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Spatiotemporal Modelling of Soil Erosion in the Sassandra Watershed (Côte d'Ivoire, Western Africa)

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ABSTRACT: Soil erosion is a natural process with worrying environmental and socio-economic consequences in watersheds. A quantitative and spatiotemporal assessment of this phenomenon is imperative and must be taken into account for integrated management of the Sassandra catchment. LANDSAT Satellite images, rainfall data, the digital elevation model, soil data, Geographic Information System (GIS) software and the Revised Universal Soil Loss Equation (RUSLE) were used to assess annual soil losses in the Sassandra catchment for the years 1986, 2002 and 2022. The results of the study show that soil erosion is increasing in the Sassandra catchment. The average soil losses obtained are 27, 37 and 39 million t/ha/yr respectively for the years 1986, 2002 and 2022.

KEYWORDS: GIS, LANDSAT, Satellite images, Soil erosion, Soil loss, RUSLE.

1 INTRODUCTION

Water erosion is the result of particles being torn off by the energy of raindrops and run-off, transported by run-off water and the localised deposition of excessively heavy sediments [1]. This is a natural process that is accelerated by human activity and contributes to the structural degradation of soils [2]. One of the most common challenges seen globally causing soil degradation is soil erosion [3]. Soil erosion is a serious threat to the environment in different region of the world, it causes problems such as physical, chemical and biological deterioration of soil properties [4]. Soil erosion affects 56% of the land surface worldwide and directly threatens regional ecological security and sustainable economic and social development [5] - [7]. It leads to the destruction of land resources, restricts food production, increases disaster frequency, reduces soil fertility, pollutes water resources, silts up reservoirs and lakes, endangers cities, and causes a series of ecological and environmental problems [8] - [10]. Concerning Africa, the intensity of water erosion has been described as very high to extreme for approximately 45 percent of the continent in the south of the Sahara area, and has been deemed moderate for approximately 30 percent and slight for approximately 25 percent [11], [12].

Soil erosion is the process of removing the upper layer of soil by agents such as wind and water. The upper soil has almost all the nutrients needed for the growth of a plant. With depth, soil fertility decreases. Therefore, erosion results in reduction of fertility of the soil by washing away the top fertile layer [13]. One of the major effects of soil erosion is the loss of arable land capable of supporting agricultural production. Approximately 30% of cropland in the whole world was unproductive, and much of them are used for growing crops during the past 40 years. Sustainable agriculture is a significant issue in all countries, particularly developing countries. In the world, nearly 24 billion tonnes of fertile soil are lost each year due to water erosion. The highest rate of soil erosion is observed in Asia, followed by South America and Africa, with a 30-40 t/ha average rate annually [12], [14]. In agricultural fields, the average rate of soil erosion varies between 0.5-400 t/ha/yr [15]. According to estimates, of the land getting degraded worldwide, 85% is due to erosion, which lowers production by roughly 17%, affects soil fertility and eventually causes land desertification [16].

Côte d'Ivoire's agricultural dynamic is based on the expansion of cash crops and food crops, at the cost of heavy pressure on natural resources [2]. Agriculture in the Sassandra catchment area is also characterised by slash-and-burn farming, mainly for subsistence and cash crops. In addition, farming is largely characterised by a low level of technology and a system of slash-and-burn cultivation. These farming practices lead to rapid deforestation and expose the soil to erosion. For better planning of agricultural development and sustainable land management in the Sassandra catchment area, the spatial and temporal evolution of soil erosion needs to be monitored.

The use of earth observation tools (satellites) and GIS makes it possible to carry out an integrated study of the area and to simulate various erosion scenarios [2]. So, recent developments in spatial technologies and remote information acquisition methods and techniques have helped to improve existing methods and have given rise to revolutionary methods of obtaining and analysing data with a view to holistic management of land, territories and natural resources on scales ranging from a small plot to a large catchment area. Researchers are proposed and developed many physical and empirical models at various scales to study and understand the types, mechanisms, and spatiotemporal distribution of soil erosion

Among the models based on the physical aspects of the erosion process, we quote European Soil Erosion Model (EUROSEM) of [17], Limburg Soil Erosion Model (LISEM) of [18], the model Areal Non-point Source Watershed Environment (ANSWERS) of [19], the Agricultural Non-Point Source Pollution Modeling System (AGNPS) model of [20], the Annualized Agricultural Non-Point Source Pollutant Loading (AnnANPSPL) model of [21], the Erosion-Productivity Impact Calculator (EPIC) model of [22], the Chemicals Runoff and Erosion from Agricultural (CREAMS) model [23], the Simulator for Water Resources in Rural Basins (SWRRB) model of [24], the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model of [25], the Water Erosion Prediction Project (WEPP) model of [26] and [27], the Soil Erosion Model for Mediterranean Areas (SEMMED) model of [28], the Soil Water Assessment Tool (SWAT) model of [29] and the MODEROSS, erosion's model of [30].

