Vegetation Dynamics and Surface Water Infiltration: Addressing Hydrological Challenges in East Baton Rouge Parish in the Louisiana State of USA Using Satellite Remote Sensing

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Abstract

Water-related disasters are increasing in frequency due to climate change, with urban areas particularly vulnerable to flooding exacerbated by declining green spaces. This study employs the Soil and Water Assessment Tool (SWAT) to analyse the impact of vegetation changes on surface infiltration rates and runoff in East Baton Rouge Parish, a region increasingly vulnerable to severe weather events. As climate change intensifies, urbanization and reduced green spaces exacerbate flooding risks, making this analysis critical for effective water management. The watershed was delineated into 47 sub-units, and SWAT was utilized to compute infiltration rates and surface runoff over a 30-year period. Results reveal a significant decrease in vegetation cover from 73% in 1994 to 68% in 2024, which corresponded with a marked reduction in infiltration rates, from 629 mm to 368 mm. This decline has led to increased surface runoff, heightening flood risks in the area. Notably, eight communities; Central, Gardere, Westminster, Oak Hills Place, Baton Rouge, Denham Springs, Monticello, and Merrydale were identified as having particularly low infiltration rates, making them highly susceptible to waterlogging and surface water pollution. The findings emphasize the need for strategic interventions to enhance infiltration capacity and restore vegetation cover, which is essential for mitigating flood risks and ensuring the sustainability of water resources in East Baton Rouge Parish.

1. Introduction

1.1 Infiltration, Vegetation dynamics and flooding

Flooding is a significant risk in East Baton Rouge Parish, Louisiana, as urbanization and climate change intensify flood vulnerabilities (Richardson, 2024). Over the past three decades, reduced vegetation and changes in land use have altered local hydrology, decreasing surface water infiltration and increasing flood susceptibility. Vegetation traditionally enhances infiltration by slowing runoff and creating soil channels through root systems, which help regulate water flow and reduce flood risk. However, in East Baton Rouge, vegetation loss has led to a decline in infiltration rates, contributing to an increase in urban flooding in low-lying areas over the last decade (Richardson, 2024; Deffes, 2024).

To address these issues, satellite remote sensing and Geographic information system (GIS) modelling can be used to assess vegetation cover and land use changes across vast regions. Landsat satellite imagery, along with vegetation indices like NDVI, reveal critical trends in vegetation health and density. Integrating this data with the Soil and Water Assessment Tool (SWAT), researchers can model the impacts of land use changes on infiltration and runoff (Osei et al., 2023). These insights are essential for sustainable flood management, providing guidance on using green infrastructure and vegetation restoration to enhance infiltration and reduce flood risks, ultimately promoting water resource sustainability in East Baton Rouge Parish.

1.2 Monitoring the dynamics of vegetation and surface hydrology using Satellite Remote sensing

In previous studies, Satellite remote sensing offers valuable tools for monitoring vegetation dynamics and surface hydrology in urban areas. Fusion of high-resolution imagery with multispectral data improves visualization of spatial features for urban forest management (Twumasi et al., 2022). Landsat MSS and AVHRR/NOAA imagery can provide spatial and temporal vegetation data for hydrologic modelling, enhancing runoff predictions (Al-Bakri & Taylor, 2003).

In urban landscapes, combining hyperspectral APEX images with Proba-V time series enables high-resolution mapping of vegetation dynamics and leaf area index (LAI), crucial for simulating interception storage (Wirion et al., 2017). The CYGNSS constellation, using GNSS-reflectometry, shows promise for monitoring soil moisture and inundation extent, though its effectiveness varies with vegetation cover and surface roughness (Chen & Yan, 2024). These remote sensing techniques offer improved spatial and temporal resolution for addressing hydrological challenges in urban areas like East Baton Rouge Parish.

Therefore, this study aims to address these pressing hydrological challenges by quantifying the impacts of vegetation dynamics on surface water infiltration in East Baton Rouge Parish. Using SWAT, a remote sensing-based model to model runoff and infiltration over a 30-year period, the research provides insights into the consequences of land use/land cover (LULC) changes on flood risk and highlights critical areas in need of strategic restoration efforts. The findings underscore the importance of preserving and expanding green spaces, implementing sustainable urban planning practices, and adopting targeted land management interventions to mitigate flood risk and enhance water resource sustainability in East Baton Rouge Parish. This work ultimately contributes to a

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better understanding of how urban vegetation management can help address the growing challenges posed by climate-induced water-related disasters.

