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Diagnosis and Qualitative Estimation of the Hydric Erosion in Watershed of Talangaï (Brazzaville) by the Application of Geographical Information System (GIS)

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Abstract: This research work exposes the results of our study about the cartographic and the qualitative estimation of the hydric erosion of the watershed of talangaï (Brazzaville) following the PAP/RAC approach, tele detection's data and the geographical information system in order to elaborate thematic cards by enlightening erosion phenomenon. In this watershed of talangaï, this phenomenon of erosion became recurrent and causes more and more spectacular and worrings. As a matter of fact, except climatic aspects of the study zone, this watershed is characterized by a large irregularity of precipitations, of steep slope, and a weak vegetable coverage; which renders it very vulnerable to the erosion. Thus, after the analysis and the treatment of collected data, from the geographical information system (GIS), the study shows that 65% of zone of study present a weak and average erodibility and 35% of a high and the highest erodibility. Likewise, the descriptive cartography of different forms of erosions shows that ravine surface and the erosion in table-cloth are the most current. Also, the consolidated card of erosion states shows in a qualitative way that soil loss in the zone of study is in relationship with its geomorphology. In short, after combining different cards of principle erosive states, a synthesis has been done producing the consolidated card of these states (Integration approach). All these unfavorable conditions; slopes; geomorphology; erodibility; friability of soils, vegetal covert …), triggering of the catastrophe about erosive phenomenon are fulfilled. Thus, the obtained results allow to identify zones which are the most concerned, and the most vulnerable to hydric erosions.

Keywords: Teledetection, Geographical Information System (GIS), Pattern PAP/RAC, Vulnerability, Soil, Hydric Erosion, Cartography

1. Introduction

The phenomenon of hydric erosion is the form of physical degradation of soils that concerned particularly tropical countries and where the pluviometer is very noticeable, leading then to considerable soils loss, in characterized zones by middle slopes at strong declivity and by a certain soils' erodibility [1]. These phenomenon of erosion became very recurrent in several countries and Congo – Brazzaville as well. The watershed of Talangaï (Brazzaville) did not escape from this rule and related stakes to become very decisive, because many factors facilitate the triggering of an accelerated dynamic of hydric erosion.

As a matter of fact, the soils degradation in the concerned zones cause enormous problems with very negative socio-economic and environmental benefits. Consequences of erosions are such as diverse sinisters are observed in these localized zones. These problems are shown by the destruction of road infrastructures, works of art, collapses and silting problem …, without forgetting the loss in human being. In a social way, we also assist to a persisting impoverishment of population, this provokes their migration to other towns. Also, in ecological way, we likely assist to the degradation of living milieu which is expressed by the reduction of biological diversity, vegetable, and forest, etc.

But, in spite of these negative impacts, very little of conservatory measures or even preventive measures are taken by authorities to struggle against these soil degradations. Thus, in this dynamic, we can ipso facto note that ravines making in zones at remarkable slope and at weak soil cohesion, silting phenomenon and landslides, etc. [2]. These phenomenon are in fact accentuated by progressive elimination of the vegetable covered, consequently to the accelerated urbanization in the said zone and of the anthropic pressure.

Figure 1. *Erosion of Ngamakosso, roadway collapse (District 6 Talangaï, Brazzaville).*

Figure 2. *Erosion of Ngamakosso, destruction of traffic ways (District 6 Talangaï, Brazzaville).*

On the other hand, the strongest urban growth in districts of the town of Brazzaville (about 79%) and specifically in this zone of study is less and less sustained by authorities who no longer develop the coherent politic in order to absorb or anticipate on current phenomenon, particularly in those of new quarters at spontaneous habitation [2] and where arrangements are not often considered. Moreover, the occupation of zones of high altitude, without true viabilization increases their sensitivity to hydric erosion. In other words, the city of Brazzaville in general and the district number six (06) Talangaï in particular covers composed soils with a large table-cloth making sand-polisher [3, 2]. They are powder and inconsistent soils that testify of their vulnerability to the erosion. It means that, several methods and tools have been developed for the estimation of the hydric erosion (USLE, RUSLE, LEAM, PAP/RAC, etc.).

The usage of the teledetection and of geographical information systems and putting in exergue hydrologic data have rendered possible the modeling and the spatialization of the hydric erosion in a reasonable way [4-6]. PAP/RAC (The Priority Actions Programme/Regional Activity Centre) approach, already used by many researchers, has shown its great usefulness for the cartography and the modeling of the hydric erosion [6-10]. What is sure, and what is friable of reliable nature of these geological formations, the destruction of the vegetable cover and the evidence of slopes are at the origin of the vulnerability state of watersheds and the accentuation of the hydric erosion in the zone of study.

So, this research work proposes to study starting from a cartography, the vulnerable zones to hydric erosion basing on the PAP/RAC pattern, data of the teledetection and the geographical information systems (GIS), this is in coherence with data issues from the geotechnical characterization of soils in place. So, this work aims at spatializing and cartographing sensitive domain and foreseeable to hydric erosion of the watershed of Talangaï and to justify it through some geotechnical characteristics of soils in place.

2. Material and Methods

2.1. Area of Study

The district 6 Talangaï is situated to the North-East of Brazzaville. It is characterized by a perimeter close to 40km with a third constituting the bank of the Congo river (right bank) in altitude 4°13'4.34"S and in longitude 15°17'1.86"E according to reference system WGS 84 ESPG4326. The zone is also characterized by hills of more and more 500m of altitude in the hydrologic point of view, it is drained by Mpila river number one and two, Tsiémé and Ngamakosso that, altogether fall in the Congo River. With a population of near 500.000 inhabitants, the district 6 Talangaï has 8 quarters which are: Mpila, Intendance, Ngamakosso, Texaco Tsiémé, Fleuve Congo, Joseph Gobali, Champ de Tir, Gaston Lenda and Maman Mbouale, (figure 3, figure 4 and figure 5).