Concerning the empirical models, the simplest and wide used model, which links soil loss to either precipitation or runoff is the Universal Soil Loss Equation (USLE) conducted by Wischmeier and Smith [31], [32]. The modified version of USLE, proposed by Williams [33], estimates the sediment transport of each storm taking into account the runoff volume instead of the erosivity of the rain. The researchers continued to improve the USLE and to develop the RUSLE (Revised Universal Soil Loss Equation), which follows the terms of the USLE by correcting some inaccuracies and by providing some improvements in the determination of factors [34]. The empirical models predict the annual average rate of long-term erosion based on the factors responsible for the phenomenon namely rainfall, soil type, and topography, the system of culture and soil conservation.

The empirical models, are most commonly used to predict soil losses due to water erosion around the world [7], [13], [30], [32], [34] - [40]. These models have also been previously used to analyze soil erosion in Africa [41] - [47] and in Côte d'Ivoire [2], [41], [48] - [54]. In the Sassandra catchment area, there are few studies assessing soil losses using empirical models [49], [51], [52], [54] and were carried out in areas covering less than 33% of the catchment area. This study was carried out on the Sassandra catchment at Soubré (covering almost 84% of the surface area of the Sassandra catchment).

The main purpose of this study aims at evaluating the spatiotemporal evolution of soil erosion in the Sassandra catchment area with the Revised Universal Soil Loss Equation (RUSLE) model integrated under a Geographic Information System (GIS) and the remote sensing data.

2 METHODS

The approach consists of a diachronic study of soil erosion [2] in the Sassandra watershed. It uses LANDSAT satellite images of 1986, 2002 and 2022, rainfall data, the digital elevation model, soil data, QGIS software and the RUSLE equation.

2.1 STUDY AREA

The Sassandra catchment at Soubré is located between latitudes 5°40' North and 9°40' North and longitudes 6°06' West and 8°48' West (Figure 1). It covers an area of 62,712 $km^{2,}$ or 19.45% of the country's total surface area. It is a cross-border basin that drains much of western Côte d'Ivoire and a small part of south-eastern Guinea. The river that characterises it rises in Guinea and flows through Côte d'Ivoire. In terms of its hydrographic network, it is one of the largest river basins in Côte d'Ivoire. Its main tributaries are the Bafing, Boa, N'Zo and Lobo rivers.