2. Research Methodology

2.1 Study Area- East Baton Rouge Parish, Louisiana State, USA

East Baton Rouge Parish (Figure 1) in south-eastern Louisiana state of USA faces significant hydrological challenges due to its geography, humid subtropical climate, and rapid urbanization (East Baton Rouge Parish, 2024). Covering around 470 square miles, this area features diverse terrain, including wetlands, river valleys, and developed urban zones, with the Mississippi River influencing its hydrology. Intense rainfall, clay-heavy soils, and low-lying terrain result in limited infiltration and high runoff, leading to frequent flooding. Urban expansion has reduced vegetation cover since 1994, increasing impervious surfaces and disrupting natural drainage (Richardson, 2024).
Vegetation plays a critical role in enhancing infiltration, but its decline has intensified issues like stormwater runoff, erosion, and reduced water quality. As shown in Figure 2, Pedestrians look on as drivers drive around barricades and through standing water on E. State Street on Tuesday afternoon, May 18, 2021, after heavy rains inundated the metro area in Baton Rouge, LA (East Baton Rouge Parish, 2024). The city-parish director of transportation and drainage in Baton Rouge said on July 30, 2021 “Some of these storms, you talk about 50-year storms or 100-year storms, well, they are happening two times, three times a year, and that is not good. You have to look at some ways to reduce the flood risk.” (Deffes, 2024). Satellite remote sensing provides a valuable tool for monitoring these vegetation changes and modelling their impact on infiltration (Osei et al., 2023; Issah et al., 2023). Findings from this research support sustainable land management and flood mitigation efforts, offering insights relevant to similar urbanized areas vulnerable to hydrological challenges.

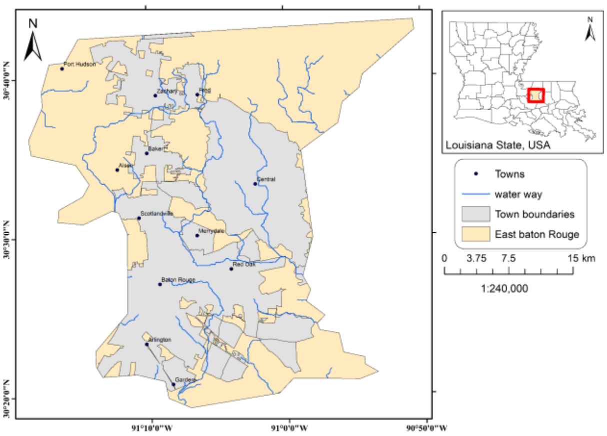

Figure 1. A Map of East Baton Rouge Parish (EBRP)

Figure 2. Issues of flooding as a result of low surface infiltration in East Baton Rouge Parish (Deffes, 2024)

2.2 Materials and Data Used

The materials and data for this study include Landsat 9 Level 2 imagery from the United States Geological Survey (USGS) Earth Explorer, used for land use/land cover (LULC) classification. ArcGIS 10.4 from the Environmental Systems Research Institute (ESRI) facilitated spatial visualization and analysis. The Arc SWAT 2012 model, developed by the United States Department of Agriculture Agricultural Research Service (USDA-ARS) and Texas A&M AgriLife Research, supported hydrological analysis. Soil data from the Food and Agriculture Organization (FAO) enabled Soil and Water Assessment Tool (SWAT) analysis. Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) data from Earth Explorer was used for channel and watershed delineation, while Google Earth Engine (GEE) facilitated supervised classification. The datasets and materials used in this study are elaborated in Table 1 with their sources.

