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Research Article

Fluvial Dynamics of the Sassandra River in the Departments of Facobly and Kouibly (Western-Côte d'Ivoire) During the Period 2016–2024

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Abstract

This study aims to characterize the morphology of the Sassandra River using satellite imagery acquired between 2016 and 2024 in order to support population safety in the context of potential flood hazards. The specific objectives are to evaluate riverbed evolution, analyze morphological changes, and identify the factors driving these transformations. Satellite images were processed using cartographic and geospatial tools, particularly QGIS 3.36, to assess river dynamics and quantify areas affected by erosion and sediment deposition. A diachronic analysis was conducted using the Normalized Difference Water Index (NDWI) to identify wetlands and monitor spatial changes in the river channel. Two four-year periods, 2016-2020 and 2020-2024, were examined to evaluate patterns of river regression and transgression. The results reveal that the Sassandra River exhibits a meandering channel pattern associated with an almost flat slope. Between 2016 and 2020, sediment deposition was the dominant process, accounting for approximately 82% of the observed changes, while erosion represented 18%. In contrast, the 2020-2024 period showed an increase in erosional activity, with erosion reaching 43% and sediment deposition decreasing to 57%. These findings demonstrate the continuous evolution of the river channel and highlight the significant influence of climate variability on fluvial processes. The observed morphological changes may increase the vulnerability of surrounding areas to natural hazards, particularly flooding. This study provides valuable information for river management, environmental monitoring, and flood risk mitigation in the Sassandra River basin.

Keywords

Sassandra River, River Morphology, Satellite Imagery, NDWI, Erosion, Sediment Deposition, Flood Risk

1. Introduction

Fluvial geomorphology addresses the physical forms and landscape structures created by river processes, which transport terrestrial material toward the sea [1]. Technological advances in remote sensing now enable the characterization of

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river morphology through satellite imagery. Satellite images are acquired from space using sensors mounted on satellites and provide information similar to aerial photographs, while offering additional topographic data. According to numerous studies, the dynamic nature of topography is associated with irregular rainfall patterns, shortened rainy seasons, increasing temperatures, and the persistence and severity of dry seasons [1-3]. Côte d'Ivoire, a country crossed by numerous river systems, is already experiencing the consequences of climate change and remains vulnerable to natural hazards [4]. Rainy seasons have become shorter, with delayed onset and earlier termination, disrupting agricultural calendars and exacerbating extreme meteorological events such as floods. Beyond their impact on river systems, these changes also affect relief, fluvial evolution, and landscape development. The western region of Côte d'Ivoire exhibits the most rugged relief in the country. Approximately one-third of this territory is mountainous [5], characterized by steep slopes and high annual rainfall exceeding 1,500 mm. Consequently, the region is highly susceptible to slope-instability processes [6], while rivers and their tributaries may trigger flooding events due to discharge variability. Within the Guémon Region, the Sassandra River, one of the country's largest rivers, provides an ideal setting for investigating fluvial geomorphological processes. In humid tropical environments, flooding is generally associated with intense or prolonged rainfall events [7]. However, the growing occurrence of natural hazards in western Côte d'Ivoire raises important scientific questions regarding the temporal evolution of the river channel, the controlling factors of its dynamics, and the impacts of climate change on both the river system and nearby populations.

2. Materials and Methodes

2.1. Presentation of Study Area

The Guémon Region is located in western Côte d'Ivoire between latitudes 5°30′N and 7°N and longitudes 8°30′W and 7°W. It comprises four departments: Duékoué, Bangolo, Kouibly, and Facobly. The region covers an area of 7,442 km^2, distributed as follows: 3,035 km^2 for Duékoué, 2,315 km^2 for Bangolo, 1,057 km^2 for Facobly, and 1,035 km^2 for Kouibly (Figure 1). The region is divided into twenty-three sub-prefectures, including five in Duékoué, nine in Bangolo, four in Kouibly, and five in Facobly [8].

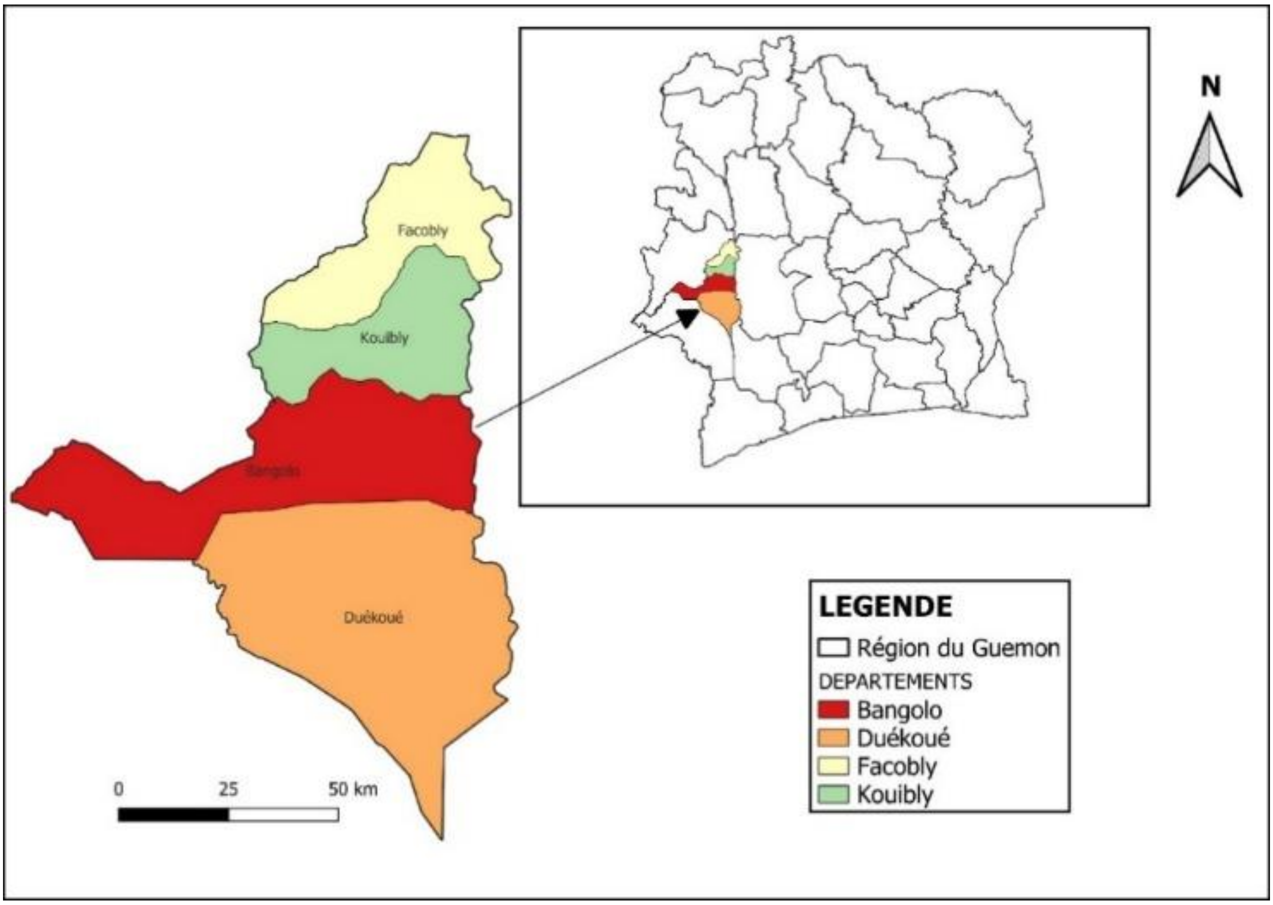

Figure 1. Geographic location of the Guémon Region.

2.2. Material

2.2.1. Acquisition of Morphological Data

This study used cartographic and satellite data acquired for the years 2016, 2020, and 2024. Landsat imagery and Digital Elevation Model (DEM) raster files were downloaded from http://earthexplore.usgs.gov the USGS EarthExplorer platform, while Sentinel-2 imagery was obtained from the Copernicus Browser platform http://copernicusbrowser. The images were produced from color composites with spatial resolutions ranging from 10 to 30 m and a cloud cover of less than 10%. The study area extends along the Sassandra River within the departments of Facobly and Kouibly. All images were acquired during the dry season, between November and March, to ensure optimal visibility. Previous studies have demonstrated that using imagery in the Tanda department by [9] from 1986 to 2000 (the same season) significantly reduces seasonal effects in change-detection analyses.

2.2.2. Cartographic Processing Tools

QGIS 3.36 software was used for image processing through the Semi-Automatic Classification Plugin (SCP). The software was also employed for georeferencing, river-channel digitization, and the production of slope and topographic maps.

2.3. Methods

2.3.1. Image Preprocessing

Prior to image analysis, preprocessing procedures were carried out to correct atmospheric and radiometric distortions. These operations were performed in QGIS 3.36 using specialized tools to ensure the accuracy and reliability of the data.

2.3.2. Diachronic Analysis Using Satellite Imagery

(i). Hydro- geomorphological Dynamics over a Defined Period

Hydro-geomorphological dynamics were assessed using satellite images from 2016, 2020, and 2024. The images were processed in QGIS 3.36 to identify changes in the river channel over time. The Normalized Difference Water Index (NDWI) was applied to extract water bodies and delineate the river boundaries. The river extents obtained for each year were compared using overlay analysis. This approach made it possible to detect areas affected by erosion and sediment deposition and to quantify the observed changes between the two study periods (2016-2020 and 2020-2024). The results were then used to evaluate the evolution of the river morphology and its hydro-geomorphological dynamics.

(ii). Digitization of River Channels

QGIS 3.36 was used to digitize the Sassandra River from satellite imagery. This process made it possible to delineate the river channel for the years 2016, 2020, and 2024.

(iii). Overlay of River Channels

The digitized river courses from different years were superimposed to visualize temporal changes. This overlay analysis highlighted areas affected by erosion and accretion, thereby revealing the spatial evolution of the river system.

(iv). Segmentation of the River Reach

Because of its considerable length and visibility on satellite imagery, the Sassandra River was divided into three sections. This segmentation enabled a more detailed analysis of geomorphological variations along the river corridor.

2.3.3. Calculation of Geomorphological Parameters

(i). Sinosity Index

The sinuosity of the Sassandra River was calculated from the digitized river traces. This parameter quantifies channel curvature and determines the degree of meandering. The sinuosity index (SI) was computed as:

$$SI = \text{Channel Length} / \text{Valley Length} \tag{1}$$

where channel length represents the actual river length and valley length corresponds to the straight-line distance between the river's endpoints.

(ii). Identification of Impacted Areas

Using the overlay of river-channel traces, areas affected by erosion and accretion were quantified. This assessment was conducted by comparing channel-width variations between 2016–2020 and 2020–2024, enabling the identification of zones subject to geomorphological change.