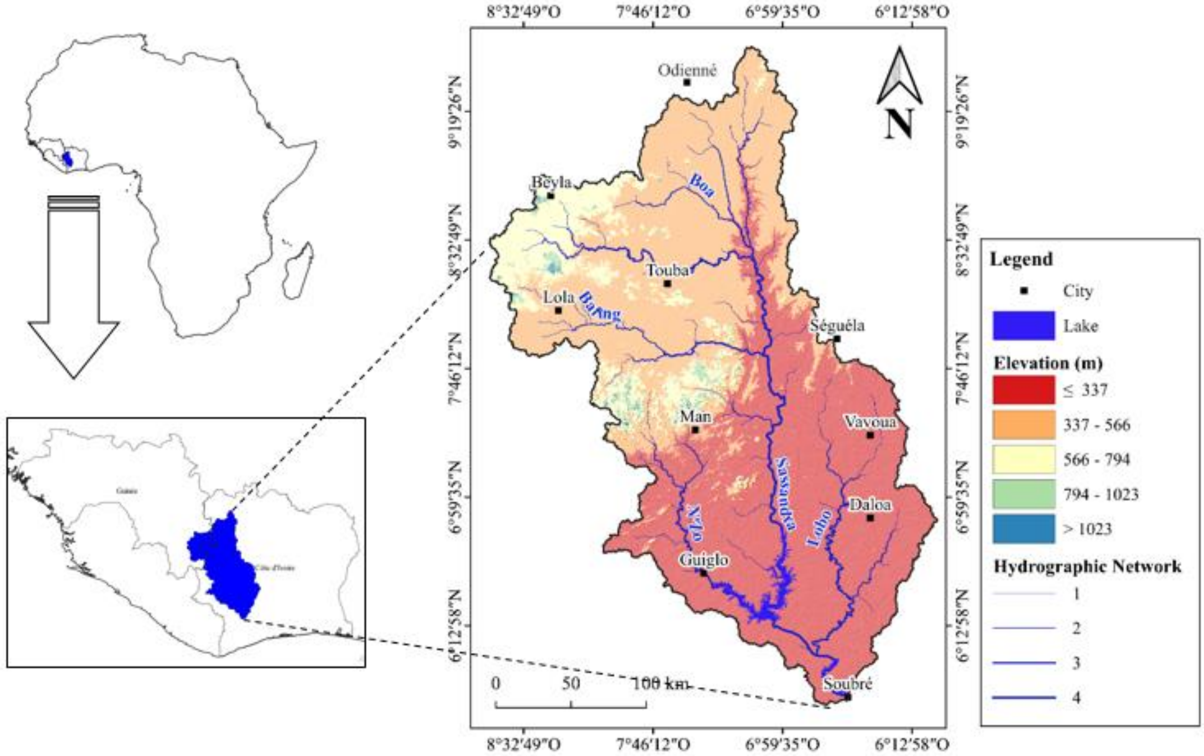

Fig. 1. Localisation of Sassandra catchement area at Soubré

This basin is characterised by a generally rugged relief. Its geology is dominated by the crystalline basement. Its aquifers are found in crystalline and metamorphic formations. Its vegetation is made up of the Guinean domain, which is the most dominant (78%), and the Sudanese domain. It contains seven soil domains, namely Ferric Acrisols, Orthic Acrisols, Eutric Cambisols, Ferralic Cambisols, Humic Ferrasols, Orthic Ferrasols and Lithosols. Its rainfall regimes are the tropical transition regime with annual rainfall reaching 1400 mm, the equatorial transition regime with annual rainfall oscillating around 1000 mm and the mountain regime where annual rainfall heights are around 1600 mm.

2.2 DATA SOURCES

2.2.1 RAINFALL DATA

Rainfall measurements were taken at three synoptic stations, Odienné (airport), Man (airport) and Daloa (airport), and at seven rain gauge stations located in Sassandra, Soubré, Gagnoa, Guiglo, Vavoua, Séguéla and Touba. The rainfall data used in this study covers the period from 1976 to 2022 for all the stations. They were obtained from the Société de Développement et d'Exploitation Aéronautique Aéroportuaire et Météorologique (SODEXAM).

2.2.2 SOIL DATA

The soil data for the Sassandra basin come from the FAO soil database (FAO, 2003). The FAO soil database was set up by the FAO and UNESCO, which decided to produce a map of the world's soils on a scale of 1: 5,000,000. The project was carried out over a period of twenty years and was the result of worldwide collaboration between numerous soil scientists. The FAO soil database comprises 4,931 map units classified according to the FAO-UNESCO legend. This soil database is available on the website of FAO (https://www.fao.org/soils-portal/).

2.2.3 Digital Elevation Model

The digital elevation model used in our study is of the SRTM (Shuttle Radar Topography Mission) type. SRTM data refers to raster and vector topographic files supplied by two American agencies, National Agency for Space Administration (NASA) and the National Geospatial-Intelligence Agency (NGA). These altimetry data were collected during an eleven-day mission in February 2000 by space shuttle Endeavour (STS-99) at an altitude of 233 km using radar interferometry. They were obtained from the USGS website (https://earthexplorer.usgs.gov/).

2.2.4 Landsat Satellite Images

The satellite images used in this work concern 10 scenes covering the entire Sassandra watershed. These are scenes 197-054, 197-055, 197-056, 198-053, 198-054, 198-055, 198-056, 199-053, 199-054 and 199-055 from the LANDSAT 5 (TM), LANDSAT 7 (ETM+) and LANDSAT 8 (OLI and TIRS) missions. These scenes are georeferenced (reference datum: WGS 84, projection system: UTM, zone: 30). The LANDSAT 5, LANDSAT 7 and LANDSAT 8 scenes are composed of seven (07), eight (08) and nine (09) spectral bands respectively. The satellite images were also obtained from the USGS website (https://earthexplorer.usgs.gov/).

2.3 RUSLE Model

The revised universal soil loss equation RUSLE [55] is used to assess soil losses in the Sassandra catchment. The RUSLE model [55] is the revised version of the USLE model [31]. According to [55], erosion is a multiplicative of rainfall erosivity (R) multiplied by the resistance of the environment, which includes the soil erodibility factor (K), the topography factor (LS), the anti-erosion practices (P) and the cover and management factor (C). To evaluate soil losses in the basin, the RUSLE model is based on equation (1).

$$A_{RUSLE} = R \cdot K \cdot LS \cdot C \cdot P \tag{1}$$

Where A_{RUSLE} represents the average annual soil loss expressed in t/ha/yr.