Material/data	Source
SRTM DEM	USGS Earth explorer
Landsat Image	USGS Earth explorer
FAO Soil Data	USDA-ARS
Arc SWAT 2012	USDA-ARS
ArcGIS 10.4	ESRI

Table 1. Materials and Data Used

2.3 Data Processing and Analysis (SWAT analysis)

The data processing and analysis in this study rely on two key hydrological methods within the Soil and Water Assessment Tool (SWAT): The Curve Number (CN) method from the United States Department of Agriculture Soil Conservation Service (USDA SCS) and the Green-Ampt Infiltration Method. The USDA SCS Curve Number (CN) method is widely used for estimating surface runoff based on rainfall, land use, soil type, and antecedent soil moisture conditions. Curve numbers range from 30 to 100, with lower numbers indicating soils and land covers that promote infiltration (e.g., forested areas) and higher numbers representing conditions that lead to more runoff (e.g., urban or paved areas) as shown in Table 3. This method provides a direct runoff calculation by categorizing the land's ability to allow infiltration. It integrates factors such as soil hydrological group (Table 2 and Figure 5), land management practices, and slope (Figure 5), making it versatile for complex landscapes. In East Baton Rouge Parish, where urbanization and varying soil types influence runoff, this method is particularly effective in differentiating areas with high and low infiltration potential (Van Den Putte et al., 2012; Osei et al., 2023).

GROUP	Description	Further Description	Minimum Infiltration Rate

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			(mm/hr)
A	Deep sand; deep loess; aggregated silts	San, Loamy sand and sandy loam types of soils. These soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively-drained sands or gravels and have a high rate of water transmission	7.6 - 11
B	Shallow loess; sandy loam	Silt, silt loam and loam soils. These soils have a moderate infiltration rate when thoroughly wetted. They consist of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures	3.8 – 7.6
C	Clay loams; shallow sandy loam; soils low in organic content; soils usually high in clay	Sandy clay loam soils. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes the downward movement of water and soils with moderately fine to fine structure.	1.3 – 3.8
D	Soils swell significantly when wet; heavy plastic clays; and certain saline soils.	Clay loam, silt clay loam, sandy clay, silt clay and clay soils. This group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious.	0 – 1.3

Table 2. The hydrologic soil groups (HSG) used for the SCS-CN method in SWAT (Neitsch et al., 2012)

For infiltration analysis, the Green-Ampt Infiltration Method is applied to simulate the rate at which water infiltrates into unsaturated soil. This method assumes that infiltration proceeds until the soil reaches saturation and models infiltration as a function of soil suction, hydraulic conductivity, and moisture deficit. The Green-Ampt method is suitable for areas with distinct wetting fronts, making it appropriate for the heterogeneous soils and vegetation types in East Baton Rouge Parish (Neitsch et al., 2012; Van Den Putte et al., 2012). The method accounts for soil texture and initial moisture content, which influence the rate and total infiltration potential.
Using these methods together (Figure 2) allowed the study to map and analyse the spatial distribution of surface runoff and infiltration across sub-basins in East Baton Rouge Parish. This spatial assessment provides critical insights into hydrological dynamics, identifying areas at risk for surface runoff and potential flood zones, as well as regions with high infiltration capacity beneficial for groundwater recharge. These analyses help to support flood management strategies, water resource planning, and ecological conservation efforts in the region.

Land-use description (Ia = 0.2S)	Curve Numbers (CN) for Hydrologic Soil Group			
Lawns, open spaces parks, golf courses	**A**	**B**	**C**	**D**
i) Good condition: grass cover on 75% or more of the area	39	61	74	80
ii) Fair condition: grass cover on 50% to 75% of the area	49	69	79	84
iii) Poor condition: grass cover in 50% or less of the area	68	79	86	89
Paved parking lots, roofs, driveways, etc.	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Paved with open ditches	83	89	92	93
Commercial and Business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious)	81	88	91	93
Row houses, townhouses, and residential with lot sizes 500m^2 or less (65% impervious)	77	85	90	92
Residential Average lot size				
1000 m^2 (38% impervious)	61	75	83	87
1350 m^2 (30% impervious)	57	72	81	86
2000 m^2 (25% impervious)	54	70	80	85
4000 m^2 (20% impervious)	51	68	79	84
8000 m^2 (12% impervious)	46	65	77	82

S = potential maximum retention in millimetres; Ia = Initial abstraction.

