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THE USE OF MULTI SOURCES DATA FOR MAPPING OF SENSITIVE AREAS TO HYDROUS EROSION IN THE MOUNTAINS OF TESSALA (NORTHERN ALGERIA)

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Abstract

The Tessala mountains constitute a fragile ecosystem, they are confronted with several problems with knowing loss of the farmed lands, bad distribution and occupation of the soil, low organic matter, rough and unstable soil (the slope exceeds in some places the 25%).

to understand the problem of hydrous erosion in the Tessala mountains, a model of approach using geographic information system was proposed. Geographic data were processed by mapping using specialized software. After treatment, we identified the areas where the susceptibility to erosion is significant. Over 80% of the land of our study area is susceptible to hydrous erosion at different degrees highly sensitive (32.5%), moderately sensitive (44%) insensitive (15%) and stability (7.5%).

Keywords: Fragile ecosystem, Geographic information system, hydrous erosion, mountains of Tessala

Introduction

Erosion is the physical process that destroys soil production ability, and runoff leads to loss of organic matter and the entire content of soil. Erosion comprises processes by which earth materials are entrained and transported across a surface, while soil loss is the material actually removed from a particular hill slope or segment (Al Hamdan et al., 2014).

In Algeria the erosion moved on average between 90 to 300 tons of land/ha/year; it is a function of the volume and the intensity of the rains, the deterioration speed of the slopes (8 to 17 mm/year) and the surface cover of the ground (Roose,1993).

According to Bissonnais and Papy (1997), hydrous erosion depends especially on the intensity of the rain. Because of the reduced surface of our study area there is not a significant variability of the rains, consequently in our work we regarded the rains as constant and homogeneous in the whole of Tesasla mountains. The rains are intense and irregular. The annual quantity is estimated with by 450 mm. more than 60% of this water fall in less than four months between November and March in the form of downpour accentuating the runoff from water. The Tessala mountains are characterized by very accentuated slopes, being able to reach in some places more than 30%, and by an unstable substrate of marly origin, these factors support the erosion of the soil (Benabdeli, 1997). Several studies using the GIS and remote sensing were carried out, for example mapping the risk of erosion using GIS in the basin of Fergoug river (Bouchtata, 2001), an hydrous erosion of the soil in the Mediterranean's mediums By (Kourl,1993) although passing by determination of the marly land to gullying by GIS in western Algeria (Kourl,1993). The combination of the multisource data by the use of a geographical Information system is the best way of approaching this type of problem, because it has the faculty to manage a significant mass of information illustrated in the form of layers. These layers of information are combined and overlaid according to the hierarchic model per degree of importance developed by Satty (1977). This approach enabled us to carry out several thematic maps which will constitute a powerful tool of the decision making.

Study area

The Tessala mountains culminate with 1061m altitude, they constitute the central part of the Tellian Atlas. The study area is at approximately 15 Km from the Western North of the city of Sidi Bel Abbes (Figure1), it is characterized by a semi arid climate with an annual rain of about 450 mm spread out over 60 days. The minimal of the coldest month and maximum average temperatures of the hottest month are respectively 1.4 °C and 35.3 °C (National office of meteorology, 2005).