Thus, the development of a cartographic database based on the various factors of the RUSLE equation and their superimposition in a Geographic Information System (GIS) contributes to modelling the process and results in a spatialisation of soil erosion at the level of the Sassandra catchment.

2.4 Spatialisation Of Rusle Factors

2.4.1 Rainfall Erosivity Factor

The rainfall erosivity factor (R) is based on the climatic conditions responsible for erosion. It corresponds to the combined action of rain and runoff on the areas affected. The more intense the rainfall and the longer it lasts, the greater is the risk of erosion. An estimate of rainfall erosivity in the Sassandra catchment is given by the revised empirical rainfall erosivity formula for West Africa [56]. This formula is expressed as equation (2).

$$R = 5.44 \sum_{i=1}^{n} \left(\frac{P_i^2}{P_m} \right) - 416 \tag{2}$$

Where R is the revised rainfall erosivity factor (MJ mm ha/hr/yr), P_i is the average monthly precipitation in month i (mm), $P_m$is the average annual precipitation over the observation period (mm) and n the number of month (n=12).

The rainfall data were used to determine rainfall erosivity in the assessment of land loss in the Sassandra catchment area.

2.4.2 Soil Erodibility Factor

The soil erodibility factor (K) is a measure of the vulnerability of soil particles to detachment and transport by rain and runoff. Although texture is the main factor influencing erodibility, soil structure, organic matter content and permeability also play a role. The equation of [22] was used to assess the erodibility factor in the Sassandra catchment. This equation takes into account the granulometry (sand, silt and clay content) and the organic fraction of the soil. The multiplicative function of [22] is given by equation (3).

$$\mathrm{K} = \mathrm{F}_{\mathrm{csand}} \cdot \mathrm{F}_{\mathrm{cl-si}} \cdot \mathrm{F}_{\mathrm{hisand}} \cdot \mathrm{F}_{\mathrm{orgC}} \tag{3}$$

With:

$$\mathrm{F}_{\mathrm{csand}} = \frac{1}{7.6}\left(0.2 + 0.3\exp\left(-0.256\mathrm{m}_{\mathrm{sand}}\left(1 - \frac{\mathrm{m}_{\mathrm{silt}}}{100}\right)\right)\right) \tag{4}$$

$$\mathrm{F}_{\mathrm{cl-si}} = \left(\frac{\mathrm{m}_{\mathrm{silt}}}{\mathrm{m}_{\mathrm{clay}} + \mathrm{m}_{\mathrm{silt}}}\right)^{0.3} \tag{5}$$

$$\mathrm{F}_{\mathrm{hisand}} = \left(1 - \frac{0.7\left(1 - \frac{\mathrm{m}_{\mathrm{sand}}}{100}\right)}{\frac{\mathrm{m}_{\mathrm{sand}}}{100} + \exp\left(-5.5 + 22.9\left(1 - \frac{\mathrm{m}_{\mathrm{sand}}}{100}\right)\right)}\right) \tag{6}$$

$$\mathrm{F}_{\mathrm{orgC}} = \left(1 - \frac{0.25\mathrm{m}_{\mathrm{orgC}}}{\mathrm{m}_{\mathrm{orgC}} + \exp\left(3.72 - 2.95\mathrm{m}_{\mathrm{orgC}}\right)}\right) \tag{7}$$

Where $\mathrm{m}_{\mathrm{sand}}m_{sand}$ is the sand fraction, $\mathrm{m}_{\mathrm{silt}}m_{silt}$ is the silt fraction, $\mathrm{m}_{\mathrm{clay}}m_{clay}$ is the clay fraction and $\mathrm{m}_{\mathrm{orgC}}m_{orgC}$ is the organic carbon content.

The soil data were used to determine the erodibility factor for soils in the Sassandra catchment. The sand, silt, clay and organic carbon content information's are available on the map extracted from the FAO soil database [57].