Table 3. Land Use, CN and Hydrologic Soil Groups (Neitsch et al., 2012)

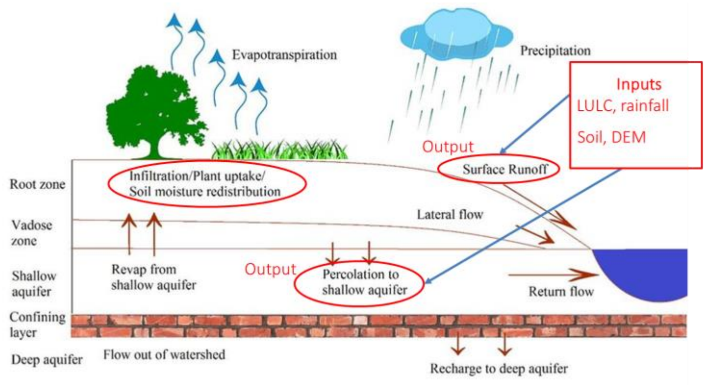

Figure 2. SWAT analysis for surface infiltration (Neitsch et al., 2012)

2.4 Catchment Delineation of East Baton Rouge Parish (SWAT)

Catchment delineation in SWAT involved defining sub-basins and drainage areas within the larger watershed. For this study, the Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) is used as the primary data source to delineate the catchment boundaries of East Baton Rouge Parish. The SRTM DEM provided a high-resolution elevation data (typically 30-meter spatial resolution), which is essential for accurate terrain representation and hydrological modelling.

The DEM enabled SWAT to identify and map the flow direction and flow accumulation within the landscape of EBRP, which are fundamental steps in defining catchment boundaries. SWAT processed the DEM data (Figure 3) to calculate slope (Figure 5), determined drainage patterns, and identified stream networks. The elevation differences within the DEM helped distinguished ridges and valleys, allowing the model to separate sub-basins within the East Baton Rouge watershed. This delineation process was critical for modelling water flow paths, as it influences where surface runoff will accumulate, the direction of water movement, and potential flood zones.

The identification of outlet points was done with the DEM where each sub-basin discharges its water into downstream reaches, ultimately contributing to the main watershed outlet. This information allowed for spatially distributed hydrological analysis across the watershed, providing a clear understanding of how topography affects water distribution. In EBRP, where elevation gradients influence runoff and infiltration rates, catchment delineation using the SRTM DEM was essential to accurately model hydrological processes, manage water resources, and plan flood mitigation efforts.

These delineated catchment and sub-basin maps as shown in Figure 3 are crucial for the subsequent SWAT analyses, including runoff estimation and estimate of surface infiltration rate within each sub-basin, and support detailed hydrological assessments tailored to the East Baton Rouge area.

2.5 Supervised Classification Using Random Forest

Supervised classification of Landsat Level 2 images (Landsat 5 for 1994 and Landsat 9 for 2024) is conducted in this study to classify land use/land cover (LULC) types, including Evergreen Forest, Mixed Forest, Residential, Range-grasses, Barren, and Water, consistent with the SWAT LULC database. The Random Forest (RF) algorithm with 600 trees is applied for the classification process due to its high accuracy, robustness to overfitting, and ability to handle high-dimensional data effectively. Random Forest, an ensemble learning method, constructs multiple decision trees during training and aggregates their outputs to make final predictions, enhancing classification reliability and performance.

For training, 150 sample points were collected from Google Earth imagery across the target classes. To maximize the model's generalization, 80% of these samples (120 points) were randomly selected for training, while the remaining 20% (30 points) were reserved for validation. The RF algorithm then uses spectral characteristics from the Landsat Level 2 imagery, such as reflectance values in various bands, to classify each pixel according to the predefined LULC classes. This spectral information enables the RF model to differentiate between classes based on their distinct spectral signatures, such as high reflectance in near-infrared for vegetated areas like Evergreen and Mixed Forest or low reflectance in visible bands for water bodies.

To assess classification accuracy, a confusion matrix is generated using the validation dataset. Key metrics, including overall accuracy and Kappa coefficient are used to evaluate classification agreement beyond chance. High values in these metrics indicate that the classification is reliable and that the RF algorithm effectively distinguishes between LULC types in the East Baton Rouge Parish area. The accuracy assessment not only validates the effectiveness of the classification but also provides insights into potential areas of misclassification, which can then be refined in future analyses. This classified LULC map is integral to the SWAT model, as it defines land cover dynamics that affect hydrological processes, such as surface runoff and infiltration, across the watershed (Osei et al., 2023).

