

Map of Soil Vulnerability and Degradation in the southern region of the province of Tlemcen (Algeria)

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ABSTRACT

The aim of the present work is to establish a map of the protection of steppe soils in the southern region of the province of Tlemcen (North-West of Algeria). The followed methodology was based on a cartographic approach developed from a cooperation project carried out by the regional activity center for Program of Shares Priority Plan of action for the Mediterranean (PAP-MAP) and the General Office of Nature Conservation of Madrid (GONC of Madrid) with the United Nations Food and Agriculture Organization (FAO). The results obtained show that most of the lands (84.34%) are highly vulnerable, 13.66% of the areas have a medium vulnerability and only 2 % of the areas have lands with low vulnerability level.

Keywords: Soil Protection, Remote sensing, Geographic Information System, Cartography, Steppic Soils.

Mathematics Subject Classification: 62P12

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1. INTRODUCTION

Today, the soil degradation is not only contributing to the depletion of the ecosystem but also endangering the quality of life and even the survival of certain vulnerable populations. According to a new report of United Nation published (FAO ITPS, 2015), the rapid deterioration of soils of the planet due to erosion, loss of nutriment and organic carbon to the water proofing and other threats can be inverted, provided to countries to take the initiative to promote sustainable management practices and the use of appropriate technologies.

Erosion is one of the major factors of degradation. It is expressed by an excessive loss of soil (irreversible loss of productivity) and a loss of organic matter, the factor of ablation might be the wind or the water. In addition to this, there is silting problem, indeed more than 20 million hectares is threatened by wind erosion in Algeria (Bensaid, 2009 in Ould Safi et al. 2018). This phenomenon represents the additional cause of degradation, characterized by a notable loss of biological resources.

Thus, the main objective of this study is to establish map of soil protection in the southern region of province of Tlemcen (north-western Algeria). On the other hand, the specific objective is designed to show the undeniable contribution to use new techniques, such as remote sensing, geographic information systems and cartography.

2. PRESENTATION OF THE AREA OF STUDY

2.1. Geographic location

The steppe zone occupies the southern part of the province of Tlemcen. It has the angular coordinates of longitude 1 ° 03 '10' 'East at 1 ° 52' 16" 'West and latitude 34 ° 41' 12' 'North at 40 ° 12' 24" 'South, with 326800 ha of territory. Generally, it is represented by large arid and semi-arid areas with an agro-pastoral vocation and which belong to all of the southern high plains of Oran. This extended includes five municipalities: Sebdou, Sidi Djillali, El Gor, El Bouihi and Aricha (Fig. 1)

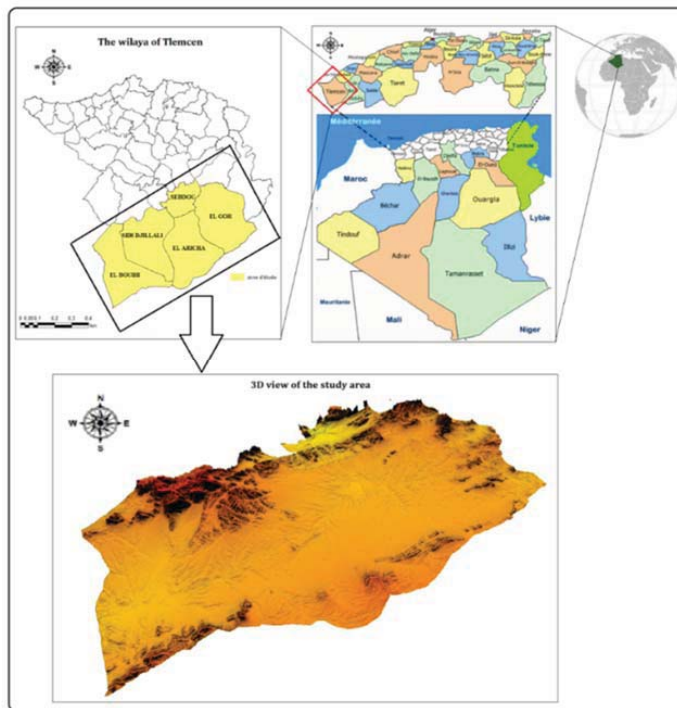


Figure 1. Location of the study area.

