Integration of remote sensing and GIS in the identification of the vegetation covers degradation of the korifla basin (NW of Central Morocco) between 1990 and 2018

D Lahcen* , N Hafida, M Souad, E H Rachid, Z Bejjaji, S Mohamed
Department of Geology, Faculty of sciences Ibn Tofail University Kenitra, Morocco

*Email : Dahmanilahcen92@gmail.com

Abstract. To characterize the evolution of the vegetation cover in the Korifla basin between 1990 and 2018, and subsequently to reconstitute, understand and explain the climatic and anthropogenic phenomena causing these changes, we adopted a methodological approach combining remote sensing techniques, geographic information systems (GIS) and statistical processing. This work consists of multitemporal satellite images at high and low spatial resolution. After the preprocessing and processing operations of these images and the calculation of the spectral indices NDWI (Normalized difference water index), NDVI (Normalized difference vegetation Index) and BI (Brilliance Index), we have developed multi-temporal maps of the vegetation, water and soil. The establishment and processing of land cover maps (LCM) through the use of the "change detection" application has allowed us to quantify the changes in vegetation cover during the last 28 years in the Korifla basin. As a result, the NDVI maps show that the vegetation cover of the Korifla basin suffered a degradation between the 1990s and 2010 against a regeneration between 2010 and 2018. This last increase is not detectable by the SVM method. As for the "change detection" technique, it confirms the regression of the areas of plant cover between 1990 and 2010 followed by an increase between 2010 and 2015 and relayed by a new regression of these areas between 2015 and 2018.

1. Introduction

Due to its geographical location on the western limit of the central Moroccan and near the coast, the Korifla basin is known for its dense forest cover and the quality of its agricultural land and also for its arid dry lands. It has experienced strong demographic growth for several decades, accompanied by changes in the landscape. These anthropogenic and climatic changes have affected the water, agricultural and environmental environments. They have made the environment vulnerable to erosion processes [1]. Knowledge of the degradation of the plant cover is essential information for the characterization of a region and therefore the development of appropriate management plans. It includes the vegetation (natural / cultivated) and land use / habitat (buildings, roads) that occupy the surface of the earth as well as hydrography [2]. This work is organized around three parts. The first introduces a presentation of the Korifla basin, its physical and human characteristics as well as land uses. The second is devoted to the identification of data, tools and detection methods used for the analysis of multi-temporal maps. The third part presents the results of comparative studies between the different methods applied for the different images and ends with a conclusion and perspectives.

The digital elevation model (DEM) produced for the Korifla basin shows that the latter extends, administratively, over most of the Zaer province and partially on the northern border of the Khouribga province. With an area of about 1847km2, it is located in the northwest of the Moroccan Kingdom, between latitudes 33 ° 10 'and 34 ° 00' North and longitudes 5 ° 56 'and 6 ° 54' West. It has a general slope SSE - NNW. Altitudes vary between 768m in the rural commune of OuladFtata...
and 213m at the city of AinAouda. Its capital is the city of Rommani. It is 77 km, on the road, from the Rabat city (Fig. 1). Physical characteristics of the Korifla basin.

In the Korifla basin, the high country is occupied by the tribes of Beni Kheiran from the Khouribga province. As for the intermediate and lower levels, they are populated by the Zaers tribes. Like all the tribes of central Morocco, the zaers had led a migratory life since the 16th century [1]. They began to settle down by changing, over time, their pastoral economic activity to agropastoral then to agricultural. In general, the distribution of the population in the korifla basin is largely influenced by their geomorphological characteristics. Indeed, the high country shows significantly lower popular densities (Lagnadiz, Oulad Ftata, Sidi Bettache and Laghoualem) compared to those of the lower plateau and the western limit of the basin (Ain El Aouda, Sidi Yahia Zaer and Sidi Bettache). For the communes of Rommani, Marchouch and Brachoua located to the east and north-east of the basin, they developed on the edge and at the confluence of the wadis (fig. 1).

Fig. 1 Human groups of the Korifla basin.

