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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/18758
DOI URL: http://dx.doi.org/10.21474/IJAR01/18758

RESEARCH ARTICLE

CONTRIBUTION TO THE STUDY OF SOIL VULNERABILITY TO WATER EROSION IN THE THIÈS PLATEAU

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Manuscript Info

Manuscript History
Received: 20 March 2024
Final Accepted: 27 April 2024
Published: May 2024

Key words:-
Water Erosion, Thiès Plateau, Vulnerabilty, Erodibility Map

Abstract

This study was carried out in the watershed located between the municipalities of Tassette and Notto, where soil water erosion is one of the most dangerous threats in the region.This work aims to quantify the degree of soil erodibility in the Thièsplateauand then draw up an erosion risk map using the improved boyoucoss method. Interpretation of the experimental results reveals that the erodibility index varies between 1.62 and 14.10, with an average value of 5.6. This variation in the erodibility index shows areas of high, moderate and very high vulnerability, respectively 59%, 18.2% and 18% of the areas studied. The progressive degradation of soils by water erosion is also amplified by inappropriate human activities, weakening the resilience of ecosystems and communities.

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Introduction:-

Soil degradation is defined as the process of reducing soil productivity or the quality of natural resources.

In Saharan and sub-Saharan countries, water resources are scarce. Added to this is water erosion, a natural phenomenon of soil degradation that depends on soil physical properties, climate and land use. However, when it comes to agricultural areas, water erosion becomes a major problem, leading to upstream soil degradation and loss of productive potential.

This process of accelerated soil degradation, observed in many regions of the world, is also very present in Senegal.

The aim of this work is to quantify the degree of soil erodibility through its textural composition, using a geotechnical approach consisting in determining the improved Bouyoucos erosion index based on granulometric distribution.

Presentation Of The Study Area

The Thiès plateau is located in western Senegal, in the Senegal-Mauritania sedimentary basin. The entire Thiès Plateau area is an ecosystem made up of three massifs (Diass, Thiès and Mont-Rolland) characterized by the presence of chains of hills of varying sizes.

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The study area is located in the municipalities of Notto and Tassette, and forms the southern edge of the Thiès plateau.

The catchment area of the study zone covers an area of 43 km^2 and a perimeter of 38 km.

The study area covers 5 villages: Kissane, Birbirane, Ngolfagnick, Diass Palam, and Palam.