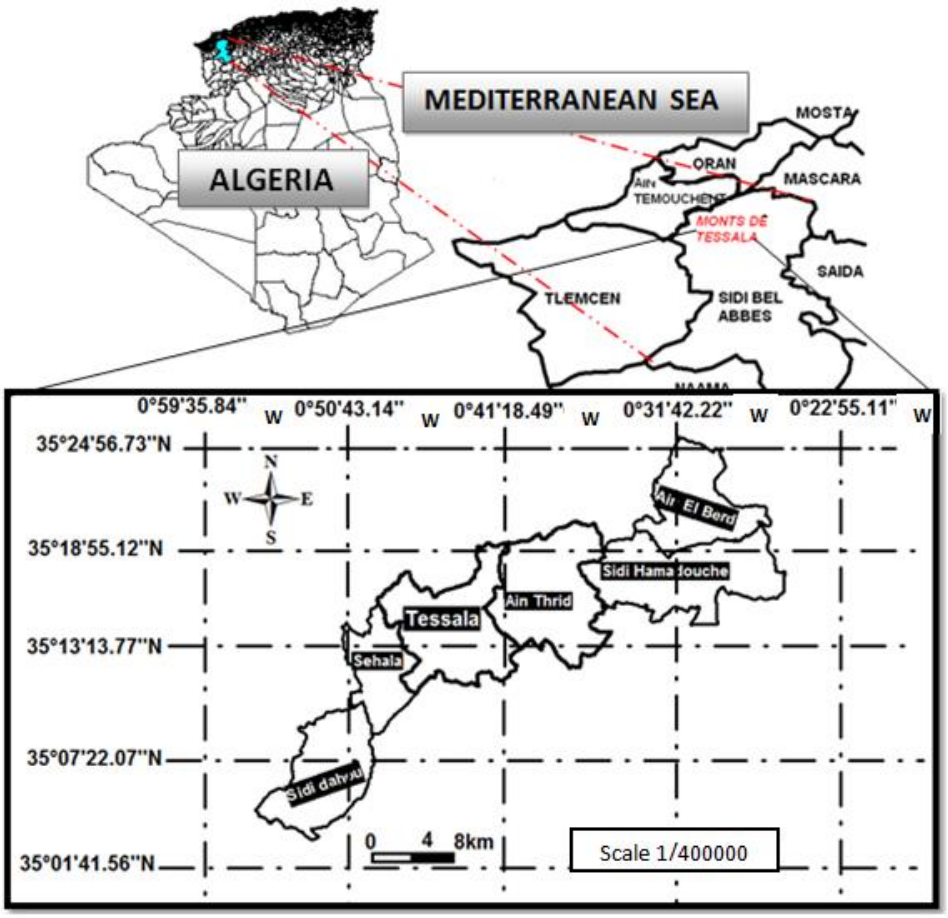

Figure 1. Localization of the study area

Material and methods

For the realization of the sensitivity map of the soil to hydrous erosion, we used the layers of following information:

The slope

On the strong slopes, the rainwater streams quickly and causes serious erosion. In the semi-arid and arid regions, the gradient of the slope is correlated positively with the surface cover of the ground by rocks fragments which decrease the streaming and the loss of soil (Cooke, 1993).

The slope supports the erosive phenomenon, because it increases the kinetic energy of water surface. We obtained this map by the digitalization of the level lines of the study area, we carried out a digital model. From this model we carried out a map of the slopes in four classes (Figure 2).