2.4.3 TOPOGRAPHICAL FACTOR

The topographical factor (LS) is the length and inclination of the slope. The topographical factor influencing erosion comprises two essential elements: slope length and steepness [34]. Slope length (L) determines runoff velocity, and particle transport increases as a function of plot length [58]. Similarly, solid transport increases exponentially with the percentage of slope [1], [59], [60]. The more the slope of a surface is steep and long, the more the risk of erosion will be high. The slope length (L) was calculated using the classic formula proposed by [32]. Its expression is given by equation (8).

$$\mathrm{L} = \left(\frac{\mathrm{F}_{\mathrm{acc}} \cdot \mathrm{C}_{\mathrm{size}}}{22.13}\right)^{\mathrm{m}} \tag{8}$$

With:

$$\mathrm{m} = \frac{\beta}{\beta + 1} \tag{9}$$

$$\beta = \frac{\sin\theta}{0.0896}\left(3.0\left(\sin\theta\right)^{0.8} + 0.56\right)^{-1} \tag{10}$$

Where F$_{acc}$$F_{acc}$ represents flow accumulation (the cumulative uphill area of a unit), C$_{size}$$C_{size}$ is cellsize (the spatial resolution of the grid), mm indicates the slope length index, is the ratio of rill to inter-rill erosion and indicates the slope value (in degrees) extracted from the digital elevation model.

Slope steepness (S) represents the effect of slope gradient on soil erosion phenomena. Slope gradient is described as the ratio of the height difference of an area to its horizontal length. Slope steepness is calculated from the formula proposed by [58] for basin regions with a slope less than 10°. For basin regions with a slope greater than 10°, this factor was determined from the formula proposed by [61]. These different formulas are expressed through equation (11).

$$\mathrm{S}=\begin{cases}10.8\sin\theta+0.03 & \text{if} \quad \theta<5^{\circ}\\ 16.8\sin\theta-0.50 & \text{if} \quad 5^{\circ}\leq\theta<10^{\circ}\\ 21.9\sin\theta-0.96 & \text{if} \quad \theta\geq10^{\circ}\end{cases} \tag{11}$$

The digital elevation model were used to produce the slope map and to determine the topographic factor in the assessment of soil loss in the Sassandra catchment.

2.4.4 Cover And Management Factor

The cover and management factor (C) must be taken into account, because the impact of raindrops, the slow-down of run-off and infiltration are going to depend on it. This coverage factor depends on the percentage of bare soil, the height of the plant cover and the architecture of the plants. It is therefore relevant to reduce the extent of soil erosion on slopes. In fact, dense plant cover is all the more effective in reducing erosion because it dissipates the energy of raindrops, slows down the flow of water over the soil surface and maintains good surface porosity, preventing surface crusting [62], [63]. The cover and management factor was determined from the relationship between it and the Normalized Difference Vegetation Index (NDVI). This relationship is based on the exponential method of [64]. Equations (12) and (13) give the NDVI expression and the Van der Knijff et al. [64] relationship respectively.

$$\mathrm{NDVI}=\frac{\mathrm{PIR}-\mathrm{R}}{\mathrm{PIR}+\mathrm{R}} \tag{12}$$

$$\mathrm{C}=\exp\left(-2.5\times\frac{\mathrm{NDVI}}{1-\mathrm{NDVI}}\right) \tag{13}$$

Where PIR is Near infrared spectral band and R is Red spectral band, 1 and 2.5 represent the parameters determining the shape of the NDVI-C curve.

The LANDSAT satellite images covering the entire Sassandra catchment were used to calculate the Normalized Difference Vegetation Index (NDVI) and to determine the cover and management factor for assessing soil loss in the basin.

2.4.5 Support Practice Factor

The support practice factor (P) or anti-erosion practices are all cultivation techniques used to reduce run-off and erosion effects. These techniques include contouring, planting grass strips between two areas of cultivation, natural or artificial mulching and the use of cover crops. Soil conservation practices characterize practices that retain a certain proportion of soil. The values taken by this factor vary from 0 to 1. For the estimation of soil losses in this study, it was assumed that no measures were taken to combat erosion. In general, farmers do not fight against erosion or do not combat effectively erosion, and cultivation practices (ploughing, weeding) contribute to further accentuating this phenomenon. In this context, the value of P is equal to 1 [2].

3 Results

The map of soil erosion in the Sassandra catchment in 1986 is shown in Figure 2. This map shows that soil losses of less than 10 t/ha/yr are observed in the south (Vavoua, Daloa, Guiglo and Soubré). Average soil loss values (10 to 50 t/ha/yr) are generally distributed throughout the Sassandra watershed. Areas with soil losses between 50 and 100 t/ha/yr and higher soil loss values (greater than 100 t/ha/yr) are mainly located in the extreme north of the catchment (east of Odienné), in the west (Beyla, Lola and Touba), in the centre (Man and Séguéla) and around Lake Buyo.

