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Mapping and Assessment of Soil Loss in Berrechid Plain Using a Gis And the Universal Soil Loss Equation (Usle)

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ABSTRACT: *Soil and water are basic resources. Their exploitation or development is a matter of survival for many, an escape from poverty for most, and an opportunity to pursue additional power, wealth and selfish interest for some* ***[1].*** *Soil erosion is a growing problem in particular in the areas of agricultural activity where soil erosion not only leads to decrease agricultural productivity but also reduces the availability of the water. The Universal Soil Loss Equation (USLE) is the most popular empirical model used globally for the prediction and control of erosion. Remote sensing and GIS are powerful tools that can be used in the collection and the combination of data* ***[2].*** *They are considered our days as essential tools in the interactive systems to aid in the decision* ***[3].*** *Berrechid plain belongs to the bioclimatic Floor semi-arid with an average annual precipitation of 380 mm, and knows a development of agricultural activities with more and more exaggerated use of chemical fertilizers. An attempt has been made to assess the annual soil loss in Berrechid the plain using the Universal Soil Loss Equation (USLE) in the framework of the SIG. Such information can help considerably to identify the priority areas for the implementation of measures to control erosion. The rate of soil erosion has been determined depending on the topography , on the soil, the texture of the soil, land use and land cover, rainfall erosivity, and the management of the cultures and the practice in the watershed using the Universal Soil Loss Equation, imaging of remote sensing and GIS techniques. The rainfed erosivity, R-factor of the USLE, varies between 40.85 and 57,549 with an average of 49,362 MJ mm/ha/h/year and erodibility of the soil K-factor is 0.02 - 0.26. The slopes in the basin are low and the LS factor has values ranging from 0 - 2.79. The factor of C has been calculated on the basis of NDVI (Normalized Difference Vegetation Index) values derived from Landsat Image-ETM. The value of P was calculated from the cropping patterns in the watershed. The loss of soil estimated annual in the watershed with the help of'(USLE) is low to medium (ranging from 0 to 9.42 t/ha/year)*

Keywords: *Universal Soil Loss Equation (USLE); Remote Sensing & GIS; Soil Loss; Berrechid Plain.*

I. INTRODUCTION

Although the climate of Berrechid plain is located in the bioclimatic Floor semi arid with an annual precipitation average of 380 mm, these last are very variable and have a stormy character and know fluctuations over the years.

One of the objectives of this work is to provide a method of mapping of areas at erosion risk, and illustrate the possibility to determine the change of the soil occupation, as well as the spatialization of USLE model, to limit the process of soil degradation in Berrechid plain. The assessment of the soil erosion risk in the study area has a need the mapping and analysis of the many factors involved in the process erosive: The Rainfalls aggressiveness, the slope and the slope length, the soil erodibility, vegetation cover and cropping practices. Each factor has a different behavior from one area to the other of the study area. It has led to a multitude of data to map, store, structure and process in a rational way.

Remote sensing and GIS are powerful tools that can be used in the collection and the combination of data [2]. They are our days as essential tools in the interactive systems to aid in the decision [3].

II. PRESENTATION OF THE STUDY AREA

The Berrechid plain, for a total surface area adjacent to 1500 km², is located to the south of Casablanca. It has the form of a broad cup, limited to the south and the South-East by the plateau of Settat, to the East and North is by the Oued Mellah, to the West and North West by the Primary outcrops and on the North by the coastal

Chaouia[4]. The morphology of Berrechid plain is regular. Level curves are directed NE-SW on the major part of the plain. Altitudes vary from 350 m in extreme cases related to Settat's plateau and 140m north of the plain related to the transition zone towards Chaouia [5]. From a geological point of view, this plain is composed of sedimentary rocks formed Cretaceous of marly limestone (Cenomanian) with intercalations of clays and marls and sedimentary rocks formed of calcareous sandstone to cemented conglomerates toward the base .The whole is surmounted by a coverage of clayey silts of the recent quaternary. This part of the low Chaouia, receives of the upstream elements of varied erosion from the high Chaouia (Plateau of Settat - Ben Ahmed) from which it is separated by the flexure of Settat [6]. The annual precipitations average in Berrechid plain varies between 280 and 310mm/year. The temperature presents wide variations between the winter and the summer, with 24.9°C as an average of the maxima and 9.6°C as an average of the minima (ABHBC). The Berrechid plain hydrographic network is little developed, although many small wadis drain the watershed of Settat - Ben Ahmed and converging toward the center of the plain. The most important wadis that threaten the city of Berrechid are essentially Mazer, Tamdrost and Lhaimeur [7].