(iii). Assessment of Bank Retreat of 2016 to 2024

Satellite images from different years were used to evaluate rates of bank retreat and sediment accumulation along the Sassandra River. Comparisons between channel boundaries across successive periods allowed changes in shoreline position to be quantified over time.

(iv). NDWI Computation of 1985 to 2024

The Normalized Difference Water Index (NDWI) was calculated from satellite imagery to assess water presence within the study area.

For Landsat 5:

$$NDWI = (\text{Band } 2 - \text{Band } 4) / (\text{Band } 2 + \text{Band } 4) \tag{2}$$

For Sentinel-2:

NDWI = (Band 3 − Band 8) / (Band 3 + Band 8) (3)

These indices were used to quantify variations in soil moisture and surface-water extent.

3. Results

3.1. Geomorphological Evolution of the Sassandra River

3.1.1. Morphological Evolution of the Rivers Channel

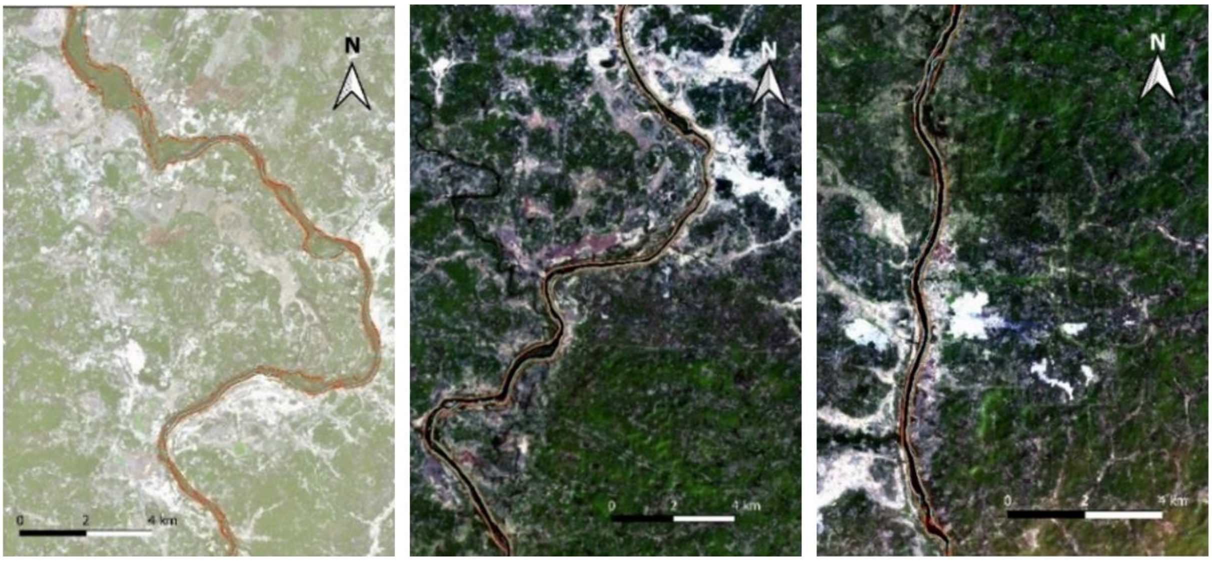

Figure 2. Superposition of river-channel traces from 2016, 2020, and 2024.

The superimposition of river-channel traces from 2016, 2020, and 2024 highlights significant changes that occurred over time. On the satellite imagery, the river appears as a dark meandering band. Detailed observation of the different river sections reveals variations in channel width and sinuosity between the study years. These changes provide evidence of the dynamic nature of the Sassandra River and its continuous geomorphological adjustments (Figure 2).

3.1.2. Analysis of Rivers Channel Sections

We analyzed the stream channel to identify and quantify the changes that had occurred. This required subdividing the channel into three sections, simplifying the task.

(i). SECTION 1

To quantify channel modifications, the river reach was subdivided into three main sections. Erosion and accretion areas were calculated for each four-year interval (2016–2020 and 2020–2024) (Figure 3).

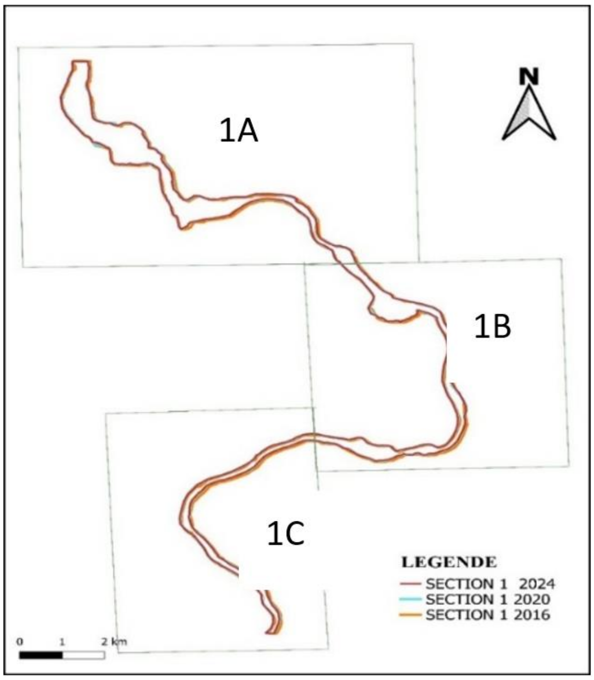

Figure 3. Superposition of river-channel traces for Section 1 (1A, 1B, and 1C).

1) Section 1A

From 2016 to 2020, the river channel mainly exhibited downstream progression, characterized by extensive impacted areas where accretion predominated over erosion (see Figure 4). Between 2020 and 2024, however, channel regression was observed, although accretion processes remained significant (Figure 4).

The Table 1 and Figure 5 present the total areas of erosion and accretiwithing the intervals considered.

Table 1. *Fluvial impacts on Section 1A the 2016-2020 et 2020-2024.*

Period	Total Erosion Area (m²)	Total Accretion Area (m²)
2016–2020	166,988.115	414,370.854
2020-2024	76856,762	162299,917

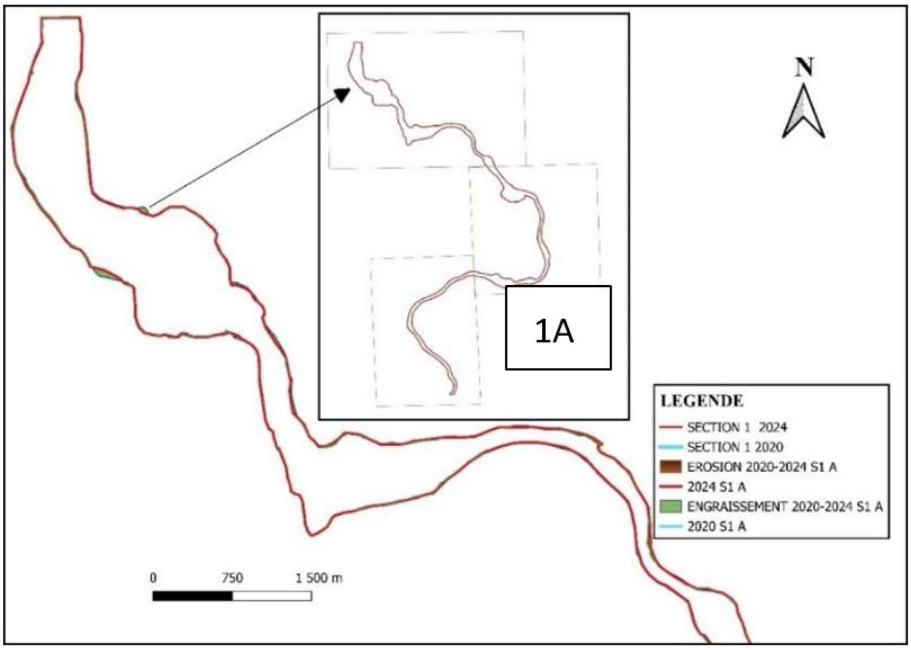

Figure 4. *River evolution in Section 1A (2016–2020 and 2020–2024).*

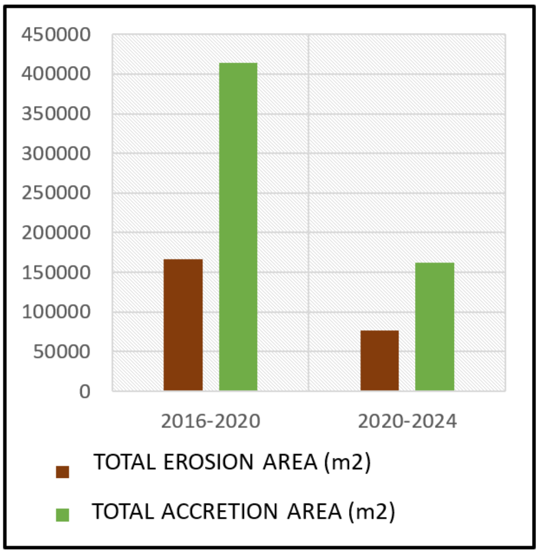

Figure 5. *Erosion and accretion areas in Section 1A.*

2) SECTION 1 B

Both erosion and accretion processes occurred during the two intervals studied (Figure 6, 7 and table 2). Nevertheless, accretion clearly dominated along this section. These geomorphological modifications reflect a progressive regression of the river channel.

Table 2. Fluvial impacts on Section 1B the 2016-2020 et 2020-2024.

Period	Total Erosion Area (m^2)	Total Accretion Area (m^2)
2016–2020	172,105.802	346,006.591
2020–2024	76,246.180	95,264.000

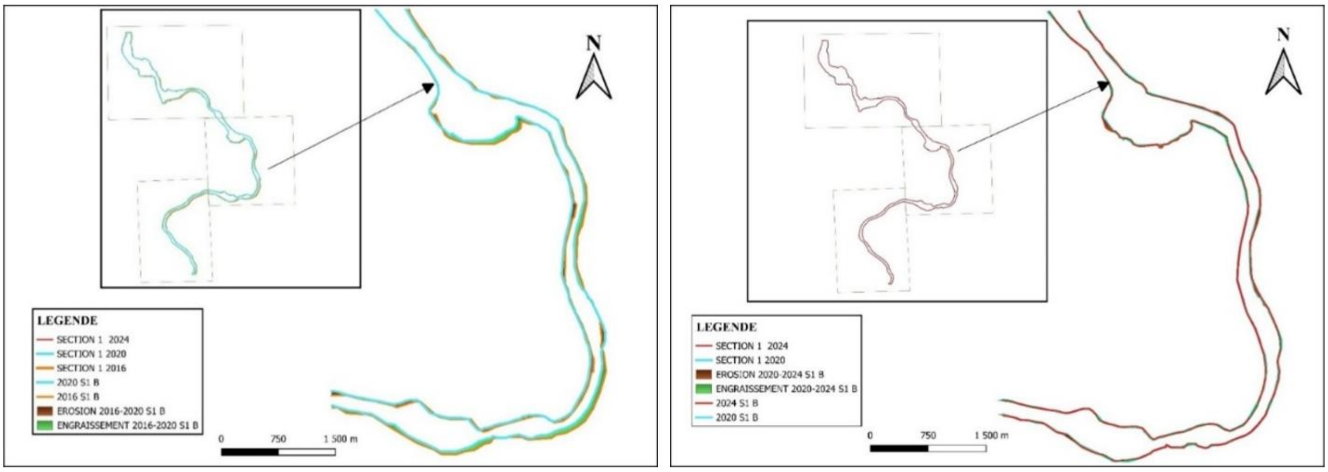

Figure 6. River evolution in Section 1B (2016–2020 and 2020–2024.

