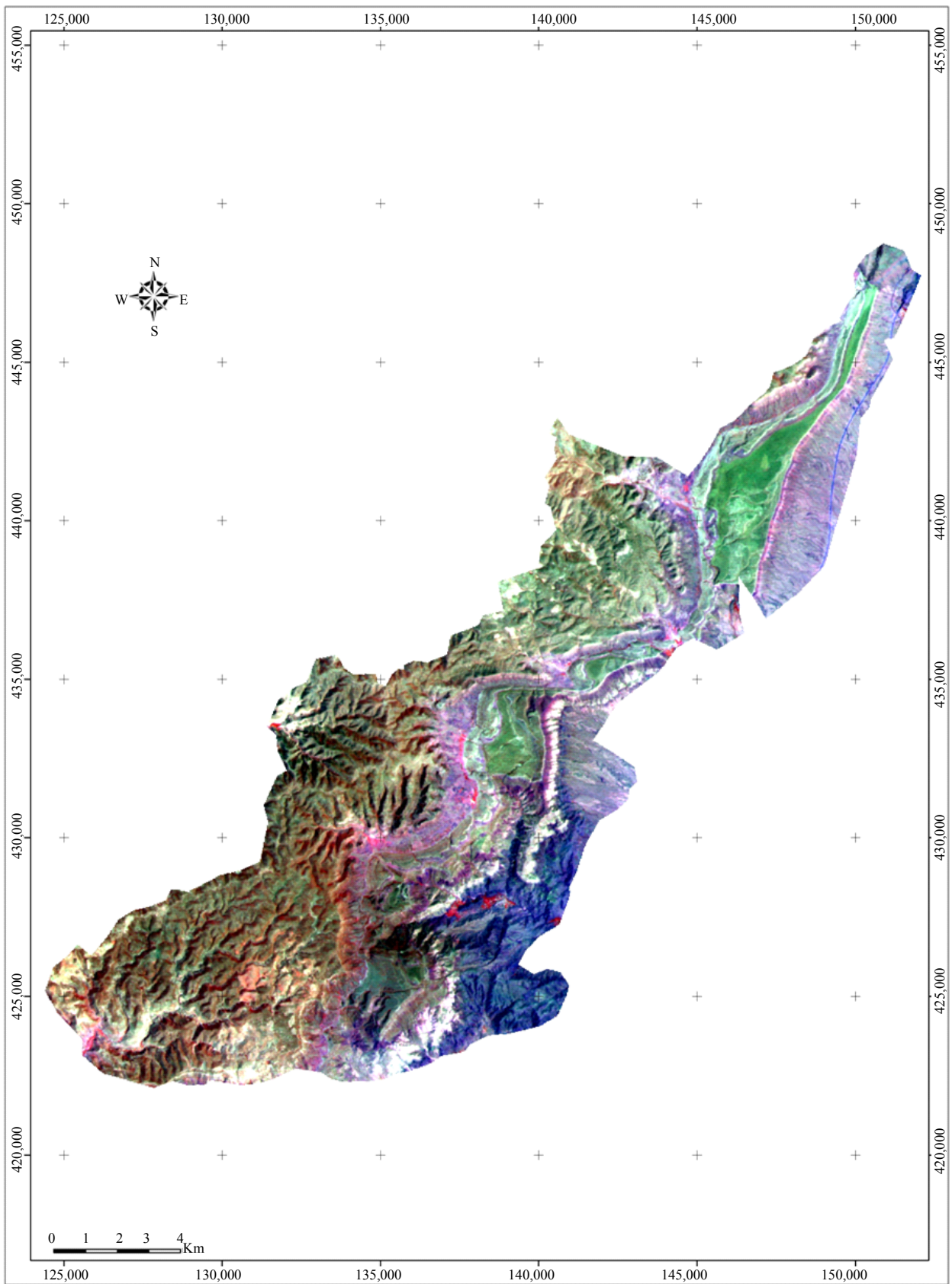


Figure 4. LANDSAT imagery ETM+ acquired in 2010 (Bands 4, 5 and 3).

spectral signatures. During this stage, it was found that six bands taken together give the best result. After this phase, the maximum likelihood algorithm was applied. The final result is then smoothed by applying a filter of 3×3 pixels for a pleasing result to see.

