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Diachronic Analysis of the Forest Vegetation Dynamic in the Daïa-Saïda Mountains (Western Algeria) and the Identification of the Degradation Factors

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ABSTRACT

This scientific article focuses on the Daïa-Saïda Mountains located in Western Algeria, the purpose of this article is to study the forest formations dynamic where the forest vegetation is very representative of thermophilic groups of western Algeria, dominated by the Aleppo pine and Barbary cedar but with remarkable bushy undergrowth.
The results allow us to affirm the regressive dynamic of the forest in this area with the increase of matorrals and deforestation. The northern part of the massif is the most affected by this phenomenon with a very large bare area due to repeated fires that has affected it.
KEYWORDS: Monitoring, Forest dynamic, Daïa-Saïda Mountains, LandSat images, Degradation factors.

INTRODUCTION

Landscape patterns are the result of ancient, diverse and complex interactions between ecological and socio-economical systems; they occur both on short-and long-term time scales [1]. The evolution study of the land occupation and its use is interesting to focus on environmental issues and they are considered as basic information necessary to the planner [2].

The Mediterranean forests constitute a fragile natural environment, deeply disturbed by multiple uses. The aggressions are variable depending on the human demography and needs, determining the progression or regression phases of the forest surface [3]. In Algeria, these forests suffered a quasi-exponential regression, and nowadays are in a critical state [4], especially in western Algeria, where the forests of the Daïa Mountains are the last barrier against the desert advancing.

The study of the forest vegetation dynamics in the Daïa-Saïda Mountains using GIS and satellite imagery was considered to estimate the extent of degradation that has effected this very sensitive and important area; it is the last wooded foothills separating the steppe zone from the coast and provide the tools for effective and rational management of space. To this end, we conducted a diachronic study of two satellite images to analyse changes in the forest types of the studied area.

1. Description of the studied area

This study was carried out on the Daïa-Saïda Mountains, with their 23500 ha; it liesabout 25 kmto the west of Saïda (the province's capital). Administratively, it belongs to the commune of Ain El Hadjar(Figure 1) with an average altitude of 950 meters and a very rugged terrain where slope classes greater than 6% represents 26.35% of the surface(Figure 2).

The forest soils are dependent on the topographic morphology with five types with dominance of modal brown calcareous soils.

The region's climate is the Mediterranean semi-arid where the average annual rainfall was 436 mm during the period 1913-1938 [5] and only 353 mm between 1983 and 2012 [6], confirming climate variability with a clear trend towards aridity reported by several authors [7;8;9;10]. This trend to aridity should be considered in all development program and operations in the productive spaces [11].

The dry period lasts almost 165 days from the month of May until mid-October, with a Q_2 of 35.1; the bioclimate of the region is semi-arid with cool winter [10]. In the summer, the sirocco, appears on an average of 12 to 30 days per year [10], these hot winds, play a particularly important role in the initiation and spread of forest fires [12] and are extremely harmful to vegetation, both by their dryness capacity and destructive forces [13].

The vegetation of this region is very representative of Mediterranean thermophilic vegetal groups, dominated by Aleppo pine and Barbary cedar but with remarkable bushy undergrowth [14] with the oleaster

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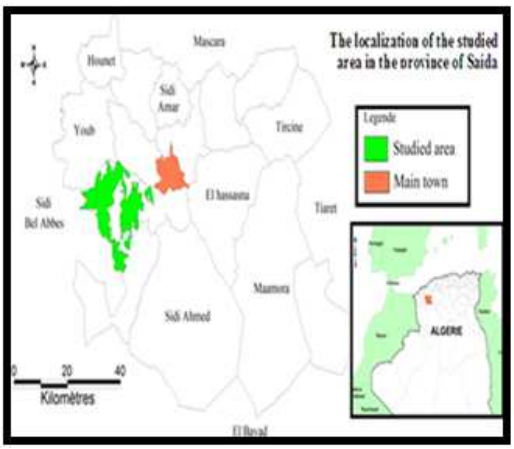
(*Olea europea* var *sylvestris*), the phyllaire (*Phillyrea angustifolia* L), mastic (*Pistacia lentiscus* L), kermes oak (*Quercus coccifera* L) and cistus (*Cistus villosus*).