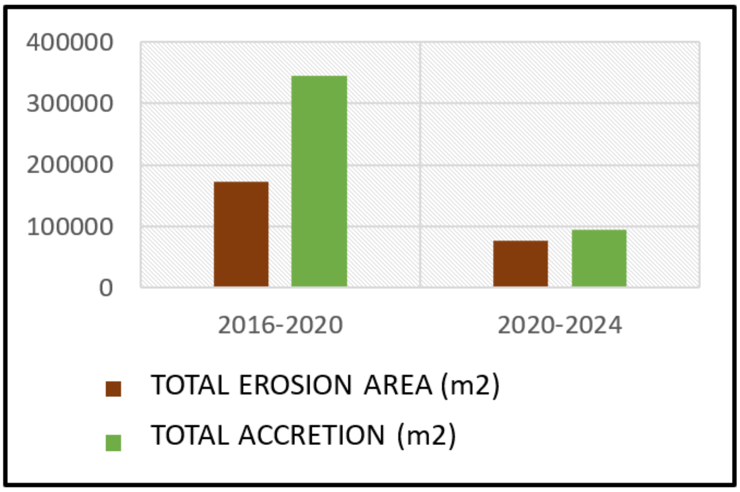

Figure 7. Erosion and accretion areas in Section 1B. the 2016-2020 and 2020-2024.

3) SECTION 1 C

Throughout both periods, visible changes affected the entire subsection. River-channel regression remained the dominant trend Figure 8 and 9). Accretion was the most important (1038,141m^2) geomorphological process during the first interval, whereas erosion slightly exceeded accretion during 2020–2024 see Table 3.

Table 3. Fluvial impacts on Section 1C the 2016-2020 and 2020-2024.

Period	Total Erosion Area (m^2)	Total Accretion Area (m^2)
2016–2020	184,500.706	426,684.618
2020–2024	51,415.864	50,377.723

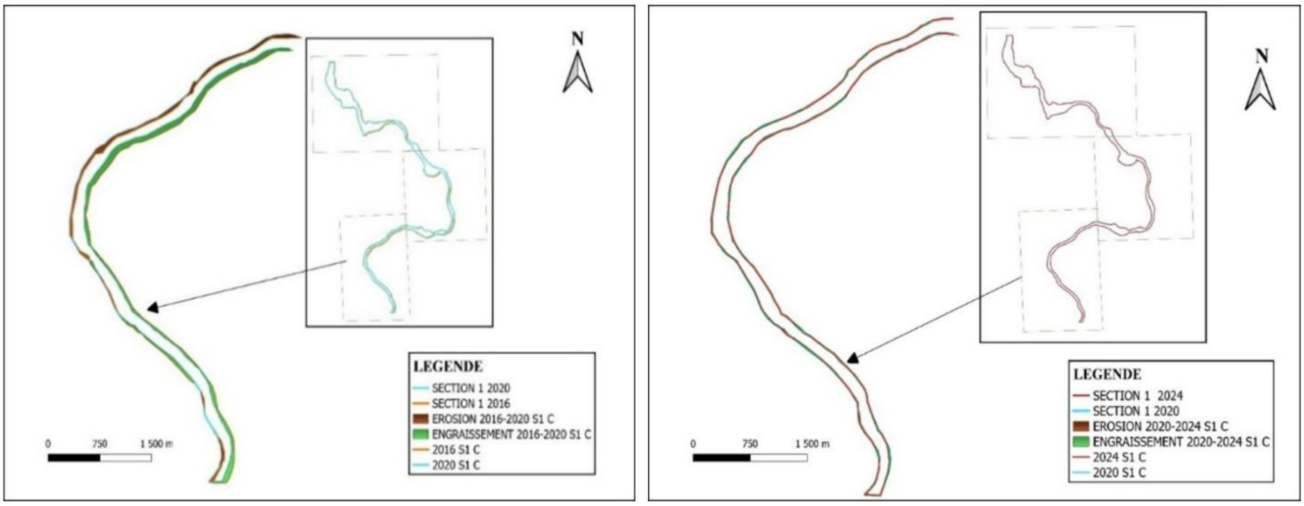

Figure 8. River evolution in Section 1C (2016–2020 and 2020–2024).

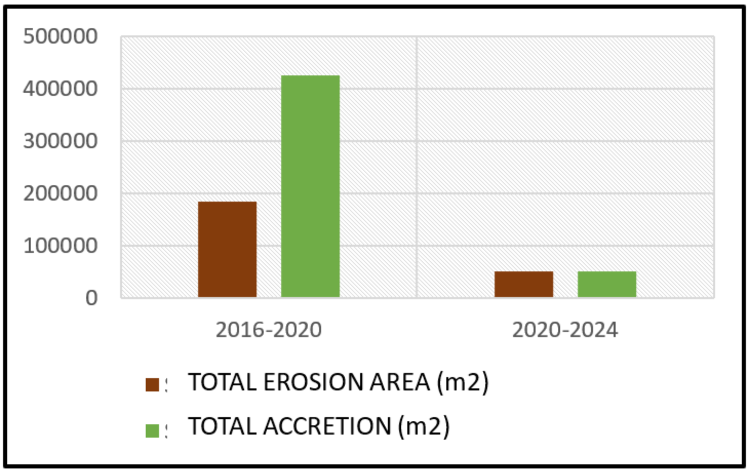

Figure 9. Erosion and accretion areas in Section 1C the 2016-2020 and 2020-2024.

(ii). SECTION 2

The second reach obtained from the segmentation of the original image was subdivided into three sections, namely 2A, 2B, and 2C. The analysis focused primarily on the extent of eroded and accreted areas, assessed at four-year intervals to capture their spatial and temporal dynamics (Figure 10).

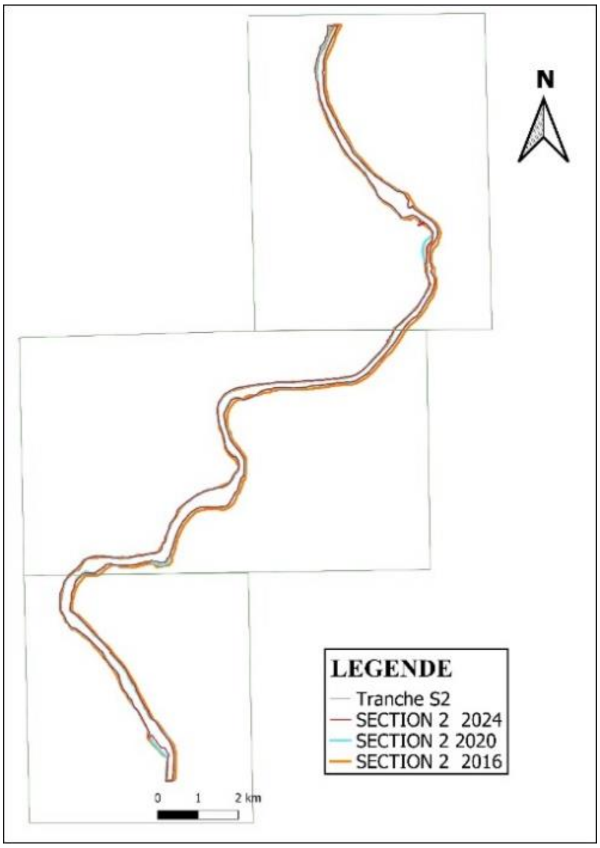

Figure 10. *Superposition of river-channel traces for Section 2 (2A, 2B et 2C) in the Kanébly.*

1) SECTION 2 A

Between 2016 and 2020, the river channel underwent notable morphological changes, with accretion processes dominating over extensive areas, as shown in Figures 11 and 12. However, during the 2020-2024 period, the channel dynamics shifted, exhibiting a trend of erosion followed by accretion (Figures 11 and 12). Collectively, these changes indicate a retreat of the river channel. The quantitative values associated with these changes are presented in Table 4.

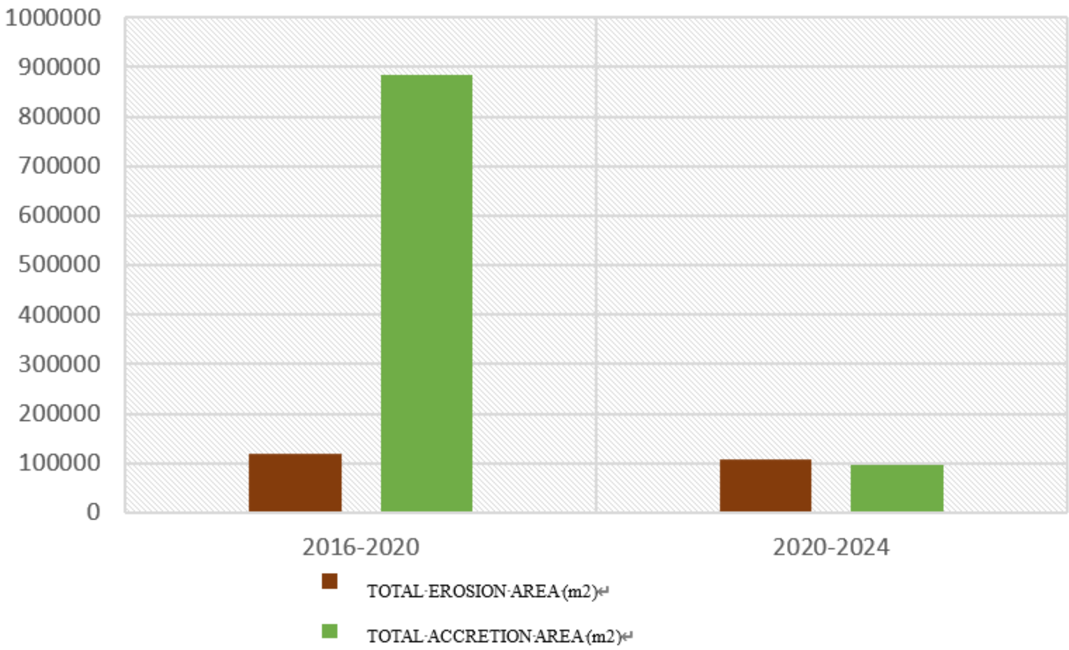

Figure 11. *Erosion and accretion areas in Section 2A de 2016-2020 and 2020-2024.*