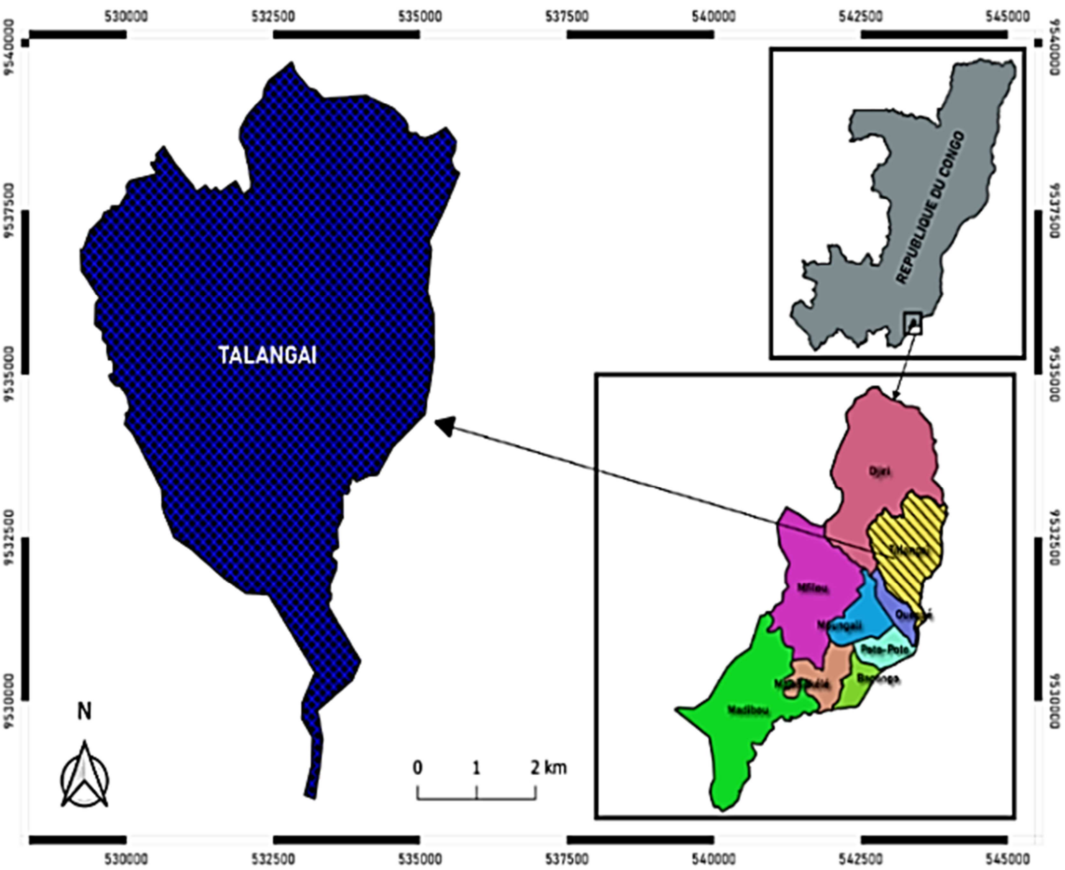

Figure 3. *Situation of the zone of study.*

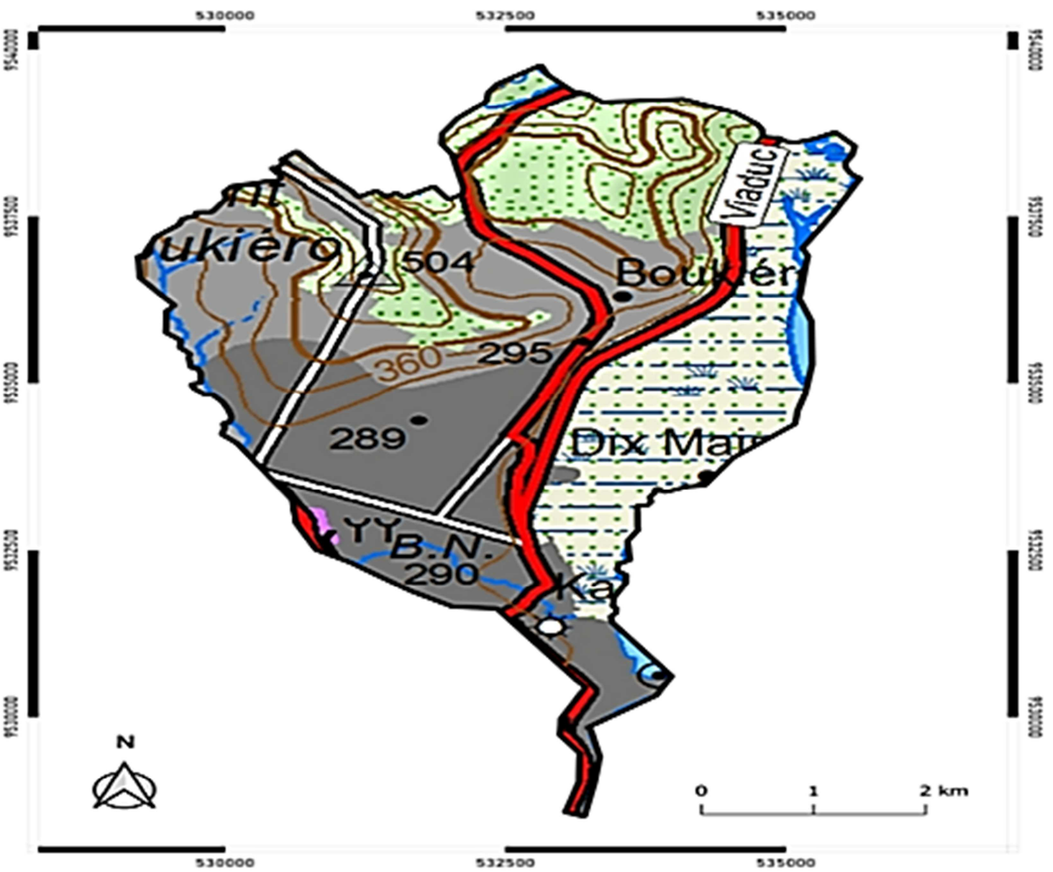

Figure 4. *Bottom of topographical beret of Talangaï.*

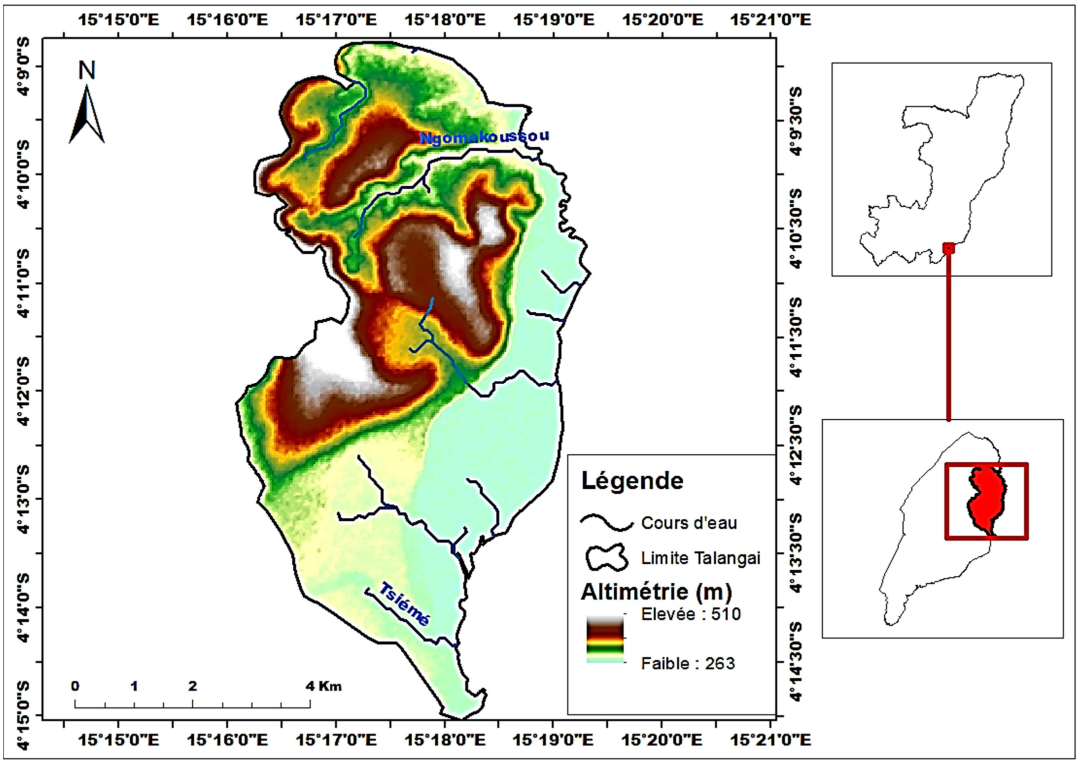

Figure 5. *Presentation of the surrending of the district 7, Talangaï under numeric pattern background of terrain (MNT).*

Then, apart from the evidence of erosions in hill areas, the geographical formations of quaternary, Talangaï is a district that undergoes multiple variations, by the transport of sediments from downtown to the East, and which, with the rise of Congo river in weak altitude zone, is created along the bank, some islands like dykes, and giving place to many marshy zones or pond. This phenomenon contributes by giving river's winding a distress aspect.

2.2. Equipment

1) A GPS of type Navstar to measure geographical coordinates;
2) Software GIS QGIS 3.16.3, ARGIS 10.4 software;
3) Satellite pictures ASTER GLOBAL DEM and Landsat 8 OLI/TIRS C1 Level-1;
4) The Numerical pattern of Terrain (MNT) (Figure 6), [11, 12].

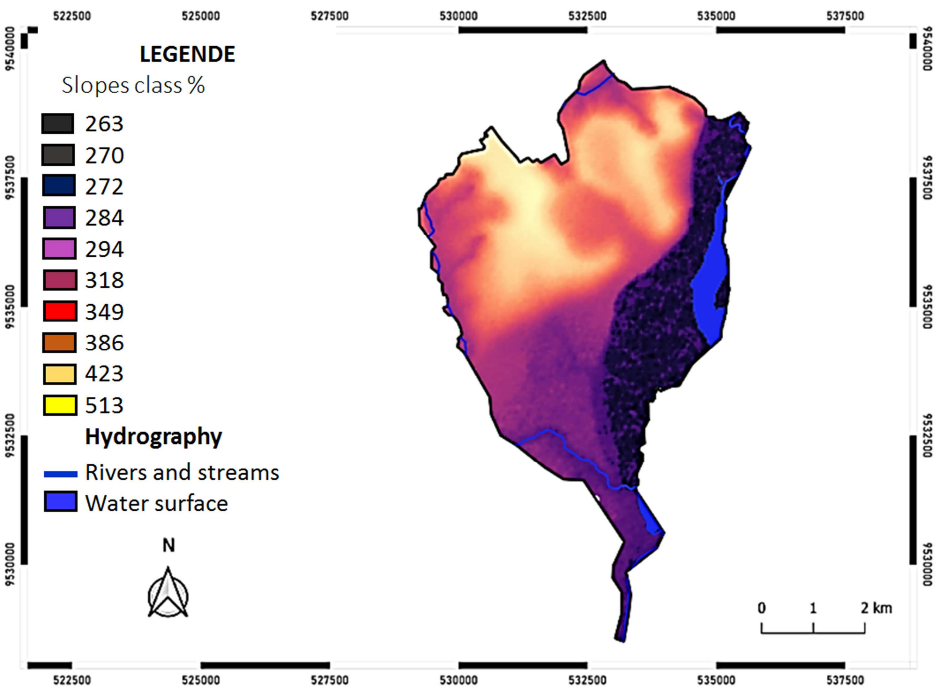

Figure 6. *Numerical pattern of terrain (MNT).*

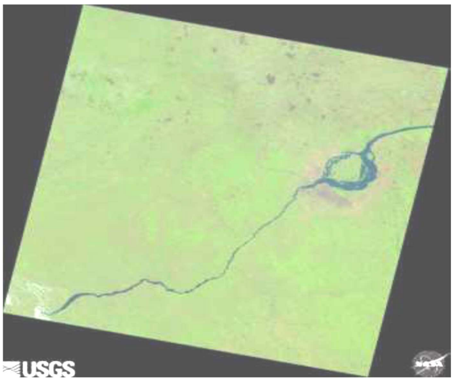

Figure 7. *The picture LandSat 8 OLI [12].*

The picture Landsat 8 OLI (Operational Land Imager)
The picture has been acquired in 2018. The cartographical projection is the UTM (Universal Translate Mercator) of the zone 33 and coordinates' system of reference is the WGS84. It has been downloaded from USGS site for an orbit (Path: 182) and a rank (Row: 063). This picture has been used to generate the vegetation cover card as well as those of the occupation of soils. (Figure 7).

2.3. Climatic Context

Studies carried out by researchers Samba and Nganga (2011) have shown that for a long time, series of climatic data subdivide the Congo-Brazzaville in two types of climates: the equatorial climate in the North and the humid tropical climate in the South. So, the study zone belongs to the humid tropical climate.

It is also characterized by an alternance of two seasons: A rainy and hot season that extend from November to April with very strong precipitations and the dried season from June to September during which water is probably rare. However, months from October to May offer a period of transition for the entrance and outing of the dried season. [13, 14].

2.4. Geological Context

The study zone is constituted by sandy soils associated to Batékés' sandstones (Clayey sandy plateau, sandy plateau, undulated sandy-plateau, undulated plateaux and the sandy slope), of sandy clayey soils (hills on schistious sandstones of Inkissi, hills on sandy clayey sandstone), soils of glacis (glacis and sandy terrace, glacis and sandy terrace in part flooded) and soils on recent alluvions (flooded valleys and low terraces, marshy).

In general, these soils are essentially sandy with some particular elements like the sandstone.

Thus, these are also soils at weak capacity of water conservation and consequently presenting a weak resistance in front of runoff and the flow of rainy water. [15].

2.5. Methodology Used

2.5.1. PAP/RAC Method

The PAP/RAC approach was Applied in 2017 [10], it has the particularity of basing only on natural factors (slope, lithological and vegetable cover). It is based on three phases according to the illustrated process (Figure 8).

The evaluation pattern of the potential erosion developed by PAP/RAC is the result of three phases, namely:

1) Predictive Approach;
2) Descriptive Approach;
3) Integration Step.