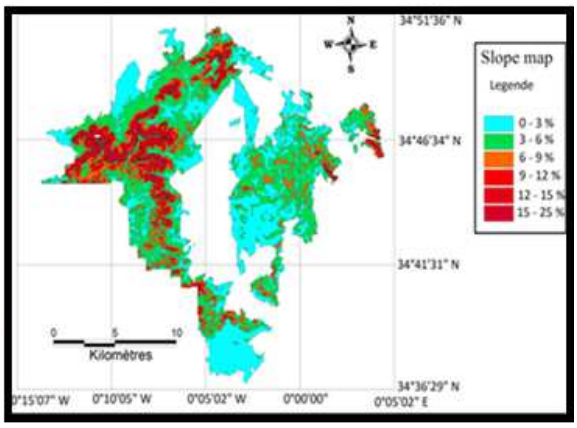


Fig. 1 (left): Localization of the studied area in the province of Saïda. **Fig. 2** (right): The slope map of the Daïa-Saïda Mountains.

2. METHOD OF STUDY

2.1. Image treatment

Our contribution is to use the satellite remote sensing techniques to study the forest formations dynamic (Bare soil and deforested land, matorrals, clear and dense forest (Figure 3)) in the Daïa-Saïda Mountains through processing and interpretation of two satellite images (1987 and 2015 LandSat images) with the development of the forest vegetation map of these two periods and the elaboration of the change map.

The processing of the satellite images was done after delimiting the studied area and eliminating all the outsider parts. A geometric correction including correction for geometrical distortions due to geometry variations in Earth-sensor and transformation of the data into true coordinates (eg latitude and longitude) in order to make the other layers of information superimposable.

The processing of this data was based on the use of the ENVI (*Environment for Vizualizing Images*) and the MapInfo software.

1- For 1987, with a Landsat 5 TM image acquired on the 28/07/1987, we proceeded to an unsupervised classification. The thematic identification of these classes is not known initially. We used a clustering algorithm called ISODATA "aggregation centers around mobile" [15]. This method was used to classify data of automated and logical at the same time which allows having a first representation of vegetation in our study area. The results were verified with the forest stand map established by the BNEF in 1990 [16].

2- For 2015, with a Landsat 8 OLI image acquired on the 13/08/2015, we have established a supervised classification. The classification is based on the knowledge of the regions defined by the user. The regions and the assigned class are relevant, which correspond to reality. We call such a set of data a ground truth. It is then possible to detect errors [17].

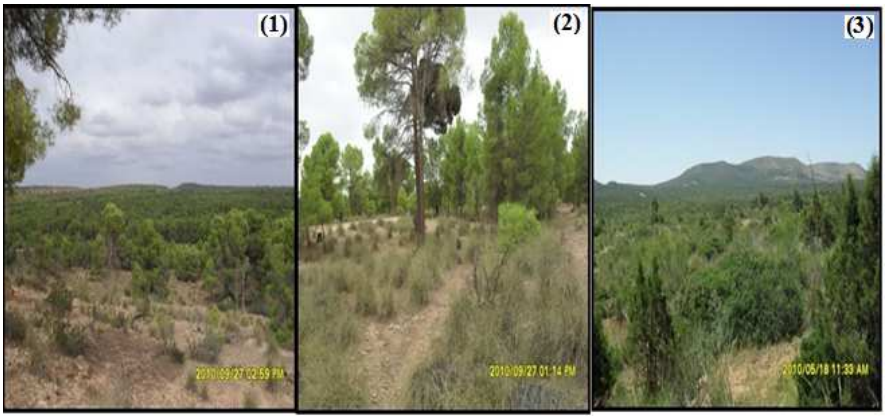


Fig. 3: Daïa-Saïda forest formations; (1) dense forest, (2) clear forest and (3) matorrals (Photos G. Kerrache)

3. RESULTS AND DISCUSSION

The comparative analysis leads to detect the changes that occurred on ecosystems resulting from human actions on its environment.