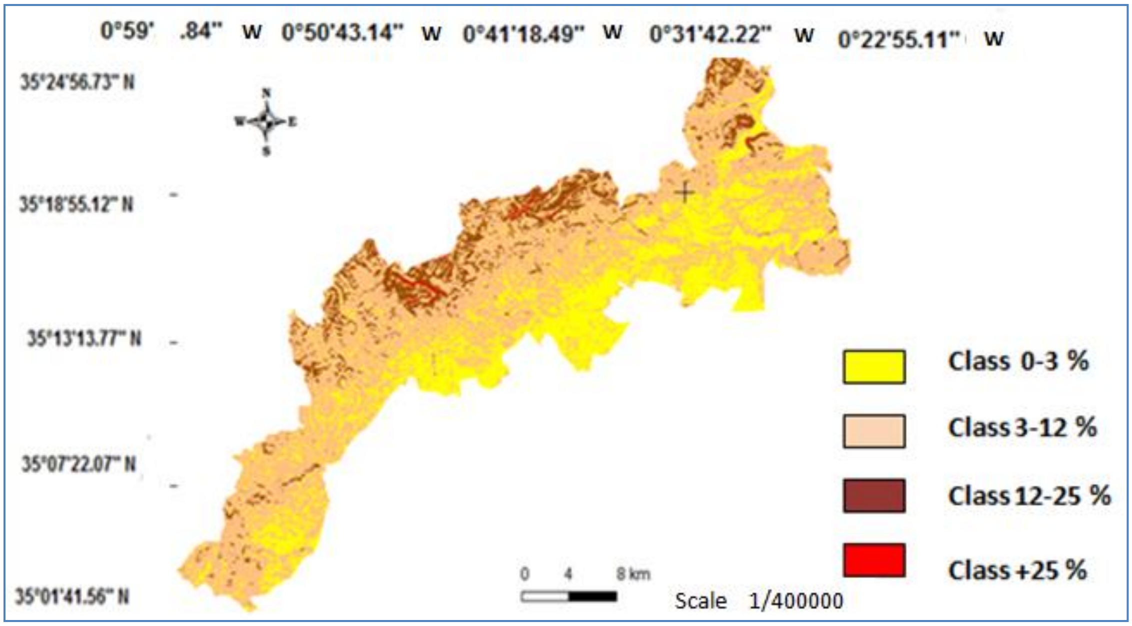

Figure 2. Slopes map of the Tessala mountains

For each class of slope a variable index between 1 and 4 is assigned (Table 1), 1 was assigned to the weak slopes (< 3°) and 4 to the strong slopes (> 25°).

Table 1. Classes of slope and assigned index

Slope (%)	Index
0-3%	1
3-12%	2
12-25%	3
+25 %	4

Lithology

The various types of rocks and their structures give an invaluable indication on the capacity of infiltration of the occupied areas by the rocks and the soil, and in consequence on the quantity of ground suspect to be eroded (Krynine, 1982). A weak infiltration indicates that a great quantity of water streams, consequently, a strong quantity of ground can be carried. The marly soils when they are dry, remain non erodible but as soon as they reach a certain moisture, their sensitivity to the detachability and the streaming increases (Chebbani, 1999). In our study area, the marls, sandy limestone and lime stones form the dominating substrate. We obtained this map by the digitalization of the lithologic map of the ORGM (regional Office of geology and the mines). After the digitalization we carried out the digitalization of the lithological substrates (Figure 3).

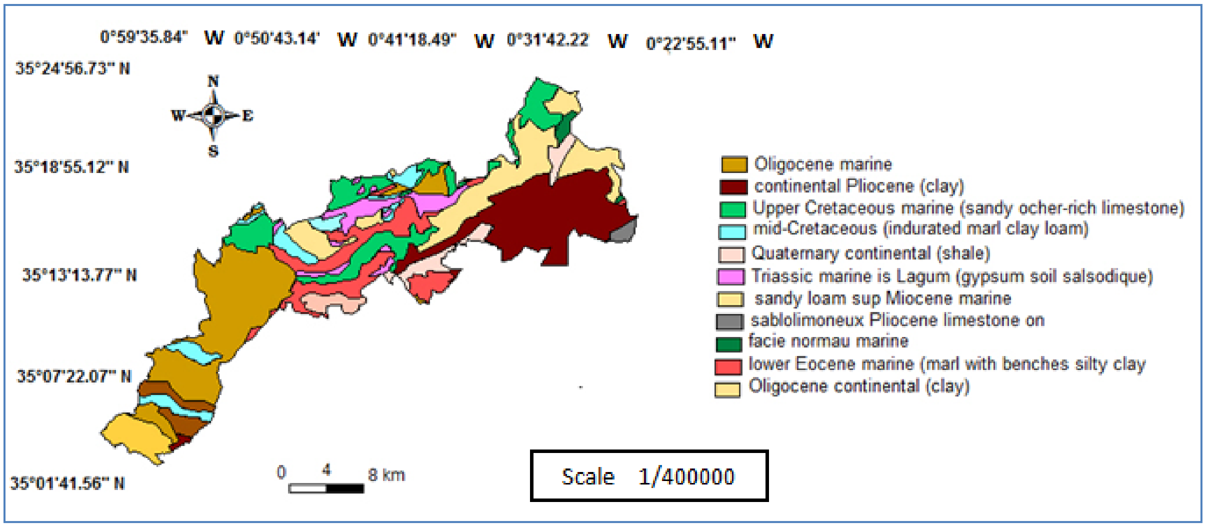

Figure 3 Map of the lithological substrates of the Tessala mountains

With our knowledge of the ground and the description of the nature of the rocks on the geological map, we determined the friability of leveling materials. One can thus distinguish three classes of materials (Table 2): Resistant, fairly vulnerable, and vulnerable. With each class a variable index between 1et 3 is assigned, 1 for materials less exposed to erosion and 3 to the most exposed materials to erosion.