Because argan exists only at altitudes below 1400 m, the Digital Terrain Model (DTM) was created for this requirement (**Figure 5**). The results of the classification in 1988, 2000 and 2010 have been refined to transform the two classes of argan forests in the corresponding classes.

For quantification and differentiation of plant canopies (including other elements: soil, water, snow, clouds ...), several indices have been developed vegetation [16,17]. The most popular and most used is the normalized difference index (Normalized Difference Vegetation Index or NDVI), developed by Rouse *et al.* (1974):

$$NDVI = (ETM4 - ETM3) / (ETM4 + ETM3)$$

In this research, this index was chosen for the space quantization of green vegetation. The NDVI's calculation was done with the ERDAS software.

3. Results

Figures 6-8 represent the different strata from the supervised classification of Landsat images in 1988, 2000 and 2010.

This classification shows the following classes:

- Cultural lands:

It includes the cereals cultivation, we also note the presence of bean, pea, and lens. It occupies 2.83% of the SBEI's surface and it's mainly situated among villages.

- The Argan:

The argan trees occupy the Argana corridor, in pure formations, and go up at high altitude. Generally, we find argan in mixture with Thuja but especially in south aspect.

It is the tree of the infra-Mediterranean and the thermo-Mediterranean climate, under an arid climate to semi-arid climate warm to moderate. The argan is kept preserved well by places, but often rather strongly degraded.

- The Holm Oak:

It's present everywhere on the summit of mountains. With the favorable weather conditions, it represents especially the meso-Mediterranean climate and the ceiling of the thermo-Mediterranean, under a bioclimate subhumide and semi-arid moderate. This formation is essentially preserved well in the highest parts or in the zones with high slope but it's especially more degraded near villages.

- Juniper oxycedar:

The Juniper oxycedar shares the same space and gen to populate the facing south hillsides where dominate dominate projecting ledges.

- The Red Juniper:

We find this species with holm oak and Thuja.

- Thuja:

It succeeds downward the Holm oak. In low height, it shares the same space as the argan but populates hillsides exposed generally to the North. In high height, it occupies the facing east hillsides. The thuja encircles in a way the area of the argan tree. The Thuja zone show several facies; the best preserved is present at the level of the central valley of the oriental part of the SBEI.

- Secondary gasolines and high way.

We can see that the classes are the most common classes in the stratum of forest that occupied more than 80% of the total area, while the classes that have the smallest proportions are: the class of that of crops and species secondary. Both represent to 20% of total area. Visual analysis of these three maps we can see that the area is quite SBEI preserved and that the trend of expanding cultivation is decreasing with the rural exodus to the city of Agadir and the scarcity of resources water. The class seems to be the most stable during the period 1988 to 2010, is the high forest, which occupies about 55% of the surface for the three dates analyzed.

The most anthropogenic activities in the area of Ain Asmama's SBEI is agriculture, beekeeping and overgrazing. Most part of the agricultural land is related with argan zone, beekeeping and overgrazing are practiced in holm oak, Thuja and Juniper areas.

4. Discussion

The evaluation of our results from the confusion matrices, we can see that the Kappa indices (0.84 for 1988 Landsat image, the image with 0.78 and 0.82 for 2000 LANDSAT image LANDSAT 2010) and the measurement accuracy (87.5%, 81.82% and 92.31%) for the three maps, indicate that the classifications are of good quality.

In order to show the evolution of each class of land use over time, we used a series of transformations of sets, the relationship between the same classes on two different dates, we can extract the areas "stable", of "regression" and "progression" of this class. It is considered that T1 is the set of pixels of the date 1 and T2 is the set of pixels for the date 2.

After the establishment of different types of links between the three dates, we calculated the rate of change between the surfaces of classes of land between the dates 1988 - 2000 (T2 - T1), dates from 2000 to 2010 (T3 - T2) and dates from 1988 to 2010 (T3 - T1).