2.6 Estimation of Surface Annual Runoff and Infiltration

SWAT is designed to estimate surface runoff, infiltration, and other hydrological processes based on spatially distributed input data such as climate, soil type, land use, and topography. This study focused on the estimation of surface annual runoff and infiltration using SWAT, along with the relevant equations involved in these processes.

2.6.1 Surface Runoff Estimation: Surface runoff is the portion of rainfall that does not infiltrate into the soil and instead flows over the land surface into streams or other water bodies. SWAT uses the SCS Curve Number (CN) method to estimate surface runoff using equations 1 and 2.

$$CN = \frac{1000}{10+0.0394\boldsymbol{S}} \tag{1}$$

Where CN is a dimensionless number ranging from 0 to 100 obtained from Table 3.

$$Q = \frac{(P-Ia)^2}{(P-Ia)+\boldsymbol{S}}, \; P > Ia, \; P \geq Q \tag{2}$$

Where;
P = Precipitation in millimetres
Q = Runoff in millimetres
S = Potential maximum retention in millimetres which is a function of the land cover and soil type
Ia (Initial abstraction) = 0.2S
For estimation of annual surface runoff, equation 2 is applied on a daily or monthly basis, and then the results are aggregated over the year (Osei et al., 2023).

2.6.2 Surface Infiltration Estimation: Infiltration refers to the process by which water enters the soil. In SWAT, infiltration is primarily modelled using the Green-Ampt method and the Horton method for different conditions (Van Den Putte et al., 2012).

a) Green-Ampt Method: This method is widely used for calculating infiltration under relatively homogeneous soil conditions. The equation for infiltration using the Green-Ampt method is shown in equation 3 (Van Den Putte et al., 2012).

$$F(t) = K_{sat} \cdot \left(\Delta\theta + \frac{H_f}{\theta_s - \theta_i}\right) \cdot \ln\left(\frac{t}{t+1}\right) \tag{3}$$

Where:

- F(t) is the cumulative infiltration (mm),
- Ksat is the saturated hydraulic conductivity (mm/h),

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- $\Delta\theta$ is the difference between initial and final volumetric soil moisture content,
- H_f is the capillary head (mm),
- θs and θi are the saturated and initial soil moisture contents (mm), respectively,
- t is time (hours).

The Green-Ampt equation can be used to estimate the cumulative infiltration during rainfall events, and in SWAT, it adjusts the soil moisture content accordingly to simulate the infiltration over time (Van Den Putte et al., 2012).

2.6.3 Horton's Method: The Horton infiltration equation (equation 4) is applied when infiltration rates decrease over time. This equation is often used to simulate infiltration rates under more complex or heterogeneous conditions where initial high infiltration rates decrease as the soil becomes saturated.

$$F_{(t)} = F_c + (F_0 - F_c)\cdot e^{(-K.t)} \quad (4)$$

Where:

- $F_{(t)}$ is the infiltration rate at time t,
- F_c is the final or equilibrium infiltration rate (mm/h),
- F_0 is the initial infiltration rate (mm/h),
- K is the decay constant (1/h), which governs the rate at which infiltration decreases over time.

The annual surface runoff and infiltration are obtained by integrating the daily or monthly estimates of runoff and infiltration across the entire year. The process generally follows these steps:

a) Daily/Monthly Calculations: Using rainfall data, land use, soil properties, and other input variables, SWAT calculates daily or monthly values for surface runoff and infiltration using the appropriate equations.
b) Summation for Annual Values: The annual surface runoff and infiltration are then estimated by summing the results for each day or month in the year.

Using SWAT, surface annual runoff and infiltration can be accurately estimated by applying these equations and methods. The model accounts for complex interactions between precipitation, land cover, soil types, and hydrological processes. These estimates are crucial for watershed management, flood prediction, and water resource planning, providing essential insights into hydrological dynamics over a range of spatial and temporal scales.