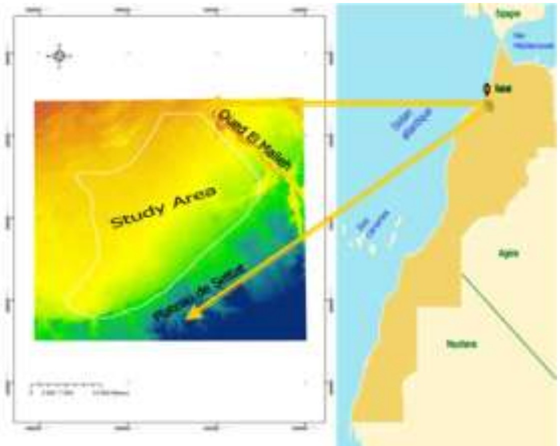

Fig. 1: The study area location [8]

III. MATERIALS AND METHODS

MATERIALS

For this study of the soil erosion in Berrechid plain we used:

- Satellite Images ETM (Sensor Enhanced Thematic Mapper ETM) of the 06/01/2016.
- A MNT (DEM) integrated in the GIS to achieve the maps of the slope length and the angle of the slope.
- The geological map and the soil map of Berrechid groundwater of [5].
- Rainfall data and climate data (ABHCH 2016).

METHODS

The methodology is to study first the parameters of the relevant factors influencing the phenomenon (the rain erosivity, the topographic index, NDVI, and the soil erodibility). Then after an Individual codification of the parameters (weight) of the different factors they were crusaders in the GIS according to the universal equation of soil loss [9]. It is a multiplicative function of five factors which control the water erosion: Climate aggressiveness, soil erodibility, tilt and slope length, soil occupation and erosion control practices **(equation 1):**

A = R * K *LS * C * P (1)

Where A is the annual rate of soil loss in t/ha/year,

- **R** is the factor of the rain erosivity; it corresponds to the annual average of the sums of the products of the kinetic energy of the rain by its intensity in 30 consecutive Min; it is expressed in MJ.mm / ha.H.year,
- **K** is the soil erodibility; it depends on the granularity, of the quantity of organic matter, the permeability and the structure of the Ground; it is expressed in t.ha.h/ha.MJ.MM,
- **LS** is a dimensionless factor depends both on the slope length and the angle of the slope. It varies from 0.1 to 5 in the most common situations of culture and can reach 20 in mountain.
- **C** is a factor without dimension that represents the effect of the plant cover,
- **P**, factor without dimension, is a report which takes account of cultural techniques "control erosion" structures such as plowing in the level curves.

The GIS allows assessing the rate of erosion on all points of the plain and the development of the synthetic map of soil loss according to the methodological flowchart **(Fig. 2).**

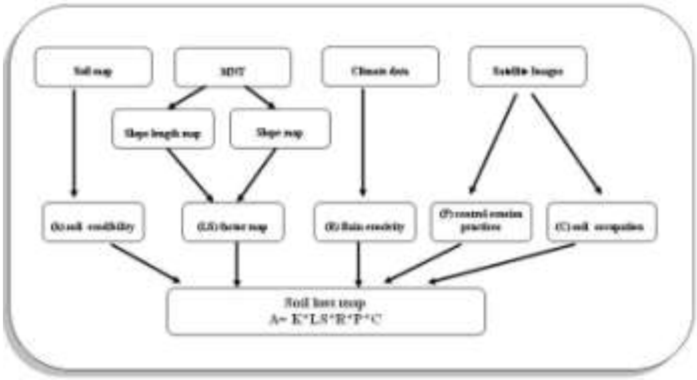

Fig. 2: The methodological flowchart

IV. RESULTS AND DISCUSSION

RESULTS

The application of the methodology described above has allowed estimating and mapping the potential erosion as well as the present erosion by the combination of the factors influencing on the water erosion.

K. SOIL ERODIBILITY FACTOR

The K factor expresses the vulnerability of the soil to be eroded by the rain. This factor depends on the physical and chemical properties of the soil particle size (particle size, aggregation, structural stability, porosity, organic matter content, etc.). The resistance to water erosion is lower for soils relatively thick that for the deep soils **[10].** As well, when superficial soils are saturated with water by the rains, a particle displacement occurs toward the bottom of the slope, even if the latter is very low. For the determination of this parameter, we retained the equation of Wischmeier and Smith. The K factor is determined according to the formula of Wischmeier and Smith, which is based on the texture of the soil (M= (% sand end% silt)*(100-% clay), the organic matter content (a), of the structure of the ground (B) which is between 1 and 4 and the permeability (C) between 1 and 6, according to the following equation:

$$1000\,k = 2.1 * 10^{-4} *(12-a)\,M^{1.4} + 3.25\,(b-2) + 2.5\,(c-3) \qquad (2)$$

