LAND USE CHANGES BETWEEN 1972 AND 2020 IN THE BENI SAF REGION (ALGERIA)

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Abstract *The protection of vegetation of any region needs an advanced diagnosis to identify the nature and the causes of degradation. Beni Saf, an Algerian region situated in the North West has been subject to a degradation of its ecosystems.The ecosystem is known for its diversity, biogeography and typical Mediterranean climate. The objective of our work is to identify the natural and anthropogenic processes which modify the structure and the use of the land. Based on GIS analysis, the vegetation's spatial and temporal change at two points in time (1972 and 2020) were studied. The analyses allowed us to see major changes within 48 years. The comparative study showed an expansion of woods replacing bushes. The surface of the latter changed from 2814 hectares in 1972 to 1530 hectares in 2020. It decreased by about 21%. Besides, there was an extension of cereal culture of 2069 hectares in 1972 to 1959 hectares in 2020 with a decrease of 2%.Indeed, a spatial and temporal development plan of the forest and agricultural territory of the study area will be proposed in order to suggest a development of the territory in the future; In order to reach the harmonious balance of the use of the space which is partly based on the aptitude of the grounds.*

Keywords: *Vegetation; Land use; Beni Saf; Anthropic; diachronic; GIS.*

INTRODUCTION

The Algerian forest, like other forests in the Mediterranean, plays a vital role in the physical, biological and economic balance of our country. This forest offers a landscape which reflects the particulars of its relief and climate. Man is responsible for the degradation of this forest by several harmful phenomena such as the extension of agricultural land, repeated fires and overgrazing (F.A.O. 2013).

The comparative diachronic studies on the north shore, according to (BARBERO *et al.*,1990), carried out in the north-Mediterranean, following the changes that have occurred on the green oak groves over 10-20 and 25 years in the disturbed zones show an acceleration of the processes of architectural organization and a continuous increase of the floristic richness reflecting well the capacity of all the stations to support more species and amplified plant production. The diachronic analysis highlights the serious transformations of our environment over time. Old photos are an important source when looking at the last century of evolution (LEPART *et al.*, 1996). It is important to think about the reintegration of degraded ecosystems into the landscape. It is an essential step in the restoration strategy, in addition to the choice of the technical objectives of the intervention (ARONSON *et al*., 1993). In this context, this study was carried out on a fragile natural environment in Beni Saf region, which has been disturbed and degraded by several natural and anthropogenic factors.

In order to deepen the knowledge of the spatio-temporal change of the vegetation in this region, two land-use maps were elaborated from old aerial photos taken in 1972 and a satellite image (Landsat 8 TM) in 2020. The objective of this study is to better understand and

take into account natural and anthropogenic processes that modify the structure and use of the territory, through a geographic information system (GIS).

MATERIALS AND METHODS

- Study area

The study area with a surface of 6162 ha is situated in the region of Beni saf in the North-western coast of Algeria (Figure 1). It is characterized by two types of reliefs : the Beni Saf massif which culminates at 409 m at Jebel Skhouna and the Tafna valley on its right bank with a relatively flat topography that extends to the end Western area of the study zone. The soil is generally very heterogeneous. The brown limestone soils and Poorly Evolved Soils of colluvial deposits occupy the region.

The type of climate is Mediterranean with a bioclimatic semi-arid scale. Its winter is warm. The average annual rainfall is 360 mm. The average monthly temperatures are around 10 ° C for the coldest months (January) and around 31°C for the warmest months (August). Béni Saf, like the whole Mediterranean region, is characterized by very important biodiversity in terms of flora, where the therophytes represent 41% of all the existing vegetation (MERIOUA *et al*., 2013, b).