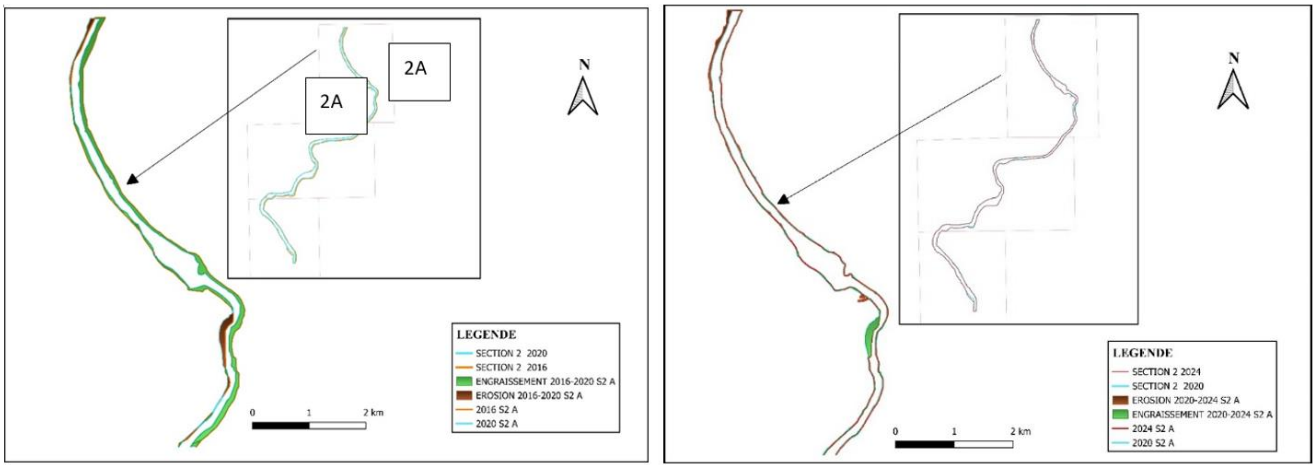

Figure 12. River evolution in Section 2A (2016-2020 and 2020-2024).

Table 4. Fluvial impacts on Section 2A the 2016-2020 and 2020-2024.

Period	Total Erosion Area (m^2)	Total Accretion Area (m^2)
2016-2020	118,084.283	884,099.049
2020-2024	108,943.987	956,53.528

2) SECTION 2 B

A widespread regression of the river channel was observed across the entire study reach, indicating a marked decrease in water extent over both time intervals. While areas of accretion were present, erosion was the dominant process, with eroded surfaces significantly exceeding accreted areas (Figures 13 and 14, Table 5). These results reflect an overall contraction of the channel and a decline in water-covered areas.

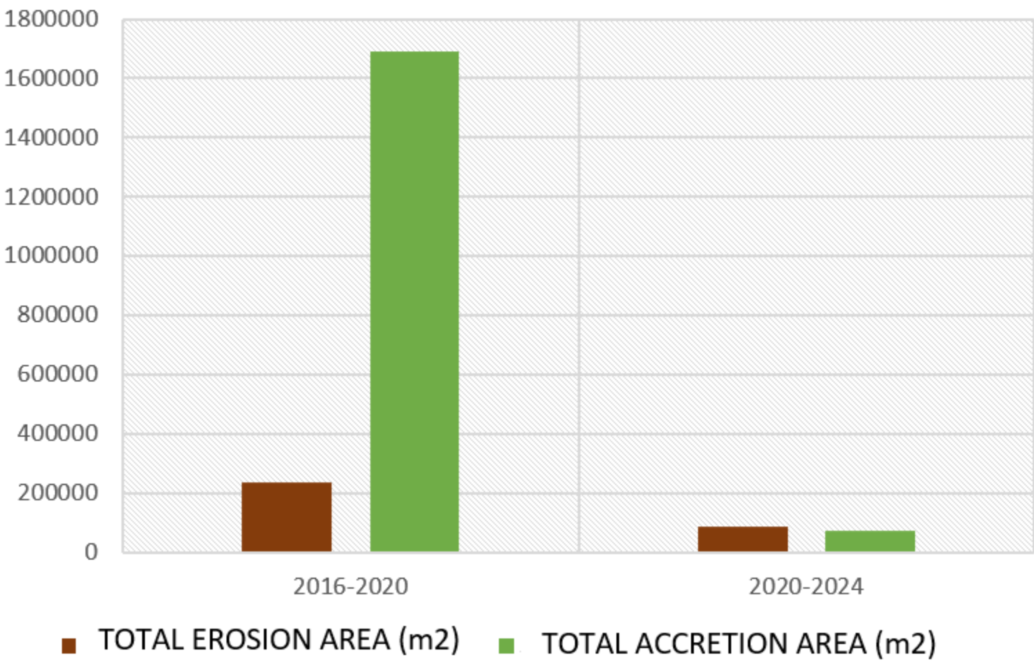

Figure 13. Erosion and accretion areas in Section 2B the 2016-2020 and 2020-2024.

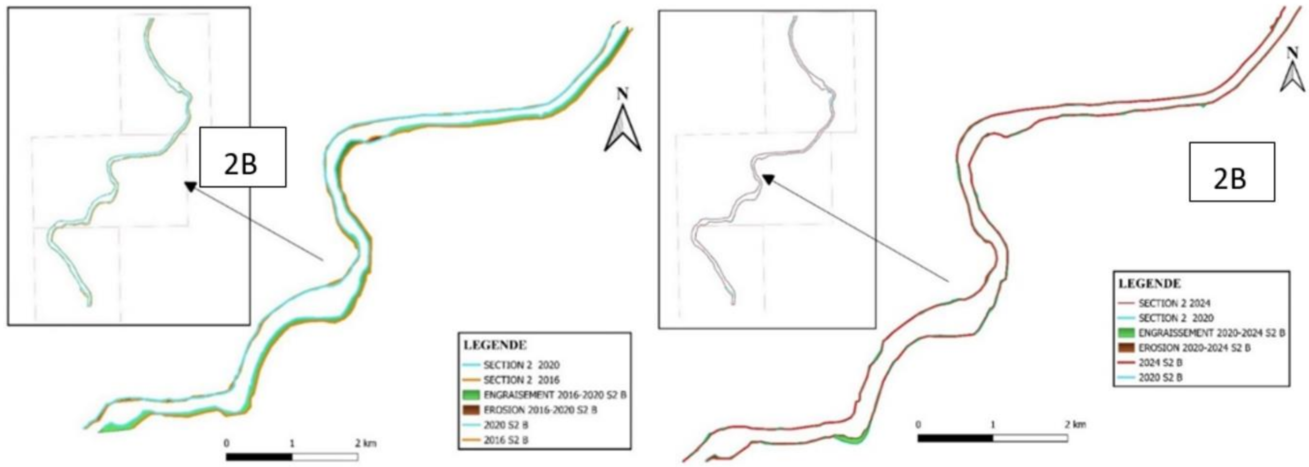

Figure 14. *River evolution in Section 2B (2016-2020 and 2020-2024).*

Table 5. *Fluvial impacts on Section 2B the 2016-2020 and 2020-2024.*

Period	Total Erosion Area (m^2)	Total Accretion Area (m^2)
2016-2020	235,137.815	169,239,8
2020-2024	894,97.374	730,35.889

3) SECTION 2 C

Between 2016 and 2020 (Figure 16), the river channel experienced substantial morphological adjustments, with accreted areas largely exceeding eroded areas. These changes indicate an overall regression of the channel. During the subsequent period, 2020-2024 (Figure 16), channel dynamics were mainly characterized by erosion and, to a lesser extent, accretion (Figure 15, Table 6). The observed patterns reflect ongoing geomorphological changes and continued channel retreat.

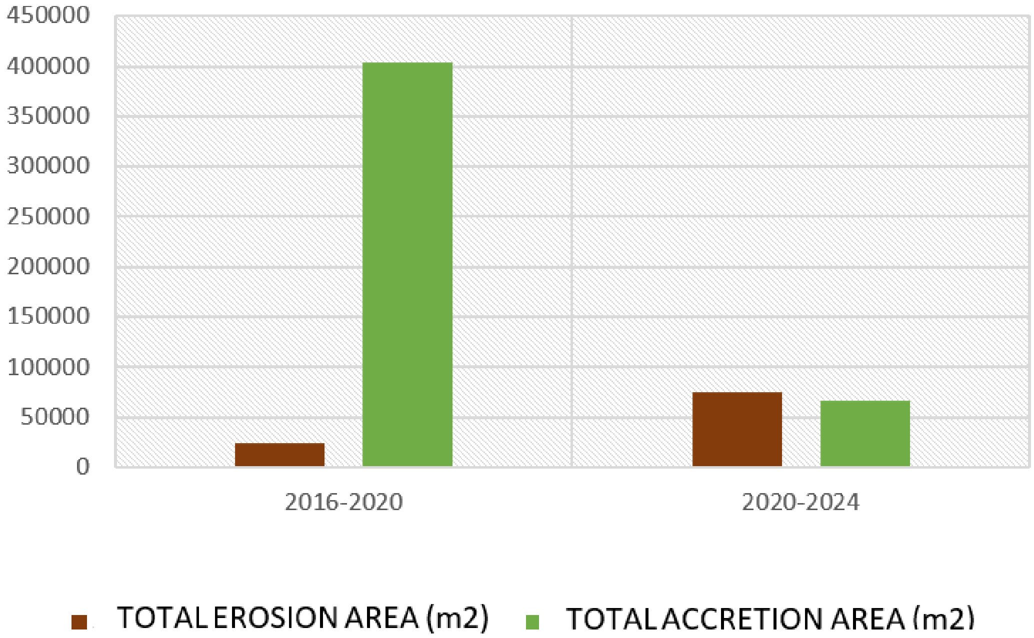

Figure 15. *Erosion and accretion areas in Section 2C the 2016-2020 and 2020-2024.*