Table 2. Classes of lithological materials and their assigned index

Lithology	Index
limestone and conglomerate with calcareous cement	1
marly likings and marly limestone calcareous	2
marls	3

Occupation of the soil

The erosion of the soil is strongly controlled by the vegetation cover whose the production depends on the biomass. Large downpours falling on a wet ground involve a streaming of 40-55% in Tunisia (Delhoume, 1987). On the other hand, under a natural vegetation cover exceeding 40% and on strong slopes, the ground losses can be reduced (Roose, 1993). In the semi-arid Mediterranean forests, the soil under forest cover is regarded as non sensitive to hydrous erosion (Delhoume, 1981) because the litter and the low vegetations support the infiltration (Roose, 1994). The loss of forest to agriculture activities makes the soil sensitive to erosion because the probability increases of having a naked ground during strong precipitations. For the not very dense cultures, it is more intense compared to the dense cultures. The occupation of the soil and the vegetation cover are badly distributed in the study area where the naked ground is not protected against erosion. Four great classes of occupation are identified: Forest, Undergrowth, cultivated soil, naked soil and fallow lands (Figure 4).

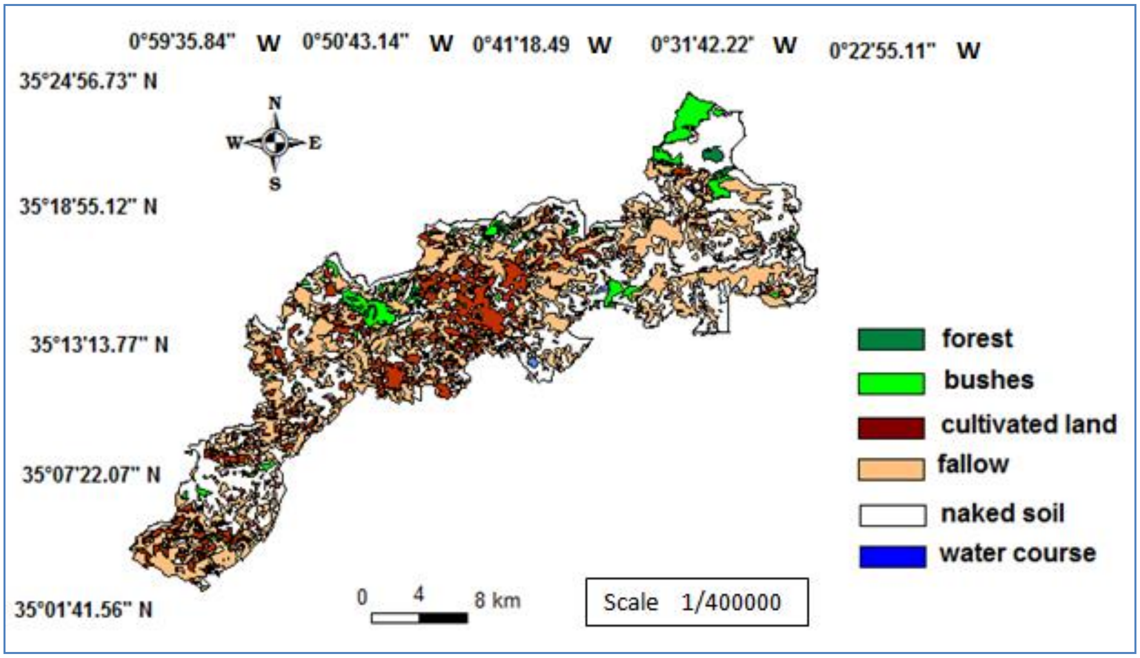

Figure 4. Map of the soil occupation

Each class is assigned with a value between 1 and 4; 1 refers to the least vulnerable class and 4 to the most vulnerable class (Table 3).

