

# ANALYSIS OF LAND COVER CHANGES WITHIN THE TERRITORY OF ‘EL HAJJAJ’, CENTRAL MIDDLE ATLAS (MOROCCO).

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**Abstract** – “El Hajjaj” is one of the ethnic communities of Central Middle Atlas Mountains in Morocco. Forests, common rangelands and private cultivated areas compose its territory. However, the proportion of common rangelands and cultivated areas has changed through time, under the influence of social and economic factors. The aim of the present research is to determine the changes in land cover within the territory of “El Hajjaj”, from a diachronic analysis of land cover maps. The research is based on the exploitation of data from Landsat image from 1987 and Spot images from 2012. The mapping of land cover reveals the expansion of cultivated areas at the expense of common rangelands, related to economic factors and deep changes in the community-based management system of pastoral resources. The emergence of arboriculture as a new agricultural speculation accelerated this phenomenon. Indeed, 90 % of common rangelands are transformed into cultivated areas mainly occupied by orchards of rosacea.

**Keywords:** the territory of “El Hajjaj”, community-based management system, cultivation, rangelands, arboriculture.

## 1. INTRODUCTION

For a long time, ethnic communities of Central Middle Atlas have managed and exploited pastoral resources according to a community-based management system. This system had several basics, such as transhumance, practices and rules for a rational exploitation of the resources (*Agdal*<sup>1</sup>, pastoral pacts<sup>2</sup>, etc.), and the presence of a representative assembly of each ethnic collectivity (tribe or fraction of tribe) named “*Jmaâ* institution”<sup>3</sup>(1,2). However, this management system experienced deep changes (3,2), leading to an irrational exploitation of pastoral resources and observable changes in land cover(4).

The territory of *El Hajjaj* in particular is experiencing significant spatial changes, parallel to changes in the community-based management system.

The research aims to determine and explain changes in land cover within the territory of “*El Hajjaj*”. To reach this goal; the methodological approach is based on a diachronic analysis of land cover. The results show an important expansion of cultivated areas in common rangelands. Currently, 90 % of common rangelands are cultivated. Moreover, arboriculture area has increase rapidly from 5.45 ha to more than 53 ha between 1991 and 2010, accelerating land cover changes.

## 2. METHODOLOGICAL APPROACH

### 2.1. Study area

The territory of “*El Hajjaj*” is located in the Central Middle Atlas Mountains. It is composed by the lands and the forest (named “forest of Southern JbelAoua”), that are around the Lake “*Hachlaf*”.

This territory belongs to the province of Ifrane, circle of Azrou, Caidat of Dayet Aoua and the rural commune of Dayet Aoua. The “Ait Daoud Oumoussa” territory in the East, the territory of “Ait Idir” in the North, the territory of “Ait Hammad Adghagh” in the West, and the “Ait Youssi” territory in the South bound it. (fig 1).

Breeders and farmers compose the population. They belong to the tribe of “*Ait Seghrouchen*”.



<sup>1</sup> Prohibition of grazing in the « *Agdal* area » during spring.

<sup>2</sup> Pacts between ethnic collectivities allowing them to use each other's rangelands, or to cross over a territory during the transhumance period.

<sup>3</sup> Representative assembly of an ethnic community (tribe or fraction of a tribe).