The Mediterranean region in general and the Maghreb, in particular are characterized by a richness of therophytes. These species with a short life are the most adapted to the aridity of the climate and resilient to water stress in summer. (STEBBINS 1952, STEBBINS AND MAJOR,1965). Thus, the Mediterranean basin is an important reservoir of plant diversity. The types of natural vegetation found in the Mediterranean lands are not only controlled by the different bioclimatic types but also by local variations in temperature and rainfall. (ZAHRAN, 2010). The third factor in the hierarchy of determinants of the distribution of plant diversity in forests is soil conditions. This term by itself integrates a variety of different factors that contribute to plant diversity, and global generalizations are unlikely to be satisfactory. (LUND *et al*., 2004).

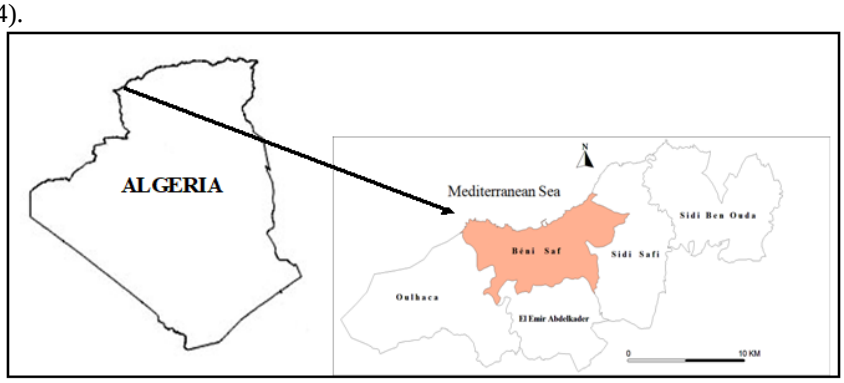

Fig. 1. Location map of the study area (MERIOUA *et al*., 2013, a)

The forest area is of 3012.8 ha (Figure 2 and Figure 3) where woods cover 1012 ha. The *Pinus halepensis* stands represent 98% whereas the *Eucalyptus camaldulensis* represents only 2%. These two species constitute the main species used in reforestation, which have taken the place of vegetation consisting of more or less dense matorrals (pinewoods), based on thermophilic species. The vegetation is the result of the integration of floristic, climatic, geological and geographical factors (LOISEL, 1978).

The matorral generally occupies the whole of the coastline with an area of 470.8 ha. It represents a formation of thorny and spiny vegetation dominated by Therophytes. The lower or herbaceous stratum consists essentially of: *Urginea maritima, Asphodelus microcarpus, Ferula communis* and other species. Bushy formations represent 1530 ha. Much of them are degraded. They are found throughout the region in the west, east and south. They are composed of *Calycotome spinosa, Calycotome villosa, Chamaerops humilis, Ampelodesma mauritanicum, Asparagus acutifolius, Rosmarinus officinalis, Cistus albidus, and Lavandula multifida* ect. (MERIOUA *et al*., 2013, b).

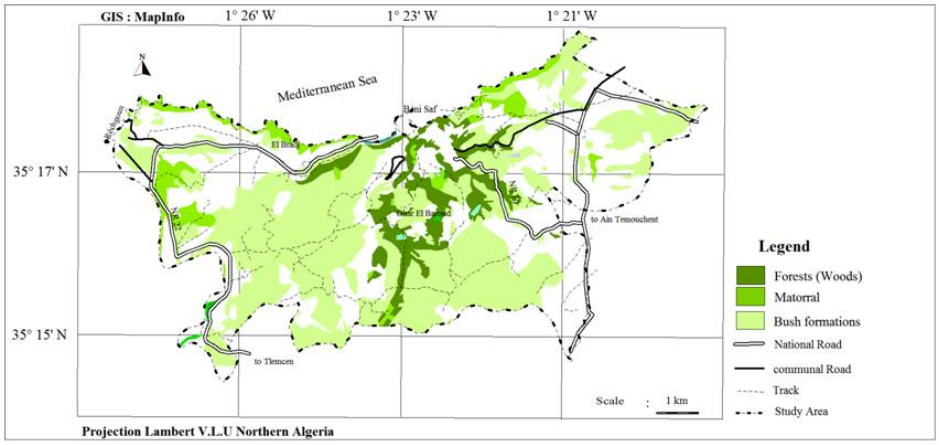

Fig. 2. Map of forest formations (year 1972)