3. Results and Discussion

The hydrological assessment using SWAT of East Baton Rouge Parish highlighted critical findings regarding the infiltration and runoff trends over the past three decades (1994–2024). This section presents detailed results and discussion on the observed changes in vegetation cover, infiltration rates, surface runoff, and community susceptibility to hydrological risks. These findings reveal the necessity for sustainable water management practices to mitigate increasing hydrological challenges.

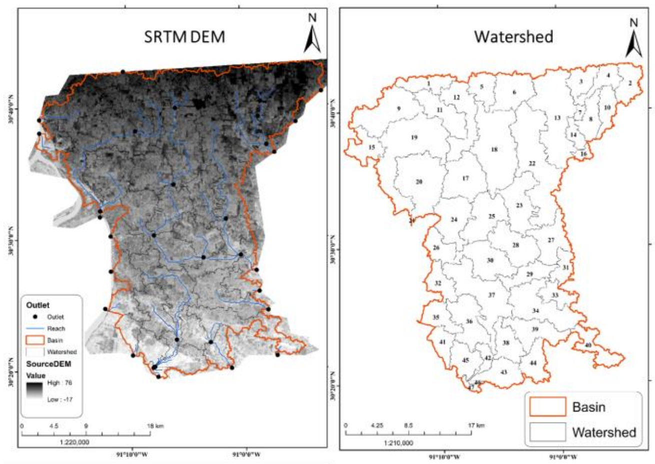

Figure 3. Delineated Catchments from the SRTM DEM

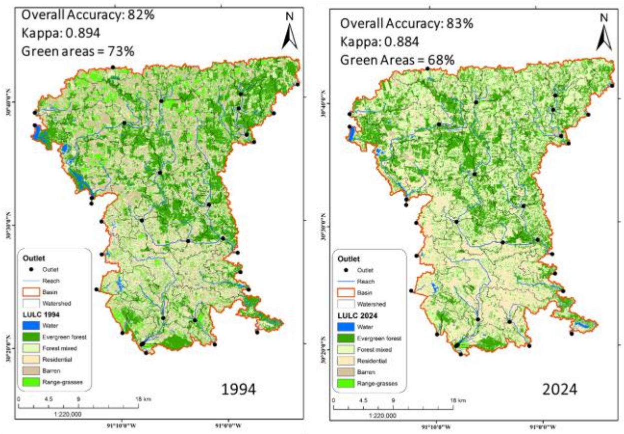

Figure 4. LULC Map of East Baton Rouge Parish (1994 and 2024 (5% decrease in green areas))

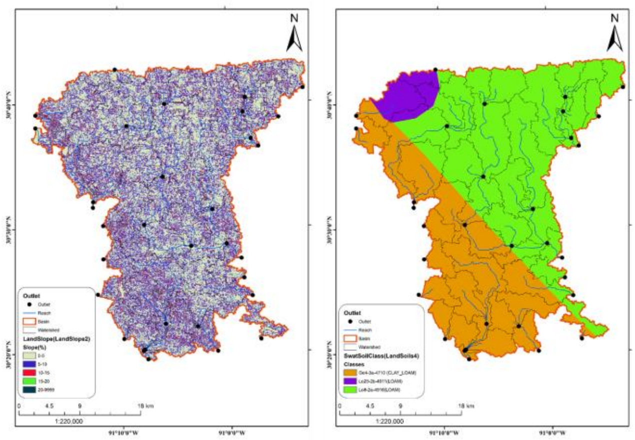

Figure 5. Slope and Soil Map of EBRP for SWAT analysis

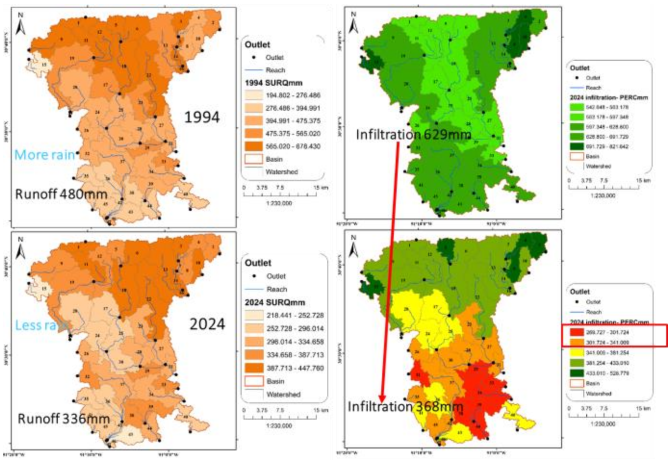

Figure 6. Estimated Surface Runoff and Infiltration in EBRP (1994 -2024)