Itoasin belongs to Hercynian massif of the Moroccan central plateau [3] and [4]. It occupies the entire Palaeozoic massif of the Zaers, which is a vast bulge with an east-west orientation. It is shaped into: the Ezzhiliga plateaus, the Atlantic low plateau of Brachoua and Marchouch, the Rommani basin and the great valleys of the Korifla, Mediour and Akrechwadi [5], [6] and [1]. The geological formations outcropping in the study area are: Palaeozoic schist, sandstone and quartzite formations of the Khatouat-Ezzhiliga plateaus and valley bottoms; the Zaers granitic massif of; the Triassic of the Rommani basin with saliferous red clays with altered basaltic intercalations; Upper Miocene marls and molasses and of the calcarenites Upper Pliocene that cover most of the Nkeila-Brachoua and Merchouch plateaus. The study area is also characterized by the presence of conglomerates with limestone pebbles, pelites with ferruginous nodules gradually passing through alternating of pelites and sandstone banks, soils with ferruginous pisolites and also alluvium and colluviums.
The pedological peculiarity of the Korifla basin derives from the predominance of detrital or magmatic intrusive and eruptive rocks. In fact, the vast majority of the granite massif of Zaër is covered by the granite arena, consisting mainly of coarse-grained sand [7]. On the other hand, the results of the study carried out by the services of the High Commission for Water and Forests and the Fight against Desertification (HCWFFD), on the types of settlement of the Korifla forest, highlight various types of soils in the area. Korifla basin. Poorly developed soils dominate in forest environments, in cultivated land, in perennial lawns and even in rangelands. In second place, there are both fersialitic soils, calcimagnesic soils and isohumic soils [8]. The Korifla basin is drained by a hydrographic network made up of the Korifla and Mediourwadis which are tributaries of the WadiGrou. WadisLatech and BouDrader are the upper reaches of Koriflariver while wadisDeffa and Khanoussa are the upstream parts of wadiMediour. At the confluence of these two wadis is built the Arid dam with a reservoir of less than 50 million m$^3$.

The Korifla and Mediourrivers and its tributaries drain the study area following the general NNW-SSE inclination and meet at the confluence located to the northwest of the municipality of Brachoua before joining the rivers of Grou and BouRegreg to flow into the Sidi Mohammed Ben Abdellah (SMBA) reservoir. The latter has a retention capacity that varies between 426 Mm³ to 1025 Mm³ (Fig. 1). The eight stations chosen to characterize the climate of the Korifla basin belong to the Agency of hydraulic basin of BouRegregwadi (OBRHBA) network[9]. They are distributed, from south to north as follows: Lagnadiz, Laghoualem, Ezzheliga, SidiBettache, Rommani, Brachoua, SidiyahiaZaer and AinAouda (Fig. 1). The topographic situation and the continentality play a main role in the amount of precipitation received and the value of the temperatures recorded. Usually, these stations belong to a single warm temperate climatic zone. In winter, the rains are much heavier than they are in summer. The summer and winter seasons are well defined. The average temperature of the coldest month is below 18°C and the temperature of the hottest month is above 22°C. Similarly, the precipitation of the driest summer month (August) is less than 40mm and less than 1/3 of the hottest winter month. According to the Köppen-Geiger climate classification [10], these thermal and pluviometric characteristics classify the Korifla basin in the Mediterranean climate zone with hot summer.

Plant cover in the Korifla basin consists of forest, matorrals, reforestation, and herbaceous strata. The plant associations confined there are the Tetraclinisarticulata, which is the main natural species of the forest massif, accompanied by the cork oak and artificial formations of Aleppo pine and eucalyptus and cypress from the Atlas. These organizing species are accompanied by a floral procession made up essentially of the wild olive, pistachio, lavender, dwarf palm, Phylirea, Rhuspentaphylla and arbutus, etc. In the Korifla basin, the Korifla forest reaches approximately 14,195 ha in total area, with 6661 ha presented by the municipality of Brachoua, 1,945 ha exist in Marchouch and 5,589 ha are presented by the municipality of Sidi Zahya Zaer[8]. The region is rich in biodiversity; but it is undergoing an important process of degradation because of: the abuse of the right of use, illegal withdrawals for the city and for carbonization, fires and pastoral overexploitation. Also, it has lost many of its natural qualities due to cultivation activities in wet areas where original and endemic flora developed [8]. The conservation of the existing ones has prompted the HCWFFD to undertake, since the launch of the Green Morocco plan (2005-2006), operations to develop the Korifla forest with the aim of minimizing its degradation. Indeed, programs to restore this plant cover have involved several communes in the Korifla Basin [8].

According to the 2014 census, the Korifla basin has a population of 193,720 inhabitants, 68% of whom live in rural to semi-rural communes (SidiYahiaZaer, OuladFlata, Lagnadiz, Laghoualem, SidiBettache, Ezzheliga, Brachoua). The 32% of the population are concentrated in the urban communes of Rommani and Ain El Aouda. The latter shows the highest density, ie 25% of the total population of the Korifla basin. Overall between 2004 and 2014, the Korifla Basin recorded
significant demographic growth estimated at 58%. It is more pronounced in the western communes than in the eastern and southern communes. With the exception of the urban communes of AinAouda and Rommani, the main activity of the populations is agriculture. Everywhere, cereal growing dominates. Only the municipalities of the lower plateau show diversity of cultivated crops (legumes, market gardening, fruit plantations, fodder crops) and in opposition in the communes of the Zaers highland, cereal cultivation is relayed by that of the fallow [1].