Tables 1-3 show the results obtained:

The results of calculating the rate of change between 1988 and 2000 show that the class "Cultures" presents an increase of about 40.37%, more than 490 ha for a period of 12 years. These results show also rely regression clas-

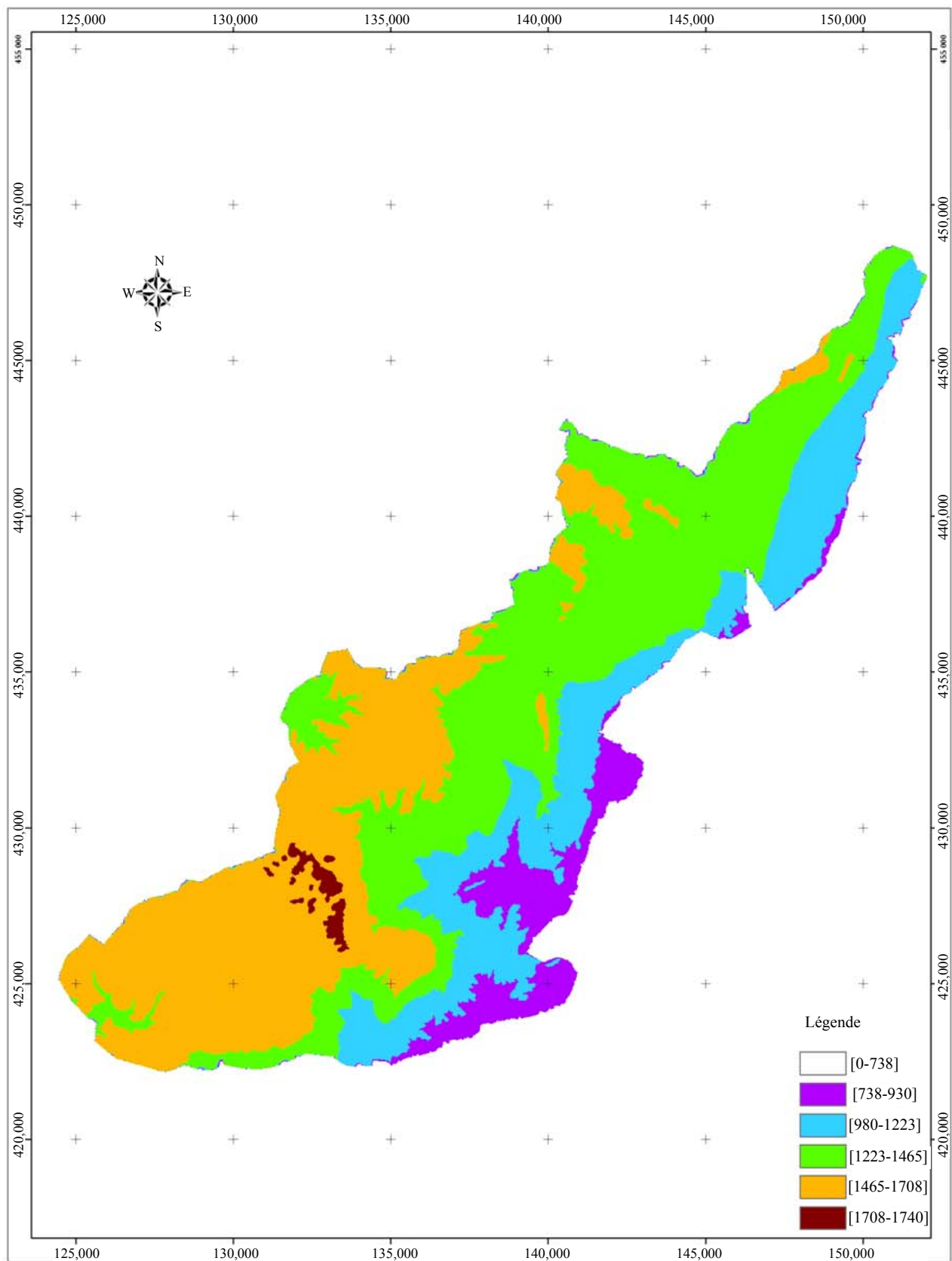


Figure 5. Elevation map of Ain Asmama's SBEI.

