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EVALUATION AND ANALYSIS OF FOREST DYNAMICS OF THE FOREST OF BENSLIMANE, MOROCCO

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Abstract- ***The Benslimane forest extends in north of Benslimane city over a rough area of 12 262 hectares. It to be part of the geographical region of the Atlantic cork oak forests.The present study, based on the use of space remote sensing and systems of geographical information (SIG), has as main objective to detect forest dynamics in the forest massif of Benslimane composed in most cases of the cork oak, Tetraclinis and secondary species.This Study allowed the elaboration of the maps of evolution of the benslimane forest, during last 20 years (between 1994 and 2013), by being based on two different methods from treatment of satellite images multidate (Landsat TM and Landsat 8): the calculation of the index NDVI and the classification object-oriented (C.O.O.).The technical of C.O.O. proves to be the best according to comparison between both methods. The approach of the dynamics of the plant communities is performed due to the superimposing of the negative and positive coats of evolution with the map of stands types, established in 1994-1998.***
After verification field, we elaborated the parcel evolution map of the stands.In the light of acquired results, it has been found a decline of 35 % of the area of cork oak (Qs) and 50 % of the area of Tetraclinis in comparison with their initial areas in 1994. So, the forest stand of Benslimane forest had in course of time a negative dynamics. Thing which imposes immediately the installation of a management strategy of this so precious national natural heritage.

Keywords – remote sensing; SIG; deterioration; forest dynamics; NDVI; C.O.O; evolution; decline

I. INTRODUCTION

The Moroccan forest covers about 9 million hectares, and offers remarkable diversity of flora and fauna as well as its important socioeconomic role. However, it is subjected to a strong pressure causing deterioration of forest ecosystems and perished-forest manifesting through deforestation (31.000 hectares / year), dams siltation (annual loss of storage capacity of 50 million of m3 equivalent to irrigate 5.000 to 10.000 hectares, the decrease of forage potential (loss of 4,8 million UF / year) as well as the loss of agricultural production (22.000 hectares of arable lands) and ecosystems simplification (biodiversity loss).

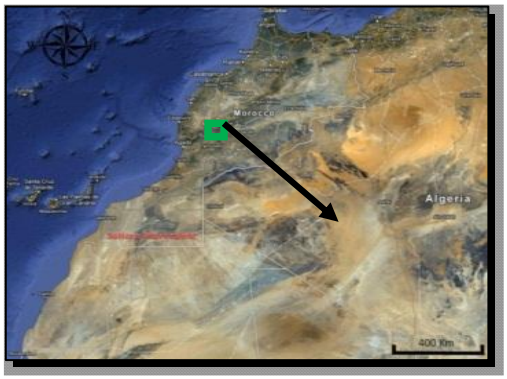
Among noble species of Morocco, there is cork oak; endemic specie underMediterranean climate, extending over important areas in the party north - western, since the lowlands of the coastal region to in Rif Central and the Medium Atlas.

The forest of Benslimane is one of the most important forests of cork oak in Morocco. It is characterized by a flora offering a common biological spectrum to the flora of Morocco, located in the Mediterranean-Atlantic floristic area. It is composed mainly by cork oak stands,Tetraclinis and the secondary species who reflect the result of the correlation of the various factors of physical environment, ecological and socioeconomic causing the current status of this biological association. However, it knowsdeterioration due to combined actions of drought and multiple pressures from overexploitation of this forest ecosystem.

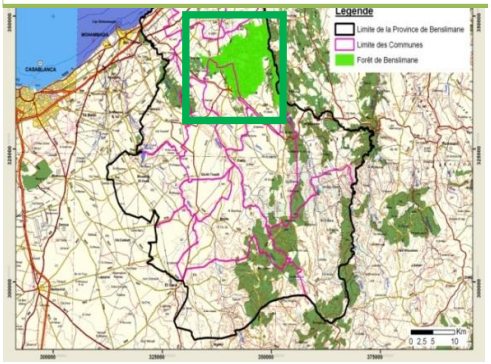
The present study based on the use of remote sensing and systems of geographical information (SIG), has as objective, the detection of the stands evolution of Benslimane forest during last 20 years (between 1994 and 2013).

II. MATERIALS AND METHODS

II.1. Presentation of the study area



Map of geographical situation of the forest of Benslimane



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The forest of Benslimane extends north of the city of Benslimane, on a rough area of 12262 hectares.