The satellite pictures have been treated with the appropriate cartograpic software (QGIS...) [16, 17].

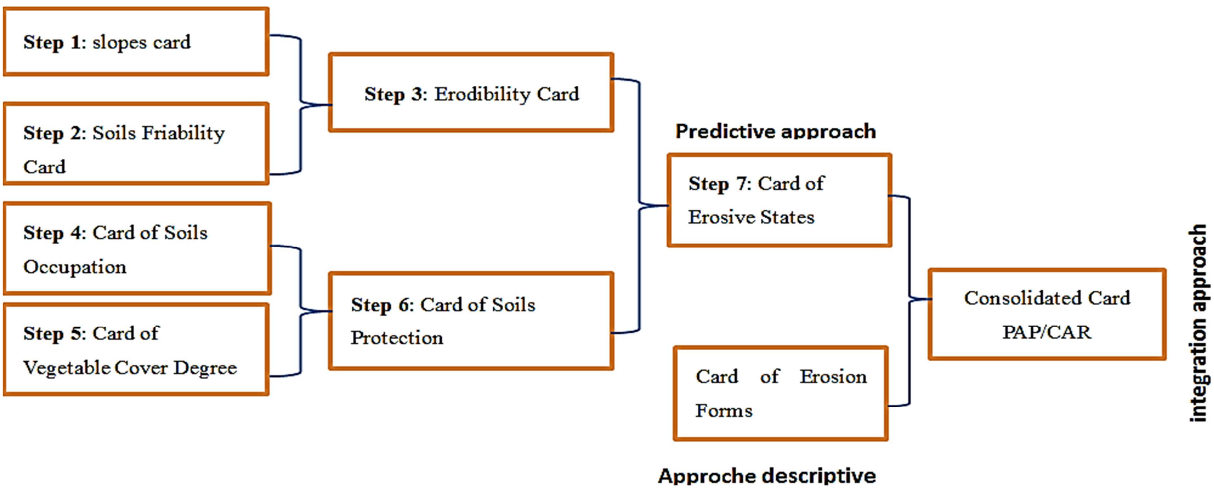

Figure 8. *PAP/RAC Method [18, 10, 16, 17].*

2.5.2. Predictive Approach (Card of Erosive States) (Tables 1, 2, 3, 4)

This approach is based on the treatments of data in order to evaluate the degree of protection of soils and the degree of erodibility according to several steps:

1) The elaboration of the slope cards.
2) The elaboration of the lithosfacies cards.
3) The erodibility card.

4) The card of soil occupation.
5) The elaboration of the vegetable cover card.
6) The soil protection card.
7) The card of erosive states.

Table 1. *Classification of parameters of the predictive approach according to PAP/RAC (1998).*

Slope			Lithos faciès		
Classes	**Incline**	**Degree**	**Classes**	**Resistance**	**Type of material**
1	Nil to weak	(0-3%)	(a)	Very strong	Non altered Compact rocks, conglomerats strongly cemented, etc.
2	Moderated	(3%-12%)	(b)	strong	Rocks or cohesive fractured soils or moderately altered.
3	Abrupt	(12%-20%)	(c)	Average	Rocks or sedimentary soils weakly or moderately compacted. (slate, schiste, marne, etc.)
4	very abrupt	(20%-35%)	(d)	weak	Rocks and/or soils less resistants or strongly/deeply altered (marne, gypse, clayey slate,
5	Extreme	(>35%)	(e)	Very weak	Sediments or furniture soils, non cohesive and detrital materials.

Soil occupation			Degree of vegetable cover		
Classes	**Protection**	**Type of coverage**	**Classes**	**Protection**	**Degree of vegetable cover**
1	Very weak	Dry Culture (herdaceous)	1	weak	<25%
2	weak	Arboriculture, culture on ligne and reforestation	2	average	25%-50%
3	average	intensive Culture of habitat proximity	3	strong	50%-75%
4	strong	Forests	4	Extreme	>75%
5	Very strong	shrub denses			
6	Extreme	schrud sparses, grazing			

Table 2. *Matrix of soil occupation and vegetable cover.*

Soil Occupation	Vegetable cover degree			
	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)
6	5(MB)	4(B)	3(M)	2(A)

With: highest (MA), high (A), average (M), weak (B) and very weak (MB).

Table 3. *Matrix of soils protection degree Vs Erodibility degree.*

Soil protection	erodibility degree				
degree	**1(EN)**	**2(EB**	**3(EM)**	**4(EA)**	**5(EX)**
1(MA)	1	1	1	2	2
2(A)	1	1	2	3	4
3(M)	1	2	3	4	4
4(B)	2	3	3	5	5
5(MB)	2	3	4	5	5

With: Highest degree (1), High Degree (2), notable degree (3), weak degree (4), very weak degree (5).

Table 4. *Matrix of slopes and friability.*

Classes of slope	Classe of lithos faciès				
	1(a)	**2(b)**	**3(c)**	**4(d)**	**5(e)**
1	1(EN)	1(EN)	1(EN)	1(EN)	2(EB)
2	1(EN)	1(EN)	2(EB)	3(EM)	3(EM)
3	2(EB)	2(EB)	3(EM)	4(EA)	4(EA)
4	3(EM)	3(EM)	4(EA)	5(EX)	5(EX)
5	4(EA)	4(EA)	5(EX)	5(EX)	5(EX)

Avec: weak (EN), Moderated (EB), average (EM), strong (EA), Extreme (Ex).

2.5.3. Descriptive Approach

This approach gives a real picture of different forms of erosion existing in the zone of study and their exposition degree to the degradation.

2.5.4. Integration Approach

It is the superposition of the card of obtained erosive states by the thematic cartography and the card of obtained erosion forms by direct descriptive cartography of erosion forms on the terrain or by satellite pictures. The cartographic system used and corresponding to PAP/RAC is a numerical method based on descriptive data of selected sites (topography, soil occupation, lithology) and spatial data of the geographical information system (GIS) compared to thematic cards; in particular Landsat 8 and observations on the ground through satellite pictures on Google Earth, of numerical patterns of terrain (MNT) through satellite pictures.

2.6. Geotechnical Tests

Sampling: The soil sampling is done from the trenches of 60 cm wide and 60 cm deep in districts of Talangai.

These samples have been placed in nylon bags for an analysis in laboratory. The identification tests have been realized for a simple geotechnical characterization:

1) The content in natural water (NFP 94-050, September 1995);
2) The granulomtrical analysis (NFP 94-050, Mars 1994);
3) The test on blue of methylene (VBS), NFP 94-068.n,

3. Results and Discussion

3.1. Interpretation of Cartographic Results of the Hydric Erosion

3.1.1. Predictive Approach

All results describing erosive states basing on the PAP/RAC approach are presented in the following cards:

(i). The Card of Curves of Levels

According to the software parameter, the obtained heights are considered more in NMM.

(Middle level of seas). So, we have:

1) Minimums: 270+2 = 272 meters;

2) Maximums: 270+100 =370 meters (figure 8).

In that card of curve of levels, values vary from 272 to 370 meters (figure 8).