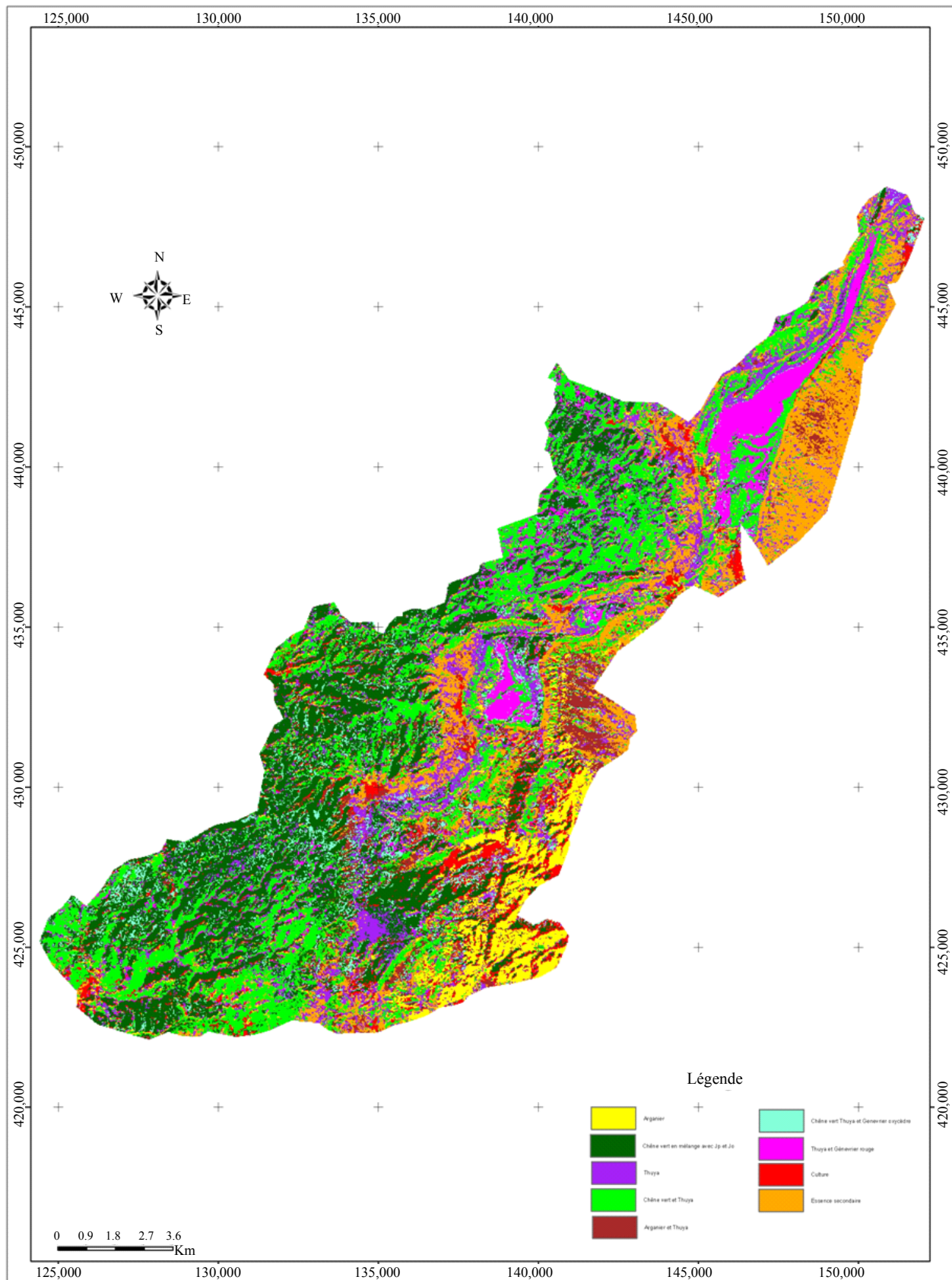


Figure 6. LANDSAT imagery TM5 acquired in 1988 classified.