On geographical plan, it is located between Rabat (administrative capital of Morocco) and Casablanca (economic capital of Morocco), almost in 25 Km in the South of the freeway linking both capitals. It is restricted in the East by the Wadi Cherrat, on the West by the agricultural fields of the rural district of Fedalate, to the South by the agricultural fields of the rural district of Ziaida and to the North by the agricultural fields of the rural district of Bouznika.

The area is located in a semi-arid bioclimatic, except for the coastal band (Bouznika-Temara) which is subjected to a bioclimatic wet. The average annual rainfall is in the order of 401 mm. it's a very soft pen plain, exposed north-west, whose extreme altitude not exceed 280 m. The most encountered geological formations are shale, sandstones and quartzite of the primary base, red clay triassic, limestones, marls, sandstone, sandand quaternary silts.

II.2. Available data

- Maps and planning documents of Benslimane forest, 1994-1998;
- Satellite images: Landsat TM and Landsat 8, used were; obtained from the website http: // glcf.umd.edu / date/.;
- MNT of the region, Downloaded free (http: // www.usgs.gov/);
- Topographic map, Benslimane sheet (1/50 000, on 1986) and SidiBettach sheet (1/50 000, on 1986), georeferenced projection cone complies lambert;
- Geologicalmap, Casablanca-Mohammedia 1/100 000 ;
- GPS data on the boundary of the study area (2013);
- Notebooks consignment forest offenses 1994-2013;

II.3. *Methods of treatment and analysis*

- The method adopted for remote sensing, is based on two techniques different from treatment of satellite images multidates (Landsat TM and Landsat 8) which allowed a spatiotemporal monitoring of the dynamics of the studied forest; namely the calculation of the index NDVI and the classification object-oriented (C.O.O.). The validation of results is performed by visits of ground.
- For every technical, a map of the vegetation dynamics of the forest of Benslimane is established for the analysis and the estimate of forested evolution for period 1994 - 2013, or 20 years old from the comparison of the recent state of forest and its reference state of 1994. Four big classes were selected for the elaboration of the evolution map :
- Areas having evolved positively (progressive evolution): non-forested land that have evolved to forest (caseof reforestations or repopulations) or only increasing density of forest stands throughout lumbering, or merging of secondary species;
- Areas having evolved negatively (regressive evolution): transformation of the forest to non-forest lands, case of decrease in density by deforestation, etc.
- The stable areas: areas whose vegetal cover has not changed for the period (1994 -2013);
- Lack of vegetation in the two dates: areas where the canopy is absent between the two dates (1994-2013);
- The results of treatments allow elaborating matrices of change which show changes intervened in surfaces. The columns of the matrix introduce surfaces by type of change to the initial state (1994), while lines point out the surfaces of entries for 2013.
- Choice of the best method and validation of results on the ground. We granted a close attention in the analysis of results and check on the ground to have a real interpretation of different types of change intervened in of the forest.
- Extraction by mask of the map of change acquired by C.O.O. by differentiating between both cantons of cork oak and Tetraclinis (without considering plots composed only of secondary species , artificial plantations and enclaves.)
- Calculating the change by canton.
- Evolution by plot: All plots of the forest were visited, their present state was compared in with their state of 1994, described in the document relating to plot description, established during the study of plan of Benslimane forest management (1994-1998).This, allowed us to establish map of parcel evolution of Benslimane forest.