Irrigated agriculture is very weak, due to the presence of a large dam reservoir, very downstream. However, an impressive development is be noted in the Rommani circle and in Marchouch. It is probably linked to the presence of the Arid dam, located further upstream at the confluence of the Khanoussa and Deflawadis. The livestock is preponderant in the economy of the Korifla basin. Large areas are cultivated to provide the necessary fodder. The rest is taken directly from natural plant cover or fallow land. The large numbers of herds pose the overgrazing problem, especially in the most vulnerable lands of the middle and upper plateaus. Goats represent a large part of the herds in the high Zaers country and the more arid lands of the southwest. Cattle, on the other hand, are mainly present in the northern fringe of the basin [1].

2. Methods

Studying the evolution of a natural or man-made phenomenon from a distance amounts to using satellite images. These taken at every moment of the day by the sensors on board satellites constitute a precious material to follow the changes of state of the various land uses over the decades or even centuries. To understand the dynamics of the degradation process of the vegetation cover in the Korifla basin between the years 1990 and 2018, we adopted a methodological approach combining remote sensing techniques as well as geographic information systems (GIS) and statistical processing. The equipment used consists of satellite, cartographic, climatic and field data and software [11].

Choice the period between 1990 and 2018 to analyze the dynamics of korifla basin coverage was directly linked to the images satellite availability of the study area downloadable from the USGS website; also the technical and mechanical condition of the sensor and the platform and the atmospheric conditions of image acquisition. The seven images chosen are those produced by the sensors on board the Landsat TM (Thematic Mapper) and OLI (Operational land Imager) satellites of the scene 195-56. These are the images of August from the years: 1990, 1995, 2000, 2006, 2010, 2015 and 2018 [11].

The preprocessing operations carried out on the seven images and the spectral indices calculation the, allowed us to develop multitemporal maps of vegetation (NDVI), water surfaces (NDWI) and soil (BI). The classification of the images of 1990, 2010 and 2018 by the SVM method (support vector machine) led to the establishment of land use maps of the Korifla basin. Subsequently, the comparison of the land use maps (SVM) with the field data acquired during the same period made it possible to verify the results, understand and explain the variations in land use in the area study. Likewise, the variations in the areas of the vegetation cover of these maps were interpreted by the climatic data of the korifla basin recorded over the period 1982 and 2012. The use of the “change detection” technique quantified the changes undergone by the vegetation cover surfaces during the last 28 years. Figure 2 below summarizes the methodology of the work that we followed to conduct this study on the Korifla basin for the period: 1990 - 2018.
Fig. 2 Methodology of the work that we followed to conduct this study on the Korifla basin for the period 1990 - 2018.

3. Results
The establishment of NDVI maps and their statistical treatment of the Korifla basin show an overall regressive variation in the area of forest cover between 1990 and 2010. It is estimated at 720 km², or 39% of the total area of the basin. During the period 2010-2018, the Korifla forest regenerated an overall area of 27% of the total area of the korifla basin, or an area of 490 km². This regeneration of the forest cover is probably favored by the combined and beneficial effects of nature and man. Indeed, between 2010 and 2018 the Korifla basin recorded large quantities of water and experienced the reforestation operations of the Korifla forest, launched since 2006 by the HCWFFD in the basin.

At the same time as this regressive evolution of forest areas, the agricultural land has recorded an increasing trend. Knowing that the dominant agricultural regime in the basin is pluvial, the extension of these lands in the perimeter of the Rommani, Marchouch and Brachoua communes could be linked to the Arid dam located upstream of these communes, as it could be at the origin of the exploitation of the wet forest lands existing in the basin. The land use maps elaborated for 1990, 2010 and 2018 show an overall decline in green areas while the others areas of development land, water and bare land have increased (Fig. 3). This increase reflects the degradation of the plant cover and the regression of edapho-climatic and geomorphological conditions as well as the demographic expansion that the Korifla basin experienced during these periods (Fig. 4).
The interannual comparison of NDVI and SVM maps show more or less the same results. Indeed, when the forest cover areas regressed between 1990 and 2018, agricultural areas suffered from deterioration. However, the increase in forest area detected by NDVI maps beyond the year 2010 is not detectable by the SVM method.

As with the information taken from NDVI and SVM maps, the “change detection” method confirms the decrease in forest cover areas between 1990 and 2010 and specifies the increase in the value of...
these areas between 2010 and 2015. Finally, this technique also clarifies the result provided by the SVM maps, that of a new regressive phase of green surfaces between 2015 and 2018.

4. Conclusion
Our study reveals the importance of using remote sensing to monitor, the spatio-temporal changes in land uses in the Korifla basin during the past 28 years. However, free satellite images with low spatial resolution and irregular temporal resolution do not allow us to deepen our study of the region. So, in order to carry out detailed and profitable work, we will need images with high regular spatial resolution and also complete climatic (temperature, precipitation, transpiration) and anthropogenic data (development plans, nature of irrigation ...) in order to establish a model of land use variations in the Koriflabasiasin and to be able to propose a participatory management of natural resources for the population of this region.

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