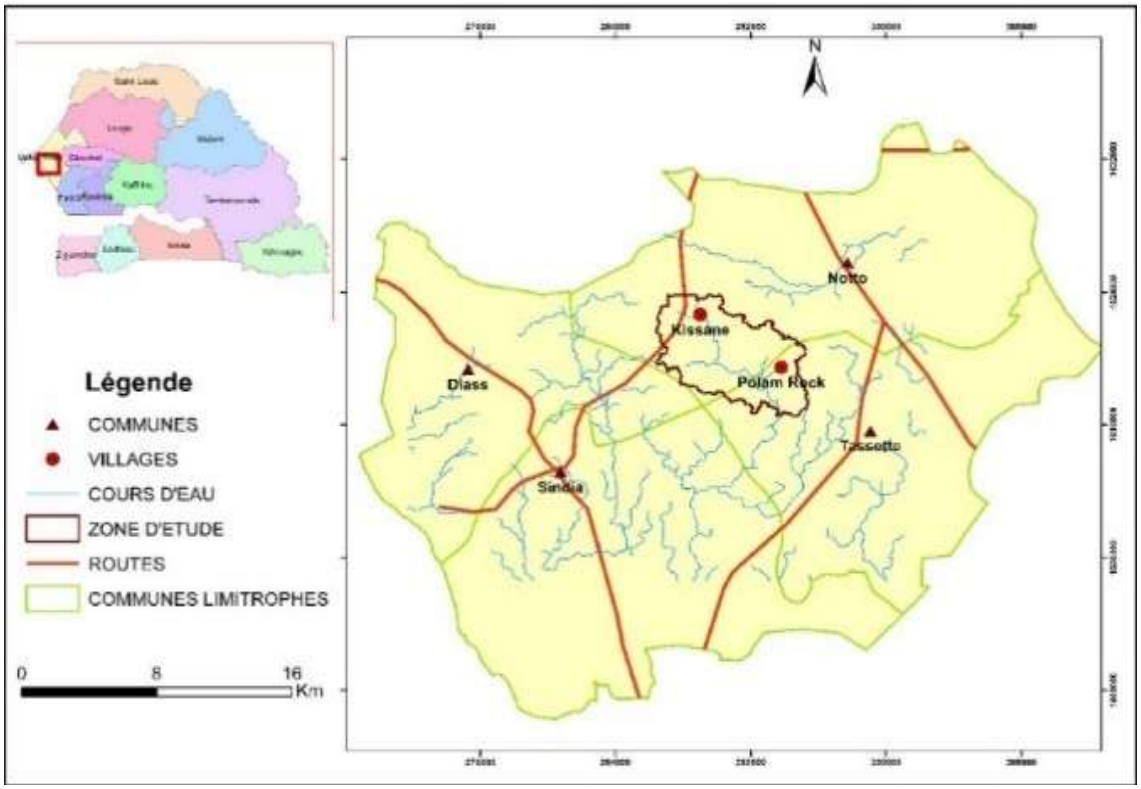

Figure 1:- Location map of study area.

Material and Method:-

Methodology:-

To carry out the study, a drilling campaign was organized.

Forty-four (45) manual test pits were drilled in the basin, allowing samples to be taken at a depth of 40 cm for geotechnical testing. The samples taken were tested in accordance with the geotechnical program, which included the following tests:

- Granulometry by sieving test;
- Consistency or Atterberg limits;
- LCPC classification
- EIROM evaluation index;

According to the BOUYOUCOS model, soil erodibility is a multiplicative function (Eq.1) taking into account the percentage of sand, silt and clay

$$\mathbf{I_{BOU}}=\frac{(\%\mathbf{sand}+\%\mathbf{Silt})}{(\%\mathbf{clay})} \quad \mathbf{(1)}$$

Following an improvement of the Bouyoucos formula by Zainal Abidin and Mukri (2002), a new erosion risk assessment formula (EIROM) is proposed to predict the degree of erosion expected across a catchment. This index has been successfully applied to the study of erosion-induced landslides in Malaysia.

$$\mathbf{EL_{Rom}}=\frac{(\%\mathbf{sand}+\%\mathbf{Silt})}{\mathbf{2}(\%\mathbf{clay})} \mathbf{(2)}$$

Setting up the improved bouyoucos model $\mathbf{EL_{Rom}}$_Rom requires pedology data. The reference sieves for the test are 2 mm, 0.2 mm and 0.08 mm.

Results and Discussion:-

The studies carried out on the samples collected enabled us to identify and classify the materials and estimate their soil erodibility indices, thus enabling us to produce a soil vulnerability map to water erosion.

Table 1:- Test results - Sand equivalent (0-40) cm.

Sample No.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Horizon (cm)	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40
% < 2 mm	98,31	97,2	97.4	98.2	97,8	99,7	96.4	94,1	97,3	97,2	99,3
MO	2.1	2.7	1.8	1.6	2.3	1.7	2.4	2.6	1.1	2.3	2.4
ES1	63.18	47.6	64.83	57.03	68.3	64.2	63.1	63.05	57.18	64.7	56.93
ES2	64.26	46.9	65.51	57.04	67.5	65.18	64.5	64.3	56.95	65.63	55.44
Moy	63.72	47.3	65.17	57.03	67.9	64.69	63.6	63.67	57.06	65.16	56.18

Table 2:- Geotechnical characteristics of samples taken.

Survey no.		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Horizon (cm)		0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-20	0-40	0-40	0-40
Denominationsin 5 classes	% Clay (<0.002m)	0	0	0	0	0	0	0	0	0	0	0
	% Fine silts	0	0	0	0	0	0	0	0	0	0	0
	%Limons Coarse (0.02-0.05mm)	8.3	7.8	7.7	6.1	5.8	9.4	8.2	9.3	7.3	8.6	28.74
	% Fine Sand (0.05-0.2mm)	15.1	10.6	6	6.53	1.4	3.9	5	2.8	8.1	6	9.79
	%Sand Coarse	74.9	79.2	83.1	85.6	79.8	54.7	80.7	75.1	83.3	38.2	60.76
	% Gravel (2-20mm)	1.7	2.4	3.2	1.77	13	32	6.1	12.8	1.3	47.2	0.71
Denominationsin 3 classes	% Clay (<0.002m)	0	0	0	0	0	0	0	0	0	0	0
	% Silt Total	8.3	7.8	7.7	6.1	5.8	9.4	8.2	9.3	5.0	8.6	28.74
	Total Sand	90	89.8	89.1	92.13	81.2	58.6	85.7	77.9	93.7	44.2	70.55
	%Gravel(2-20mm)	1.7	2.4	3.2	1.77	13	32	6.1	12.8	1.3	47.2	0.71

Table 3:- LCPC classification.