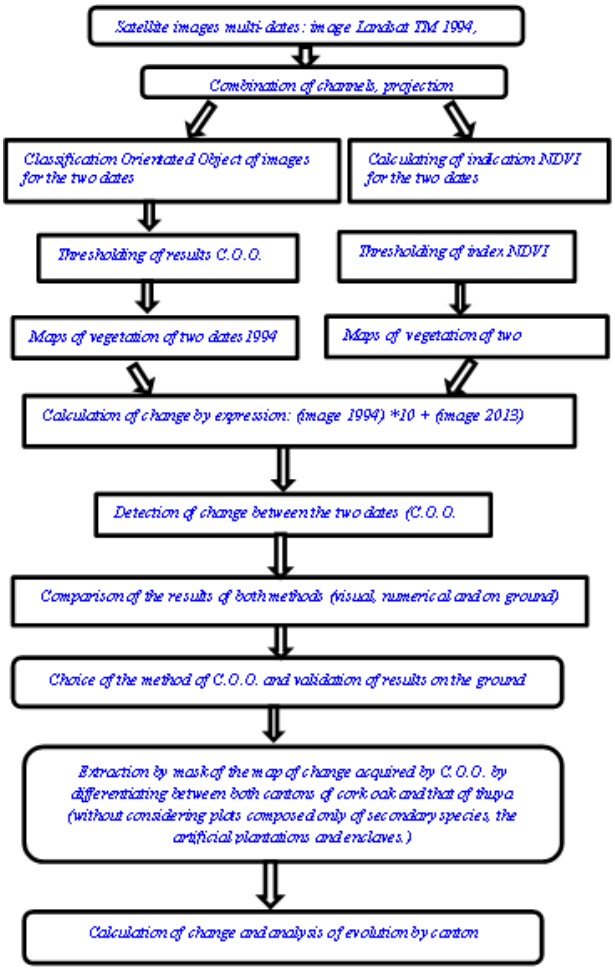

Fig. 1: Methodology of work

III.RESULTS AND DISCUSSION

III. 1. Cartographic presentation of the results obtained

The merging of partial results from different stages of classification allowed us to acquire from maps of vegetation (Figures 2, 3, 4 and 5).

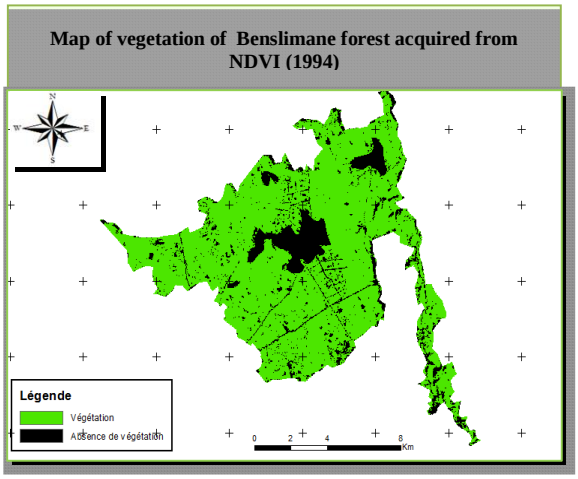

Fig.2: Map of vegetation of Benslimane forest acquired from NDVI (1994)

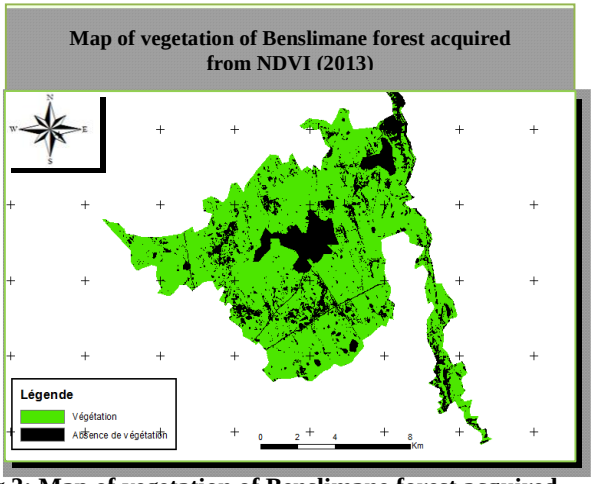

Fig.3: Map of vegetation of Benslimane forest acquired from NDVI (2013)

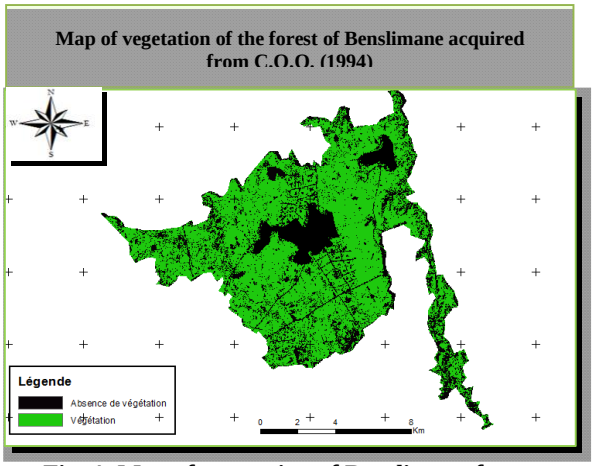

Fig. 4: Map of vegetation of Benslimane forest acquired from C. O.O. (1994)

