Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN (O): 2320-5407
ISSN (P): 3107-4928

Article DOI:10.21474/IJAR01/24031
DOI URL: http://dx.doi.org/10.21474/IJAR01/24031

RESEARCH ARTICLE

MAPPING OF FLOOD RISK AREAS IN THE CATCHMENT AREAS OF RUE MINISTRE, DJIBI AND BÉTÉ (ABIDJAN DISTRICT) USING REMOTE SENSING AND GIS

Koffi Ehouman Serge[1], Kamagate Azoumanan[2], Nagnon Yéo[1], Dao Amidou[1], Seydou Touré[1] and Kamagate Bamory[1]

1. Geosciences and Environment Laboratory (LGE), Training and Research Unit for Environmental Sciences and Management, University NanguiAbrogoua (UNA), 02 Bp 801 Abidjan 02, Côte d'Ivoire.
2. Training and Research Unit for Marine Sciences, University of San-Pedro, City: San Pedro 01 BP 1800 San Pedro 01, Côte d'Ivoire.

Manuscript Info

Manuscript History
Received: 16 June 2026
Final Accepted: 18 July 2026
Published: August 2026

Key words:-
Flood risk zones, Watershed, Rue Ministre, Bété and Djibi, Remote sensing and GIS.

Abstract

The watersheds of Rue Ministre, the Djibi, and the Bété rivers, located on the outskirts of Abidjan, have experienced significant real estate development over the past ten years. This urbanization could increase their vulnerability to flooding. It is in this context that this study aims to map the flood zones of the Rue Ministre, Djibi, and Bété watersheds using a combined approach of Remote Sensing and Geographic Information Systems (GIS). The methodology employed involves calculating two indices derived from the slope map (TWI and SPI). The results obtained after the creation of thematic maps showed that flood-prone areas are estimated at approximately 12.02% of the Rue Ministre watershed, approximately 11.36% of the Djibi watershed, and approximately 3.81% of the Bété watershed.

Introduction:-

Natural disasters have always existed and are a common and recurring phenomenon in human history (Antoine et al., 2008). The risks of flooding have been recognized as a major threat due to the extent and scale of the damage they cause each year worldwide (Leulmi, 2025). They accounted for 34% of disasters recorded globally between 1990 and 2007. Indeed, cities are increasingly the places where natural disasters occur (Grimm et al., 2008; Joerin& Shaw, 2010; Wamsler, 2014), affecting more than 2 billion people over the past twenty decades (Ekmekcioğlu et al., 2022; UNISDR, 2015; World Health Organization, 2017). Their impacts can be devastating, resulting in direct annual economic losses of tens of billions of dollars (Fu et al., 2020; Guindo et al., 2020). Flood risk is therefore characterized by a combination of hazard and vulnerability. Since these components are subject to strong spatio-temporal variability, their combination is all the more complex, potentially leading to a multitude of actions. Furthermore, urban flooding constitutes a major obstacle to development and endangers populations, particularly inhabitants of rapidly expanding cities in developing countries (A. Bhas et al., 2012).

Corresponding Author:-Koffi Ehouman Serge
Address:-Geosciences and Environment Laboratory (LGE), Training and Research Unit for Environmental Sciences and Management, University NanguiAbrogoua (UNA), 02 Bp 801 Abidjan 02, Côte d'Ivoire.

Catastrophic urban flooding results from several combined and interconnected factors, including intense rainfall, rising river levels, and inadequate drainage systems. These factors contributing to the spread of these hazards are amplified by uncontrolled global climate change and urbanization (IPCC, 2014; Hallegatte et al., 2013). Ocha, (2012) states that a Dozen West African countries are suffering from severe flooding which has caused more than 159 deaths and affected nearly 600,000 people in towns and cities that are inadequately equipped to deal with extreme rainfall events. In Côte d'Ivoire, urban flooding is among the most significant natural hazards. For years, Ivorian coastal cities have frequently experienced flooding. Despite having a substantial stormwater drainage network, Abidjan, with its 6,321,017 inhabitants (Koffi, 2021), is not immune to this phenomenon. Indeed, as a modern city, the economic capital of Côte d'Ivoire is subject to flooding every rainy season, causing grief to many families and enormous material damage.

Faced with the recurring floods in the Abidjan district, and considering the inconvenience and damage they cause, several researchers (Hauhouot, 2008 and Alla, 2013) have examined flood risks in urbanized areas, specifically in the impoverished neighborhoods of the Abidjan district. This phenomenon has generated considerable interest. In a broader context, it appears necessary to analyze the vulnerability of areas undergoing urbanization to flood risks, similar to the frequent flooding in the district's urbanized areas, in order to implement prevention strategies for better protection of the population and their property. It is within this context that the present study was titled " Mapping of Flood Risk Areas in the Watersheds of Rue Ministre, Djibi, and Bété Rivers Using Remote Sensing and GIS." The overall objective of this study is to map flood risks using a combined approach of Remote Sensing and Geographic Information Systems (GIS) to identify flood-prone areas in these watersheds.

Materials and Methodology:-

Material:-

Geographical location of the study area:-

The Rue Ministrewatershed is located northeast of the city of Abidjan (the economic capital of Côte d'Ivoire). This watershed covers an area of 30 km$^{2.}$It lies entirely within the municipality of Cocody and is situated between 5°10' and 5°30' North latitude and 3°50' and 4°10' West longitude. The Aghien Lagoon watershed is a peri-urban basin straddling three municipalities within the same district. It is urbanized, encompassing the most populated neighborhoods of the municipality of Abobo. Its area is 365 km^2. It notably includes two basins drained by the Djibi and Bété rivers, tributaries of the Aghien Lagoon. The Bété basin covers an area of 267 km^2 and the Djibi basin covers 78 km^2 (Koffi, 2021). The geological basement is composed of two units: the sedimentary basin in the south and the crystalline and crystalline basement in the northern part of the Djibi and Bété regions (Jourda, 1987).