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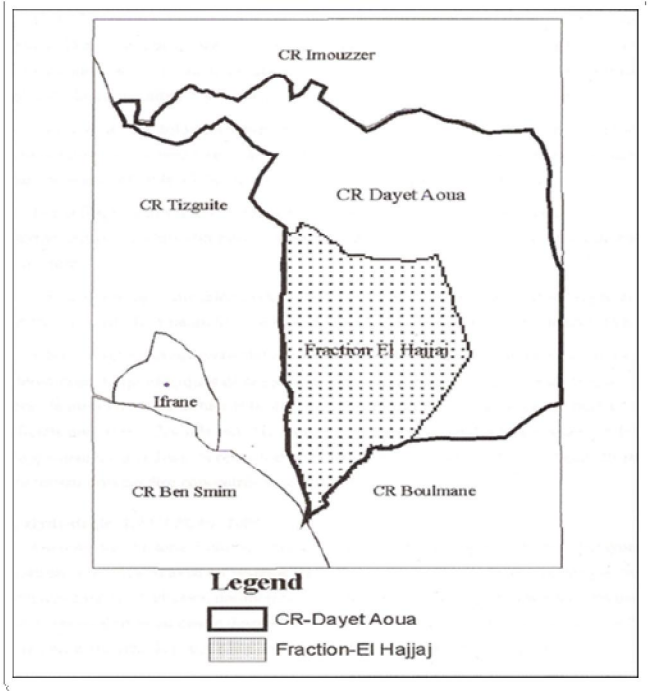
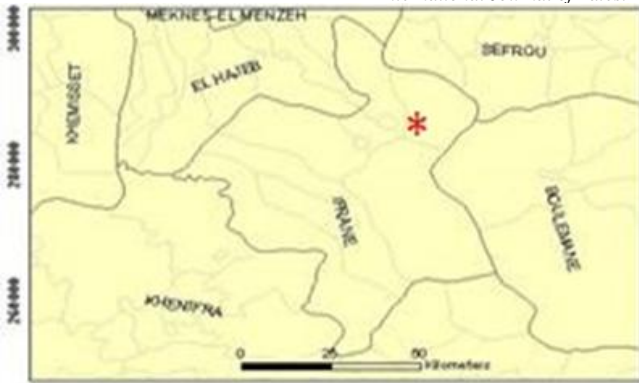


Fig 1. Situation of El Hajja territory

## 2.2. Material and Methods

Diachronic analysis method (5,6) was used to determine changes in land cover within the territory of “El Hajja”. The principle of this method is based on the classification of land cover units at different dates. It first assigns classes, then detects the changes (7).

The situations to compare were chosen based on filed information’s, gotten through discussions with the population. They mentioned the 80’s as the beginning of spatial changes. The availability of data led to the situations in 1987 and 2012.

The diachronic analysis followed the steps bellow:

- Mapping land cover units’ using satellite images. These are the 1987 Landsat satellite image with a resolution of 30 m, and the 2012 SPOT satellite images with a resolution of 1.5 m;
- evaluating the classification;
- calculating land cover classes areas.

### ➤ Mapping land cover using satellite images

Mapping land cover was carried out via the decision tree-supervised classification. Parameters used to classify the images are respectively:

- Reflectance.
- NDVI (Normalized Difference Vegetation Index).
- DTM (Digital Terrain Model).

The NDVI (Normalized Difference Vegetation Index) is an index sensitive to the vigor and quantity of vegetation. It is calculated on ERDAS IMAGINE 2013 from red (R) and near infrared (IR) channels.

NDVI values range from -1 to +1, with negative values for areas other than plant covers, such as snow or water, where red reflectance is greater than near infrared. For bare soils, the reflectance’s being of about the same order of magnitude in the red and the near infrared, the NDVI has values close to 0. The vegetation has positive values of NDVI, generally between 0.1 and 0.7. The highest values correspond to the densest cutlery.

The NDVI image was generated from the two images. Next, NDVI values were correlated with vegetation types. For vegetation with similar values for the NDVI, DTM and reflectance allowed the differentiation between different classes of vegetation, based on its occurrence as a function of altitude for the DTM and on the radiometric values for the reflectance.

In response to the research’s objective, we reduced the analysis to two classes of land cover, namely:

- Common rangelands,
- Cultivated lands.

### ➤ Evaluation of the classification

The verification of the classification was carried out through the confusion matrix, obtained via a statistical tool included in the ENVI 4.7 software. This matrix informs about two types of errors, those of commission or the user, and those of omission or the producer (8). It also calculates the Kappa index, making it possible to evaluate the accuracy of a classification (9). Ground truth points constituted a basis for validating the results obtained.

### ➤ Calculating land cover classes’ area

In order to calculate land cover classes’ area, we used ARCGIS 10.1 software. Diachronic analysis then resulted in the analysis of the evolution of land cover classes’ area between 1987 and 2012.

## 3. RESULTS AND DISCUSSIONS

### 3.1. Diachronic analysis of land cover between 1987 and 2012

#### ➤ Evolution of cultivation at the expense of common rangelands

Land cover maps, generated from the 1987 Landsat image and Spot images for 2012, reveal the changes below (table 1).