Sample	S1	S2	S3	S4	S5	S6	S7	S8	S9	S 10	S 11
Horizon (cm)	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40

% < 2	98,3	97,2	97.4	98.2	97,8	99,7	96.4	94,1	97,3	97,2	99,3
% < 0,200	23.4	18,0	14.3	12.6	18,0	45,0	15,7	19,0	12,0	59,0	38.5
% < 0,080	8.3	7.8	7.7	6.1	5.8	9,4	8,2	9.3	7.6	8,6	28.7
Liquidlimits	11.2	9.6	8.7	12.4	7.5	8.6	9.6	8.4	8.5	9.4	26.6
Plasticity Index	6.2	6.1	5.9	6.3	6.3	7.2	6.1	6.2	6.3	10.2	11.6
Curvaturecoefficient	0.91	1.09	0.96	1.10	0.93	0.97	0.95	0.98	1.20	0.97	-
Uniformity coefficient	1.58	1.51	1.53	1.58	1.61	1.57	1.55	1.6	1.59	1.55	-
LCPC	siltysand	siltysand	siltysand	siltysand	clayeysand	clayeysand	clayeysand	siltysand	siltysand	clayeysand	clayeysand

Identification tests carried out in the laboratory on the 44 samples enabled us to classify them as follows:

- 71% siltysand;
- 29% clayeysand;

Depending on the value of the Cu uniformity coefficient, three levels of soil erodibility are defined:
-Uniformity coefficient ≤ 5: highly erodible soil ;
- 5 ≤ Uniformity coefficient ≤ 15: moderately erodible soil;
- Uniformity coefficient ≥ 15: weakly erodible soil.

Determination of soil textural composition at watershed level enabled us to calculate the Cuuniformity coefficient and produce the erodibility map of soils in the study area.

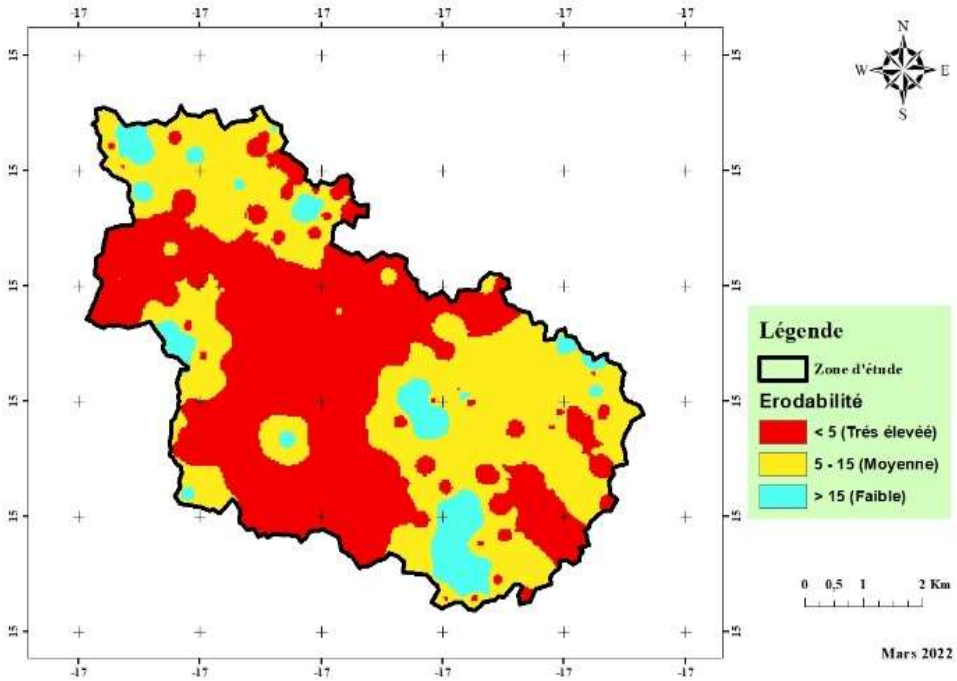

Figure 2:- Soil erodibility map based on uniformity coefficient.