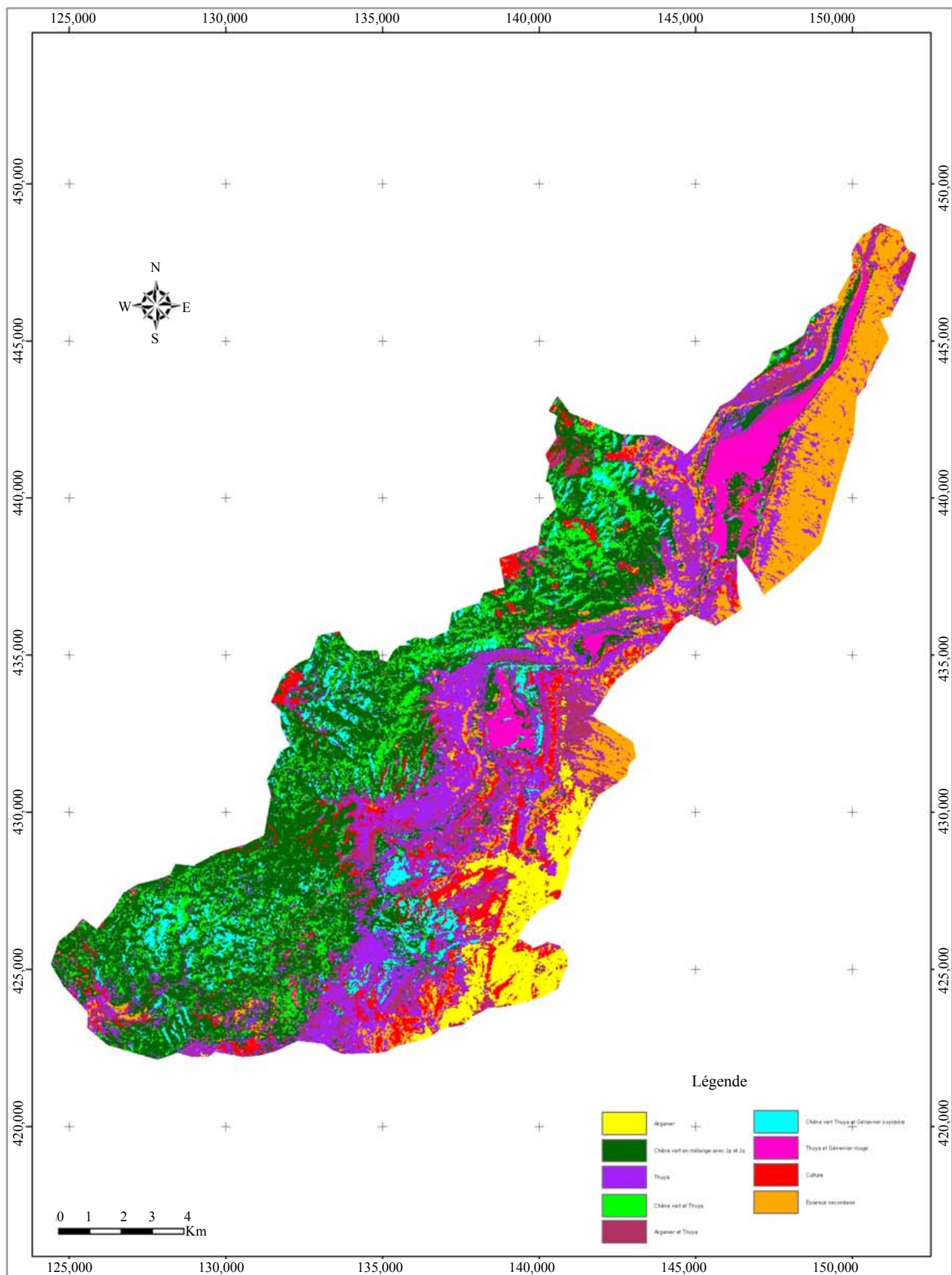


Figure 7. LANDSAT imagery ETM+ acquired in 2000 classified.