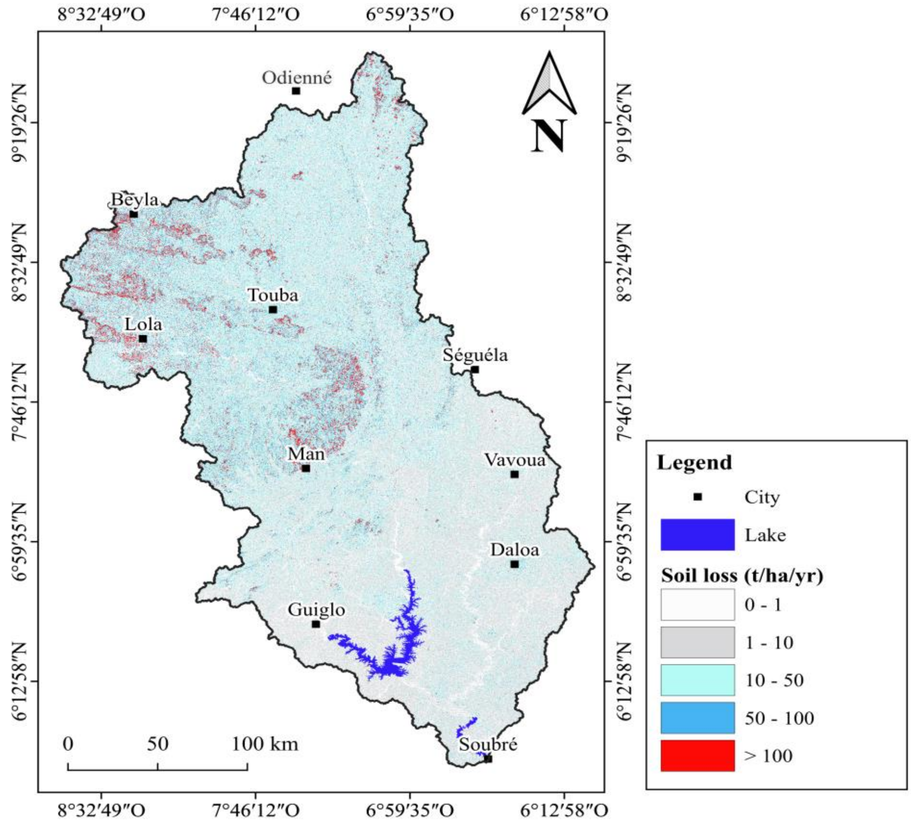

Fig. 2. Soil erosion of 1986 in the Sassandra catchment area

Figure 3 shows the soil erosion map of 2002 in the Sassandra catchment. Soil loss values (less than 10 t/ha/yr) are generally distributed throughout the Sassandra catchment. Average soil loss values (10 to 50 t/ha/yr) are mainly recorded in the northern half of the basin. Areas with soil loss between 50 and 100 t/ha/yr, although represented in only a small proportion, have a spatial distribution virtually identical to the one of 1986, with areas with high soil loss values (over 100 t/ha/yr). These are located in the extreme north of the catchment area (east of Odienné), in the west (Beyla, Lola and Touba) and in the centre (Man).