3.1. The situation in 1987

Following the establishment of various units of land use in 1987 (Figure 4), we can see that, over an area of 23500 ha, dense forests occupied 6203.98 ha or 26.39% of the space, clear forest 6902.3 ha with 29.36%, the matorrals 5145.6 ha covering 21.88% and the bare soil with deforestation 5255.5 ha or 22.35% of the space. According to the results, we can see that the forests occupied 55.75% of the studied area, degraded vegetation (Shrubland) occupied 21.88 % and 22.35% for the bare soil.

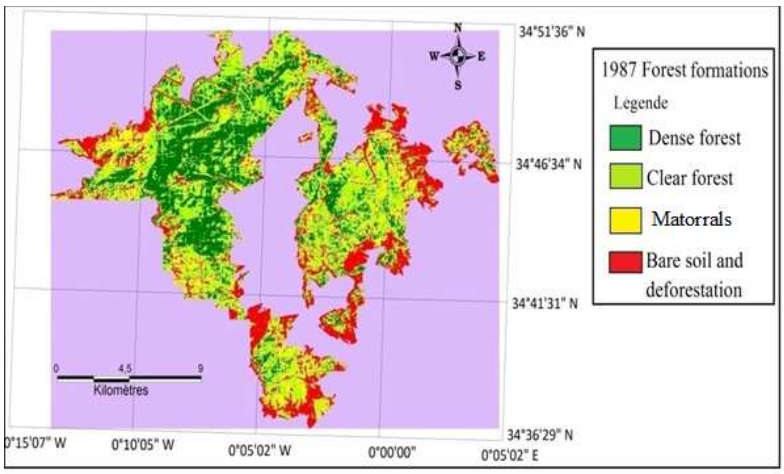


Fig. 4: The Daïa-Saïda forest formations in 1987.

3.2. The situation in 2015

Following the digitalization of various units of land use in 2015 (Figure 5), we can see that, dense forests occupy 5974.94 ha or 25.41 % of the space, clear forest 6366.73 ha with 27.08 %, the matorrals 5638.2 ha covering 23.98 % and the bare soil with deforestation 5527.7 ha or 23.51% of the space. According to the results, we can see that the forests occupy 52.49 % of the studied area, degraded vegetation (Shrubland) occupy 23.98 % and 23.51 % for bare soil.

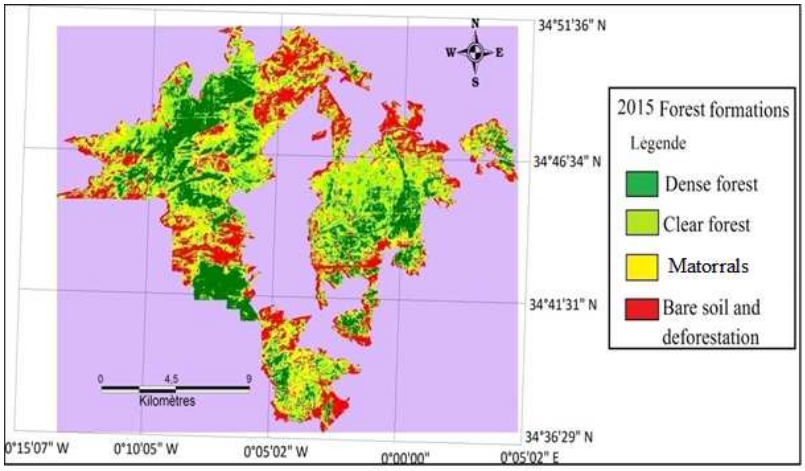


Fig. 5: The Daïa-Saïda forest formations in 2015.