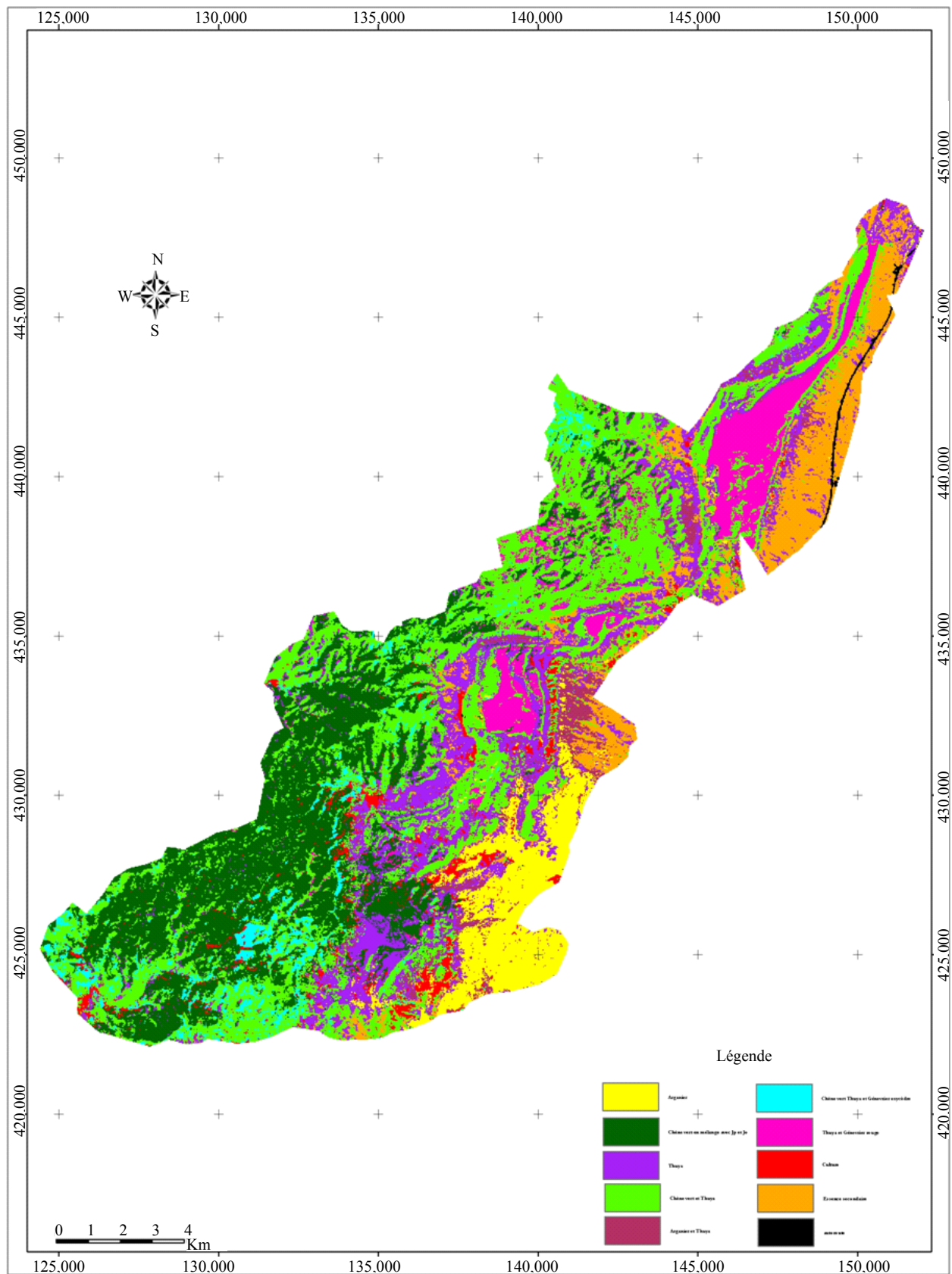


Figure 8. LANDSAT imagery ETM+ acquired in 2010 classified.

sses “and Thuja Green Oak” and “Eastern Red Cedar and Thuja” respectively 67.88% and 34% (**Table 1**).

During this period, we see that only classes “Argan,” “Holm Oak and Thuja” and “Thuja in mixture with red Juniper” have expanded significantly while other classes show a continuous decrease. Also, note the appearance of the highway linking the city of Agadir and Marrakech (**Tables 2 and 3**).