2.2. Description of the natural and physical environment

The steppe of the province of Tlemcen forms a geomorphological unit characteristic of the Atlas domain. It is surrounded by two mountain ranges: the Tellian Atlas and the Saharan Atlas.

The strong slopes are generally located in the northern and southwestern parts of the area of study. They are characterized by an uneven relief, especially in the mountains. These massifs have altitudes which is between 1500 and 1800 m. The highest point is located in the Tenouchfi mount (1843 m). The mountains are stretched towards the north going to Terni by Djebel Ouargla (1717 m), and then towards the west till Bouihi with Djebel El Abed (1600 m). The steppe plains form a high plateau, with an altitude that varies between 1100 and 1200 m (Ghennou, 2014).

The hydrographic network contains several rivers (endorheic and exorheic) coming from all the directions and with a temporary regime. They are fed by three large watersheds: the Tafna watershed (municipality of Seb dou), the Chott Echergui watershed (municipalities of Sidi Djillali, El Bouihi, El Gor and El Aricha) and the water catchment area. Macta, municipality of El Gor (Ennebati, 2015).

Most of the steppe soils are characterized by the presence of calcareous accumulation which reduces the useful soil depth. They are generally poor in organic matter and susceptible to degradation (POUGET, 1980).

According to Haddouche (1998), the steppe is characterized by the following soil classes:

- Mineral soils of erosion;
- Soils with little evolved wind and alluvial supply;
- Calcimagnetic soils ;
- Halomorphic soils;
- Isohumic soils.

The area of study climate is characterized by a long period of drought summer varying from 5 to 6 months. The past decades have seen a significant decrease in average annual rainfall.

The vegetation is composed mainly of sparse open formations; Alfa steppes (*Stipa tenacissima*), white wormwood steppes (*Artemisia herba alba*) and mixed steppes; as well by reforestation of Aleppo pine (*Pinus halepensis*) and matorrals where remains relics bushes and shrubs based on juniper (*Juniperus oxycedrus*), green oak (*Quercus rotundifolia*), Lentisque (*Pistacia lentiscus*), rosemary (*Rosmarinus officinalis*), from Diss (*Ampelodesma mauritanica*) and dwarf palm (*Chamaerops humilis*) (Zékri et al. 2014) .

3. MATERIALS AND METHODS

3.1. Digital data

The image used in this study was obtained from LANDSAT-8, catch ETM⁺ and acquired on November 20, 2014. The ground resolution is 30 m x 30 m. Trichromics has been established from the combination of channels of blue (ETM⁺ 2), red (ETM⁺ 4) and near infrared (ETM⁺ 5).

The mapping of soil protection against degradation was based on the use of the GIS tool: ARCGIS 10 software

3.2. Methodological approach

The use of new approaches to measure the state of degradation through spatial analysis remains an unavoidable pathway (Haddouche, 2009).

The methodology followed (Fig. 2) to determine the sensitivity of the area of study to degradation was based on a cartographic approach developed from a cooperation project, carried out by the regional activity center for Program of Action Priority Plan of Actions for the Mediterranean (PAP-MAP) and the General Office of Nature Conservation (GONC Madrid) with the United Nations organization for Food and Agriculture (FAO).