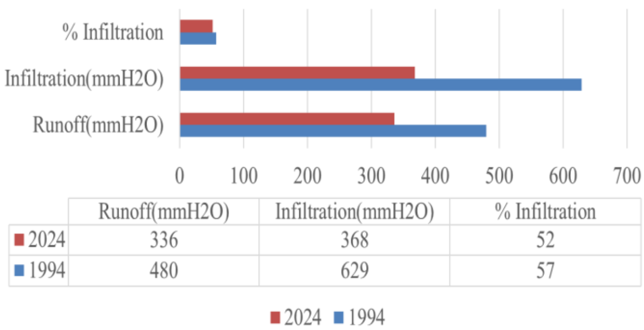

Figure 7. Dynamics in Surface water infiltration as a result of Vegetation change from 1994 to 2024

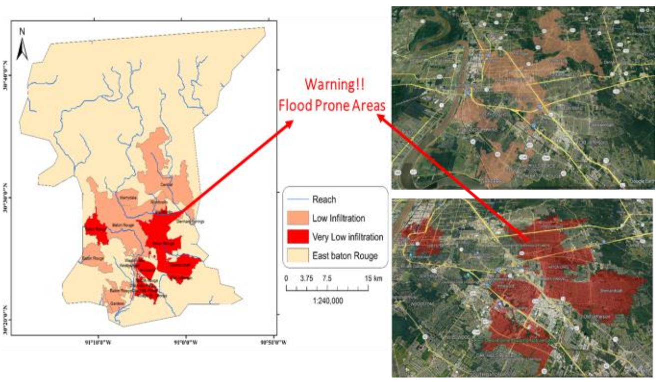

Figure 8. Flood prone areas resulting from Low infiltration from 57% to 54% in EBRP (1994 -2024)

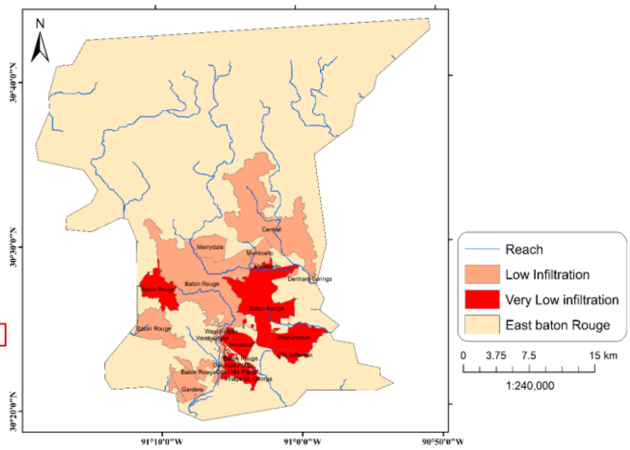

Figure 9. Low Infiltration in EBRP

3.1 Vegetation Cover Decline and Implications

Between 1994 and 2024, vegetation cover in East Baton Rouge Parish decreased from 73% to 68%, representing a 5% reduction over 30 years using the LULC map from the supervised classification with Overall accuracies of 82% and 83%, Kappa of 0.894 and 0.884 for 1994 and 2024 respectively as shown in Figure 4. This decline is likely driven by urban expansion, deforestation, and land use changes favouring development over conservation. Reduced vegetation impacts hydrological processes, particularly infiltration and runoff, as vegetation plays a significant role in intercepting rainfall and enhancing soil water absorption (Tan et al., 2023; Osei et al., 2023).

The reduction in vegetation cover diminishes the area's natural infiltration capacity, which results in increased surface runoff and a greater likelihood of waterlogging and erosion (Osei et al., 2023). This change is also consistent with findings from Pyke et al. (2011), who demonstrated that reduced vegetation cover leads to higher runoff rates, which, in turn, amplifies flood risks and exacerbates pollution from surface water runoff.