The Rue Ministrewatershed has a simple geology: Quaternary sands and muds, clayey sands with some layers of variegated clays from the Continental Terminal, and Cretaceous sandy limestones (Tastet and Guiral, 1994). However, the Rue Ministrewatershed exhibits three soil types: Xanthic Ferralsols, which occupy the largest part of the area, and Gleysols in the east. dystric and a small part of the south dotted with ferraliticarenosols. Furthermore, the Djibi watershed is situated in a Gleysol -type soil. dystric soils to the west and xanthic ferralsols to the east, however, the Bété catchment area is covered by Acrisols in the northwest, interspersed with Orthic Acrisols and Xanthic Ferralsols, these soils also occupy most of the center of this area and a small part to the east of the basin is occupied by gley (Tastet, 1979).

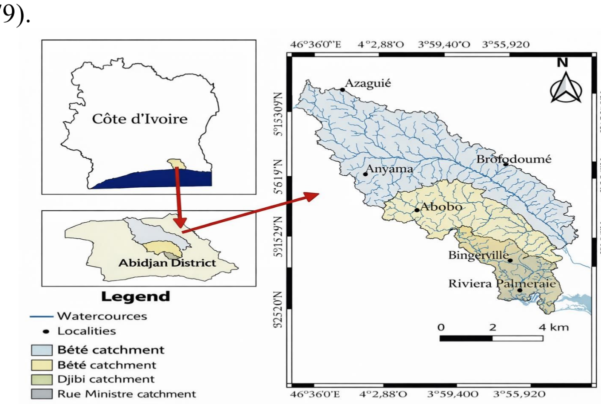

Figure 1: Geographical location of the study area

The elevation maps of the watersheds of the Rue Ministre (Figure 2A), the Djibi (Figure 2B), and the Bété (Figure 2C) reveal five distinct classes. The first class, the very low elevation class, is represented in blue and corresponds to elevations of 41.41 m, 38.97 m, and 38.94 m or less in the Rue Ministre, Djibi, and Bété watersheds, respectively. The second class, the low elevation zone, is shown in light green and corresponds to elevations between 41.41 m and 59.81 m in the Rue Ministre watershed and between 38.97 m and 63.23 m in the Djibi and Bété watersheds. The third class corresponds to areas of medium altitude, represented by the color light yellow. This class encompasses a wide range of altitudes, from 59.81 m to 78.21 m in the Rue Ministre watershed and from 63.23 m to 87.48 m in the Djibi and Bété watershed. The fourth class corresponds to areas of high altitude, characterized in the Rue Ministre watershed by altitudes between 78.21 m and 96.60 m, which are lower than the altitudes in the Djibi and Bété watershed, ranging from 87.48 m to 111.74 m. This class is represented in orange. Finally, the fifth class represents areas of very high altitude, with values exceeding 96.60 m in the Rue Ministre watershed and exceeding 111.74 m in the Djibi and Bété watershed. This class is represented in red. The values of the fourth and fifth classes indicate that the flow in this area is high, and those observed from the first to the third classes highlight the presence of a weak flow.

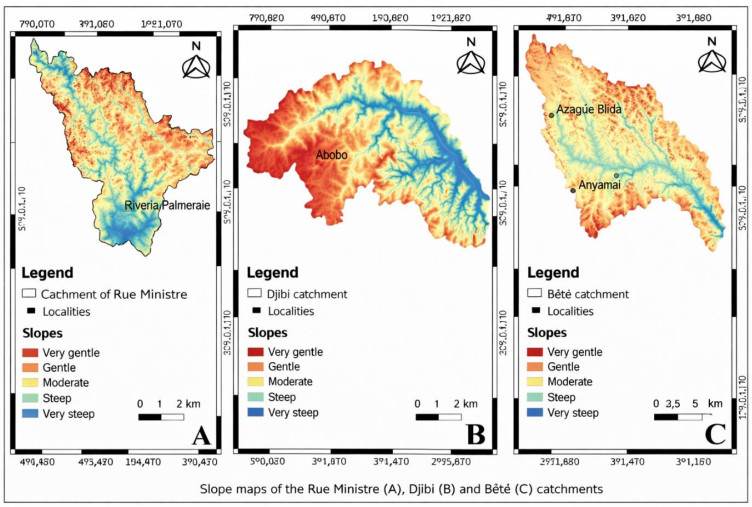

Figure 2: Relief map of the catchment areas of Rue Ministre(A), Djibi(B) and Bété(C)

Table 1: Elevation classes of the catchments

Evaluation class	Rue Ministre (m)	Djibi (m)	Bété (m)	Hydrological interpretation
Very low	≤ 41.41	≤ 38.97	≤ 38.94	Low flow velocity, water accumulation
Low	41.41 – 59.81	38.97 – 63.23	38.94 – 63.23	Potentially flood-prone areas
Medium	59.81 – 78.21	63.23 – 87.48	63.23 – 87.48	Transitional hydrological conditions
High	78.21 – 96.60	87.48 – 111.74	87.48 – 111.74	Significant surface runoff
Very high	> 96.60	> 111.74	> 111.74	Very rapid runoff

The elevation classes reveal marked topographic contrasts between the three catchments. The very low and low elevation classes (≤ 41.41 m for Rue Ministre, ≤ 38.97 m for Djibi and ≤ 38.94 m for Bété) correspond to areas where flow velocity is reduced and water accumulation is favoured. These low-lying zones are therefore naturally predisposed to flooding.