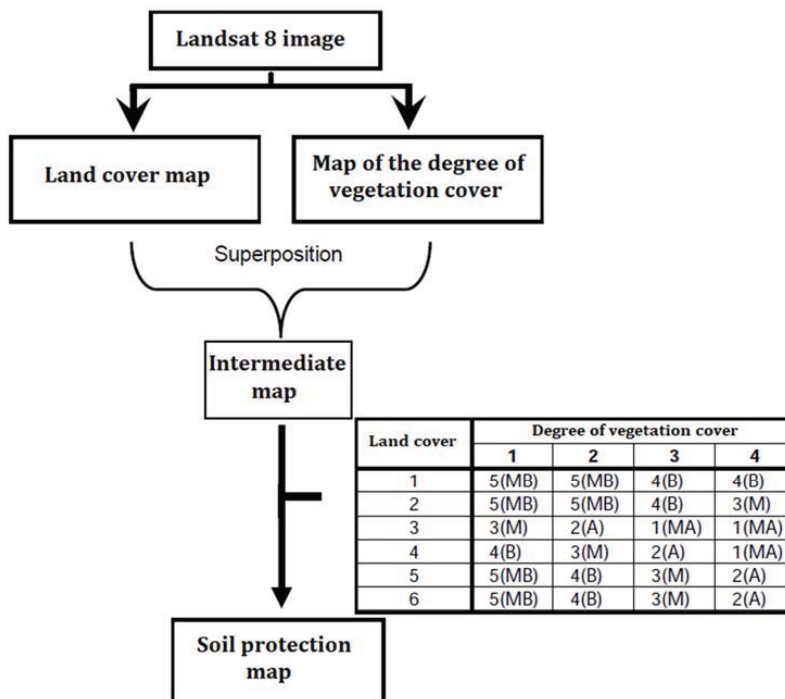


Figure 2. Methodology flow chart.

4. RESULTS

4.1. The land cover map

The land cover map is based on the LANDSAT-8 satellite image, data collected from the forest conservation of province of Tlemcen and field observations, a land use map of the area of study was established.

The maximum likelihood classification, based on direct observation of land use categories, has resulted in a land cover map. Seven classes are thus identified: forests, maquis, rangelands, crops, bare soil, urban and water (Fig. 3 and Table 1).

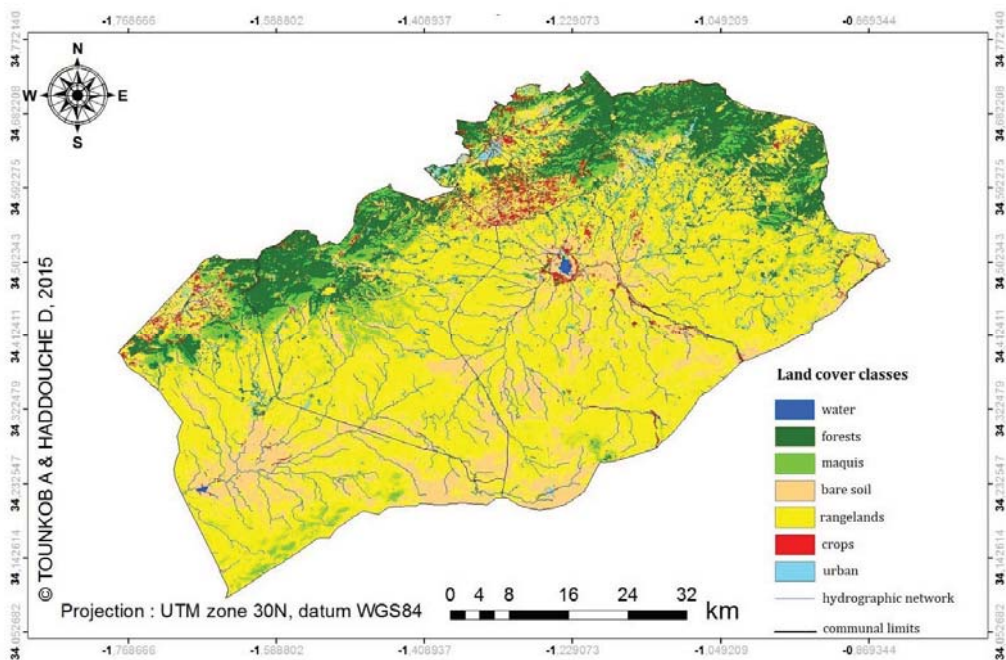


Figure 3. Land cover map of study area.

Table 1: Percentage of various land cover classes in the study area.