Table 3. Classes of occupation of the soil and assigned index

Occupation of the soil	Index
Forest	1
Undergrowth	2
Cultivated soil	3
Naked soil and fallow lands	4

The methodology developed in this study uses rules of qualitative evaluations and the organization of the parameters intervening in hydrous erosion (Roose, 1994) occupation of the soil, substrate and classes of slope. These data are integrated in the software Mapinfo 6.5, where one uses an appropriate programming language (Structure Querry Language) for the combination of these layers of information, according to the rule of decision mentioned in the table 4 and 5. As an example we give the case of a weak slope of about 3%, as a stable slope and its ground is non-vulnerable to hydrous erosion, if it is covered with a forest it even resting on a stable calcareous substrate, we assign index 1. On the other hand if a slope is stiffer (higher than 25%), without vegetation cover and on non-stable substrate, we conclude that the sensitivity of its soil to hydrous erosion is strong, and we give it the index (4).

Results and discussion

The combination per pair of the three factors conditioning hydrous erosion, namely the slope, the substrate and the occupation of the soil led to establish the two following matrix.

Matrix of the erosion potential

The matrix of the potential of erosion was worked out by the interaction between the substrates of the soil constituting our study area and four classes of slopes (Table 4).

Table 4. Matrix of erosion potential

Substrate / Slope	resisting	Fairly Resisting	Vulnerable
0-3%	1	1	1
3-12%	1	2	2
12-25%	2	3	4
+25%	4	4	4

The four classes of the hydrous potential of erosion in our study area are: (1) very low potential, (2) low potential, (3) average potential and (4) strong potential. The erosion potential map (Figure5) gives us an idea about the predisposition of the soil to hydrous erosion. It is noticed that, there is a proportional relation between the slope conditions and the dynamics of the substrate.