In contrast, the high and very high elevation classes (> 96.60 m for Rue Ministre and > 111.74 m for Djibi and Bété) are characterised by rapid surface runoff, which limits water stagnation. The greater extent of low-altitude areas within the Rue Ministre and Djibi catchments partly explains their higher flood susceptibility compared to the Bété catchment.

Data:-

Method:-

Flood vulnerability mapping:-

The flood sensitivity map is produced from the combination of two indices: the topographic moisture index or Topographic Wetness Index (TWI) and Stream Power Index (SPI) derived from the slope map and specific catchment area. Characterization of the topographic wetness index (TWI) and stream power index (SPI) and creation of the flood sensitivity (or hazard) map.

Establishing the sensitivity map:-

The TWI is the topographic moisture index introduced by Beven and Kirkby (1979). It is defined as an index used to quantify the effects of topography on hydrological processes (Lee et al., 2017). Indeed, it is used to assess soil moisture (Hojati and Mokarram, 2016) and to locate areas of temporary (Nibigira, 2019) or long-term (Kopecký and Čížková, 2010) water accumulation in a landscape.

$$\mathrm{TWI} = \ln(\mathrm{As} * \tan \beta)$$

The SPI, for its part, is an index that estimates the susceptibility of rivers to erosion (Bizzi and Lerner, 2015) and characterizes the intensity of surface runoff (Khosraviet al., 2019).

The basic formulas for their determination are defined as follows (Moore et al., 1991):

$$\mathrm{SPI} = \mathrm{As} * \tan \beta$$

With: $\boldsymbol{As}$: represents the specific catchment area or surface unit where the experiments are conducted (Specific Catchment Area or SCA) (Ali et al., 2014); β is the local slope angle.

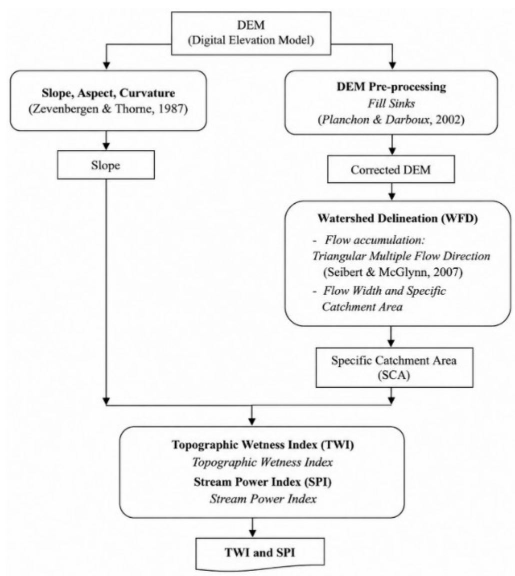

Figure 3: Methodology for calculating TWI and SPI

Standardization of flood factors:-

This standardization involves classifying flooding factors such as the Topographic Wetness Index (TWI) and the Surface Flow Index (SPI). Exported as raster maps from SAGA software, the TWI and SPI maps are then imported into ArcGIS for combination. First, a quantile reclassification was performed using the following geoprocessing tools: Spatial Analyst Tools - > Reclassification -> Reclassification. This classification is the most widely used method for constructing sensitivity maps (Khosravi et al., 2019). The values obtained for each index are distributed into four intervals from class 1 to class 4 as a common scale for each factor.

Parameter weighting:-

The weighting involves assigning each parameter an influence factor out of a total of 100. Furthermore, a higher influence factor is assigned to the TWI because it is more representative of potentially floodable areas than the SPI. As shown in the table below, the lowest SPI classes correspond to the highest TWI classes (Ramiaramanana, 2020).

Table 1: Classification and weighting of TWI and SPI parameters

Settings	Classification	Influencing factor	Scale factor
TWI	12-14	75	4
	9-12		3
	6-9		2
	4-6		1
SPI	0-1.6	25	4
	1.6-3.2		3
	3.2-4.8		2
	4.8-6.4		1

Combinations of flooding factors:-

The combination of flooding factors is necessary to establish the flood sensitivity map (Tehranyet al., 2015). This is the combination of the Topographic The Wetness Index (TWI) and the Stream Power Index (SPI) are calculated using the Weighted Overlay module of ArcToolbox . In practice, this is done by successively using the geoprocessing tools : Spatial Analyst Tools -> Overlay -> Weighted Overlay. This overlay, according to the ESRI platform (2020), involves reclassifying the obtained values according to a common measurement scale (1 to 4) and weighting them according to the influence factor (out of a total of 100) of each raster.

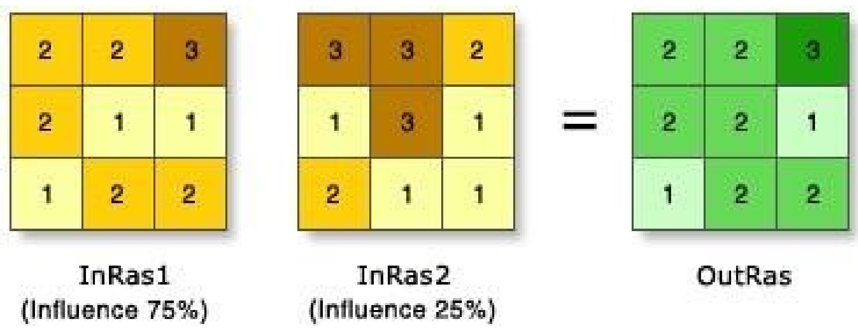

Figure 4: Illustration of the application of weighted overlay on the ESRI platform (2020).