Class	Area (ha)	Percentage (%)
Forests	49061.168	15
Maquis	17818.014	5.45
Bare soil	61402.203	18.8
Rangelands	182744.59	55.91
Crops	9577.749	2.91
Urban	6085.749	1.86
Water	228.31	0.07

The very low vulnerability areas represent 16.93 % of the study area (forests, urban and water). The forests (15 % of the area), effectively protect the soil from any losses by the permanence of their vegetation cover which softens the impact of raindrops. The litter and plant fragments, that cover the ground, slow down the runoff and limit the soil stripping. On the other hand, the root system maintains the cohesion of the soil, while the organic material, by improving the structure of the surface horizons, makes them more permeable.

The low vulnerability zone covers 5.45 % of the area of study and includes maquis vegetation with a vegetal cover less dense than that of the forest. Because of the importance of spacing between two neighboring plants, as well as their sizes, the soil is less protected by the plant cover than in the cases mentioned above.

The average vulnerability zone covers 2.91 % of the surface of the studied area and represents the crops. These lands are classified as medium resistance against erosion because intense irrigation favors this latter process. On the other hand, the soil is periodically exposed to it.

The area of high vulnerability occupies about 55.91 % of the studied area. It is represented by the paths where vegetation is very sparse. This is the most dominant class because the year 2014 is an exceptional year in precipitation. This has favored a good biological recovery especially in annual crops.

The zone of very high vulnerability represents 18.8 % of the steppe of the province of Tlemcen. It is occupied by bare grounds.

4.2. Degree of vegetation cover map

The vegetation cover map was derived from the NDVI "Normalized Difference Vegetation Index". It is the most well-known and most widely used index for detecting the phases of green plant development from multispectral remote sensing data.

NDVI is determined from planetary reflectance in red (around 0.45 μm) and near infrared (around 0.65 μm) channels (Rouse et al. 1974 in Tucker et al. 1986):

$$\text{NDVI} = (\text{PIR} - \text{R}) / (\text{PIR} + \text{R}), \text{the NDVI varies between } -1 \text{ and } +1.$$

Where PIR: Near infrared channel; R: red channel.

The different classes of vegetation cover and their degrees of sensitivities are mentioned according to the FAO model (PAP / PAC, 1998) in the table below:

Table 2: Classes of vegetation cover and their degrees of sensitivities (PAP/PAC, 1998).

NDVI index	Vegetation cover	Degree of sensitivity
> 0.4	Vegetation dense (> 75 %)	4
0.2 - 0.4	Vegetation mean (50 - 75 %)	3
0.1 - 0.2	Low rate (25 - 50 %)	2
< 0.1	Very low rate (< 25 %)	1

The analysis of the vegetation cover map (Fig. 4) has shown us that the state of the vegetation cover in the study area is alarming. Moreover, most of the steppe of the province of Tlemcen (65.4 % of the surface) has a very low rate (less than 25 %) of recovery (Table. 3). In the second position 33.47 % of the surface is occupied by zones with a degree of vegetation cover between 25 – 50 %. On the other hand, zones with dense vegetation cover do not exceed 1.13 % (1.12 % for the class of 50 – 75 %, and only 0.01 % for zones with a very dense vegetation cover > 75 %).