Table 4:- EIROM erosion risk assessment index.

Sample No.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Horizon (cm)	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40	0-40
% < 2 mm	98.3	97.2	97.4	98.2	97.8	99.7	96.4	94.1	97.3	97.2	99.3

% < 0,200 mm	23.4	18	14.3	12.6	18	45	15.7	19	12	59	38.54
% < 0,080 mm	8.3	7.8	7.7	6.1	5.8	9.4	8.2	9.3	7.6	8.6	28.74
EROM	7.33	7.38	7.25	9.08	9.98	7.70	6.84	6.08	7.19	9.08	2.40
Degreesof erodibility	High	High	High	Very High	Very High	High	High	High	High	Very High	Moderate

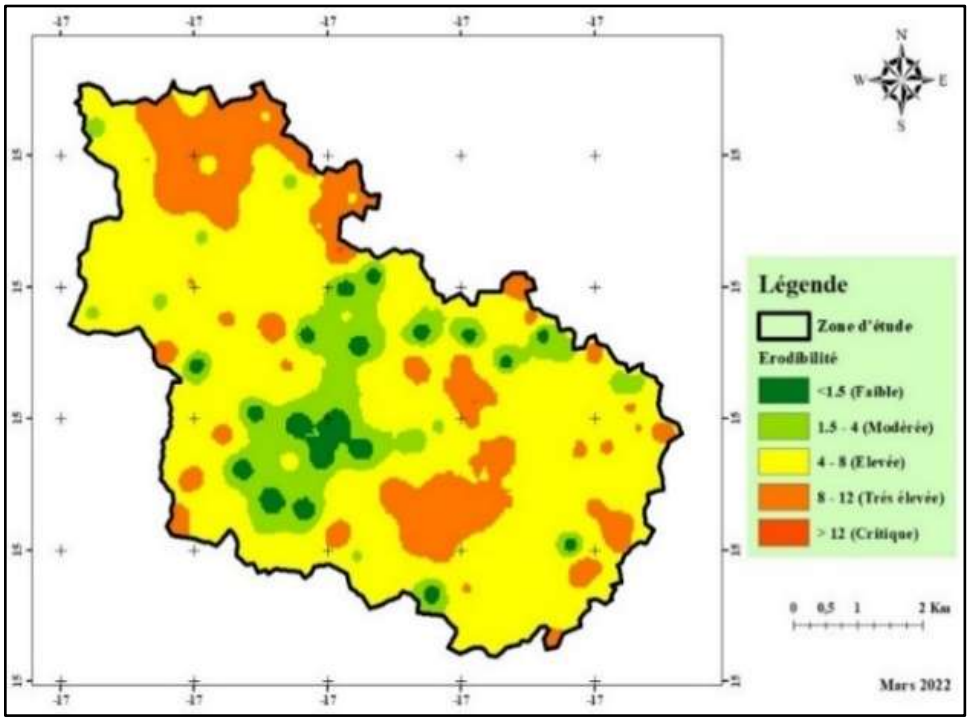

Figure 3:- Soil erodibility map according to EIROM.

Determination of the textural composition of samples taken from the watershed enabled us to calculate the EIROM index. We note that the erodibility index varies between 1.62 and 14.10, with an average value of 5.6. This variation in the erodibility index shows areas of high vulnerability to erosion, representing 59%, areas of moderate vulnerability, 18.2%, and areas of very high vulnerability, 18%.

The erodibility map shows that the steeper the slopes of the watershed, the higher the soil erodibility index values. This can be explained by its topography, which features fairly steep slopes, and the steeper they are, the greater the energy required for water flow to carry away fine soil.

To combat water erosion, strategies such as mechanical soil conservation can be used. These techniques not only evacuate water, but also control and maintain its flow. These include grassed strips, benches, stone barriers, low walls and half-moons.

Conclusion:-

The Thiès plateau, with its rugged relief, is subject to advanced degradation due to numerous natural factors such as water erosion.

This experimental work enabled us to quantify the degree of erodibility of soils in the study area, based on their textural composition. The originality of our method lies in the fact that a geotechnical approach consisting in the determination of the improved Bouyoucos erosion index based on granulometric distribution was used.

The erodibility maps produced can be used by decision-makers to inform their water erosion control initiatives.

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