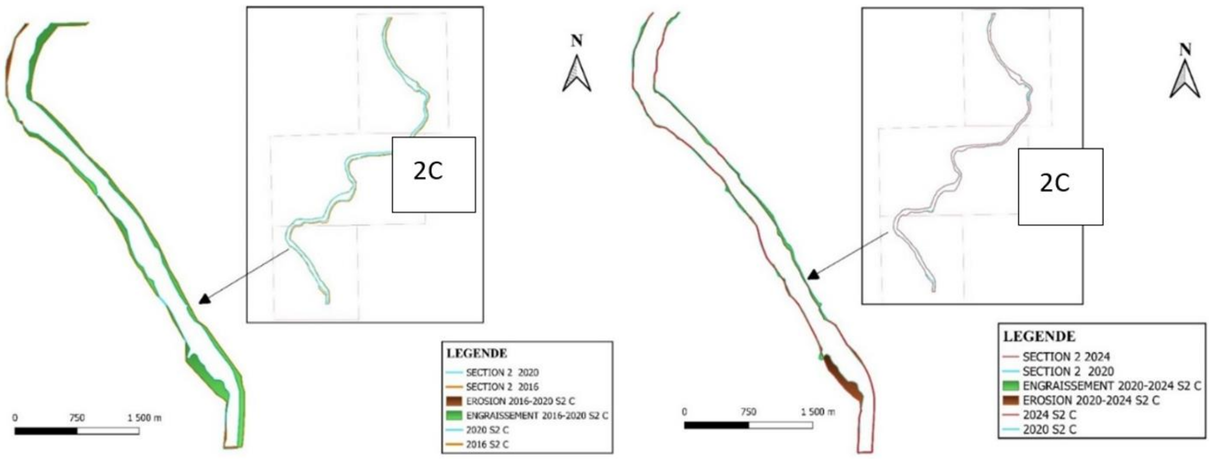

Figure 16*. River evolution in Section 2C (2016-2020 and 2020-2024).*

Table 6*. Fluvial impacts on Section 2C the 2016-2020 and 2020-2024.*

Period	Total Erosion Area (m^2)	Total Accretion Area (m^2)
2016-2020	237,74.681	404,295.209
2020-2024	744,71.354	667,17.609

(iii). SECTION 3

The third reach, derived from the segmentation of the original image, was divided into three subsections (3A, 3B, and 3C) to facilitate a more detailed analysis. Particular emphasis was placed on the measurement of eroded and accreted areas, with changes evaluated over four-year intervals in order to characterize the morphological evolution of the channel (Figure 17).

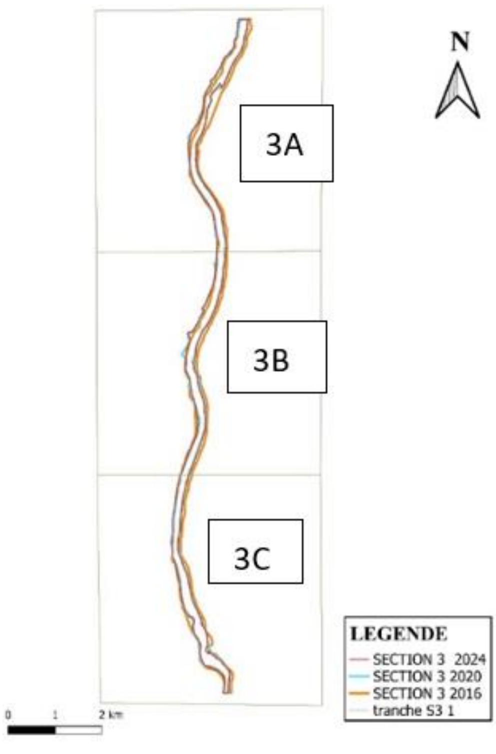

Figure 17*. Superposition of river-channel traces for Section 3 (section 3A, 3B et 3C) in the Piébly and Sinikosson.*

1) SECTION 3A

Between 2016 and 2020, substantial variations were observed in the river channel (Figures 18 and 19), with accretion emerging as the dominant process across parts of Section 3A. During the subsequent period (2020-2024), channel dynamics were mainly characterized by erosion, followed by localized accretion. The quantitative assessment of these fluvial changes is presented in Table 7.

Table 7. *Fluvial impacts on Section 3A the 2016-2020 and 2020-2024.*

Period	Total Erosion Area (m^2)	Total Accretion Area (m^2)
2016-2020	138,260.322	361,466.786
2020-2024	529,16.16	442,23.79

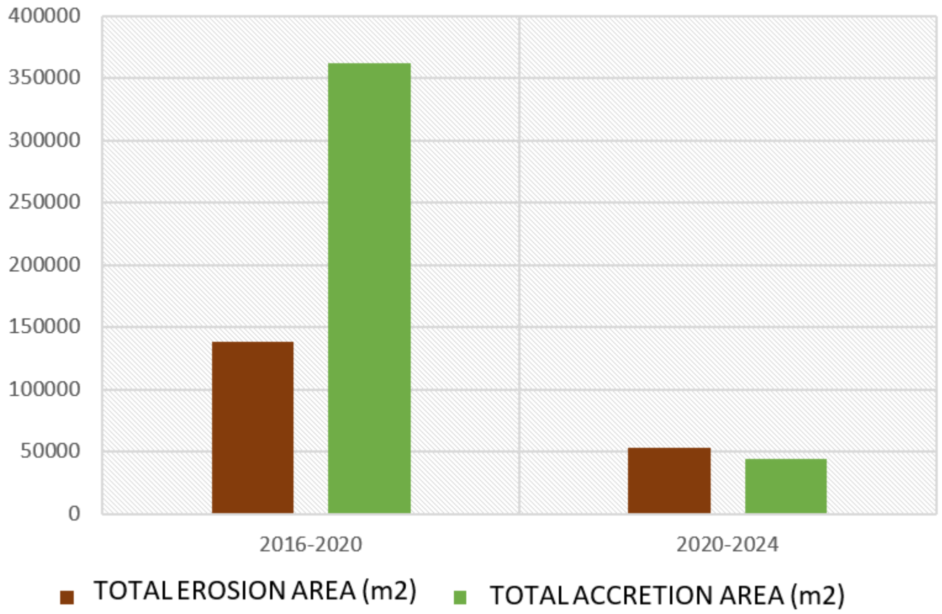

Figure 181. *Erosion and accretion areas in Section 3A the 2016-2020 and 2020-2024.*

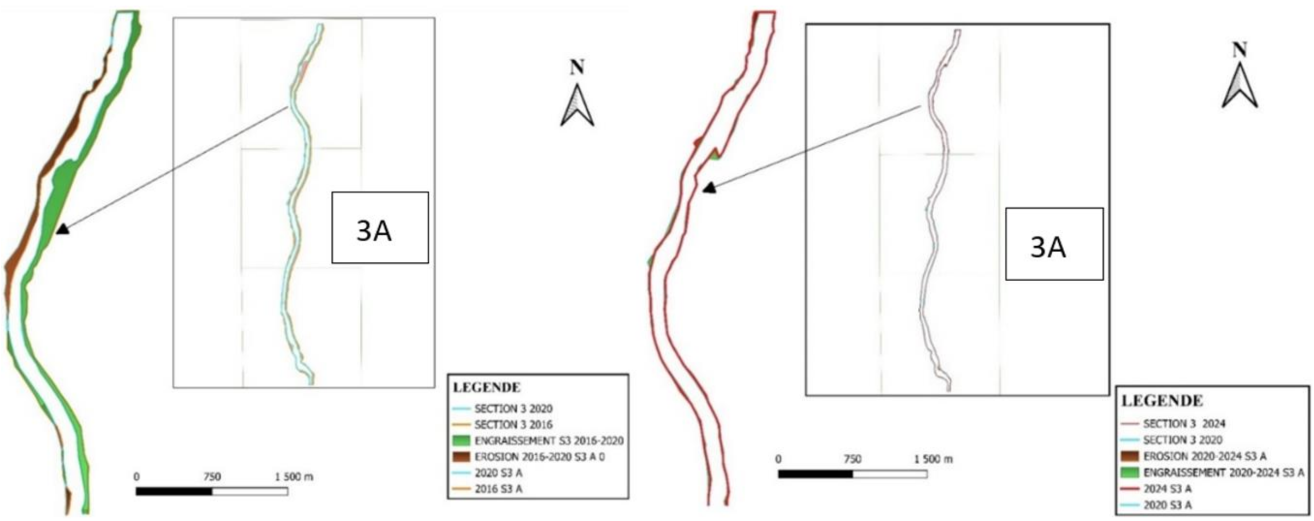

Figure 19. *River evolution in Section 3A (2016-2020 and 2020-2024).*

2) SECTION 3 B

From 2016 to 2020, accretion was the dominant process in Section 3B, with a total accreted area of 354,409.669 m^2, significantly exceeding the eroded area of 93,951.1774 m^2 (Table 8; Figure 20). These changes are clearly illustrated by the comparative river-channel analysis shown in Figure 21. However, between 2020 and 2024, the channel dynamics shifted, with erosion becoming the prevailing process, although localized accretion was also observed (Table 8).

Table 8. *Fluvial impacts on Section 3B the 2016-2020 and 2020-2024.*

Period	**Total Erosion Area (m^2)**	**Total Accretion Area (m^2)**
2016-2020	939,51.774	354,409.669
2020-2024	412,648.058	538,32.119

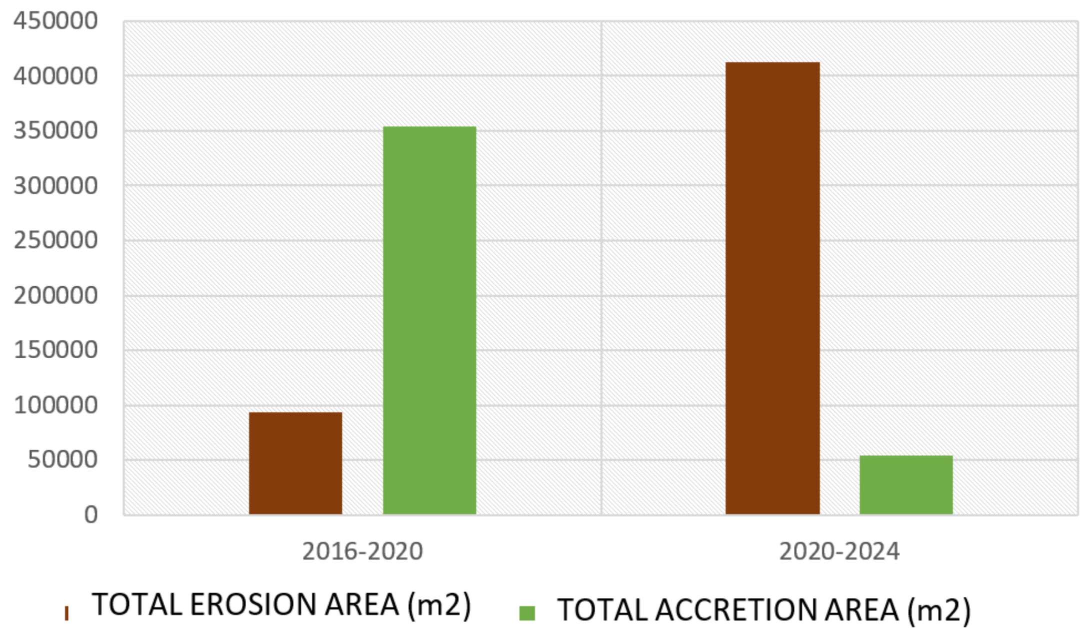

Figure 20. *Erosion and accretion areas in Section 3B the 2016-2020 and 2020-2024.*