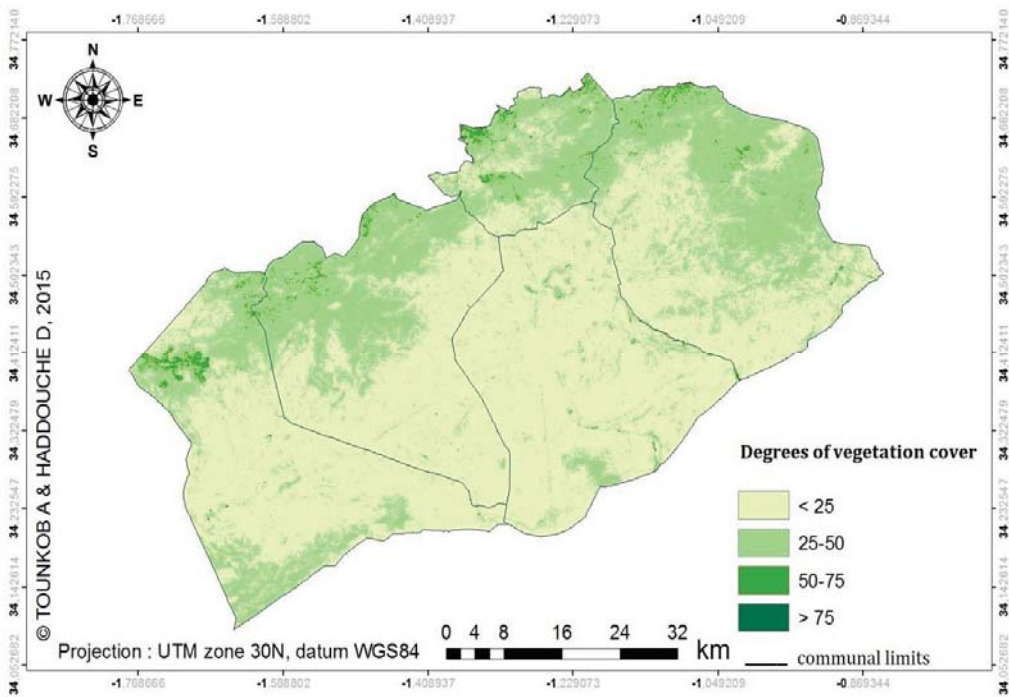


Figure 4. Degrees of vegetation cover map of study area.

Table 3: Percentage of various vegetation cover classes in the study area.

Degrees of vegetation cover	Area (ha)	Percentage (%)
< 25	213638.58	65.4
25 – 50	109338.46	33.47
50 – 75	3673.68	1.12
> 75	44.29	0.01

4.3. Map of soil vulnerability and degradation

The soil protection degree map is obtained by applying the matrix presented in Table 4.

Table 4: Occupation of soil cover vegetation *matrix* (PAP/PAC, 1998).

Land cover classes	Degrees of vegetation cover			
	1	2	3	4
1	5(MB)	5(MB)	4(B)	4(B)
2	5(MB)	5(MB)	4(B)	3(M)
3	3(M)	2(A)	1(MA)	1(MA)
4	4(B)	3(M)	2(A)	1(MA)
5	5(MB)	4(B)	3(M)	2(A)

The soil protection map (Fig. 5) considers both: the nature of the occupation and the degree of soil cover. The soil protection map reflects the state and density of the vegetation cover. Areas of low protection are occupied by bare soil, annual crops, low density vegetation ... etc. The best protected areas are those occupied by dense forests.