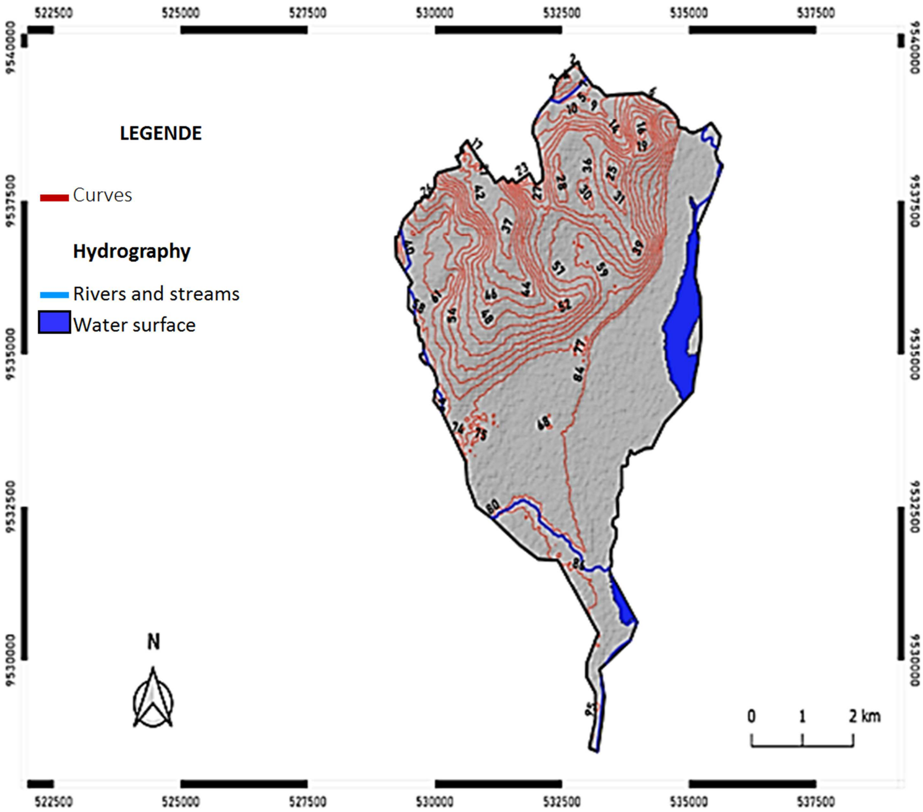

Figure 9. *Level curves.*

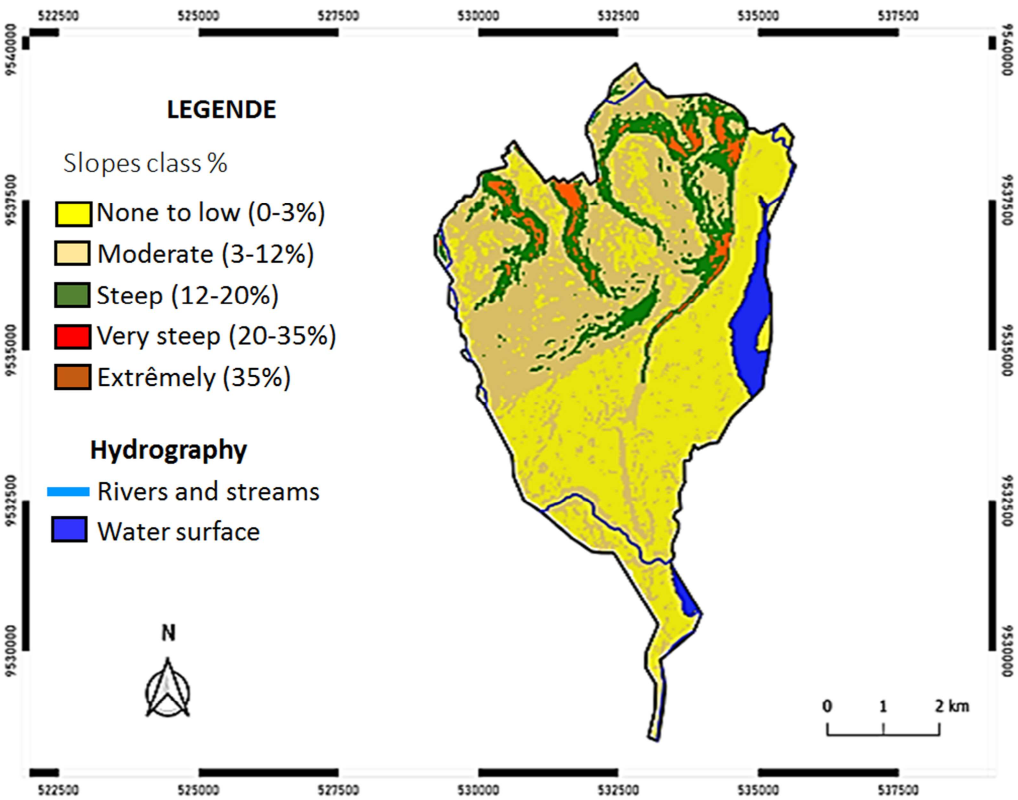

Figure 10. *Slopes map.*

(ii). Slopes Map

The slope is a major factor in the evaluation of the sensitivity of an erosion terrain.

The slopes vary between 0 and 35%. Moreover, this card shows that the degree of the slope is generally steep (12-20%) and is visible in a part of all study zone. This class does not dominate because it is not found in all the region.

The moderate class (3-12%) also occupies a big part of the study zone and is mixed to the very steep class.

We also notice that the very steep class (20-35%) to the highest altitudes appears as ligaments on the steep slopes.

The class zero with a weak percentage (0-3%) is distinguished by some spots. Finally, the extreme class, (>35%) presents only some characteristics above the very steep class. So, this card shows that those slopes render the zone of study, sensitive to erosive actions of precipitations and the biggest activity of water runoff, causing then a considerable ravine. (Figure 9).

(iii). Map of the Lithosfacies

The Lithosfacies Map shows that the zone of study is dominated by a lithology polisher (sandstone of Stanley Pool SP) that represents 65% of total area, shared out at East and along the Congo River to the South. The remainder of the surface (35%) is constituted by Batékés soil shared out in the North-west of the zone (figure 10).

(iv). Material Resistance Card

This card represents the resistance of materials for erosion. According to the repartition of this resistance, we distinguish only two classes of resistances out of five, which are: classes (d) and (e) that correspond respectively to weak classes and very weak. It is to note that classes of superior resistances (average, strong, very strong) are not present. This result can be explained by the fact that the obtained rocks after elaboration of the card of lithos faciès, give only sands and sandstone (Batékés sand and Stanley Pool sandstone) (figure 11).

(v). Erodibility Card

The card of erodibility is the result of the superposition of the card of slopes and those of resistance to erosion of materials. (Table 5).

Polygons resulting from crossed product of two tables are classified according to a matrix in order to priorize the terrain according to the erodibility degree. The erodibility is always extreme when the slope is strong and/or the terrain is of weak resistance.

The spatial distribution of different classes of erodibility shows that on all the formation of Batékés soil, the erodibility is moderated (EM) and this on very strong slopes, the formation of erodibility is extreme (EX). This is due to its friability (Figure 12), (Table 1).