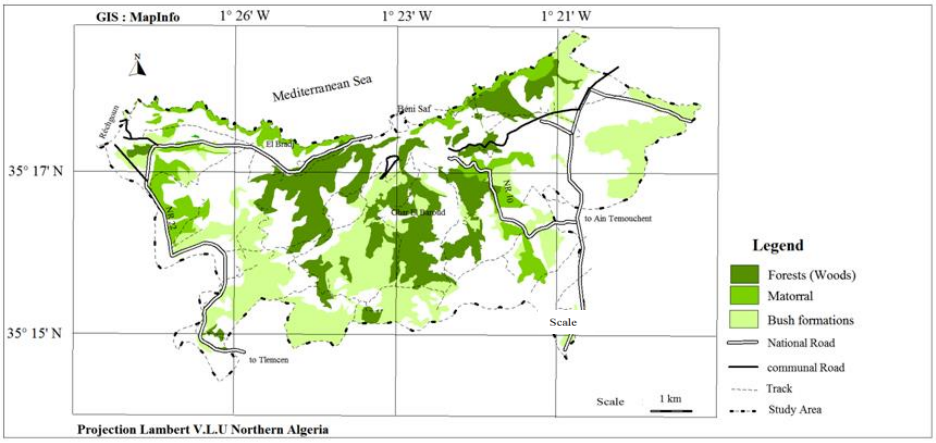

Fig. 3. Map of forest formations (year 2020)

- **- Image analysis**

The analysis concerns the assessment of the degradation state of plant formations in the region of Beni Saf. A mapping study linked to a diachronic analysis is required for the assessment and monitoring of spatial and temporal changes. In order to reveal spatially and quantitatively the changes occurring during the time, it is necessary to refer to the topological combination of the two coverages carried out over two periods (1972 and 2020). For this purpose, two land use maps of the study area (Figure 4 and Figure 5) were established. The

first one was based on aerial photos at scale 1: 20 000 in 1972. The second one was based on satellite images (Landsat 8 TM) on 28 June 2020 (frame 199-036).

This work enabled a diachronic study of the vegetation dynamics. Both methods require visual interpretations of the photos and images, followed by subsequent field observations to validate and confirm the data. This analysis allowed us to reconstruct the qualitative and quantitative changes in this zone between 1972 and 2020. Aerial photos are the only source available for mapping land use at remote dates of the study area.

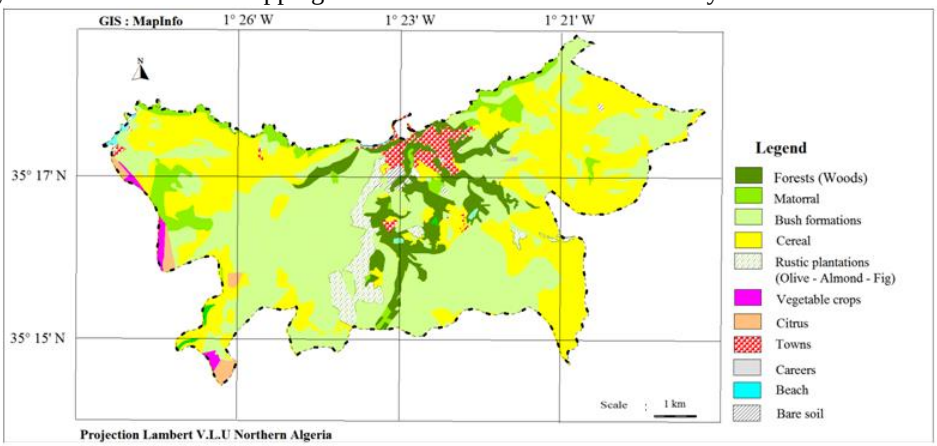

Fig. 4.Map of land use in the area of Beni Saf (year 1972)