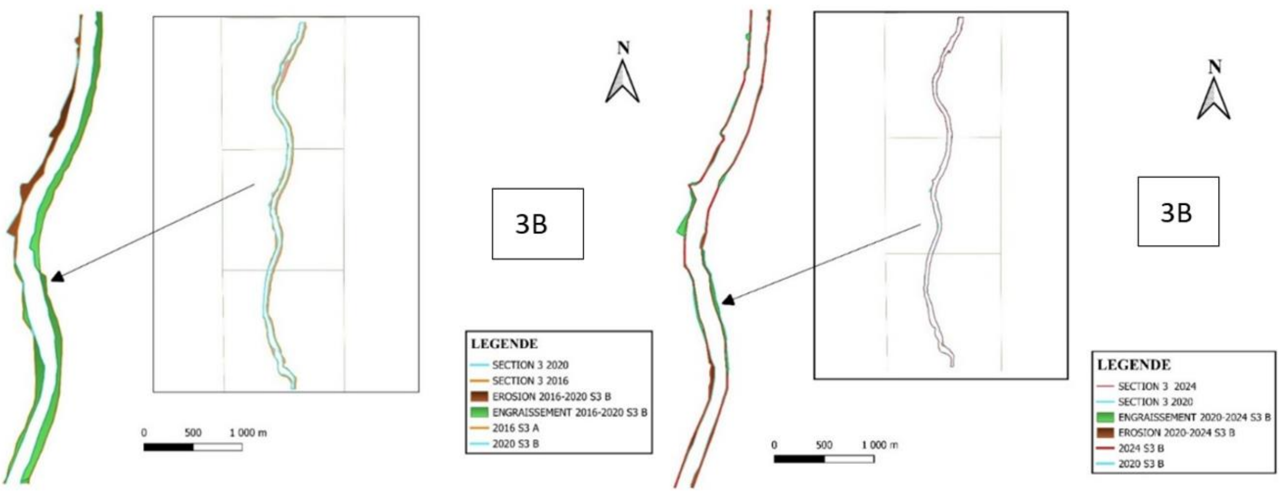

Figure 21. *River evolution in Section 3B (2016-2020 and 2020-2024).*

3) SECTION 3 C

Between 2016 and 2020, the river channel exhibited areas affected by both erosion and accretion, with the latter representing the dominant geomorphological process (Figure 23). During the subsequent period (2020-2024), channel adjustments continued, with accretion and erosion occurring at nearly equal rates of areal change (Table 9). These results suggest a relative balance between erosional and depositional processes within Section 3C during the latter interval.

Table 9. *Fluvial impacts on Section 3C the 2016-2020 and 2020-2024.*

Period	Total Erosion Area (m^2))	Total Accretion Area (m^2)
2016-2020	138,55.235	324,124.092
2020-2024	522,33.422	544,04.062

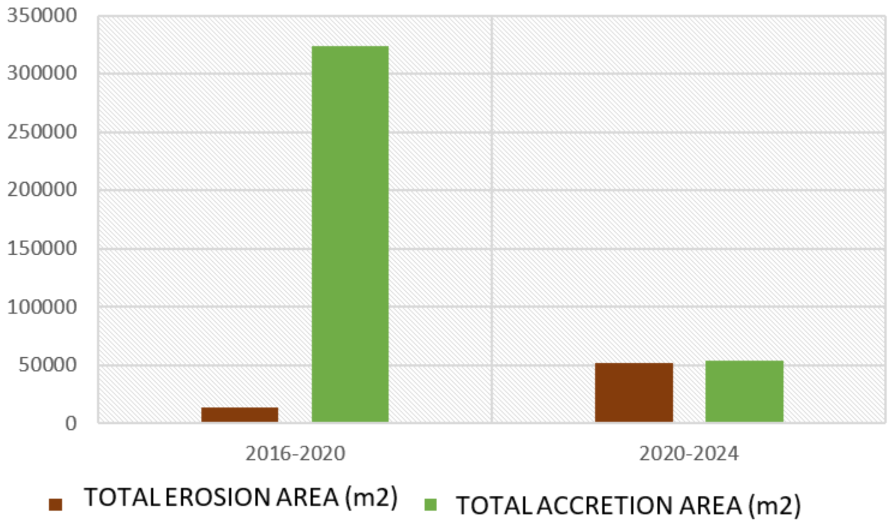

Figure 22. *Erosion and accretion areas in Section 3C the 2016-2020 and 2020-2024.*

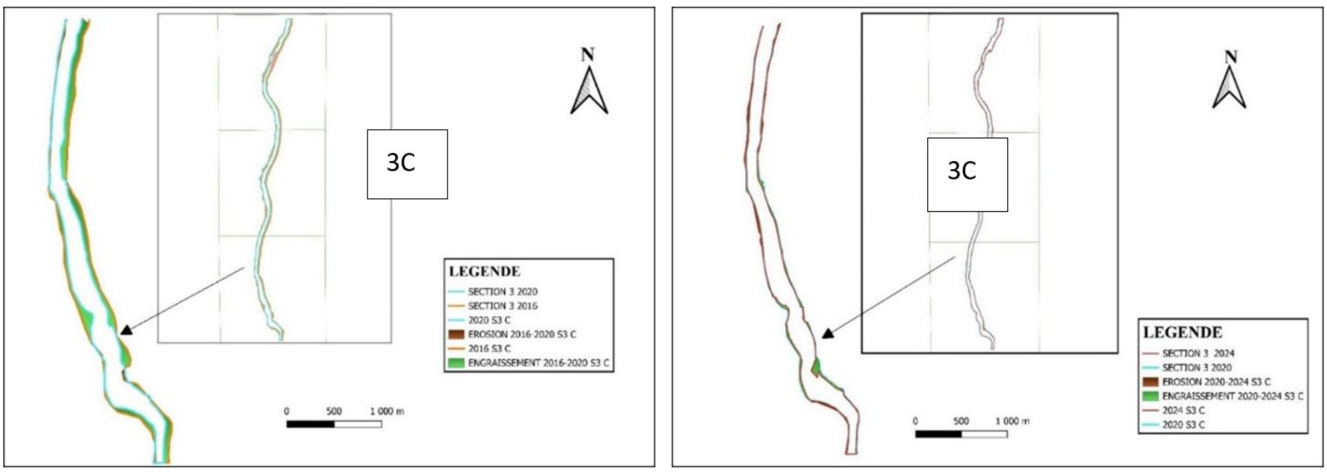

Figure 23. *River evolution in Section 3C (2016-2020 and 2020-2024 and 2016-2020 and 2020-2024.*

3.1.3. Assessment of River Stability (2016-2024)

The cumulative erosion and accretion areas enabled the estimation of the overall geomorphological impact and river-channel stability. Between 2016 and 2020, accretion accounted for approximately 82% of the total impacted area, while erosion represented 18%. This interval was therefore characterized by channel regression accompanied by extensive sediment accumulation. Between 2020 and 2024, erosion represented 43% of the total impacted area, whereas accretion accounted for 57%. Although the difference between the two processes was less pronounced than during the previous interval, accretion remained dominant. (see Table 10, Table 11 and Figure 24).

Table 10. Summary table of impact over the 2016-2020 interval.

years	Sections	Eroded area	Accreted area
2016-2020	1	166,988.12	414,370.85
		172,105.8	346,006.59
		184,500.71	426,684.62
	2	118,084.28	884,099.05
		235,137.82	169,239,8
		237,74.681	404,295.21
	3	138,260.32	361,466.79
		939,51.774	354,409.67
		13855,235	324124,092
total (m^2)		114,665,8.73	520,785,4.87
Total impacted area (m^2)		635,451,3.6	
% EROSION rate		18	
% ACCRETION rate		82	

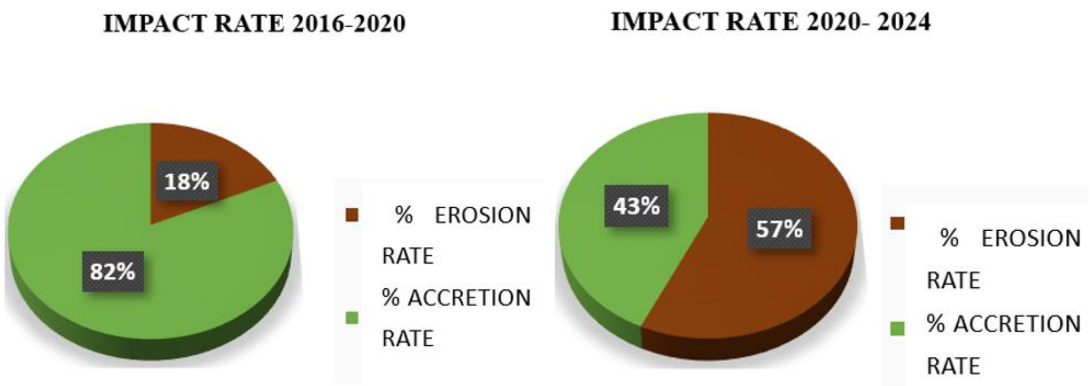

Figure 24. Assessment of erosion and accretion impact rates the 2016-2020 and the 2020-2024.

Table 11. Summary table of impact over the 2020-2024 interval).

Years	SECTIONS	Eroded area	Accreted area
2020-2024	1	768,56.762	162,299.92
		762,46.18	95,264
		514,15.864	503,77.723
	2	108,943.99	956,53.528
		894,97.374	730,35.889

Years	SECTIONS	Eroded area	Accreted area
		744,71.354	667,17.609
		529,16.16	442,23.79
	3	412,648.06	538,32.119
		522,33.422	544,04.062
Total (m^2)		918,372.399	695,808.637
Total impacted area (m^2)		161,418,1.04	
% EROSION rate		57	
% ACCRETION rate		43	

3.2. Geomorphological Characteristics River

3.2.1. NDWI Water Index Years 1985 and 2024

The processing of Landsat-5 (1985) and Sentinel-2 (2024) imagery using specific spectral bands within QGIS 3.36 allowed the calculation of NDWI values and the identification of water bodies and flood-prone areas. The comparison of both years revealed spatial changes in surface-water distribution, reflecting climatic and environmental changes over time (Figure 25).