Flood sensitivity map:-

The flood sensitivity map is the result of combining two indices from the DEM: the Topographic Wetness Index (TWI) and the Surface Flow Index (SPI). The resulting values are classified into four categories according to their sensitivity level. After weighting, these values are then summed to produce an output raster, which in this case is the flood sensitivity map.

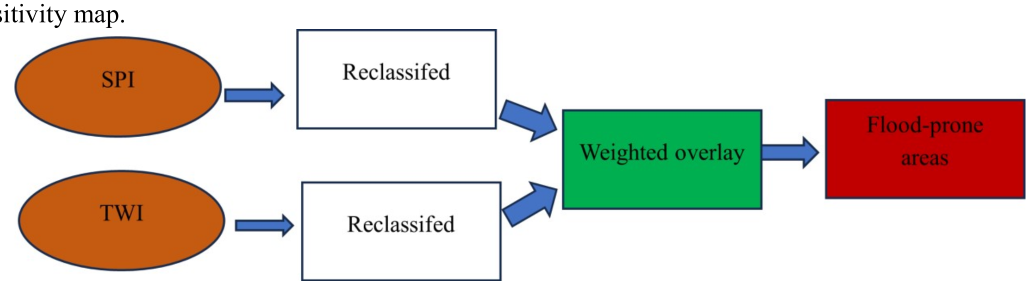

Figure 5: Calculation procedure in the Model Builder application of ArcMap .

Results:-

The flood zone map is derived from the flood sensitivity map. Furthermore, the average level of flood sensitivity will be set as a threshold. Values above this threshold will then represent flood zones.

Topographic moisture index (TWI) map of the Rue Ministre, Djibi and Bété watersheds:-

Figure 6(A) shows the topographic moisture index map of the Rue Ministre watershed with index values ranging from 8.78 to 19.4; Figure 6(B) shows the topographic moisture index map of the Djibi watershed with index values ranging from 8.15 to 19.2; and Figure 6(C) shows the topographic moisture index map of the Bété watershed with index values ranging from -12.60 to -0.47. The Rue Ministre, Djibi, and Bété watersheds, with index values below 19.4, 19.2, and -0.47 respectively, have the lowest topographic moisture indices in the study area. Conversely, the highest TWI values are shown in dark blue, with indices greater than or equal to 19.40 for the Rue Ministre watershed, 19.20 for the Djibi watershed, and -0.47 for the Bété watershed. These indices follow the watershed's course from the outlet through the hills, with a high concentration of steep slopes. It is observed that lower TWI values indicate steeper slopes. Conversely, high TWI values indicate areas with gentle slopes.

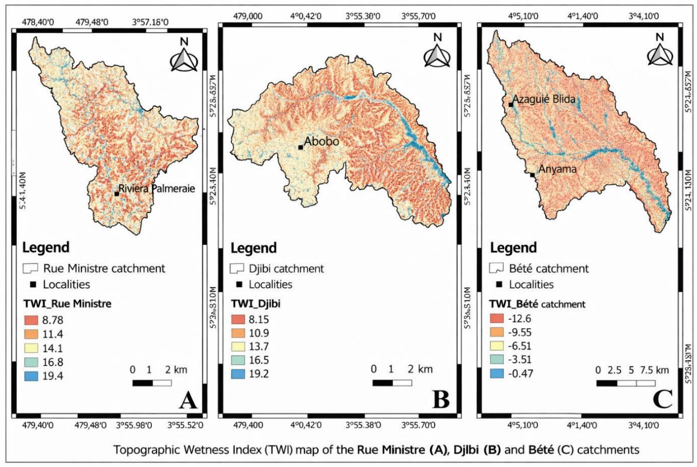

Figure 6: Map of the topographic moisture index (TWI) of the Rue Ministre(A), Djibi (B) and Bété (C) watersheds.

Table 2: Topographic moisture index (TWI)

Catchment	Minimum value	Maximum value	High TWI classes
Rue Ministre	8.78	19.40	≥ 19.40
Djibi	8.15	19.20	≥ 19.20
Bété	-12.60	-0.47	≥ -0.47

The TWI values indicate that areas located close to the hydrographic network exhibit the highest moisture levels. Maximum TWI values reach 19.40 in the Rue Ministre catchment, 19.20 in the Djibi catchment and 0.47 in the Bété catchment. These high values reflect zones with elevated soil moisture, high water storage capacity and frequent surface saturation.

The similarity of maximum TWI values in the Rue Ministre and Djibi catchments suggests comparable hydrological behaviour driven by intense urbanisation and extensive soil sealing, which significantly reduce infiltration capacity. Conversely, the lower TWI values observed in the Bété catchment indicate more favourable infiltration conditions, likely associated with lower urban density and the presence of vegetation cover (Table 2).

Flow power index (SPI) map of the Rue Ministre, Djibi and Bété watersheds:-

Figure 7(A) shows the flow power index map of the Rue Ministre catchment with index values ranging from -6.91 m to 2.62 m; Figure 7(B) shows the flow power index map of the Djibi catchment with index values ranging from -6.91 m to 2.81 m; and Figure 7(C) shows the flow power index map of the Bété catchment with index values ranging from -6.89 m to 2.44 m. The catchment index values between -6.91 m and 0.38 m represent the lowest flow power indices in the study area. The highest SPI values are shown in dark blue: 2.26 m for the Rue Ministre catchment, 2.86 m for the Djibi catchment, and 2.44 m for the Bété catchment. These values follow the course of the catchment, from the outlet through the hills, with a high concentration of steep slopes. As a result, lower SPI values indicate steeper slopes. Conversely, high SPI values indicate areas with gentle slopes.