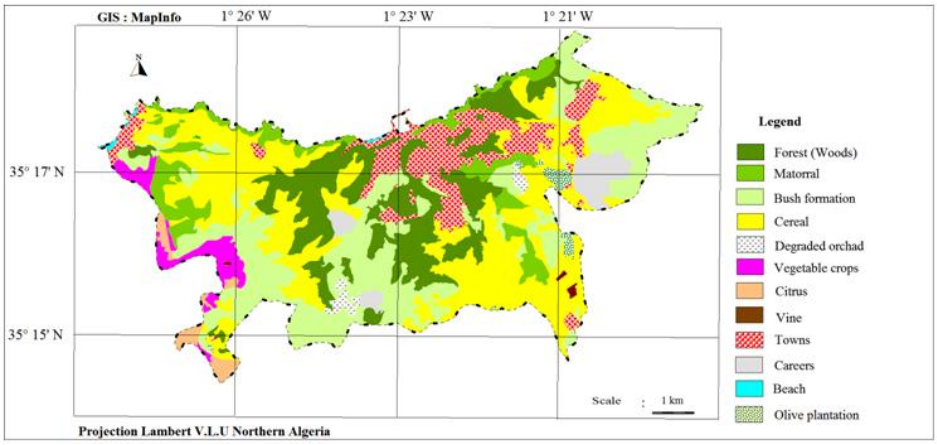

Fig. 5.Map of land use in the area of Beni Saf (year 2020)

The compilation of this map was carried out using the classical method, which consists in gathering a series of aerial photos. A photo-interpretation operation was then made in order to delimit natural areas and human activities (forests, agriculture, town planning, etc.).

The studies, carried out using Landsat TM images, generally selected the three channels that were best for discriminating forest types: a near-infrared channel TM4, an intermediate channel TM5 and a Visible TM1, TM2 or TM3 (DURRIEU, 1994). For this purpose, the choice was made on the channels: TM5, TM4 and TM3 (Color infrared). This choice was based on the significant spectral correlation between these channels, which also

allowed the visualization of the image in colored compositions (red, green and blue "RGB") that optimized the information for the interpretation of the thematic content of the Landsat TM image.

Corrections were made in the classification phase of the image to relate the radiometric values to thematic classes which characterized the occupation of the ground. It was the supervised approach that was used on the basis of the duly identified sites: forest formations, agricultural land and other places of human activity which were digitized in the form of different geo-referenced layers on the Landsat TM satellite images after being processed and called (Radiometric and geometric correction) under the ENVI 4.2 and Image pre-processing, classification and spatial analysis were done using MapInfo 8.5 software.

The GIS was designed to study synthetic human activities and natural environments distributed throughout the territory (FCBN, 2006). The target objectives aimed to a better understanding of natural and anthropogenic processes that alter the structure and land use (THÉRIAULT, 1996).

From these cartographic and statistical results, it was possible to make a thorough analysis of the facts of evolution over 48 years of land occupation in this region of Western Algeria. Many primary product verification missions were carried out on the study site to check the various themes recognized on the maps, already designed at the office, and to evaluate the quality of the results obtained. Transformations from one unit of land use to another were assessed through the reduction or increase of the initial unit surface to realize a balance sheet per unit. Thus, a deep analysis of each change was made and explained from the location of this change. The operation consisted in superimposing the data of 2020 with those of 1972. The data resulting from this crossing were exploited in order to highlight the changes obtained between the two dates.

RESULTS AND DISCUSSIONS

The study of the maps and the histogram (Figure 6) revealed that woods areas have increased from 477.70 ha in 1972 to 1012 ha in 2020. This expansion is mainly due to the efforts of forest services in protecting the watershed through various techniques of reforestation where the *Pinus halepensis* constituted the main species.