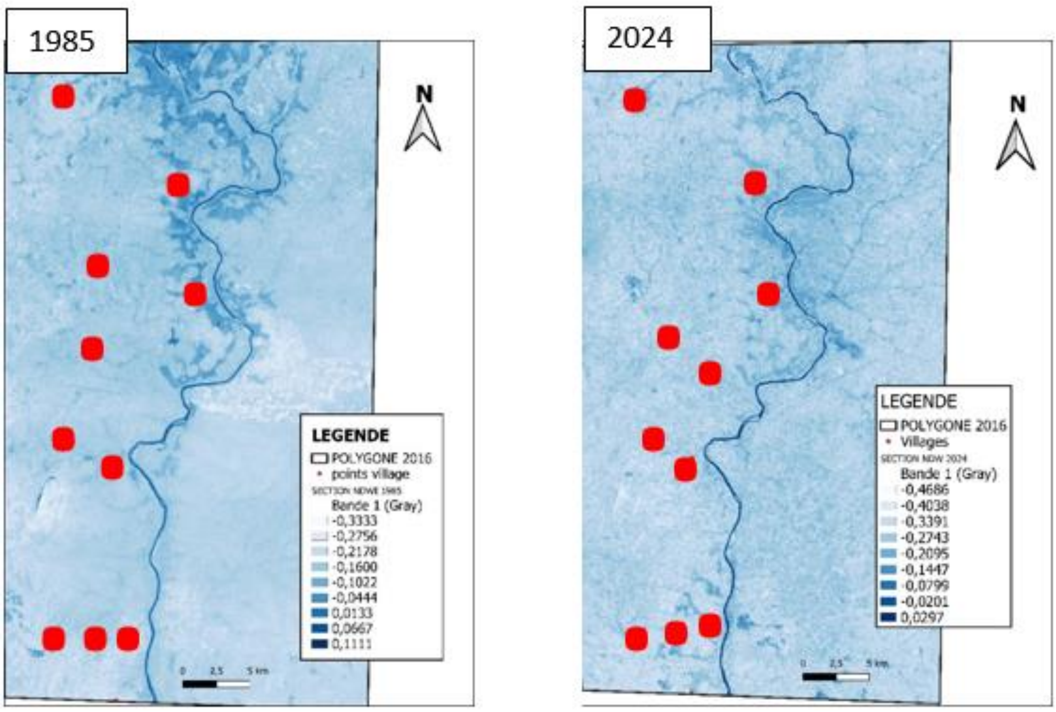

Figure 25. NDWI maps of the Comoé Estuary for 1985 and 2024.

3.2.2. Sinuosity Index

The lengths of the river sections and the straight-line distances between endpoints were measured from the 2024 river trace. Sinuosity indices were subsequently calculated. (Figure 26, Table 12).

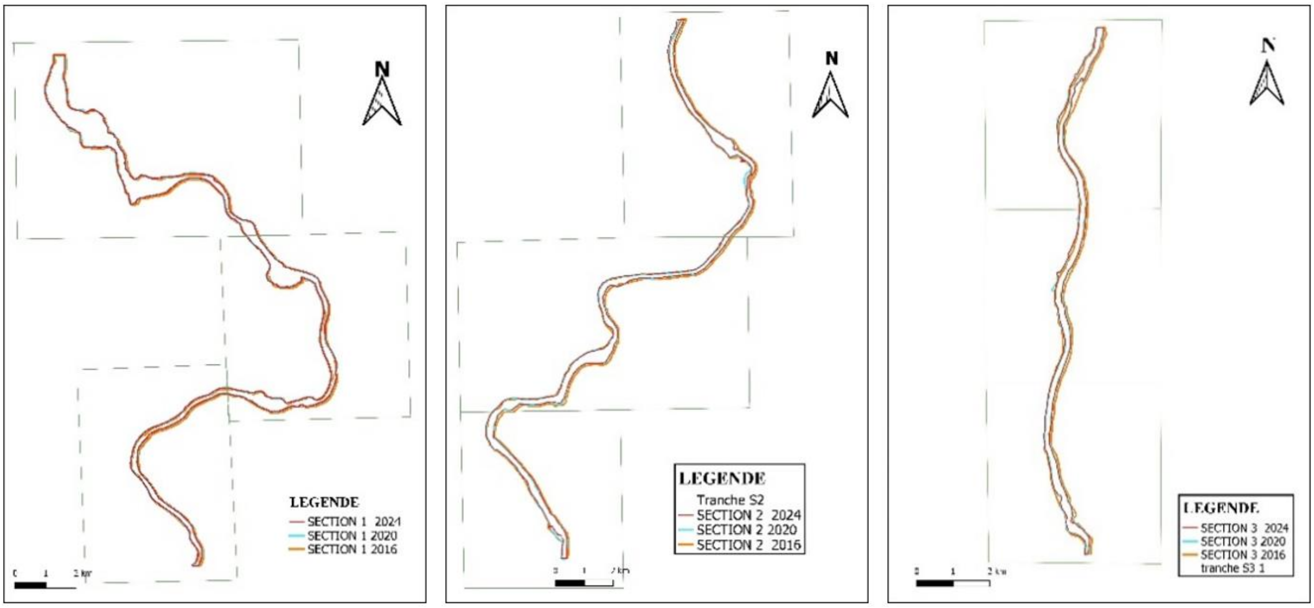

Figure 26*. River-channel traces used for sinuosity analysis 2016, 2020, 2024.*

Table 12*. Detection of the river morphology.*

Section	Channel Length (m)	Straight Distance (m)	Sinuosity Index
Section 1	61,413.57	16,503.09	3.72
Section 2	57,064.31	19,132.01	2.98
Section 3	31,945.57	13,992.53	2.28

These values indicate a strongly meandering river system, as all sinuosity indices are greater than 1.5.

3.2.3. Rainfall Variability the 1985 and 2020

Rainfall records obtained from Access Climate indicate relatively stable precipitation during the dry season between 1985 and 2016. However, rainfall totals increased significantly in 2020, reaching 319.58 mm. This increase may reflect changing climatic conditions affecting hydrological dynamics within the study area. The following Table 13 reports rainfall values during drought periods.

3.2.4. Slope Analysis

Based on Digital Elevation Model processing, the Sassandra River was found to exhibit an essentially zero slope throughout the study reach. Such conditions favor sediment deposition and the development of meandering channel patterns (Figure 27).

Table 13*. Estimation of rainfallnusing virtual stations.*

DEPARTEMENTS	years	November	December	January	February	March	TOTAL (mm)
KOUIBLY	1984-1985	13,71	18,46	27,95	26,89	85,96	172,97
KOUIBLY	2015-2016	60,12	3,16	4,22	2,11	109,69	179,3
KOUIBLY	2019-2020	137,64	14,77	0	17,4	149,77	319,58

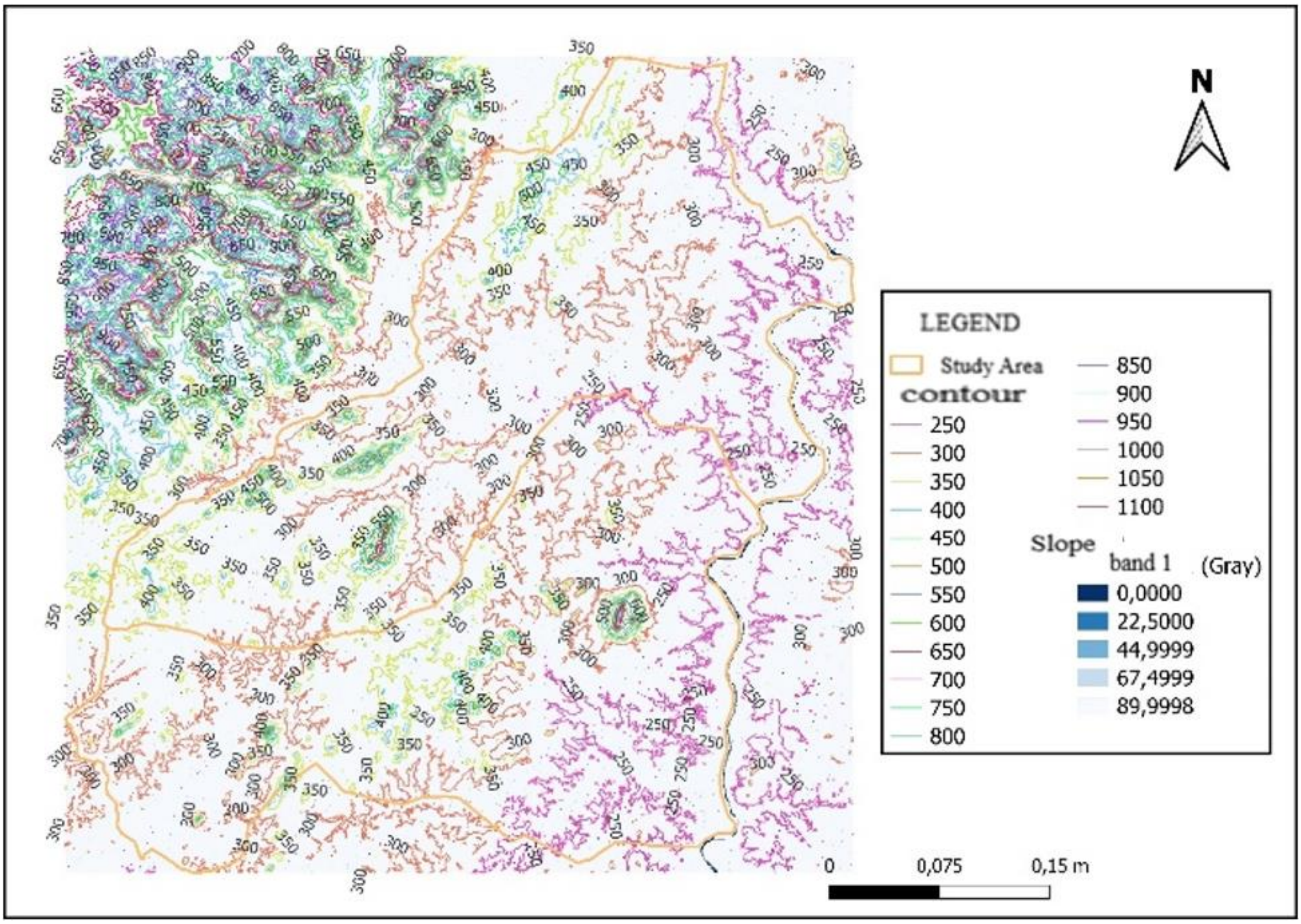

Figure 27. *Combined altitude and slope map.*

4. Discussion

The spatio-temporal analysis of the Sassandra River using Sentinel-2 imagery demonstrated substantial geomorphological changes along the river course between 2016 and 2024. The overlay of river-channel traces made it possible to quantify erosion and accretion processes and to identify the dominant trends affecting channel evolution. This methodological approach has previously been used successfully in studies of river dynamics in West Africa [10].