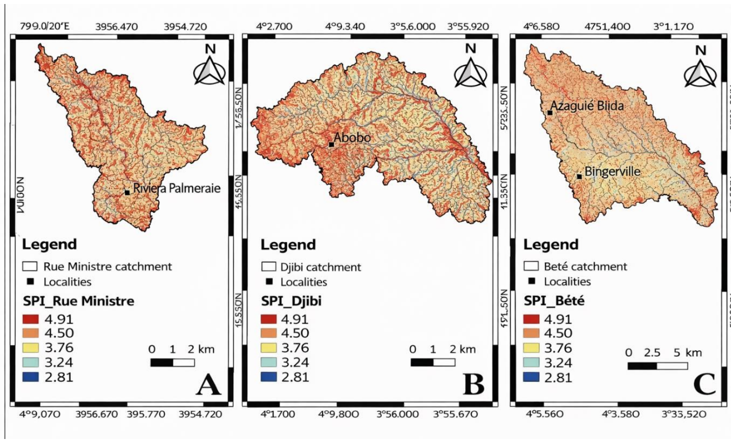

Figure 7: Flow power index (SPI) map of the catchments of the rue Ministre (A), the Djibi (B) and the Bété (C).

Table 3: Stream Power Index (SPI) values

Catchment	Minimum value	Maximum value	High SPI values
Rue Ministre	-6.91	2.62	≥ 2.26
Djibi	-6.91	2.81	≥ 2.86
Bété	-6.89	2.44	≥ 2.44

The SPI values show a strong relationship with slope conditions. Maximum SPI values of 2.62 in the Rue Ministre catchment, 2.81 in the Djibi catchment and 2.44 in the Bété catchment indicate that areas with gentle slopes tend to concentrate surface runoff while exhibiting reduced flow velocity.

Low SPI values are associated with steeper slopes, where runoff is more efficient and water accumulation is limited. The higher SPI maxima observed in the Rue Ministre and Djibi catchments therefore contribute to their greater susceptibility to flooding compared to the Bété catchment (Table 3).

Flood vulnerability map of the watersheds of Rue Ministre, Djibi and Bété:-

The flood sensitivity maps of the Rue Ministre(Figure 8A), Djibi (Figure 8B), and Bété (Figure 8C) watersheds are derived from the combination, within the Geographic Information System (GIS), of the following indices: the Topographic Wetness Index (TWI) and the Flow Power Index (SPI). They are illustrated in Figure 8 and highlight 5 zones.

The zone of very low flood sensitivity: this represents 15.21% of the total catchment area of Rue Ministre, 12.82% of the Djibi catchment, and 7.82% of the Bété catchment. These areas are considered to have very low flood sensitivity. They are characterized by a steep slope with very high runoff. The zone of low flood sensitivity: this occupies 43.86% of the catchment area of Rue Ministre, 60.76% of the Djibi catchment, and 20.72% of the Bété catchment. In these areas, the slope and flow are relatively steep with high runoff. The zone of medium sensitivity: this occupies 28.91% of the catchment area of Rue Ministre, 34.11% of the Djibi catchment, and a smaller proportion of 12.10% of the Bété catchment. These areas are characterized by a relatively gentle slope, distributed evenly across the study area. The high sensitivity zone comprises 9.32% of the Rue Ministre watershed, 9.94% of the Djibi watershed, and a smaller proportion (3.18%) of the Bété watershed. In these areas, the slope is gentle with low runoff and a high degree of impermeability. The very high sensitivity zone comprises 2.7% of the Rue Ministre watershed, 1.42% of the Djibi watershed, and a relatively small proportion (0.64%) of the Bété watershed. These areas are characterized by a very gentle (almost zero) slope with very low runoff (no flow). These zones correspond to the locations of water points and follow the hydrographic network.

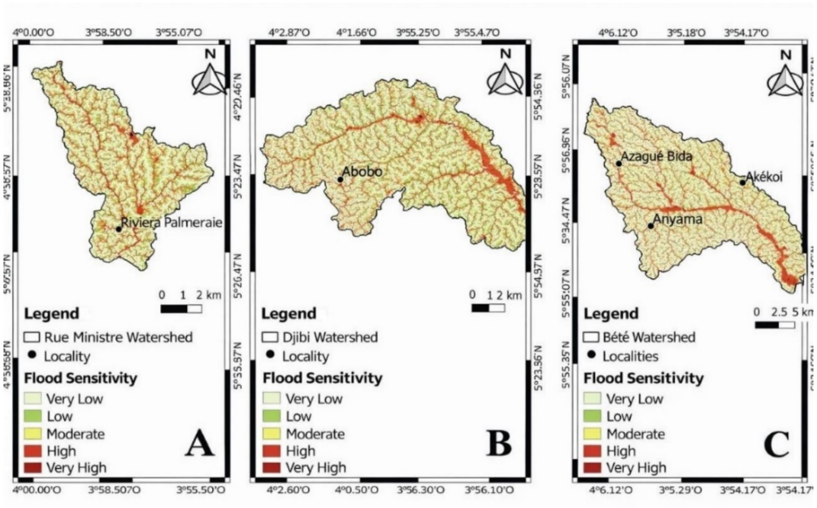

Figure 8: Flood sensitivity map of the catchment areas of the Rue Ministre(A), the Djibi (B) and the Bété (C).