Starting from the soil map of Berrechid plain and based on our knowledge of the field, we classified, and then codified, the different units of soil, which has led to a map of erodibility **(Fig.3).**

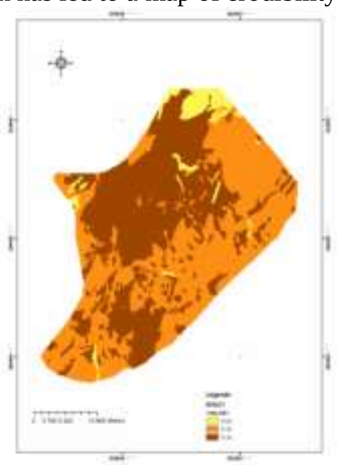

Fig. 3: K. soil erodibility map

THE TOPOGRAPHIC FACTOR, LS

This factor represents the combined effect of the length and the angle of the slope. It plays an important role with the stiffness and the length of the slope (from the place where the elements of the soil are detached up to the place where they are deposited **[11].**

The topographic factor (LS) was calculated from the tilt of the slopes and their length by the formula of Wischmeier & Smith **(equation 3):**

$LS= (L /22.13)^{m\,*}(0.065 +0.045.S+ 0.065.S^2)$ (3)

Where **L** is the length of slope in m,

S is the inclination of the slope in %,

M is a parameter such as m = 0.5 If the slope is > 5%, m = 0.4 If the slope is 3.5 to 4.5%, m = 0.3 If the slope is 1 to 3 per cent and m = 0.2 If the slope is < 1%. m is a parameter such as m = 0.5 If the slope is > 5%, m =0.4 if The slope is 3.5 to 4.5%, m = 0.3 If the slope is 1 to 3 per cent and m = 0.2 If the slope is < 1%.

From the digital terrain model (MNT), and using GIS we obtained the slope map and the map of the slope length, and using the formula of Equation 3 the GIS compute the LS factor map (**Fig. 4).**

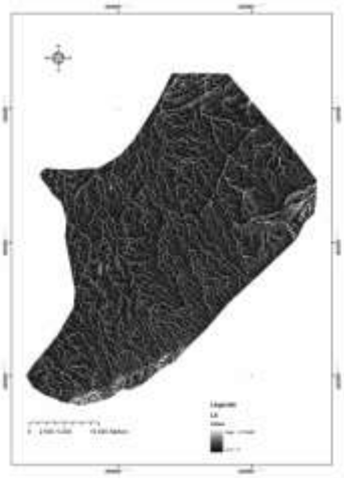

Fig. 4: the topographic factor map, LS

CLIMATE FACTOR (R)

The rain is the engine component of the erosion. Without precipitation there is no water erosion. However the rain intensity is the main factor in the erosion. The more the intensity is high, more the effect of threshing of the soil is pronounced.

The estimation of the R factor according to the formula of Wischmeier & Smith requires knowledge of the kinetic energies (EC) and the average intensity on 30 minutes (I30) of rain drops of each shower. It is given by the empirical formula of Wischmeier & Smith (1978) (**equation 4):**

$R = k^* EC^* I_{30}$ (4)

K is a coefficient that depends on the system of units of measurement.

The only available data concerning precipitation in the stations that are located in the basin or in its vicinity are monthly averages and annual. Some authors **[12—14]** have developed alternative formulas that do only imply the annual precipitation to determine the R factor.

HEUSCH **[15]** has developed for stations of Morocco an empirical formula which allows calculating the factor of the rain erosivity; **(equation 5):**

$R = 143 \log (p * p_{24}{}^2 * 10^{-6}) + 89.7$ (5)

P = precipitation Annual Average (mm);

P24 = Maximum precipitation in 24 hours, return period 20 years (mm).

These data are transformed into matrix map by ordinary kriging in the GIS **(Fig.5).**

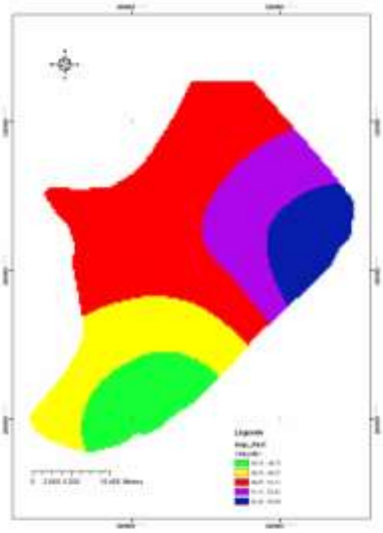

Fig. 5: the Climate factor map, R

THE GROUND OCCUPANCY FACTOR (C)