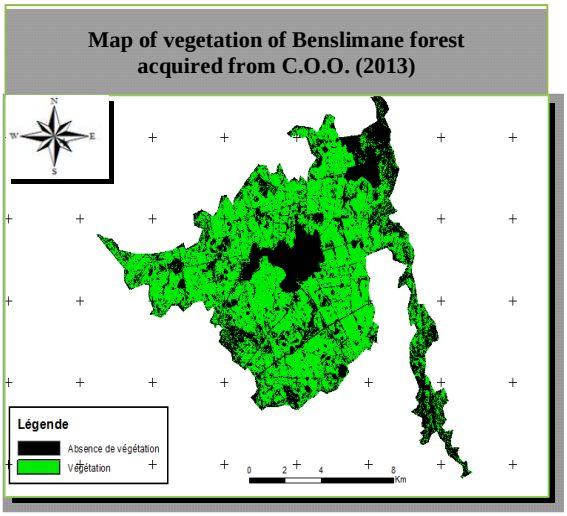

Fig. 5: Map of vegetation of Benslimane forest acquired from C.O.O. (2013)

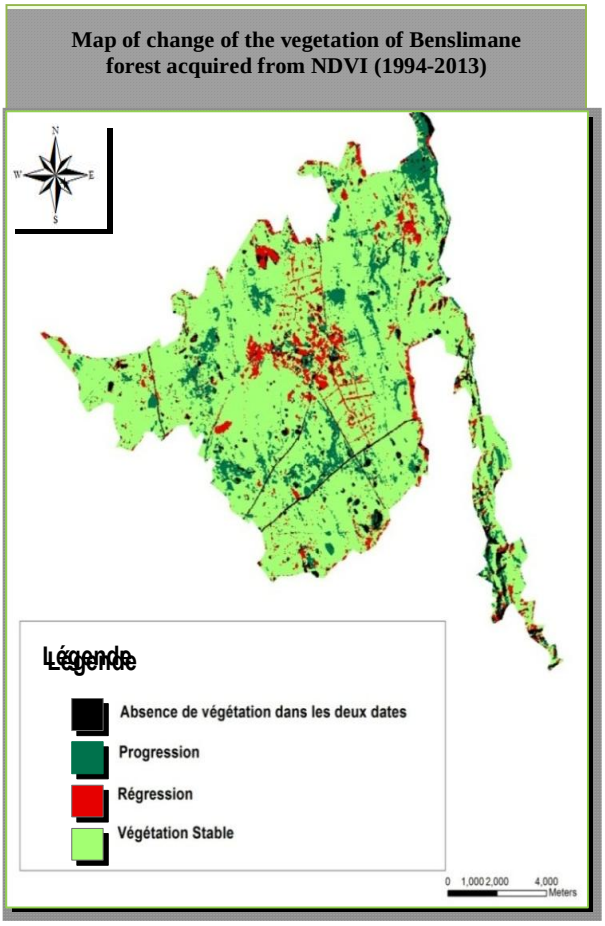

Fig. 6: Map of change of the vegetation of Benslimane forest acquired from NDVI (between 1994 and 2013)

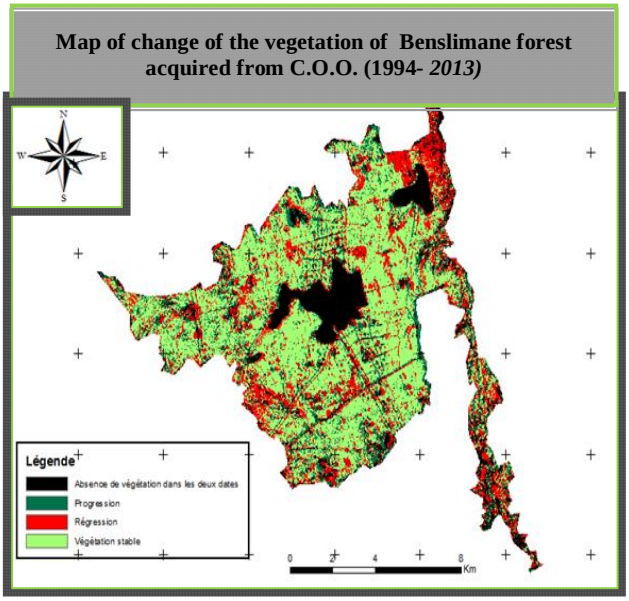

Fig. 7: Map of change of the vegetation of Benslimane forest acquired from C.O.O.(between 1994 et2013)

Table I: Matrix of change NDVI (in number of pixel)

Image *NDVI on 2013* / *Image NDVI on* 1994	**Presence of vegetation**	**Absence of vegetation**
Presence of vegetation	119772	13119
Absence of vegetation	19776	7707