These results allow us to affirm the regressive dynamic of forest in this area (Table I) with the increase of matorrals with 492.6 ha and deforestation with 272.2 ha and a remarkable regression of the dense forest (-229.04 ha) and the clear forest (-535.57 ha).

We note from Table I, a clear regression of the dense and Claire forests but the regression in the dense forest is very important with the loss of 535.5 ha this coincides with a sharp increase in degraded formations (Matorrals) and bare soil due to the negative action of the degradation factors in this region.

Table I: Forest formations change in the Daïa-Saïda Mountains from 1987 to 2015.

	1987	2015	Change
Bare soil with deforestation	5255,5	5527,7	+ 272,2
Matorrals	5145,6	5638,2	+ 492.6
Clear forest	6902,3	6366,7	-535.57
Dense forest	6203,9	5974,9	-229.04
Total	23507,5	23507,5	–

3.3. Degradation factors of the forest formations of Daïa-Saïda Mountains

Algerian forests like all Mediterranean forests, appears as a plant formation of which trees are in a state of continual struggle against drought and degradation factors. Given all the historical elements that marked and the pressures on it constantly, forests seems to slide quickly on the way to a gradual degradation of the main species and its replacement by the bush and matorrals[18, 19].In Algeria, forest vegetation cover is permanently subjected to aggressions of human and animal origin, which face the rustic vegetation despite its resistance faculties can no longer resist and maintain [14].

[20] in 1948,states that in the western region of Algeria, where the afforestation rate is only 9%, clearing through deforestation raged with particular intensity and all coastal chains are now bare. This situation has not changed since, and the degradation factors are the same such as forest fire, land clearing, erosion, windthrow, illicit cutting and overgrazing (Figure 6).

Considering that more than 12 million ha are subject to the action of water erosion in Algeria; climate, slope, lithology and lack of vegetation explain that nearly 2000 to 4000 t/km^2/year of sediment is ripped from watershed of the Atlas Tell [21], a specific rate of the watersheds erosion among the highest in the world [22]. In semi-arid Mediterranean forests, soils under forests are considered not susceptible to water erosion [23] but many forest lands are in a naked state and some steep slopes to forest vocation are cleared for the benefit of agriculture in Algeria, so the implementation of soil cultivation makes it susceptible to erosion.

Grazing areas are not defined, and the herd has to graze in the forest, suitable environment for cattle and sheep. The poor majority of the rural population has fallen back on goats and sheep as the main source of incomes. Pastoral charge is important, sheep are the most numerous but the goats yet much less represented, are most devastating, because they may feed on tree branches [24].

Fig. 6: The degradation causes in the forest formations of the Daïa-Saïda Mountains (land clearing, windthrow and overgrazing). (Photos G. Kerrache)

Of all the degradation factors, fires are the most devastating causing the total destruction of vegetation on site but in addition, it also alters the soil, disfigures the landscape and often compromises the plant recovery [14].

[25]said: 'Of all the causes of destruction threatening the Algerian forest, there is certainly no worse than the fire'. The Daïa-SaïdaMountains are a remarkable example where the northern part is the most affected by this phenomenon with a very large bare area due to the repeated fires (Figure 7) that has affected this part (the most important dates are 1994 with 2100 ha and 2014 with 1400 ha destructed by fire). We have to note also that an area of 880.8 ha of dense forest was completely burned down in the late summer 2015. [14], notes that with the current rate of destruction of the plant heritage by fire, in a century the forest vegetation will be destroyed.