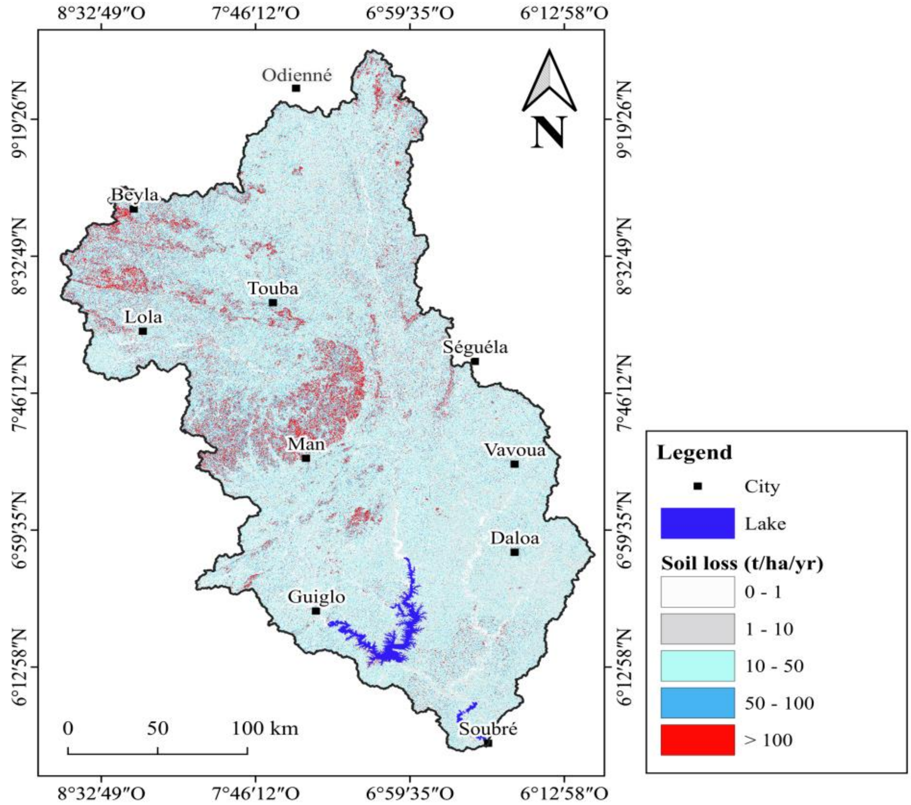

Fig. 3. Soil erosion of 2002 in the Sassandra catchment area

The spatial variation in water erosion in the Sassandra catchment in 2022 is shown in Figure 4. Like the areas with soil loss values of less than 10 t/ha/yr, the areas with average soil loss values (10 to 50 t/ha/yr) are distributed throughout the catchment, only the former cited are dominated by the latter cited. The areas with above-average soil loss values (between 50 and 100 t/ha/yr) and those with higher soil loss values (over 100 t/ha/yr) have a spatial distribution in the catchment similar to that in 1986. They are mainly observed in the extreme north of the catchment (east of Odienné), in the west (Beyla, Lola and Touba), in the centre (Man and Séguéla) and around the Lake Buyo. Nevertheless, it should be noted that the land loss values for these areas in 1986 are higher than those for 2002.

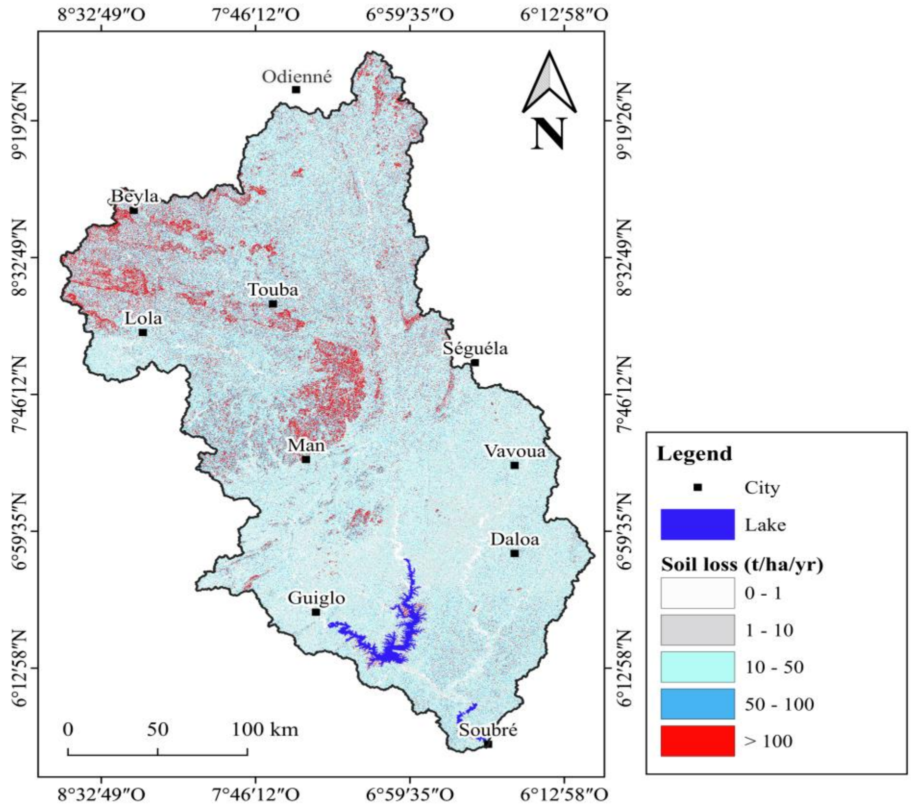

Fig. 4. Soil erosion of 2022 in the Sassandra catchment area

A comparison of soil erosion over the three periods shows that the percentage of erosion rates greater than 100 t/ha/yr is 38% from 1986 to 2002 and 47% from 1986 to 2022. In terms of the total quantities of soil transported per year over the entire catchment area, the figure rose from 27 to 37 million tons between 1986 and 2002, rising to 39 million tons by 2022. This corresponds to average soil losses of 43 t/ha/yr, 55 t/ha/yr and 63 t/ha/yr respectively of years 1986, 2002 and 2022.