Table 4: Distribution of flood susceptibility classes

Flood susceptibility class	Rue Ministre (%)	Djibi (%)	Bété (%)
Very low	15.21	12.82	7.82
Low	43.86	60.76	20.72
Moderate	28.91	34.11	12.10
High	9.32	9.94	3.18

The distribution of flood susceptibility classes highlights a clear spatial differentiation among the three catchments. Areas classified as having high and very high flood susceptibility represent 12.02% of the Rue Ministre catchment and 11.36% of the Djibi catchment, whereas they account for only 3.82% of the Bété catchment.

These highly susceptible zones are mainly associated with gentle slopes, high TWI values and moderate to high SPI values, and are generally located along the hydrographic network. Their limited extent in the Bété catchment confirms its comparatively lower vulnerability to flooding (Table 4).

Maps of flood zones in the catchment areas of Rue Ministre, Djibi and Bété:-

The flood zones identified from the sensitivity maps of the three watersheds are shown in Figure 9. The results illustrated in Figure 9 indicate that the areas above the established average threshold, i.e., those with "high" and "very high" sensitivity, constitute the flood zones. These flood risk zones cover slightly more than 12.02% of the Rue Ministre watershed (Figure 9A) across all three watersheds. Non-flood zones occupy 87.98% of the total watershed area. While the Djibi watershed (Figure 9B) has a flood risk of approximately 11.36% and non-floodable areas cover 88.64% of the total area, the Bété watershed (Figure 9C) has a very low flood risk compared to the other two watersheds, with only about 3.81% of its area flooded. Analysis shows that the Rue Ministre watershed is more vulnerable to flooding (12.02% of the watershed) than the Djibi (11.36%) and Bété (3.81%) watersheds.

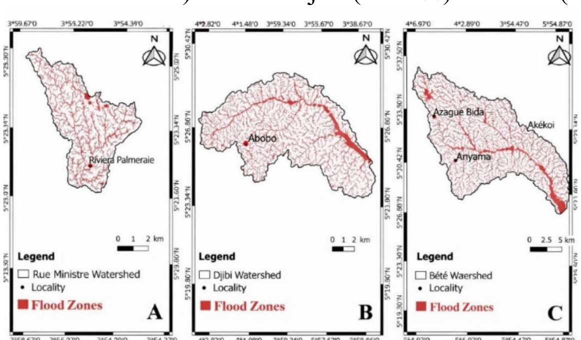

Figure 9: Map of flood zones in the catchment areas of Rue Ministre (A), Djibi (B) and Bété (C).

Table 5: Distribution of flood-prone and non-flood-prone areas

Catchment	Flood-prone areas (%)	Non-flood-prone areas (%)
Rue Ministre	12.02	87.98
Djibi	11.36	88.64
Bété	3.81	96.19

The final flood zoning indicates that flood-prone areas occupy approximately 12.02% of the Rue Ministre catchment, 11.36% of the Djibi catchment and only 3.81% of the Bété catchment. This result clearly demonstrates that the Rue Ministre catchment is the most exposed to flooding, followed closely by the Djibi catchment.
The much lower proportion of flood-prone areas in the Bété catchment can be attributed to its lower degree of urbanisation, better vegetation cover and more favourable infiltration conditions, which collectively reduce surface runoff and flood occurrence (Table5).

Discussion:-

The overall objective of this study was to map, using a combined approach of Remote Sensing and Geographic Information Systems (GIS), the flood zones of the catchment areas of Rue Ministre, Djibi and Bété. According to the results obtained, the thematic maps of the Topographic Wetness Index (TWI) indicate that areas near the hydrographic network have a high TWI, ranging from 16.8 to 19.40 for the Rue Ministre watershed, from 16.5 to 19.20 for the Djibi, and from -3.51 to -0.47 for the Bété. These areas with a high TWI correspond to areas where the humidity level, water storage capacity, and surface saturation are extremely high. They are described as the areas most susceptible to flooding. These results are similar to those of Ramiaramanana (2020), who showed that a high TWI is characteristic of areas with a gentle slope and a high-water storage capacity. The high values of the topographic moisture index (TWI) could result from a long process of sealing the watersheds of Rue Ministre and the Djibi River. These watersheds are heavily urbanized. This urbanization exacerbates the slowing of infiltration, as buildings and asphalt paving promote the accumulation and almost complete runoff of rainwater (Traoré, 2016; Gogbé et al., 2016; Kinakpefan, 2023). However, the low TWI values in the Bété watershed indicate low or moderate urbanization, with the presence of vegetation cover being a predominant and essential element promoting infiltration.

However, the flow power index (SPI) map shows that SPI values correlate with slope. For areas with steep slopes, the flow power index values are also high: 2.62 for the Rue Ministre watershed, 2.81 for the Djibi, and 2.44 for the Bété. Thus, areas with low SPI exhibit low runoff. This observation is also supported by Ramiaramanana (2020), who found that areas with almost no slope have low SPI, or even no runoff. For flood-prone areas, it appears that they cover approximately 12.02% of the Rue Ministre watershed, 11.36% of the Djibi watershed, and about 4% of the Bété watershed. Thus, the Rue Ministre watershed is more vulnerable to flooding, with a larger proportion (12.02%) of the watershed affected than the Djibi (11.36%) and Bété (3.81%) watersheds. This same phenomenon has also been observed in West Africa, particularly in Dakar (Senegal) and Ouagadougou (Burkina Faso), where human settlements were severely affected by flooding in 2009 (Di Baldassarre et al., 2010). According to these authors, the recent floods in Africa are primarily linked to rapid urbanization. Indeed, they emphasize that this increased vulnerability of human settlements can be attributed to a number of socioeconomic factors: rapid population growth, precarious infrastructure, and widespread poverty. In some regions of Africa, this vulnerability is exacerbated by uncontrolled urbanization, which leads to populations being increasingly exposed to the risk of flooding (Hardoy et al., 2001; Douglas et al., 2008). Floods are due both to the occupation of flood-prone areas by populations and to a disruption of river and rainfall regimes, caused by climate variability.