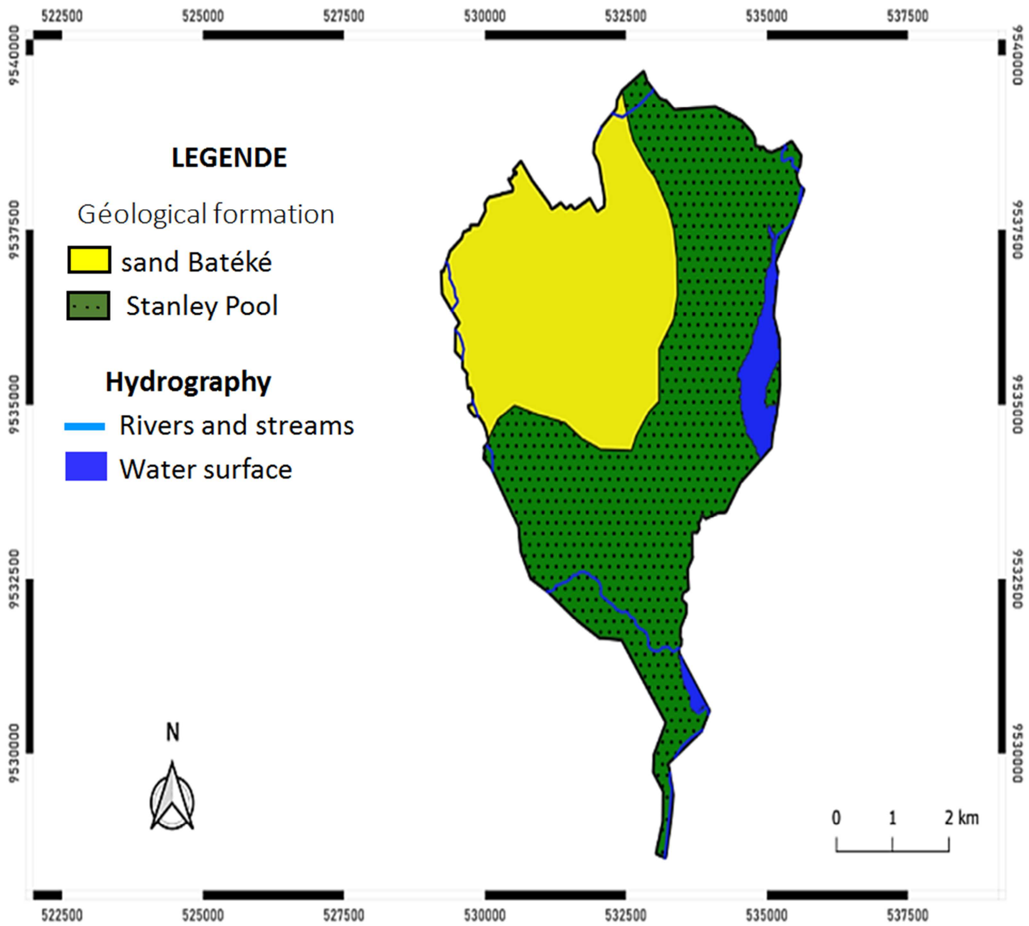

Figure 11. *Map of lithofacies.*

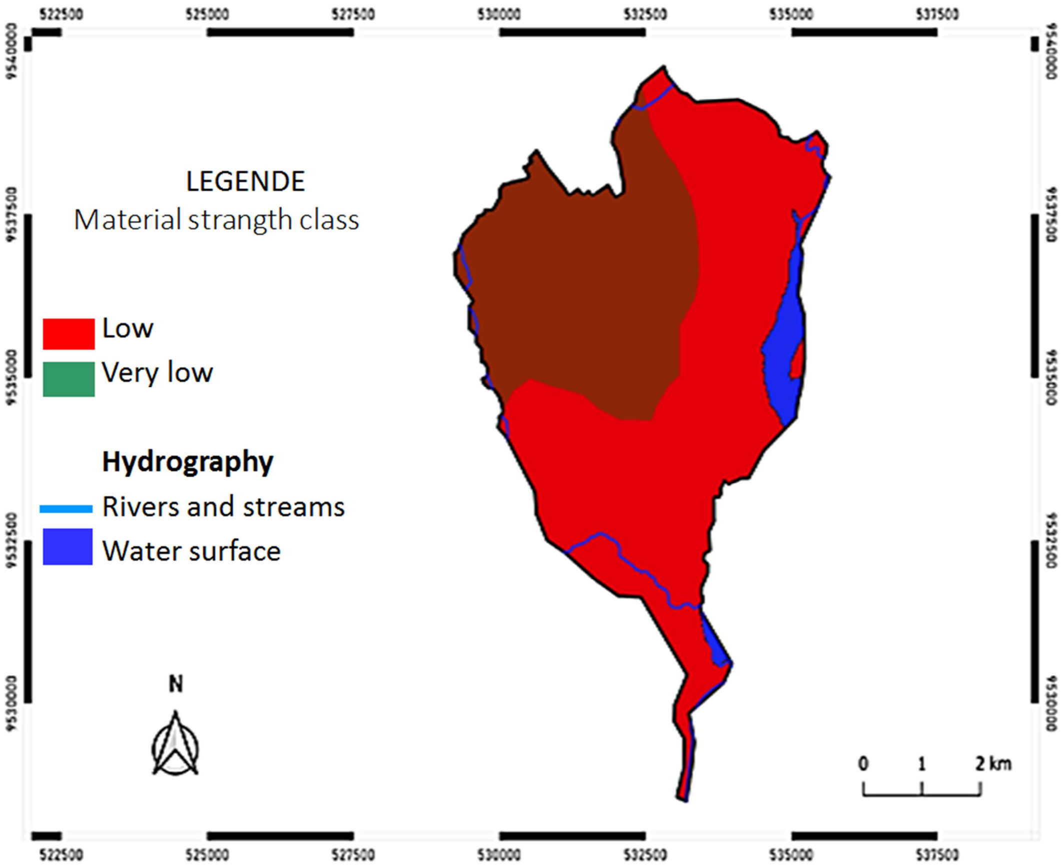

Figure 12. *Material resistance card.*

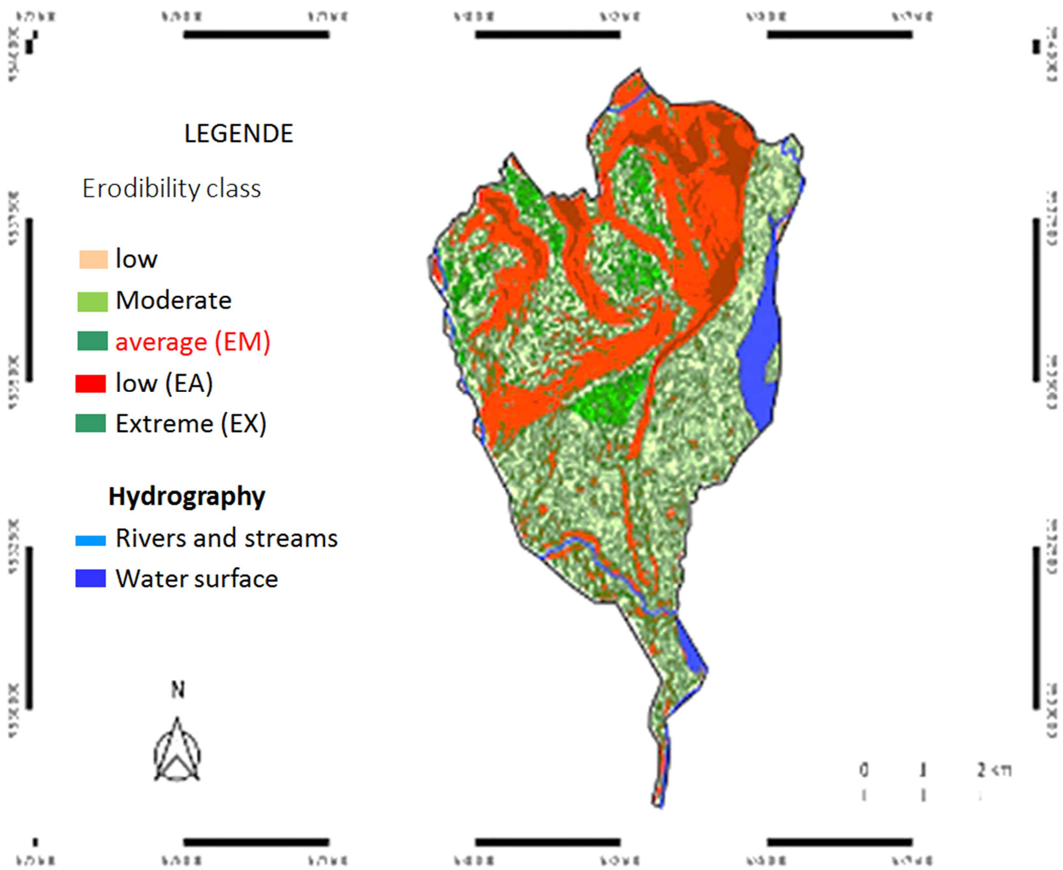

Figure 13. *Erodibility card.*

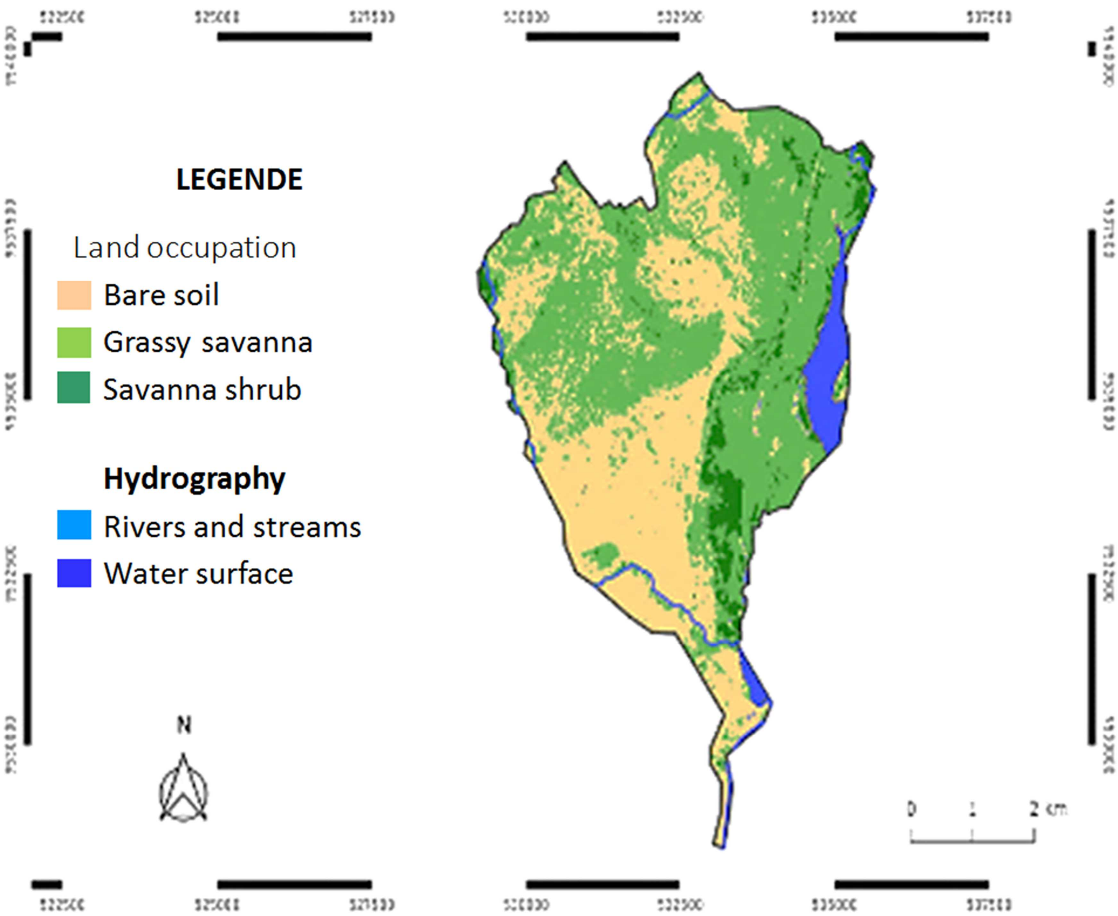

Figure 14. *Soils occupation card.*

Table 5. *Matrix erodibility.*

slope	Resistance classe	erodibility
1 (3)	a	[EN (9); EN (30); EB (70)]
2 (12)	b	[EB (18); EM (39); EM (79)]
3 (20)	c (6)	[EM (26); EA (47); EA (87)]
4 (35)	d (27)	[EA (41); EX (62); EX (102)]
5 (59)	e (67)	[EX (65); EX (86); EX (126)]

The values of erodibility degree are: EN (9; 30); EB (18; 70); EM (26; 39; 79); EA (41; 47; 87); EX (62; 65; 86; 102; 126).

On the formation of Stanley Pool, it exists three types of erodibility: the weak (EN) which is concentrated on the set of formation, the strong (EA) that appeared visibly and the middle (EM) which is mixed to others.

At the polish level of Inkissi, which is the most resistant formation in the zone, there is a strong proportion of weak erodibility (EN) and moderated (EB).

(vi). Soils Occupation Card

The occupation of soils is dominated by classes of naked soils that occupy the quasi-totality of the studied zone. It is spread on near of 60% of the total surface of the study zone. It is generally met on soils of moderated slope and abrupt, and so in zone strongly urbanized. The class of grassy savanna comes at the second position. It spreads on outskirts and on slopes. Finally, shrub savannas that spread along the river and the viaduct. These are the only types of vegetable cover which we find in the region.

Thus, the predominance of naked soils (soil without vegetable cover) on the quasi-totality of the study zone renders soils very vulnerable to the erosion (figure 13).

(vii). Vegetable Cover Card

The vegetable cover depends on the increase and the development of the vegetation in the relationship with the variation of the climatic erosion.

The NDVI (Normalized Difference Vegetation Index), the calculation of the vegetation indication of the study zone has been calculated from the satellite picture Landsat 8 taken in 2018. It shows four classes of values NDVI. The highest values (0.349; 0.441) correspond to shrub savanna zones where the vegetation is the densest in the study zone. The high values (0.278; 0.349) represent the vegetation density, the vegetation of middle density is represented by values comprised between (0.207; 0.278) and weak values (0.207; 0.068) correspond to zones of spared vegetation and of cultivated soils.

The study zone is characterized by a very dense vegetation of the class of density (>75%) with shrubby cover often degraded or absent (on the card). The class of density (50%-75%) (dense Vegetation) is a little more visible than the first. It surrounds with very dense vegetation of the study sector, while the middle vegetation class (25%-50%) represents the part of the vegetation the most streamed in the study of zone.

Residences and buildings are represented by density class (<25%), where the vegetation is quasi non-existent. It is the presentation the most visible in the zone of study (Figure 14).

Thus, the zone of study presents weak characteristics in vegetal cover, with grassy vegetation of the South-East.

(viii). Soils Protection Card

The vegetation protects the soils from the ablation in reducing the energy of erosive agents and of the pluvial erosion intercepting rain drops through the superior parties of plants.

Values of protection degree of soils are: MB (3.067; 3.208; 4.067; 4.208); B (3.278; 4.278; 4.349); M (2.067; 3.349); A (2.208); MA (2.278; 2.349).

The card of soils protection shows different zones divided into five: very weak (MB), weak (B), Middle (M), High (A) and the highest (MA).

The class of the very weak protection (MB) spreads on all zone of study, in places where the litho faciès is constituted of Batékés soils and where we meet urban zones. In effect, it is all the study zone that is not protected in all.

We meet from the South-East to the North-East zones of class of weak protection degree (B), which surrounds almost all zones of classes of high protection degree (A) and average (M) that spreads along of the watercourse.

The very high class (MA) is quasi-identic to the high class (A).

All other classes are found in places none or less lived. Zones of strong and high erosion correspond to zones of strong anthropic activity where important human populations live.