5. Conclusions

A view of the results obtained, we considered that the

extractions of LANDSAT imagery, from the supervised classification are of sufficient quality (87.5% accuracies for Landsat image of 1988, 81.82% for that of 2000 and 92.31% acquired in 2010) to establish the changes observed on the images during the past 20 years. We found that the significant changes occurred in the first period (1988-2000) and they mainly concern classes “Cultural Forests and anti Desertification (HCEFLCD) for reforestation and soil and water’s conservation.

The land cover map of Ain Asmama SBEI’s, constitutes a basic tool for any development program of this natural heritage.

Table 1. Land covers change between 1988 and 2000.

Ranges	Area in 1988 (ha)	Area in 2000 (ha)	T2 - T1	TC	TC (%)
Argan	1,376,235	11,789,325	-1,973,025	-0.14	-14.34
Holm oak in mixture with red Juniper and oxycedar	57,225,375	7,509,645	17,871,075	0.31	31.23
Thuja	30,705,525	47,386,125	166,806	0.54	54.32
Holm oak in mixture with Thuja	5,120,055	164,457	-3,475,485	-0.68	-67.88
Argan with Thuja	12,105,225	18,724,275	661,905	0.55	54.68
Holm oak in mixture with Thuja and Juniper	1,108,935	1,213,335	1044	0.09	9.41
Thuja in mixture with red Juniper	1,490,355	98,334	-507,015	-0.34	-34.02
Cultural lands	12,184,875	1,710,405	4,919,175	0.40	40.37
Secondary gasolines	32,465,475	271,296	-5,335,875	-0.16	-16.44
TOTAL	235,642,275	235,642,275			

T1 = area in 1988, T2 = area in 2000; TC = rate of change between 2000 and 1988.

Table 2. Land covers change between 2000 and 2010.

Ranges	Area in 2000 (ha)	Area in 2010 (ha)	T2 - T1	TC	TC (%)
Argan	11,789,325	16,578,148	478,882,256	0.41	40.62
Holm oak in mixture with red Juniper and oxycedar	7,509,645	52,447,844	-226,486,056	-0.3	-30.16
Thuja	47,386,125	35,356,619	-120,295,056	-0.25	-25.39
Holm oak in mixture with Thuja	164,457	70,152,194	537,064,944	3.26	326.57
Argan with Thuja	18,724,275	9,040,394	-968,388,056	-0.52	-51.72
Holm oak in mixture with Thuja and Juniper	1,213,335	7,674,869	-445,848,056	-0.37	-36.75
Thuja in mixture with red Juniper	98,334	15,712,244	587,884,444	0.6	59.78
Cultural lands	1,710,405	6,669,569	-104,344,806	-0.61	-61.01
Secondary gasolines	271,296	21,252,607	-587,699,313	-0.21	-21.66
High way	0	757,785	75,778,457	1	100.00
TOTAL	235,642,275	23,5642,275			

T1 = area in 2000, T2 = area in 2010; TC = rate of change between 2000 and 2010.

Table 3. Land cover change between 1988 and 2010.

Ranges	Area in 1988 (ha)	Area in 2010 (ha)	T1 - T2	TC	TC (%)
Argan	1,376,235	16,578,148	2,815,798	0.20	20.46
Holm oak in mixture with red Juniper and oxycedar	57,225,375	52,447,844	-4,777,531	-0.08	-8.35
Thuja	30,705,525	35,356,619	4,651,094	0.15	15.15
Holm oak in mixture with Thuja	5,120,055	70,152,194	18,951,644	0.37	37.01
Argan with Thuja	12,105,225	9,040,394	-3,064,831	-0.25	-25.32
Holm oak in mixture with Thuja and Juniper	1,108,935	7,674,869	-3,414,481	-0.31	-30.79
Thuja in mixture with red Juniper	1,490,355	15,712,244	808,694	0.05	5.43
Cultural lands	12,184,875	6,669,569	-5,515,306	-0.45	-45.26
Secondary gasolines	32,465,475	21,252,607	-11,212,868	-0.34	-34.54
High way	0	757,785	757,785	1	100.00
TOTAL	235,642,275	235,642,275			

T1 = area in 1988, T2 = area in 2010; TC = rate of change between 1988 and 2010.

To preserve this area, the local people must adhere to a sustainable development of this region by creating an association to exploit with rationalization the natural resources for the future regeneration.

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