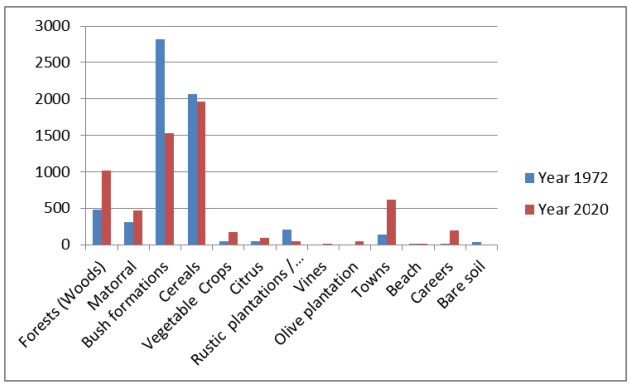

Fig. 6. Diachronic representation of land use (1972 and 2020)

The climatic variations and anthropogenic pressures have caused these stands and the appearance of resistant species. These species include *Chamaerops humilis*, *Ampelodesma mauritanicum*, *Calycotome spinosa*, *Chrysanthemum coronarium*, *Asphodelus*

microcarpus, Urginea maritima, Ferula communis, Calycotome spinosa, Asparagus albus, etc. The manifestation of a certain imbalance and degradation of the vegetation was characterized by the presence of species such as *Ampelodesma mauritanicum , Chamaerops humilis* Subsp. *argntea, Urginea maritima , Asphodelus microcarpus , Ferula communis*. (QUÉZEL *et al*., 1992).

The importance of the bush stratum was a sign of considerable degradation often reaching the irreversible stage. The IP perturbation index calculated for the study area was very high, it was about 68% (MERIOUA *et al*., 2013, b).This disturbance and imbalance of plant populations were caused by a strong anthropogenic pressure (LOISEL, GOMILA 1993, FAO 2013). In addition, fires are a major disturbance of the Mediterranean landscapes. They were linked to intense anthropogenic pressures, but also to the xerophytic and pyrophytic nature of the vegetation (DELABRAZE, VALETTE 1974, LE HOUEROU 1980, TATONI AND BARBERO 1990).

The matorral area has a slight increase between 1972 with 307.30 ha and 2020 with 470.80 ha.This vegetation generally occupied the coastline. *Olea europaea , Ceratonia siliqua and Pistacia lentiscus* were the main species of this unit. It was found spontaneously in the study area, mixed with a few feet of *Pinus halepensis*, and constituted a preformation of a forest with, *Asparagus* , *Calycotome* , *Lavandula dentata*, *Withania frutescens*, etc. Thus, the presence of *Ampelodesma mauritanicum* and *Chamaerops humilis* generally reflected stages of degradation (Quézel 2000).This preformation underwent a process of maturation, which led to the formation of low and thorny vegetation dominated mainly by therophytes with a rate of 41% (Merioua *et al*., 2013, b).

This therophytisation was a form of resistance to drought and a stage of ultimate degradation of the vegetation (SAUVAGE 1961, GAUSSEN 1963, NEGRE 1966, DAGET 1980, QUÉZEL 2000, BENABADJI, BOUAZZA 2000). Changes in the floristic composition, in particular, the abundance of therophytes were linked to the increase in luminosity at the level of the lower strata (FLORET *et al*., 1992).

The occupation by bush formations underwent significant changes from 2814.12 ha in 1972 to 1530 in 2020 (Table 1, Figure 6) with a reduction of around 21%. It was justified by the extension of woods (reforestation), town planning and quarries. Fires and clearing left a strong mark on the physiognomy of this type of vegetation, particularly in the South and East of the study area. A large space of bush formations was transformed into cereal-growing tracts or fields. The arable crops, generally cereals, decreased from 2068.90 ha in 1972 to 1958.73 ha in 2020 (a decrease of almost 1.79%) instead of bushy formations. Vegetable crops with a favorable space on the banks of the Tafna River increased by almost 172.70 ha. On the other hand, the area occupied by rustic plantations such as almond, fig and olive trees decreased from 208.30 ha in 1972 to only 48.20 ha in 2020 due to the lack of water resources at the level of the zone.