The plant cover is the essential element of the soil protection against erosion. It provides information on the degree of Soil protection. In effect the plant cover allows the reduction of the splash effect on the soil. A soil well covered by vegetation slows the water flow while a bare soil is more exposed to erosion. The values of C vary from 1 for the bare soil to 0.001 for the dense forests and mulched cultures crops abundantly **[16].**Table 1 gives the values of C of a few crops **[17].**

Table1: Cultural Index C of a few crops **[17].**

Type of vegetation	**C**
Bare land, Bare fallowing	1
Fruit Cultivation	0,9
Winter Wheat	0,7
Grain rotation	0,4
Fodder	0,2
Grain rotation + Fodder	0,1 à 0,01
Improved Pasture	0,01

The C coefficient used in our case it is that calculated by remote sensing: the NDVI (**Fig. 6).**

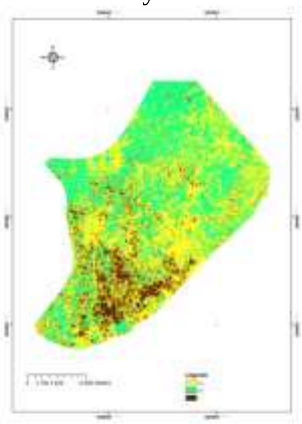

Fig. 6: The ground occupancy factor map **"**C".

THE CONTROL EROSION FACTOR (P)

The cultures in the level curves, in alternating bands or in terraces, the reforestation in benches, mounding and ridging are the most effective practices for the conservation of soils. The values of P are less than or equal to 1.

The value 1 is assigned to the land on which any of the practices mentioned is used **[11] [18].** The values of P vary according to the practice adopted and also according to the slope. In all the plain, there are no control erosion facilities, and farmers do not use farming practices anti-erosion structures. Cultures are especially grain and the plowing is rarely parallel to the level curves. There are a few tests of rehabilitation of forests by reforestation but not in benches. In this context, the P value = 1 has been assigned to the whole area of the plain.

THE SOIL LOSS MAP

By applying the USLE equation (equation 1), the GIS compute the risk map of soil loss of in Berrechid plain, the soil loss estimated annual in the watershed with using the USLE is low to medium (ranging from 0 to 9.42 t/ha/year) **(Fig.7)**

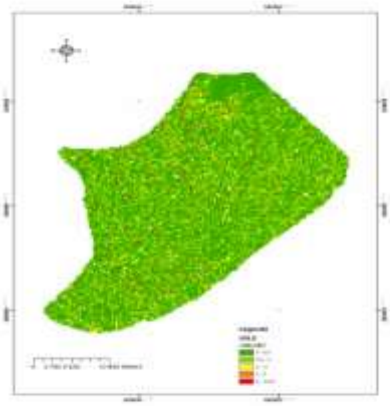

Fig. 7: The Soil loss map of Berrechid plain (USLE).

V. DISCUSSION

The implementation of the USLE model brings interesting information on the ongoing process in Berrechid plain. The estimate of soil loss given would therefore be representative of the situation on the study area. Soil losses averages vary in function of the occupation of the land. The greater rate of soil loss is located in the regions of bare soil; however the existence of such a loss of soil is not only due to the lack of vegetative cover; in effect, the erosive potential, which is the abstraction of the nature of the soil occupation, has always assigned the greatest value for the bare soil. The type of cover in place is necessary to curb the water erosion; The loss of soil estimated annual in the watershed with the help of'(USLE) is low to medium (ranging from 0 to 9.42 t/ha/year), a large percentage of the sector of study presents a low loss of soil this does especially not say that these sectors are well developed because this rate of loss of soil come either from the fact that the slope is low or the fact that the nature of the soil and the aggressiveness of the rains intervenes against erosion.

VI. CONCLUSION

The results of the application of the universal equation of losses in soil using the geographic information system in the plain of Berrechid showed that the Watershed loses up to 9.42 t/ha/year. These values correspond to a low to average soil erosion. The decisive factors for the erosion in the plain of Berrechid are the rain aggressiveness and to a lesser degree the soil erodibility and vegetation cover. This work results show the interest of the use of the technology of remote sensing and GIS in the assessment of the vulnerability to erosion in Berrechid plain. The method used has helped to identify areas at risk of erosion in the water in Berrechid plain and the erosion risk map developed could constitute a basic document for any proposed development. The method of soil loss (USLE) under GIS provides an important aid to decision makers and planners to simulate scenarios of the evolution of the region and plan interventions to combat erosion. It also allows following the impact of these developments controlling the erosion in the region.

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