Table* II: *Matrix of change C. O.O. (in number of pixel)

Image C.O.O. on 2013 / Image C. O.O. on 1994	**Presence of vegetation**	**Absence of vegetation**
Presence of vegetation	78846	36809
Absence of vegetation	22143	22576

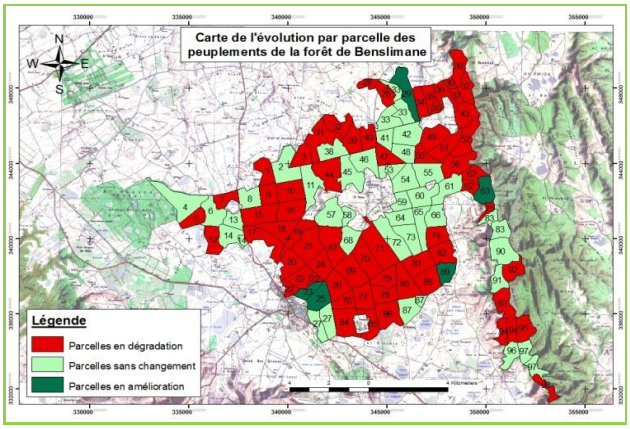

Fig.8: Map representing the plot evolution of stands of Benslimane forest (after check on the ground)

By using the results of C.O.O. only, we extracted by mask of the map of change without considering plots composed only of secondary species, the artificial plantations, and enclaves. So, we can differentiate between two cantons of the cork oak and Tetraclinis as illustrated in the map below:

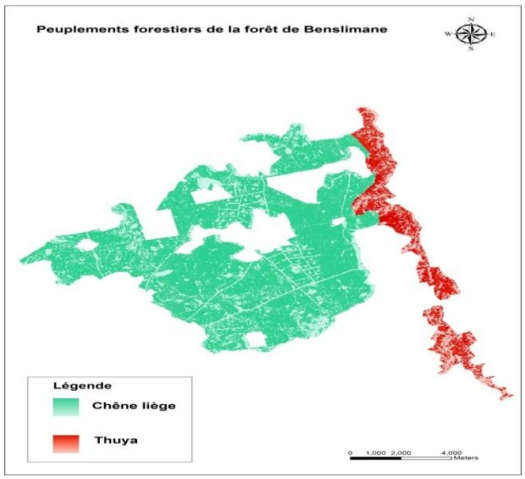

Fig. 9: Map *of stands of the forest of Benslimane*

Thereafter, we can count the number of pixels by class identified (undersides table):

- Class 11 correspond to the absence of vegetation in the two dates
- Class 12 correspond to the vegetation progression
- Class 21 correspond to the vegetation regression
- Class 22 correspond to stable vegetation in the two dates

Table III: Number of pixels by canton and class of change

Canton	11	12	21	22	Total	Area (Ha)
Qs	8275	19286	29523	47648	104732	9425,8
Ta	7005	2927	7402	4384	21718	1954,62

Table IV: Results of the evolution of the forest during period (1994 - 2013)

Occupation of the soil	*1994 (source: the study of plan of Benslimane forest management)*		*Degradation*		2013		*Annual average rate*	
	Sup (ha)	**%**	**Sup (ha)**	**%**	**Sup (ha)**	**%**	**Sup (ha)**	**%**
Qs	7581,7	62	-2657,07	-35	4924,63	40	-132,8	-1,74
Ta	1335,9	11	-666,18	-50	669,72	5	-33,3	-2,63

III.2. comparison between the results of NDVI and the object-oriented classification (C.O.O.):

-Results NDVI: the regression of the area is valued at 1180,71 Ha, or 10 % of the area of the forest in 1994, while

progression touched nearly 1779,84 Ha, or 15 % of its area in 1994.

-Results C.O.O.: The decline of the area is valued at 3312,81 Ha, or 27 % of the area of the forest in 1994, while progression touched about 1992,87 Ha, or 16 % of its area in 1994.

The NDVI is an index based on the detection of chlorophylls activity, and includes all vegetation, that this is trees, shrubs or vegetation of field. That explains why the surface of vegetation in image of NDVI is important than that of classification object-oriented , and that the obtained surfaces of vegetation in decline are less important than those from classification object-oriented .

This, because the principle of C.O.O. is very different, it does not address isolated pixel, but pixel groups (objects) which represent the different forest stands. So, results acquired from C.O.O. and proved on the ground are satisfactory and considered to be better than those based on NDVI.