4 DISCUSSION

Soil losses in the Sassandra catchment were assessed on the basis of USLE factors, namely rainfall erosivity, topography, soil erodibility, cover management and support practice.

Analysis of the results of soil erosion mapped over the Sassandra catchment shows a gradual increase in the rate of erosion from 1986 to 2002 and from 2002 to 2022. This increase leads to an increase in the total quantities of soil transported each year over the entire catchment area.

The factors involved in assessing soil erosion can be divided into two groups: static variables and dynamic variables. The static variables concern the soil erodibility factor (K factor) and the topographical factor (LS factor). The dynamic variables are the rainfall erosivity factor (R factor), the cover and management factor (C factor) and the support practice factor (P factor).

In this research, the R factor varied very little over time from 1986 to 2002 and from 2002 to 2022. The P factor was considered to be equal to 1 over the entire catchment area during all the years of the study. As for the C factor, it changed considerably in space and time from 1986 to 2002 and from 2002 to 2022 as a result of anthropogenic activities in the catchment. These activities involve the exploitation of timber for export and the mobilisation of vast areas for cash crops (cocoa, coffee, rubber and oil palm), followed by slash-and-burn cultivation. The K factor, derived from morpho-pedological studies, remained constant over the three years and its values varied very little (0.12 to 0.17 t.h.MJ-1.mm-1). The topographical factor (LS) deduced from the digital elevation model (DEM) was constant over the three periods but its values were significant (0 to 110.52).

This analysis shows that the increase in the rate of erosion observed over the three periods is closely linked to variations in the topography and vegetation cover of the catchment. In fact, soil losses are considerably higher in areas of steep slope, in areas of low vegetation cover in areas of steep slope and low vegetation cover. As far as slopes are concerned, their impact on runoff is more than remarkable. In fact, the steeper the slope, the greater the runoff, with the resultant detachment, uprooting and entrainment of soil particles. In addition, the absence of plant cover can exacerbate the impact of run-off.

The results for soil erosion in the Sassandra basin are very satisfactory, given the improved RUSLE equations with which the various factors were evaluated. Indeed, the highest values of soil loss determined corroborate those of [52] who obtained high values of soil loss in the department of Man. Also, the values of the erodibility factor (K) in this study vary between 0.12 and 0.19. These values are in the same order as those determined by [65] and [66] for ferrallitic and ferruginous soils in West Africa ($0.15 \le K \le 0.35$). Its Furthermore, the assessment of the C factor from the NDVI is very suitable, especially for historical images such as those used in this study. Variation in this factor is one of the causes of the variation in the erosion rate observed over the study periods (1986 to 2022). Coulibaly et al. [2] studied soil erosion in the Bâoulé catchment and came to the same conclusion. In addition, the topographical factor (LS) evaluated using the equations proposed by [58] and [61] highlighted the influence of slope on soil erosion. Li et al. [7] came to a similar conclusion.

The results obtained constitute a great interest in so far as they bring new knowledges to decision-makers about the dynamics of soil erosion in the Sassandra catchment. The methodology used makes it possible to determine with greater precision the areas of eroded land in a catchment, and to identify the main factors with a proven impact on soil erosion. This knowledge is vital for the development of effective land conservation policies that are useful for the integrated management of catchment areas. In addition, this study is a contribution to the mapping of land degradation in the world in general, and to the achievement of objective 15 of the Sustainable Development Goals.

5 Conclusion

This study involved modelling the diachronic evolution of soil erosion in the Sassandra catchment. The study showed that from 1986 to 2022, soil erosion is increasing over time. The rates obtained in 2022 (39 million tons) are higher than those in 2002 and 1986 (37 million tons and 27 million tons), i.e. an increase of 38% from 1986 to 2002 and 47% from 1986 to 2022. This gradual increase of soil erosion over time is largely due to the destruction of vegetation cover as a result of human activities in the basin (logging for export, mobilisation of vast areas for cash and food crops, slash-and-burn cultivation). However, a contribution from topography cannot be ruled out.

The results obtained are relevant, and the spatial distribution of soil losses in the Sassandra catchement can be used to guide policy-makers on areas which to intervene in the watershed to alleviate the effects of erosion for a sustainable management of lands.

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