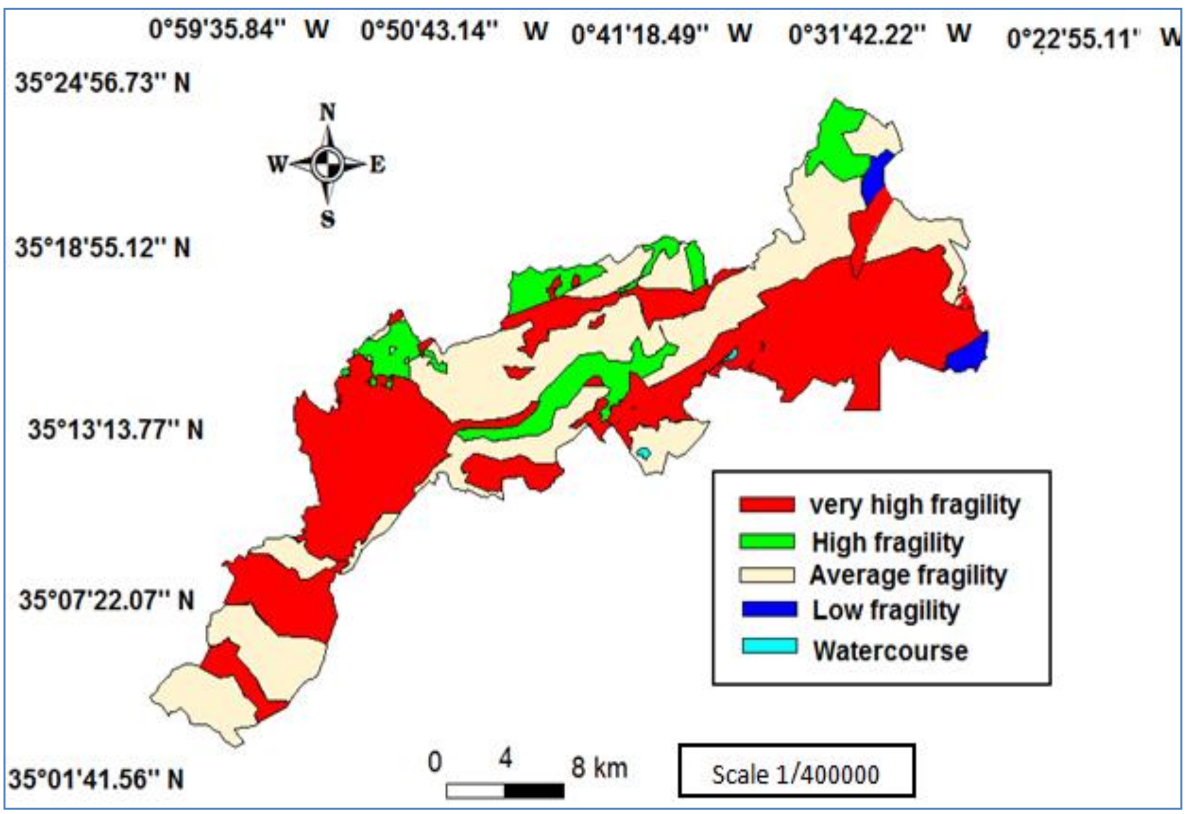

Figure 5. Map of the erosion potential in the study area

The soil sensitivity map (Figure 6) was made by the interaction between the potential of erosion and the occupation of the soil, using the rule of decision presented in table (5) with four classes of sensitivity of the soil.

Table 5. Matrix of the soil sensitivity to hydrous erosion

Potential of erosion Occupation of the soil	Very low potential	low potential	Moderate potential	High potential
Forest	1	1	1	1
Undergrowth	1	2	3	4
Soil cultivate	2	2	4	4
Naked soil and fallow lands	2	3	4	4

The map of the soil sensitivity to erosion shows that the surfaces of the four classes are different with predominance from class 3. This is because of agriculture activities on soil with strong degree of slope (> 20 %). These results show also the vulnerability to erosion in the study area is primarily controlled by the density of vegetation cover and the degree of slope. The effect of hydrous erosion started by the human agricultural actions on the soil, with strong slopes (> 12%). The classes of sensitivity of the soil to hydrous erosion in the mountains of Tessala show the following characteristics: The stable class represents (7.5%). It is only localized on the top of the study area, and comprises stable substrates of calcareous nature, covered and protected by dense vegetation against hydrous erosion. The low sensitivity class, where the expansion is more significant (15 %) compared to the first. is characterized by fairly resistant substrates with a scattered vegetation cover and less protection. The third class known by average sensitivity and almost covering the half of the studied area with (44 %), is over substrates fairly resistant to the slopes (variable between 12 and 25 %) where the vegetation becomes bushier and scattered, which accentuates the vulnerability of these areas to hydrous erosion. The fourth class is strongly sensitive, with 32.5 % of the occupation of soil in the study area. It is formed of very unstable marls forming the substrate of a strongly difficult ground where the slopes are about 25% (Figure 6). The absence of vegetation cover exposes it to strong erosion which appears in the various shapes of gullies (U, V) and even the gully in tunnel.