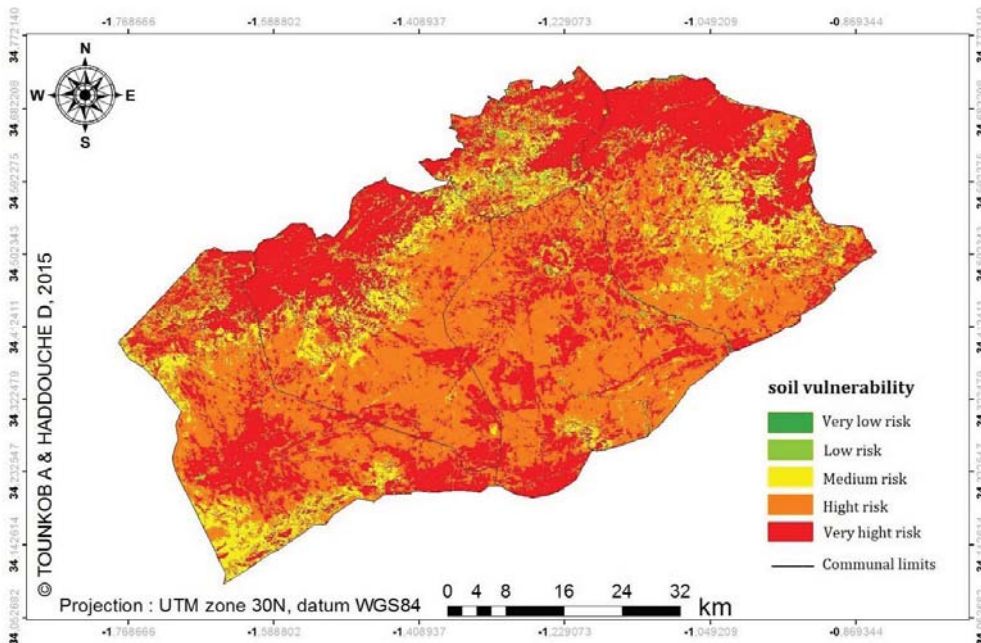


Figure 5. Soil protection map of study area.

The Analysis of the map shows that the majority grounds of study area are vulnerable to all types of degradation, this is due to the shortage of protective plant cover. Areas with low and very low protection represent 84.34 % of the total surface of the studied area. The areas with average protection represent 13.66 % and the rest (2 %) gathers the areas with high and very high protection (Table 5).

Table 5 : Percentage of various soil protection classes in the study area.

Soil protection classes	Area (ha)	Percentage (%)
Very low protection	126149.71	38.62
Low protection	149326.02	45.72
Average protection	44623.285	13.66
Hight protection	5984.8193	1.83
Very hight protection	546.56067	0.17

5. DISCUSSION AND CONCLUSION

Currently, the area of study is in a very scary state. The importance and acceleration of its degradation has been demonstrated by numerous recent studies (Tounkob, 2016; Ennebati, 2015; Zenouche, 2015; zekri et al, 2014; Bekkouche, 2011). This degradation is reflected in the reduction of biological potential and the breakdown of ecological and socioeconomic balances.

The degradation of vegetation cover is the result of the interaction of natural and anthropogenic factors. Natural causes are primarily due to physical and biological events: drought, climatic change, pest or disease outbreak... etc. In dry lands, plants often grow near their limits of tolerance, so even slight changes in environmental factors or a little disturbance can lead to more bare ground, species loss, and degradation.

Currently, humans are both the cause and victims of desertification. The harmful human activities that destroy vegetation include deforestation of unsuitable land, shifting cultivation without adequate fallow periods, unbalanced fertilizer use, overgrazing, overexploitation, mismanagement of water resources, urbanization, non-adoption of soil-conservation management practice, salinization, alkanization of soil because of faulty irrigation techniques, they contribute seriously to the desertification. Indeed, Tounkob (2016) proved that the overexploitation of what remains of steppe pathways due to anthropozoic pressure on an increasingly reduced living space, because the current pastoral load in this region is 3 sheep per 1 ha.

This study, through a spatial analysis, showed the alarming state of degradation in study area. The majority grounds of study area are vulnerable to all types of degradation; this is due to the shortage of protective plant cover (65.4 % of the surface has less than 25 % of recovery). Areas with low and very low protection represent 84.34 % of the total surface of the studied area. The areas with average protection represent 13.66 % and the rest (2 %) gathers the areas with high and very high protection,

indeed more than 2/3 of the total area is vulnerable to water erosion, wind erosion and sand encroachment. These factors favor more the problem of desertification, which is affecting this type of environment in Algeria.

In order to preserve this natural environment, it is urgent to:

- Solicit the development of rural localities including remote villages by electricity and diesel. This will help reducing the forest clearing;
- Ensure the strict application of the prohibition of illegal plowing in steppe areas and move from agriculture to arboriculture, and also encourage the development of regulated pastures to compensate for sparse herbaceous areas;
- Restore the vegetation cover where it has disappeared by planting specialized and arid-tolerant trees and shrubs (*Ceratonia*, *Prosopis*, *Cactus*, *Atriplex*...etc.) and protecting it where it exists (the defensive that allows the regeneration of the plant cover);
- Diversification of income by the integration of other activities in parallel with the breeding (Arboriculture, Rustic fruits such as pistachios, Small farms, Apiculture ... etc.);
- Integration of actions with high labor potential (pastoral planting; conservation works of water and soil).

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