During the 2016–2020 period, channel evolution was marked by extensive accretion, representing approximately 82% of the impacted area according to the authors' interpretation. Sediment accumulation contributed to bank stabilization but may also reduce channel capacity and aquatic biodiversity. Conversely, between 2020 and 2024, erosion became more pronounced and accounted for approximately 57% of the observed impacts, indicating renewed channel adjustment. Overall, the Sassandra River experienced a progressive narrowing of its active channel due to alternating phases of sediment accumulation and bank erosion. These geomorphological modifications have direct consequences for local populations through their effects on fishing activities, biodiversity conservation, and water availability [11].

NDWI analysis further revealed changes in water distribution and flood-prone zones between 1985 and 2024, illustrating the influence of climate variability on river behavior. Previous studies have shown that long-term climatic disturbances can significantly alter aquatic ecosystems and river morphology. Given [12, 13], the high sinuosity values obtained (mean sinuosity index ≈ 2.95), the Sassandra River can be classified as a meandering river. Consequently, settlements located close to the river may face increasing flood hazards under conditions of intense rainfall, particularly when overflow occurs from the minor channel into the floodplain.

5. Conclusion

This study investigated the fluvial geomorphology of the Sassandra River within the departments of Facobly and Kouibly using satellite imagery acquired during the dry season. The main objective was to understand the evolution of the river channel through the identification and analysis of morphological changes occurring between 2016 and 2024. The results revealed significant geomorphological processes, particularly erosion and accretion, along the river course. Climate variability appears to be one of the principal factors responsible for the observed changes in the fluvial system.

The assessment of river stability showed that accretion was the dominant process between 2016 and 2020, accounting for more than 82% of the observed impacts, whereas erosion represented approximately 18%. In contrast, the period 2020–2024 was characterized by an increase in erosion, which reached approximately 43%, while accretion decreased to about 57%.

The study also identified the main factors controlling river morphology. These include:

1) A mean sinuosity index of approximately 2.95, indicating a highly meandering river pattern.
2) Rainfall variations ranging from approximately 173 mm in 1985 to 320 mm in 2020 during the dry season.
3) An almost zero channel slope throughout the study reach.

Overall, the findings indicate that the meandering Sassandra River experienced substantial channel adjustments during the 2016–2024 period. Geographic Information System (GIS) techniques proved effective for characterizing the spatio-temporal dynamics of the river and monitoring geomorphological changes. Future studies should focus on:

1) Seasonal variations in channel morphology;
2) Identification of areas most vulnerable to erosion;
3) Assessment of climate-change impacts on river dynamics;
4) Evaluation of additional hydrological parameters such as flow velocity, discharge variability, and sediment load.

Considering the increasing erosion risk and the potential occurrence of floods, water-management measures such as hydraulic structures, flood-control systems, or properly designed drainage channels should be considered in order to reduce flood hazards and improve the resilience of riverside communities.

Abbreviations

DEM	Digital Elevation Model
SCP	Semi-Automatic Classification Plugin
SI	Sinuosity Index
NDWI	Normalized Difference Water Index
GIS	Geographic Information System
LANDSAT	Land Satellite
QGIS	Quantum Geographic Information System
GIS	Geographic Information System

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Author Contributions

Chiayé Larissa Koffi Epse Coulibaly: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft

Jean Emmanuel Obrou: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources

Blandine Akissi Egoran Epse Kouassi: Formal Analysis, Methodology, Software, Visualization

Sylvain Monde: Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Gregory, K. J. (2000). The Changing Nature of Physical Geography. Arnold, co-published in the USA by Oxford University Press, London and New York, (51), pp 274-275. https://doi.org/10.19044/esj.2014.v10n2p%25p2

[2] Afouda, A., & Adisso, P. (1997). Stochastic Study of Dry Sequence Structures in Benin. In Sustainability of Water Resources under Increasing Uncertainty (Proceedings of the Rabat Symposium S, April 1997), IAHS Publication No. 240, pp. 43–50. https://www.scirp.org/reference/referencespapers?referenceid=3148015

[3] Benzarti, Z., & Habaieb, H. (2001). Study of Drought Persistence in Tunisia Using Markov Chains (1909–1996). Science and Global Change / Drought, 12 (4), pp. 215–220. http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=13441238

[4] N'Guessan, B. V. H., Saley, M. B., Wade, S., Valere, D. E., Kouame, F., & Affian, K. (2014). Flood Risk Mapping through a Combined Remote Sensing and Geographic Information Systems Approach in the Department of Sinfra. European Scientific Journal, 10 (2), pp. 170–191. https://doi.org/10.19044/esj.2014.v10n2p%25p

[5] CNRA (2009). The Regional Directorate of the CNRA in Man: Key Facts and Figures. Final Report, Côte d'Ivoire, 12 p.

[6] Boyossoro, H. K., Koffi, F. K., Saley, M. B., Biémi, J., & Traoré, I. (2007). Climate Insecurity and Geohazards in Côte d'Ivoire: A Study of Soil Water Erosion Risk in the Semi-Mountainous Region of Man (Western Côte d'Ivoire). Science and Global Change / Drought, 18(1), pp. 29–37. https://doi.org/10.1684/SEC.2007.0064

[7] Saley, M. B. (2003). Spatially Referenced Hydrogeological Information System, Pseudo-Image Discontinuities and Thematic Mapping of Water Resources in the Semi-Mountainous Region of Man (Western Côte d'Ivoire). PhD Thesis, University of Cocody, Abidjan, 211 p..

[8] RGPH, (2014): General Population and Housing Census: Overall Results. National Institute of Statistics, Côte d'Ivoire, 12 p.

[9] Barima, Y. S., Barbier, N., Bamba, I., Traoré, D., Lejoly, J., & Bogaert, J. (2009). Landscape Dynamics in the Forest–Savanna Transition Zone of Côte d'Ivoire. Bois et Forêts des Tropiques, 299(1), pp. 15–25. https://doi.org/10.19182/bft2009.299.a20419/

[10] Garnier, A., Dufour, S., Lespez, L., Caillault, S., & Delahaye, D. (2014). Spatio-Temporal Analysis of the Fluvial Dynamics of a Sahelo-Sudanian River between 1967 and 2007: The Case of the Yamé River in Dogon Country (Mali, West Africa). Revue Internationale de Géomatique, 24(3), pp. 279–306 https://doi.org/10.2307/1467814

[11] Mendoza, G. H. (2014). Identification of Biodiversity Loss Risks under Anthropogenic Pressures and Climate Change by 2100: Application of Dynamic Conservation to the Alpes-Maritimes Territory. Doctoral Thesis in Science and Engineering Risk Management, École Nationale Supérieure des Mines, Paris, France, 321 p.

[12] Feminella, J. W. (1996). Comparison of Benthic Macroinvertebrate Assemblages in Small Streams. Journal of the North American Benthological Society, 15, pp. 651–669. https://www.journals.uchicago.edu/doi/abs/10.2307/1467814

[13] Clarke, A., Nally, R. M., Bond, N., & Lake, P. S. (2010). Flow Permanence Affects Aquatic Macroinvertebrate Diversity and Community Structure in Three Headwater Streams within a Forested Catchment. Canadian Journal of Fisheries and Aquatic Sciences, 67(10), pp. 1649–1657. https://doi.org/10.1139/F10-087

Biography

Chiayé Larissa Koffi Epse Coulibaly is a Assistant Professor in the Department of Geological and Mining Sciences at the University of Man in Côte d'Ivoire. She earned her Ph.D. in Marine Geoscience and Sedimentology from Félix Houphouët Boigny University in Abidjan in 2017, as well as a master's degree from the same institution in the same field in 2014. She is the head of the Department of Mining and Reservoirs at the University of Man. She has supervised more than seven master's students, served as an examiner for several master's theses, and participated in numerous national and international conferences.

Jean Emmanuel Obrou is a geologist and researcher affiliated with the University of Man. In 2024, he obtained a Master's degree in Geology, Mining and the Environment (Geology specialisation) from the same institution, where his research focused on characterising the geomorphology of the Sassandra River, which runs along the borders of the departments of Facobly and Kouibly, using satellite imagery. He has also held a Bachelor's degree in Geological Sciences since 2022, during which he studied the estimation of morphometric parameters of landforms associated with water erosion in a sub-watershed. His research focuses on geomorphology, remote sensing and environmental management.

Blandine Akissi Egoran Epse Kouassi has a PhD in Earth Sciences (2017), holds a Master's degree in Earth Sciences (2014), and since December 2025, has been the Deputy Director of the Oceanographic Research Center at the University of San Pedro. Specializing in marine geology and oceanography, she focuses her research on coastal dynamics, coastal sedimentology, sequence stratigraphy, and applied geosciences. Her work focuses on characterizing sediment deposits, the morphodynamic evolution of beaches, coastal erosion in Ivory Coast, and the impact of human activities, especially marine sand extraction. She is also interested in biostratigraphy, cyclostratigraphy, and the analysis of sedimentary basins, with a particular focus on the Ivory Coast basin.

Sylvain Monde is a Full Professor of Geosciences at Félix Houphouët-Boigny University (UFHB), Côte d'Ivoire, where he currently serves as Head of the Department of Geosciences. He holds two Ph.D. degrees: one from UFHB and another from La Rochelle University (France), complemented by postdoctoral research in oceanography at Québec University (Canada). Professor MONDE's research spans marine geology, sedimentology, coastal dynamics, and hydrosedimentary modeling. He has authored over 130 scientific publications and supervised numerous doctoral and master's theses. His work has contributed to national and international projects, including oceanographic missions and environmental assessments. He is actively involved in scientific networks such as the International Association of Sedimentologists and the Order of Geologists of Quebec. Beyond academia, he serves as a municipal councilor in Azaguié and Vice-President of the Commission for Social and Cultural Affairs. His career reflects a strong commitment to scientific excellence and sustainable development in Africa.

Research Field

Chiayé Larissa Koffi Epse Coulibaly: Marine Geosciences, Micropaleontology, Paleontology and Stratigraphy, Petroleum Exploration and Production, Coastal Dynamics, Geological and Geochemical Mapping, Sedimentology of Sedimentary Formations

Blandine Akissi Egoran Epse Kouassi: Coastal Dynamics, Marine Sedimentology, Sequence Stratigraphy, Applied Geosciences, Coastal Erosion, Geo-environmental Hazard, Structural Geology, Land-Use Planning and Natural Resource Management

Jean Emmanuel Obrou: Continental geomorphology and river dynamics, Remote sensing applied to earth sciences, Satellite image processing and analysis, Hydrology and the study of water erosion, Characterization of catchment areas, Mining geology and environmental management, Geological mapping and geographic information systems

Sylvain Monde: marine geology, sedimentology, coastal dynamics, and hydrosedimentary modeling