Table 1

Statistical comparison of changes in land use

Designations	**Year 1972**		**Year 2020**		**Yaw**
	area (ha)	**Rate**	**area (ha)**	**Rate**	
Forests (Woods)	477.70	7.75%	1012.00	16.42%	+8.67%
Matorral	307.30	4.99%	470.80	7.64%	+2.65%
Bush formations	2.814.12	45.66%	1.530.00	24.83%	-20.83%
Cereals	2.068.90	33.58%	1.958.73	31.79%	-1.79%

Vegetable Crops	43.50	0.71%	172.70	2.80%	+2.09%
Citrus	46.30	0.75%	88.73	1.44%	+0.69%
Rustic plantations / Degraded orchard	208.30	3.38%	48.20	0.78%	-2.60%
Vines	-	-	8.10	0.13%	-
Olive plantation	-	-	48.01	0.78%	-
Towns	137.10	2.22%	619.80	10.06%	+7.84%
Beach	15.11	0.25%	15.53	0.25%	0.00%
Careers	7.50	0.12%	189.40	3.07%	+2.95%
Bare soil	36.17	0.59%	-	-	-
Total	6162.00	100.00%	6162.00	100.00%	-

The area of citrus remained constant for 48 years; this type of cultivation is also on the banks of the Tafna River. The vineyards occupied an important area before 1972 in the zones of El Bradj and Gaadet El Ghozlene, as evidenced by the existence of cellars. During the 1970, these species were replaced by cereal crops. At the beginning of the year 2000, vineyard cultivation was restored in the region by a few winegrowers. It extended over a few hectares (8 ha). Urban landscapes and secondary agglomerations witnessed a significant increase. This area occupied 137 ha in 1972 and 619.80 ha in the year 2020, a difference of 482.80 ha. The demographic factor and the development of the industrial fabric seem to be the main causes.

CONCLUSIONS

Human activities have been modifying natural habitats and the spatial distribution of species for thousands of years and have thus played a key role in shaping recent and contemporary evolutionary pressures in natural populations. The impact of human activities stems from their effects on both the ecological conditions within habitats, which shape natural selection pressures and adaptive variation, and the spatial configuration of habitats in the landscape, which determines gene flow and seed dispersal. By modifying the action of selection and gene flow, human activities have become a key element of the process of population differentiation. (THOMPSON, 2005).

In the cartographic framework and through the GIS, the areas occupied by plant communities, agriculture and town planning, etc., during two well-defined periods 1972 and 2020, witnessed many changes. The natural plant space, like the bush formations (natural vegetation) of the study area, decreased by almost 21%. They were invaded by the urban fabric, agricultural land and reforestation (an increase of 10%). The phenomenon of degradation left a strong imprint on natural environment in the region of Beni Saf. Indeed, the vegetation underwent an increasing degradation caused by several natural agents such as the aggressiveness of the climate (irregularity of the rains), in addition to the human activities such as fires, overgrazing, clearing, urbanization and pollution. In fact, these conditions gave birth to bushy formations (Matorrals) with resistant species colonizing the natural environment and replaced the woody which became too fragile. Among these species: *Chamaerops humilis, Ampelodesma mauritanicum, Calycotome spinosa, Chrysanthemum coronarium, Asphodelus microcarpus, Urginea maritima, Ferula communis. Calycotome spinosa, Asparagus albus*, etc. justified the degradation of nature. The protection and valorization are the main solutions to revitalize the structure of these stands which are menaced.

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