Conclusion:-

The objective of this study was to identify, through the combined use of remote sensing and Geographic Information Systems (GIS), flood zones in the Rue Ministre, Djibi, and Bété watersheds. The methodology employed enabled the creation of flood zone maps based on indices derived from slope maps. This index is the Topographic Humidity Index (THI). The Wetness Index (TWI), which quantifies the effects of topography on hydrological processes, and the Stream Power Index (SPI), derived from slope maps and specific watersheds within a GIS, are used to analyze these data. Sensitivity maps developed from the TWI and SPI have highlighted areas of high flood sensitivity within the three watersheds, characterized by very gentle slopes. This zone encompasses areas surrounding the hydrographic network, covering approximately 12.02% of the Rue Ministre watershed, approximately 11.36% of the Djibi watershed, and approximately 3.81% of the Bété watershed.

References:-

1. Abdellah B., 2008. Risques d'inondation et occupation des sols dans le thoré.
2. Abhas K. J. Bloch R. Et Lamond J. (2012): villes et inondations, guide de gestion intégrée du risque d'inondation en zone urbaine pour le XXI siècle, résumé à l'intention des décideurs, Banque mondiale, Washington, 63 pages
3. Ali G., Birkel C., Tetzlaff D., Soulsby C., McDonnell J. J. & Tarolli P. 2014. A comparison of wetness indices for the prediction of observed connected saturated areas under contrasting conditions. Earth Surface Processes and Landforms, 39(3) : 399413.
4. Alla D. A., 2013. Risques naturels dans l'agglomération d'Abidjan (Côte D'Ivoire). Thèse de doctorat D'État Ès-Sciences Humaines, Université Félix Houphouët Boigny, Abidjan, Côte D'Ivoire, 387 p.
5. Angui N., Biemi J. (1984). Géologie et hydrogéologie des nappes de la région d'Abidjan.
6. Antoine, J. M. (2009). L'histoire du climat par ses extrêmes. Sources géohistoriques et inondations dans les Pyrénées depuis le Petit Age Glaciaire. Archéologie du Midi médiéval, 27(1), 143-155.
7. Beven K. J. & Kirkby M. J., 1979. A physicallybased, variable contributing area model of basin hydrology/Un modèle à base physique de zone d'appel variable de l'hydrologie du bassin versant. Hydrological Sciences Journal, 24(1): 43-69.
8. Bizzi S. & Lerner D. N., 2015. The use of stream power as an indicator of channel sensitivity to erosion and deposition processes. River Research and Applications, 31(1): 1627.
9. Dembélé O., & Ouattara I. (2019). Contribution du SIG à la Prévention et à la Gestion des Risques d'inondation dans le District de Bamako au Mali. European Scientific Journal, ESJ, 15(30), 256. Retrieved from https://eujournal.org/index.php/esj/article/view/12536
10. Di Baldassarre G., Montanari A., Lins H., Koutsoyiannis D., Brandimarte L. &Bloschl G., 2010. Flood fatalities in Africa: From diagnosis to mitigation, Geophysical Research Letters, 37 : 1-5.
11. Douglas I., Alam K., Maghenda M., McDonnell Y., McLean L. & Campbell J., 2008. Unjust waters: climate change, flooding and the urban poor in Africa, Envirorunent et Urbanization, 20 (1): 187-206.
12. Ekmekcioğlu, Ö., Koc, K., &Özger, M. (2022a). Towards flood risk mapping based on multi-tiered decision making in a densely urbanized metropolitan city of Istanbul. Sustainable Cities and Society, 80, 103759. https://doi.org/10.1016/j.scs.2022.103759
13. ESRI., 2020. Superposition pondérée. Consulté le 03 août 2020, sur ArcGIS for Desktop: https://desktop.arcgis.com/fr/arcmap/10.3/tools/spatialanalysttoolbox/weighted-overlay.htm.
14. Fu, G., Meng, F., Rivas Casado, M., & Kalawsky, R. S. (2020). Towards Integrated Flood Risk and Resilience Management. Water, 12(6), 1789. https://doi.org/10.3390/w12061789
15. GIEC (2014). Changement climatique, rapport de synthèse, 161p
16. Gogbé T., Kouassi N. G., Traoré K. M. & Kouadio N. E. (2016). Cartographie des espaces vulnérables aux risques d'inondation dans la ville de San Pédro, REGARDSUDS Revue de Géographie, d'Aménagement Régional et de Développement des Suds, Institut de Géographie Tropicale, 27p
17. Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global Change and the Ecology of Cities. Science, 319(5864), 756-760. https://doi.org/10.1126/science.1150195
18. Guindo Allaye, Diawara Hamidou, Bengaly Souleymane Et Dembele N'dji dit Jacques (2020). Apport de la télédétection et du SIG à l'étude du risque d'inondation: Cas du Bassin versant de Missabougou
19. Hallegatte, S., Green, C., Nicholls, R. J., & Corfee-Morlot, J. (2013). Future flood losses in major coastal cities. Nature Climate Change, 3(9), 802-806. https://doi.org/10.1038/nclimate1979
20. Hardoy J. E., Mitlin D. & Satterthwaite D., 2001. Environmental Problems man Urbanizing World: Finding Solutions in Cities in Africa, Asia and Latin America, Earthscan, London, 440 p.
21. Hauhouot Célestin., 2008. Analyse du risque pluvial dans les quartiers précaires d'Abidjan. Etude de cas à Attécoubé. Geo-Ecoè-Trop, 32 : 75-82.
22. Hojati M. et Mokarram M., 2016. Détermination of a topographic wetness index using high resolution digital elevation models. European Journal of Geography, 7(4) : 4152
23. Joerin, J., & Shaw, R. (2010). Chapter 9 Climate change adaptation and urban risk management. In R. Shaw, J. M. Pulhin, & J. Jacqueline Pereira (Éds.), Community, Environment and Disaster Risk Management (Vol. 4, p. 195-215). Emerald Group Publishing Limited. https://doi.org/10.1108/S2040-7262(2010)0000004015
24. Jourda J.-P., (1987). Contribution à l'étude géologique et hydrogéologique de la région du grand Abidjan (Côte d'Ivoire). Géologie Appliquée, Université Scientifique et Médicale de Grenoble, Suisse, 299 p.
25. Khosravi K., Shahabi H., Pham B. T., Adamowski J., Shirzadi A., Pradhan B. & Hong H., 2019. A comparative assessment of flood susceptibility modeling using MultiCriteria Decision-Making Analysis and Machine Learning Methods. Journal of hydrology, 573 : 311-323.