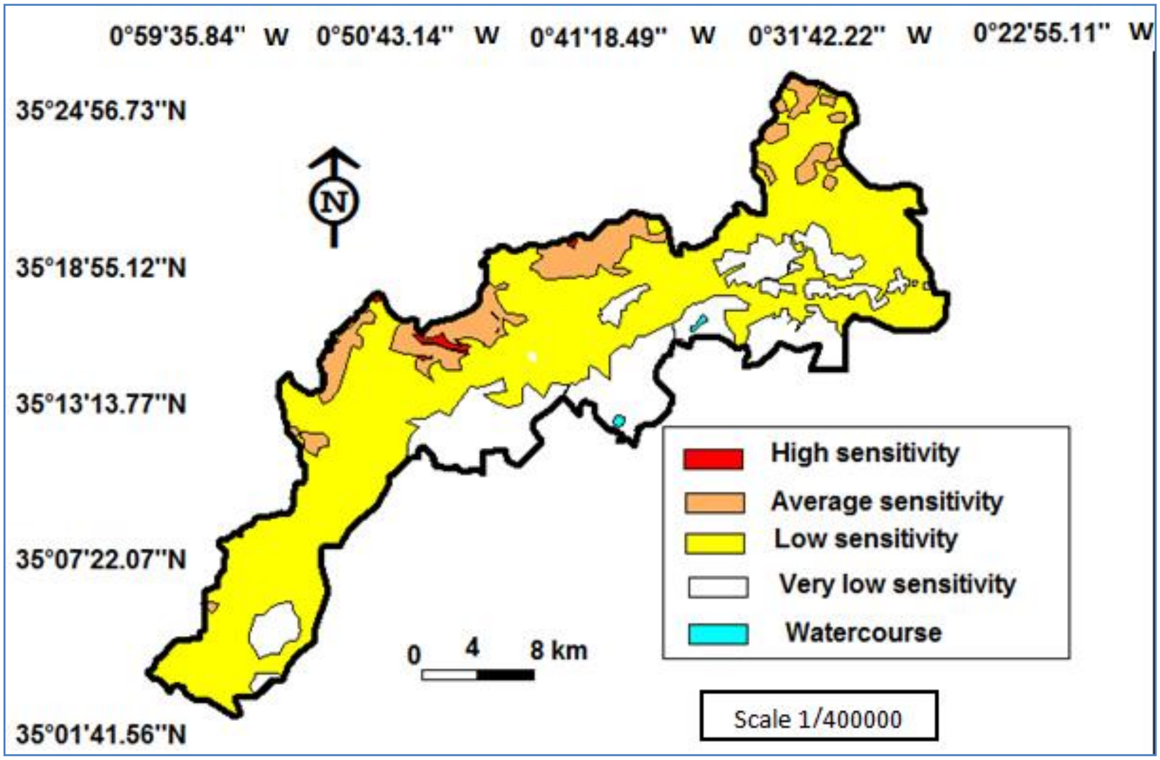

Figure 6. The hydrous erosion in the study area

In the absence of former work in the study area, the validation was made by direct confrontation with the reality of ground. The rate of exactitude was evaluated to approximately 80 % at the time of a mission on the ground following the production of the map of sensitivity, and this by examining the result with a score of points distributed well on the territory and covering the various classes of erosion. We noted intense erosion, (approximately 72%) on the central part of the South-eastern slope of the mountains of Tessala. The erosive intensity becomes rather average on the southern slope, but the agressivity of the climate prevents any spontaneous reconstitution of the natural vegetation.

This phenomenon begins in the form of claws from a few centimeters to transform itself into drains, which in their turn, evolve/move to become ravines of several meters of depth. The field work assures us the width and the damage which can cause gullying with the farming lands. We could see how the streaming digs the ground and creates ravines of more than 2m of deepness. The farming land loss is considerable especially in the areas of cereals cultivation, which does not provide any protection against erosion (Figure 7). In the mountains of Tessala, even the trees did not escape from the destructive action of erosion. Indeed the action of scouring is so intense that the trees are uprooted and is likely to fall to the least rains (Figure 8).

Figure 7. Ravine on farming land in the mountains of Tessala

Figuer 8. Impact of hydrous erosion on the trees in the study area

Conclusion

In the mountains of Tessala, there are inter relationships between the various causes which contribute to the erosive process. The technique of overlay has the advantage of limiting to the maximum the errors met in the mapping of erosion.

Knowledge thus acquired makes it possible to identify and propose to the decision makers in good time, measurements of corrections, and other actions with the effects especially related to the human activity, by establishing maps of sensitivity of the soil to hydrous erosion brought up to date, where one can make a follow-up of the vulnerable areas.

The results of this work show the interest of the use of the technology of the GIS in the evaluation of the vulnerability to erosion in mountainous area. The map of erosion sensitivity can constitutes a background document for any protection actions. The geographical information systems have significant advantages. These tools of processing and multidisciplinary data exploitation constitute a mean allowing, having a good idea, updated regularly, of the landscape units on immense territory, and minimizing the cost of the soil investigations (better choice of the sites to be observed, reduction of the number of survey visits on the ground, saving of time and means).

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