**Table 1.** Evolution of common rangelands' cultivation phenomenon

Land cover classes	Area in 1987 (in ha)	Area in 2012 (in ha)
Common rangelands	2995	300
Cultivated areas included in common rangelands	0	2695

The results revealed an expansion of cultivated areas in common rangelands. In the territory of "El Hajjaj", only 300 ha are still considered as common rangelands, whereas about 90% of common rangelands are nowadays cultivated.

This change is a consequence of the precarious economic situation of the population. In fact, population increase has led to an increase in the needs of both men and herds, and the first consequence was the break-up of the rangeland exchange pact<sup>4</sup> with the tribe of "Ait Seghrouchen of Sefrou". Forced to be content with high-altitude pastures, the breeders of "El Hajjaj" exploit continuously pastoral resources of high lands, but especially resources offered by the forest which constitutes 65% of the territory (10).

Permanent constructions on common rangelands led to the abandon of the practice of "Agdal". Thus, pastoral and sylvopastoral resources are under continuous pressure.

The degradation of overexploited resources had a negative impact on the economic situation of the population, which depends on free natural resources.

The precarious economic situation has gradually led to the weakening of the "Jmaâ institution" and the decline of the community interest in conserving natural common resources. New social consensus took place, showing the outweighing of individualistic interests on the community interest. In fact, individualistic interests override customary rules and the law prohibiting any individual transaction or appropriation of common lands including rangelands (Article 4 of the *Dahir*<sup>5</sup> of 1919, governing common lands). This law stipulates in its first article that "Jmâas" (ethnic communities) cannot exploit or cultivate common rangelands since they are a common property of all members of the ethnic community.

#### ➤ **Arboriculture: the factor accelerating changes in land cover**

The introduction of arboriculture since the 1990s by urban investors was the factor accelerating the cultivation of common rangelands. Indeed, planted area increased from 5.45 ha to more than 53 ha between 1991 and 2010 (11). (fig 2).

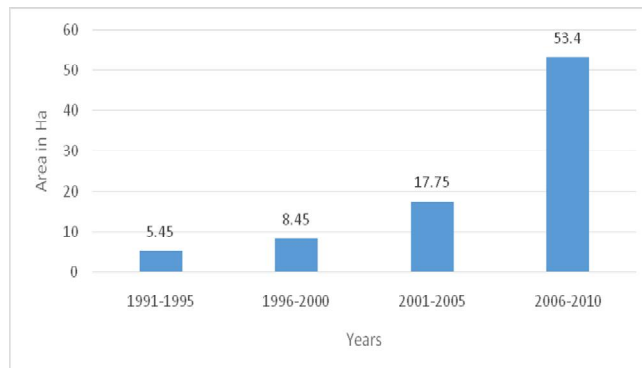
The profitability of this new agricultural speculation has then increased the prices of lands. Prices per hectare have increased from 7000 Dh (700 \$ US) before the introduction of arboriculture, to more than 120 000 Dh per ha currently.

<sup>4</sup>This pact allowed « El Hajjaj » to use rangelands of Ait Seghrouchen of Sefrou in Autumn-Winter season.

<sup>5</sup>Law in Moroccan legislation

This situation has stimulated breeders to sell parts of common rangelands to urban investors, even if customary rules and the *Dahir* of 1919 prohibit it.

The consequence is a drastic reduction of common pastoral area, leading to a loss of about 323000 Forage units / year. Breeders compensate this loss by the overexploitation of forest resources, especially trees, by the generalization of logging practice.



**Fig 2.** Evolution of arboriculture area in the territory of "El Hajjaj" between 1990 and 2010

#### 4. CONCLUSIONS

The present study allowed quantifying and explaining the changes in land cover in the territory of one of the ethnic communities in Central Middle Atlas in Morocco (*El Hajjaj*). One major transformation has been identified, namely the expansion of cultivated areas in common rangelands. This change is due to demographic and economic factors, leading to the disturbance of community-based management system of pastoral resources. Indeed, the pressure on natural resources and the precarious economic situation led to the raise of new social consensus meeting individual interests instead of common interests.

This situation results in an accelerated change of land use, especially after the introduction of arboriculture by urban investors, and a transgression of the law, but also traditional rules, prohibiting any individual exploitation of common rangelands.

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