The weak protection of the study sector is explained by the much degraded vegetable cover because of the important needs in culture soils and of overgrazing (Table 6), (Figure 15).

Table 6. *Matrix resulting from soils' protection card.*

Soil Occupation	Vegetal cover degree	Soils Protection
1 (2)	1 (0.0667)	[MB (4.067); MB (4.208); B (4.278); B (4.349)]
2 (3)	2 (0.208)	[MB (3.067); MB (3.208); B (3.278); M (3.349)]
3 (4)	3 (0.278)	[M (2.067); A (2.208); MA (2.278); MA (2.349)]
	4 (0.349)	

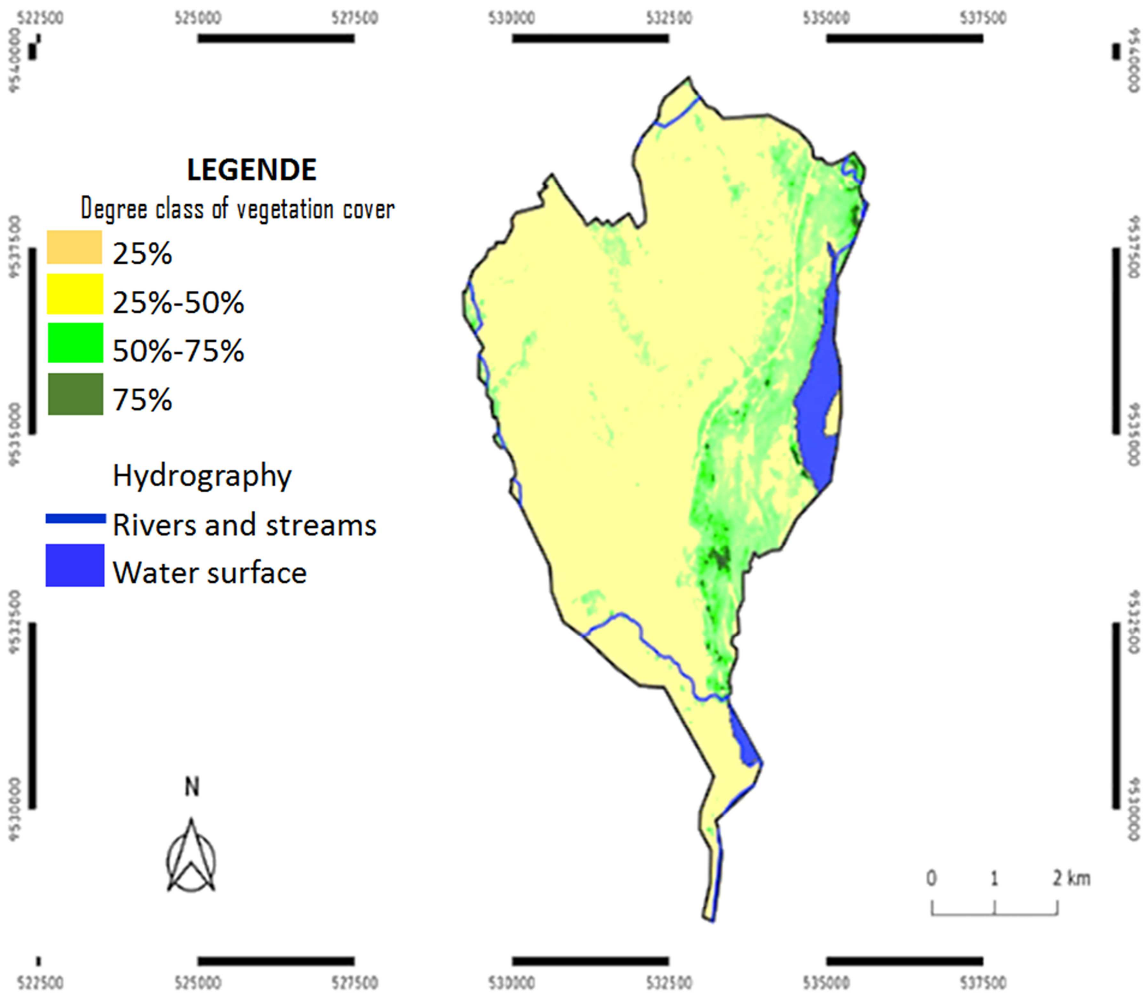

Figure 15. *Vegetal cover card.*

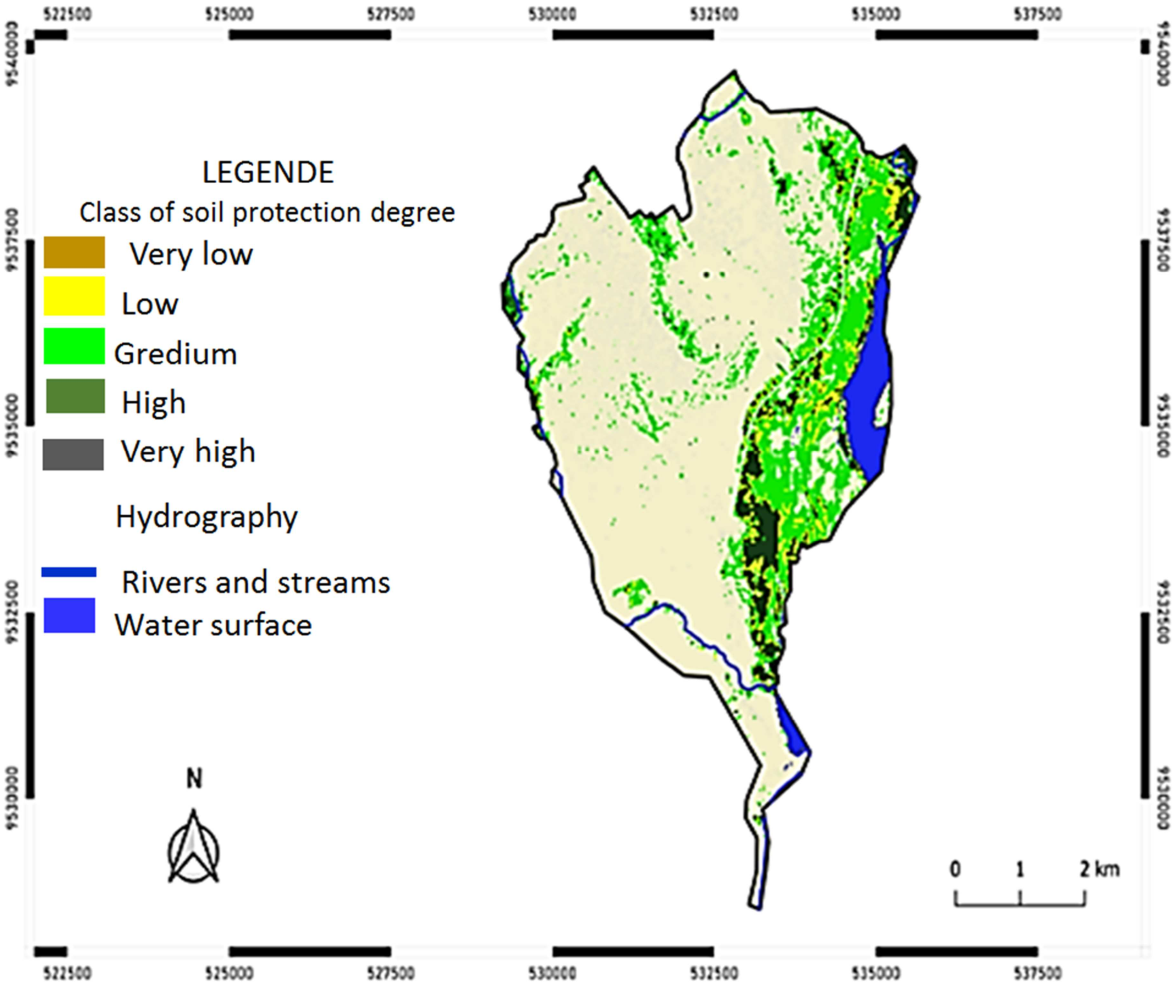

Figure 16. *Soils protection card.*

(ix). Card of Erosive States

The card of erosive states conjures five representative of erosion degree. It deals with classes of very weak degree, weak, notable, high and very high.

The degree of high erosive states is the most represented in the study zone, followed by the notable degree. Weak and notable degrees are mixed in the homogeneous way in slopes level.

The very weak degree of erosive states are non-existents in our study zone.

The sandy formation of Batékés is classified of notable degree if not of degree to erosive risk. Stanley Pool in the contrary is constituted of a mix of the weak class and of the degree to risk. We can see by this card the influence of material resistances so the lithologic formations, of slopes and of vegetal cover on the erosive of the study zone (Figure 16), (Table 7).