26. Kinakpefan Michel Traoré, « Évaluation du risque d'inondation par intégration du SAGA Wetness Index (SAGAWI) et de l'Analyse Hiérarchique des Procédés (AHP) : cas du District Autonome d'Abidjan », Belgeo[En ligne], 1 | 2023, mis en ligne le 23 août 2023, consulté le 23 décembre 2024. URL : http://journals.openedition.org/belgeo/60310 ; DOI : https://doi.org/10.4000/belgeo.60310
27. Koffi E. S. (2021). Estimation et modélisation des flux d'eau et de matière à la lagune Aghien : source potentielle d'eau potable du district d'Abidjan (Côte d'Ivoire), dans un contexte d'urbanisation et de variabilité climatique, thèse de doctorat, 221p
28. Kopecký, M., et Čížková, Š. (2010). Using topographic wetness index in vegetation ecology: does the algorithm matter? Applied Vegetation Science, 13, 4, 450-459.
29. Lee S., Kim J. C., Jung H. S., Lee M. J. & Lee S., 2017. Spatial prediction of flood susceptibility using random-forest and boosted-tree models in Seoul metropolitan city, Korea. Geomatics, Natural Hazards and Risk, 8(2) : 11851203.
30. Leulmi, L. (2025). Défis des risques des inondations: la résilience urbaine en question Cas de la ville de Skikda (Doctoral dissertation).
31. Moore I. D., Grayson R. B. & Ladson A. R., 1991. Digital terrain modelling: a review of hydrological, geomorphological, and biological applications. Hydrological processes, 5 (1) : 3-30.
32. Nibigira, L. (2019). Etude des risques naturels liés aux interactions entre les mouvements de masse et le réseau hydrographique dans la région des lacs Kivu et Tanganyika. (Doctoral dissertation, Université de Liège, LIEGE, BELGIQUE).
33. Ocha., 2009. Rapport de situation n°3, Afrique de l'ouest. Inondation 2009. 5 p.
34. Ramiaramanana F. N. (2020). Risque d'inondation en milieu urbain : vulnérabilité et informalité. Cas de l'agglomérationd'Antananarivo, Madagascar.
35. Tastet J. et Guiral, D. (1994) Géologie et sédimentologie. In: Environnement et ressources aquatiques en Côte d'Ivoire : 2. Les milieux lagunaires. (J.-R. Durand, D. Philippe & D. Guiral, eds.), Paris : ORSTOM, 35–58pp
36. Tastet J.-P. (1979). Environnements sédimentaires et structuraux du Quaternaire du littoral du Golfe de Guinée. (Côte d'Ivoire, Togo, Bénin). Thèse de Doctorat d'état, Université de Bordeaux I, France, 181 p.
37. Tehrany, M. S., Pradhan, B., Mansor, S., & Ahmad, N. (2015). Flood susceptibility assessment using GIS-based support vector machine model with different kernel types. Catena, 125, 91-101.
38. Tra Bi Z. A., (2013). Etude de l'impact des activités anthropiques et de la variabilité climatique sur la végétation et les usages des sols, par utilisation de la télédétection et des statistiques agricoles, sur le bassin versant du Bouregreg (Maroc), Thèse de doctorat Université Hydrosciences Montpellier, France, 190 p.
39. Traoré K.M. (2016). Analyse des vulnérabilités de la ville côtière de San-Pedro (sud-ouest de la Côte d'Ivoire), thèse de doctorat, Géographie, Université Félix Houphouët Boigny de Cocody, Abidjan, 355p.
40. UNISDR. (2019). Global assessment report on disaster risk reduction 2019. United Nations Office for Disaster Risk Reduction.
41. Wamsler, C. (2014). Cities, Disaster Risk and Adaptation (0 éd.). Routledge. https://doi.org/10.4324/9780203486771
42. World Health Organization. (2017). World health statistics 2017 : Monitoring health for the SDGs, sustainable development goals