III.3.The forest evolution during period (1994 - 2013) according to results O.O.C.:

As result, the cork oak occupied 40 % of study areas and Tetraclinis 5 % of the complete surface.

A geographical area of 7096 Hectares remained unchanged of point of view forested coverage since 1994. The area that has undergone an evolution of covered is 5305 Ha, or 43 % of the area of study, divided between 1992,87 Ha in progressive evolution against 3312,81 Ha in regressive evolution.

During the period 1994 - 2013, the cork oak (Qs) and the Tetraclinis (Ta) knew important changes. The decline of the area of cork oak is valued at 2657,07Ha, or 35 % of its area in 1994. This decline corresponds to an average rate of 132,8 Ha/ year, or an average annual rate of decline of 1,74 %. Similarly, the decline of the area of Tetraclinis is valued at 666 Ha, or 50 % of its area in 1994. This decline corresponds to an average rate of 33,3 Ha/ year, or an average annual rate of decline of 2,63 %.

III.4. Explanatory factors of identified changes

Based on the results obtained, prospection in the field and the analysis of existing documents in administration of waters and forests ,we have found that the forest of Benslimane, as the most part of the Moroccan forests, knew a dynamics in both directions, positive and negative, caused by several factors. But unfortunately, negative change or deterioration is more important than progression.

The weak progress can be explained by transformation of few futaie (trees with one foot, from seeds) to coppice (from stump sprouts: trees with two or three stems by stump) further to the cuts of rejuvenation, by the restoration of ecosystems by Eucalyptus plantations on 300 Ha (consolidation of existing reforestations) and assisted regeneration actions by Tetraclinis plantations where only 323 Ha has been successful on 932 Ha planted (for a success rate of 35 %), by a weak dynamics of natural regeneration and by the merging of secondary species in some empty.

The regression can be explained by:

- The periods of drought which engender deterioration and mortality of the subjects of cork oak;
- The deterioration of the cork oak further to invasion and competition of secondary species;
- Sanitation Cuts and stumping;
- Anthropozogene action: illegal cuts of wood cup illicit of lively wood and problem of overgrazing.
- Tetraclinis plantations where only 323 Ha has been successful on 932 Ha planted (for a success rate of 35 %), by a weak dynamics of natural regeneration and by the merging of secondary species in some empty.
- Decline can be explained by:
- The periods of drought which procreate deterioration and mortality of the subjects of cork oak;
- The deterioration of the cork oak further to invasion and competition of secondary species;
- Sanitation Cuts and stumping;
- Anthropozogene action: criminal cuts of wood cup illicit of lively wood and problem of overgrazing.

IV. CONCLUSION

The diachronic study is based on the use of multitemporal image (Landsat TM 1994 and Landsat 8 2013). This study has allowed mapping the evolution of the forest stands using remote sensing and SIG. The Acquired results show that the cork oak and Tetraclinis, which are main species of the forest, have declined respectively to 35 % and 50 % compared to the initial area in 1994.

Also, As result from analyses, the sported natural essence like the cork oak and Tetraclinis occupies respectively 40 % and 5% of areas afforested of study area.

A geographical area of 7096 Hectares remained unchanged of point of view forested coverage since 1994. The area that has undergone a cover evolution is 5305 Ha, or 43 % of the area of study, divided between 1992,87 Ha in progressive evolution against 3312,81 Ha in regressive evolution.

The dynamic analysis of forest areas of the forest Benslimane (mapping of changes and qualitative evaluation on the ground) highlighted several factors of degradation of the forest. In fact, in addition to the decrease in the density of cork oak stands, reduction of vegetation cover, and trees mortality, the forest lost structure, function and productiveness normally allocated to these ecosystems.

It follows that the degradation of the Atlantic cork oak forests is the result of the interference of several natural factors, anthropic, historical and forested management. The capacities of resistance of the forest diminished a lot and the signs of its deterioration are very visible.

The alarming situation and the issues and challenges in this study area led the forest managers to develop solutions able to ensure the development and the sustainability of Benslimane forest.

To restore degraded ecosystem of the cork oak and Tetraclinis, the forested administration undertakes a program of regeneration of this species. Discussions and interviews with the local managers as well as field visits for qualitative evaluation have shown that the perimeters reforestation is doomed to failure. The probable reasons of failure are linked in:

•None respect for young plantations until age of defensibility,
• Phytosanitary Problems,
• Effects of adverse weather conditions (drought),
• Edaphic conditions adverse for the cork oak.

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