Table 7. *Erosive state polygon matrix.*

Soils protection degree	Erodibilite degree	Erosive degree
MA (2.278; 2.349)	EN (9; 30)	[1] [11.28; 32.28; 11.35; 32.35]; [1] [72.28; 72.35; 20.28; 20.35]; [1] [81.28; 28.28; 41.28; 81.35; 28.35; 41.35;]; [2] [89.28; 43.28; 49.28; 89.35; 43.35; 28.35; 49.35]; [2] [67.28; 88.28; 128.28; 64.28; 104.28; 67.35; 88.35; 128.35; 64.35; 104.35]
A (2.208)	EB (18; 70)	[1] [11.21; 32.21]; [1] [72.21; 20.21]; [2] [81.21; 28.21; 41.21]; [3] [89.21; 43.21; 49.21]; [4] [67.21; 88.21; 128.21; 64.21; 104.21]

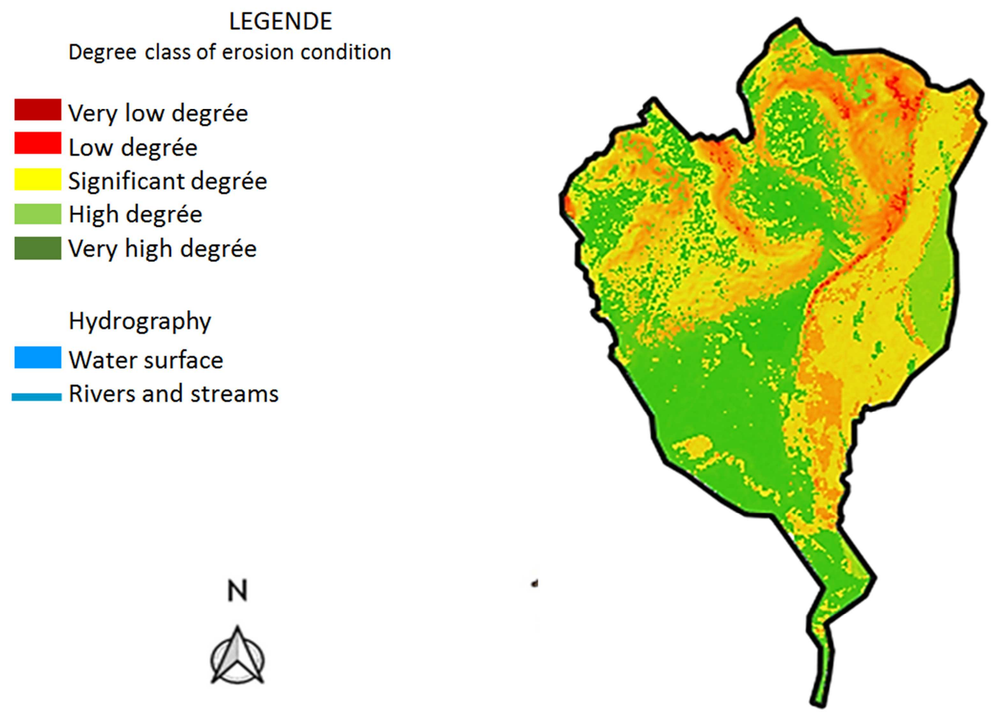

Figure 17. *Card of erosive states.*

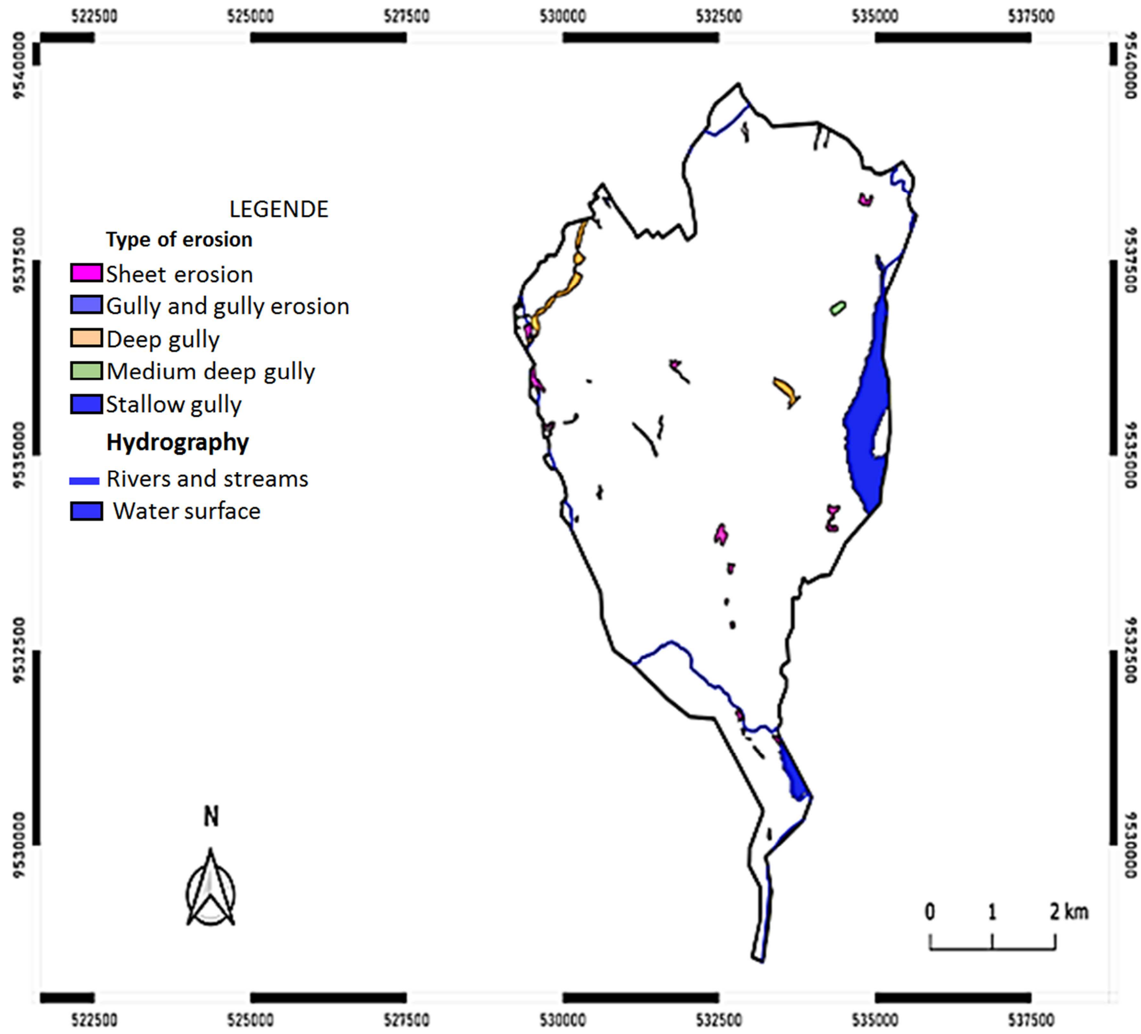

Figure 18. *Card of erosive forms.*

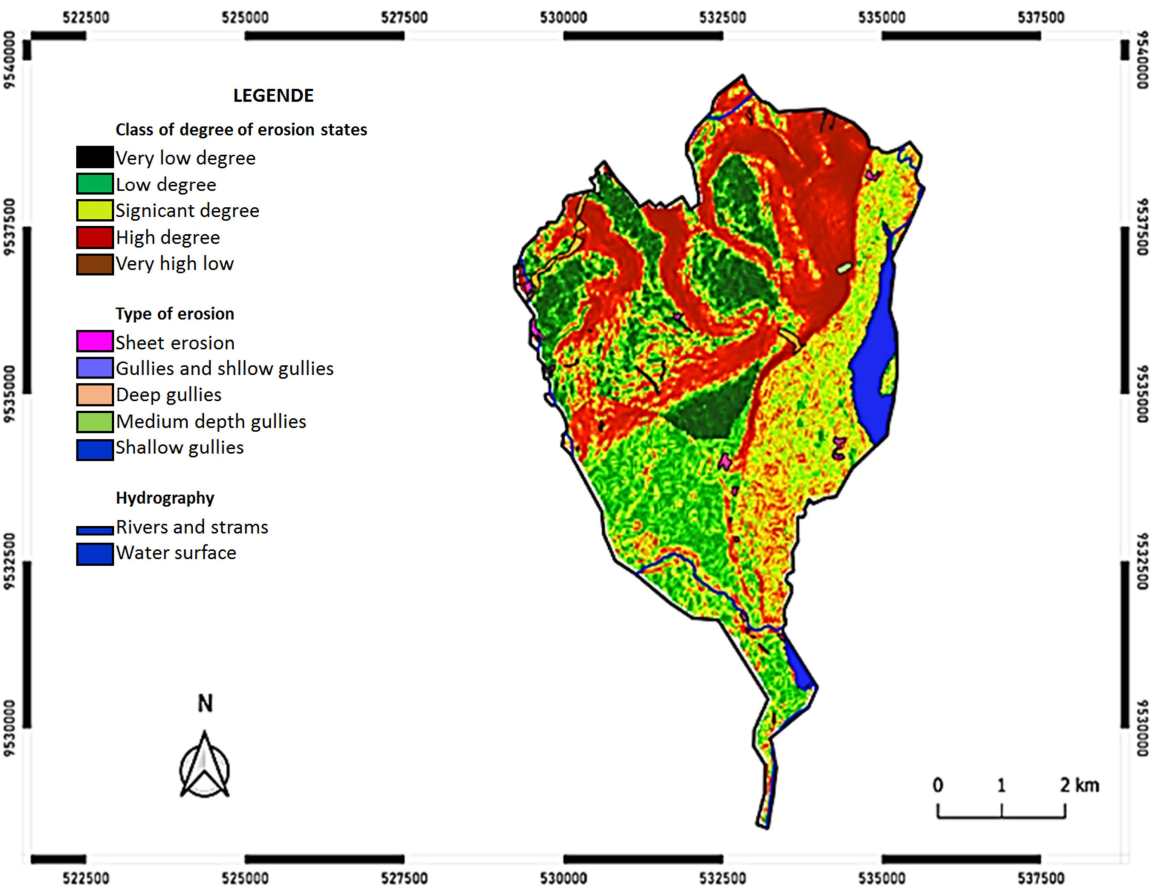

Figure 19. *Consolidated erosion card PAP/RAC.*

3.1.2. Descriptive Approach of Erosion Forms

The distribution of erosion forms in study zone shows that deep ravines (C4) and moderately deep (C3) in their all do not represent a big part of the surface of the study zone and are often the most encountered in steep terrains or at the level sides. These are rather the channels, the superficial ravines (D2) and erosions in water-table (L23) which are the most presents.

The census of these erosive forms, mainly near rivers and water plans, is explained by the vulnerability of the territory, the action of water-course and anthropic actions. The superficial ravines are observed in Northland on the peripheries of the study zone (Figure 17).

3.1.3. Integration Approach: Realization of the Consolidated Erosion Card

The superposition of the card of the erosive states and erosive forms has provided a cartographic product that reflects the reality of the state of soils degradation and the tendency of future erosions.

It is resulted that final identified cartographic product and evaluated at the same time to the potential erosion (predictive) and actual in its different forms, intensities and evaluative tendencies.

Zones at weak and moderated risk of erosion correspond to the types of erosion such as ravines and surface ravines and erosion in table-cloth. While forms of erosion at middle deep, deep ravines coincide with zone at high and very high risk of erosion (Figure 18).