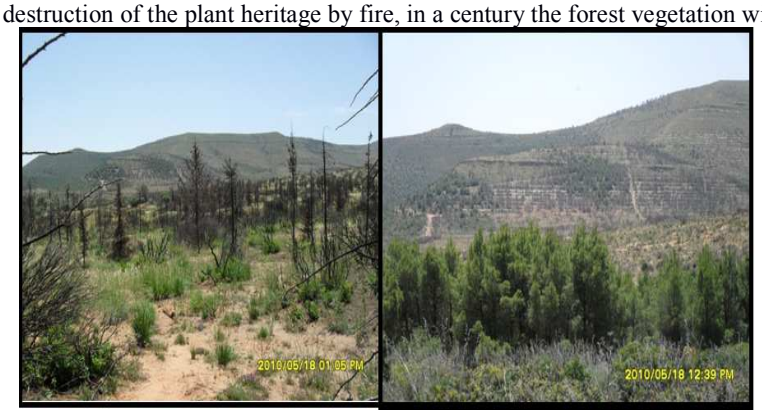


Fig. 7: The impact of fire on the forest formations of the Daïa-Saïda Mountains(Photos G. Kerrache).

3.4.Impact of premanagement works on the forest formations of the Daïa-SaïdaMountains.

Foresters themselves often have applied, exploitation and conservation techniques developed for European forests, techniques that can be disastrous in the Mediterranean area, noted [26].

One of those techniques applied in the Daïa-SaïdaMountains,is the forest premanagement; an ambitious program launched during the 70's, defined by [27] as, all operations with the objective of cutting the forest estate, its subdivision and its mapping to a computerized layout emphasizing the production function but taking into account the protection and recreation functions. Based on a geometric plotting, the premanagementworks has been established uniformly in a mountainous forest without establishing any preliminary study.With the following schema: First, transects of 4 meters wide are opened (with bulldozer) with 300 meters spacing in the east-west direction and 350 meters in the north-south direction. After a fraction of the primary network (transects) is extended to 8 meters to build forest roads. In the end, partitions are opened inside the parcels, open to bulldozer with a width of 3 meters and whose spacing is 25 meters.

Those works have generateda very large bare area (about 13.2%), that led to serious disasters,especially in particular conditions of the region (capricious weather, torrential rain, mountainous area, strong human impact ... etc.).

The openings of the premanagement applied on a Mediterranean mountainous region favour the flow of water,which is a potential source of erosion [28], the linear runoff leads to the creation of the claws and gullies which ravaged almost the majority of these openings (Figure 8), this is an intense erosion within the forest ecosystem supposed to be the most protective against this phenomenon.

Those openings have accentuated to the phenomenon of edge effect within the forest ecosystem and generating different observable phenomena in forest formations such as the proliferation of shrub species that vigorously resprout at the expense of potential species (The Aleppo pine) and the proliferation of *Cistus villosus* and species of the herbaceous stratum like wall barley (*Hordeum murinum* L), the barbed goatgrass (*Plantago lanceolata* L), *aegilops triuncialis*…etc., those species are highly flammable inducing and favoring the outbreak and spread of fires.

One result of the high penetrability of the forest is the increase in offenses, which was generally limited to forest interfaces (the outskirts of the forest), forest officials have recently noticed their resurgence within the forest area with the security improving and mainly the vehicular access to those areas, like the illicit cutting where this crime was totally absent during the période 1976-1987 but from 1999, this type of crime has multiplied with an alarming frequency, this type of crime is very harmful given the ecological and economic damage.

Fig. 8: Linear erosion ravaging the premanagement openings in the Daïa-Saïda Mountains (Photos G. Kerrache).

Conclusion

In this diachronic study of the forest formations of the Daïa-SaïdaMountains with the treatment and the classification of two satellites images of two periods, using remote sensing and GIS allows to have accurate information on the changes in areas of the affected land.

The main result of this study is the state of degradation of this region that suffers from many problems, which are the causes of its deterioration such as fire who is the main responsible of this situation combined with the land clearing, illicit cutting, windthrow, erosion and the overgracing.

This study highlighted the impact of poor management on the forest ecosystem in the Daïa-SaïdaMountains with de damages caused and amplified by the premanagement works in this region.

In the end, the issue of forest remain unsolved in Algeria, the forest sector is still struggling in a political and economic stagnation that prevents the development of effective policy, fires and overgrazing remain valid and the forest heritage is dislocated at the mercy of cyclical conditions [29].

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