3.2. Results Interpretation of Geotechnical Tests of Soils Place

3.2.1. Content in Water

The table 8 shows that the contents in water of two representative samples vary from 6.3% (sample 2) to 7.19% (sample 1). According to the notion of water retention, these soils are very draining.

Table 8. *Results of the water content of Talangaï soils.*

N° of sampling	1	2
Longitude	15.2988933	15.1711949
Latitude	-4.23563170	-4.1356385
Wet Mass	321.64	256.37
Dry Mass	300.05	241.10
Water Mass	21.59	15.27
Water content (%W)	7.19	6.33
Middle (%W)		4.64

3.2.2. Granulometric Analysis

Results of granulometric analysis for both sampling are shown in the tables 9 and 10.

Table 9: *Granulometric analysis of the sample n°1 of Talangaï (sampling n°1).*

sieve (mm)	**2**	**1**	**0.63**	**0.400**	**0.315**	**0.160**	**0.080**
% passer-by	100	98.11	97.0.5	89.39	79.39	59.35	10.45
The percentage of fines is of 0.45%							

Table 10. *Granulometric analysis of the sample n°2 of Talangaï (sampling n°2).*

sieve (mm)	**2**	**1**	**0.63**	**0.400**	**0.315**	**0.160**	**0.080**
% passer-by	100	97.73	95.68	91.66	78.93	31.63	11.93

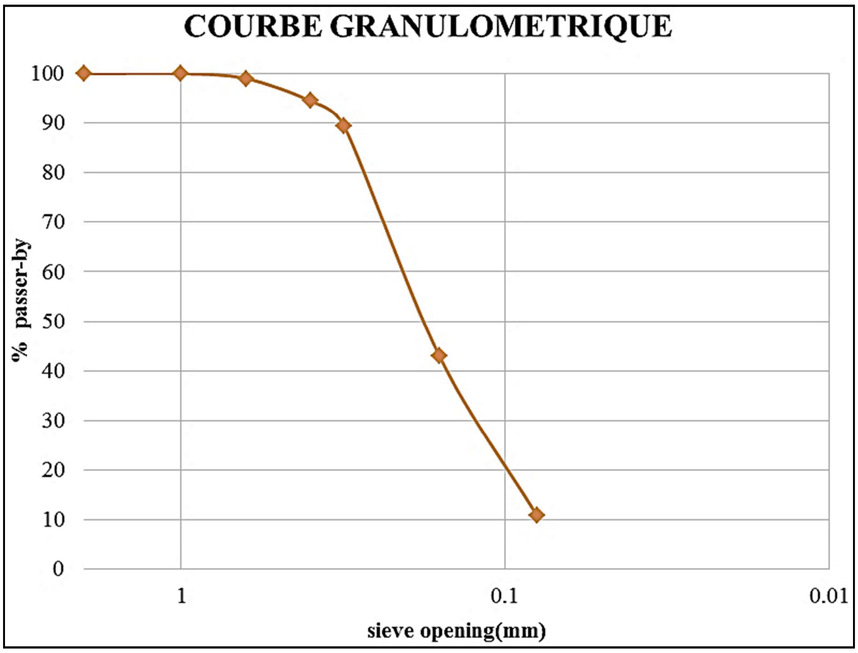

Figure 20. *Granulometric curve sampling n°1 of Talangaï.*

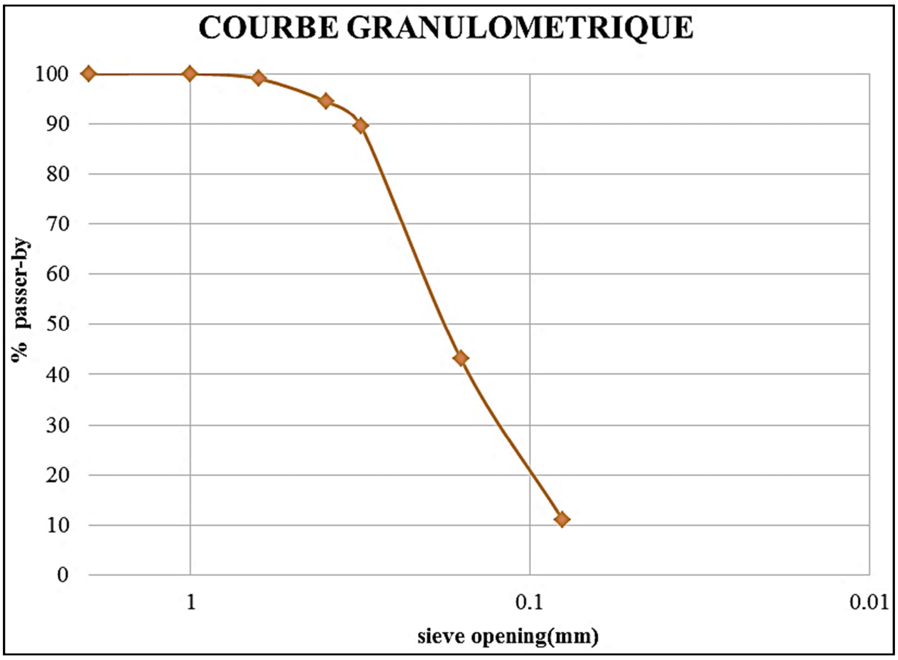

Figure 21. *Granulometric curve sampling n°2 of Talangaï.*

The percentage of fines is 11.9%. The granulometric curves (figure 20, figures 21) show characteristic of a fine clayey soil in presence. These results confirm hypotheses largely shored up in the spatialization of numerical data from the geographical information systems (GIS) and the PAP/RAC approach.

The visible progress of the evolution of the granulometric curve of soils in place shows that it is about sandy soils and none-cohesive, vulnerable to erosions. The sensitivity to superficial erosion is confirmed from the obtained results [table 12].

The geotechnical realized tests show that these soils belong to fines soils, characteristics of a remarkable erodibility in presence of an acceleration or of a suppression due to precipitations.

3.2.3. Values to Blue of Methylene (VBS)

The results of the value to the blue of Talangaï methylene sampling reveal that these soils are sensitive to the appearance of a sensitivity to water (table 11).

Table 11. *Results of tests in blue of methylene.*

Sample n°1	
Mo (dry Mass of the sample, in g)	98.68
Vo (total Volume of absorption, in cm^3)	20
VBS (on material O/D, in g/100g)	0.20
Sample n°2	
Mo (dry Mass of the sample, in g)	96.61
Vo (total Volume of absorption, in cm^3)	15
VBS (on material O/D, in g/100g)	0.16

4. Discussion

Many studies have been carried out in the frame of this issue relying on different approaches about the predictions in hydric erosion risks, and the sensitive of soils to erosions. These studies, that have often realized with different methodological approaches, show most of them, the predominance of erosion in table-cloth in different slope basins, [17, 19, 20, 10, 21, 22].

So, in comparing our results with other works already done in this framework with different approaches (USLE, RUSLE …) the PAP/RAC method is more qualitative.

In the present case, we can notice that the rates of erosion increase, in the significant way with the slope, and the dominion of none-arranged soils showing therefore a remarkable erodibility, this contributes to the considerable increasing of loss of soil.

In comparing obtained results in these works with works already realized and reference above, we deduct that taking into account temporal variability, of erosion process, of different geomorphological basins and of the pluviometer has an impact on the intensity of erosion. From this notice, we note that the risk of erosion in the time is higher in mountainous zones having almost any vegetable cover. However, we can say that in zones the most threatened by the risk erosion are localized in hills [17, 10, 20]. The obtained results in different cards also show that soils covering the study zone are friable and favor to the erosion. In fact, these phenomena are generated not only by the importance of slopes, weak vegetal cover, fiability of material and soil erodibility, but also by geotechnical nature of soils in place (spraying soil at strong erodibility).

In short, in spite of differences that can sometimes be important in terms of methodological approach, the given zone study, climate and other parameters, the obtained results are very similar to certain research works carried out [6, 10, 17, 19, 20, 21].

Also, the loss of vegetable cover destroys the protection of soil and of the ablation of a part of soils reducing the energy of the erosive agents of rainy water, by intercepting rain drops with plants [10].

5. Conclusion

This study has allows us to model through multi-sources data of study zone, data of teledetection and of geographical information system (GIS), sensitive to the hydric erosion from the thematic cards y using PAP/RAC approach.

From the light of the obtained results and at the level of our researches, the prevention of these disastrous lies on the surveillance of the temporary variation of the erosive process, waiting for the true political arrangement of territory and remedy.

The hydric erosion forms that exist in zones are the erosion in table-cloth due to battle of rains on the opened surfaces; (the inhabitants' court, zone of terraces not yet exploited, ravinely due to the energy of runoff along the slopes and the erosion of mass due to the gravity of slope.

The predictive phase has supplied information on the actual state of the land degradation at the level of degree influence of diverse factors which control the hydric erosion. This shows that about 65% of the studied area have weak and middle erodibility and 35% to a high and higher erodibility.

The descriptive approach has shown that the degradation and the loss of soils are manifested by different forms of hydric erosion with the predominance of ravines, surface ravines. The superposition of the descriptive and predictive phases has evidenced the global tendency of the evolution of the surface soils.

Finally, some states very degraded coincide to the forms of spectacular erosions and others more stable than minor forms of erosion or even in stable zones. Areas with higher sensitivities require continuous, preventive and priority action.

Appendix

Results of the various samples taken in the study area source: Building and Public Works Control Office.

Table 12. *Resultats of various soil samples taken in the study area.*

Depth (m)	Type of soil	Dmax (mm)	Fines content	IP(%)	Friction angle (°)	Cohesion (bar)	Class according to GTR
0-3	Clayey sand with occasional gravel	2	41-44				
3-4			40	≤12	-	-	A_1
4-5		10	30				
0-2							
2-3		1	20-28	-	20	0,035	B_5
3-5	loamy sands						
0-2							
2-3		1	25-26	-	20	0,03	B_5
3-5							
0-2							
2-3		11	8-11	-	25	0,01	B_1
3-5	Fine sands						
0-4		2	8-17	-	28	0	B_1-B_5
4-5							
0-2							
2-3							
3-4	Loamy sands	2	25	-	-	-	B_5
4-5							

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