3.2 Infiltration Rate Decline Across Communities

The infiltration rate in East Baton Rouge Parish has significantly decreased from 629 mm in 1994 to 368 mm in 2024, marking a 5% reduction as shown in Figure 6 and Figure 7. This decline is associated with the loss of vegetation (Figure 4), which has left soils more compacted and less able to absorb water. The reduced infiltration rate increases surface runoff and contributes to frequent flooding events, especially in low-lying and densely populated areas (Issah et al., 2023).

Eight (8) communities were identified with notably low infiltration rates: Central, Gardere, Westminster, Oak Hills Place, Baton Rouge, Denham Springs, Monticello, and Merrydale (Figure 8 and Figure 9). These communities are particularly vulnerable to waterlogging and surface runoff due to their low infiltration rates and urbanized landscapes. The identification of these communities emphasizes the localized nature of the hydrological challenges in East Baton Rouge Parish. Targeted interventions, such as increasing green spaces and implementing permeable pavement solutions, could be beneficial in improving infiltration and managing runoff in these areas (Uribe et al., 2022).

3.3 Surface Runoff Trends and Contributing Factors

The analysis shows a reduction in surface runoff from 480 mm in 1994 to 336 mm in 2024 (Figure 6 and Figure 7), despite the observed decrease in vegetation cover. This reduction in runoff may be attributed to improved stormwater management practices and sustainable development strategies within the parish, which help mitigate excessive runoff even in the face of declining green space (Pyke et al., 2011). Changes in precipitation patterns, influenced by climate variability, may also contribute to these runoff reductions (Osei et al., 2023; Issah et al., 2023). For instance, altered rainfall distribution patterns, such as more frequent but less intense rain events, could lead to less runoff generation, allowing more water to infiltrate rather than flow over the land surface. This adaptation effect highlights the importance of water-sensitive urban design practices that can help offset hydrological impacts from land cover changes, albeit partially.

3.4 Surface Runoff Trends and Contributing Factors

At the end of the study, 47 distinct watersheds as shown in Figure 3 were delineated in East Baton Rouge Parish. These watersheds were analysed to understand spatial differences in infiltration, runoff, and vegetation coverage. The analysis of watershed-level data reveals that certain areas, particularly those encompassing the eight (8) identified communities (Figure 9), are disproportionately affected by reduced infiltration capacity (Figure 6 and Figure 7). This spatial delineation allows for more precise planning and intervention strategies, as resources can be allocated based on watershed susceptibility to flooding and runoff risks.

The low infiltration rates in Central, Gardere, Westminster, Oak Hills Place, Baton Rouge, Denham Springs, Monticello, and Merrydale also depend on the high density of impervious surfaces, such as roads, sidewalks, and buildings, which restrict water infiltration (Osei et al., 2023). These findings suggest that community-level improvements, such as increasing green infrastructure and implementing rain gardens, could substantially improve water resilience (Church, 2014).

3.5 Implications for Water Management and Resilience Strategies

The findings emphasize the need for proactive water management and sustainability-focused interventions in East Baton Rouge Parish. Restoration of vegetation cover, where feasible, is essential to enhance infiltration rates and reduce runoff. Additionally, sustainable urban planning, such as incorporating green infrastructure and rainwater harvesting systems, can significantly mitigate runoff and enhance infiltration (Pappalardo et al., 2017; Osei et al., 2023; Issah et al., 2023). Interventions targeting the eight (8) identified communities could be especially impactful, as they face higher risks of flooding, waterlogging, and surface water pollution due to low infiltration rates.

Efforts to enhance water resilience must include policies and practices that prioritize vegetation restoration and sustainable urban design. Improved stormwater management strategies, informed by the delineated watershed data, can also help balance the reduction in infiltration rates, providing a buffer against the adverse impacts of climate change and urban expansion on the hydrological system (Pappalardo et al., 2017).

4. Conclusion

This study was able to assess the transformative impact of vegetation dynamics on surface water infiltration rates. The results highlight that vegetation cover in East Baton Rouge Parish decreased from 73% in 1994 to 68% in 2024, a 5% reduction primarily due to urban development. This decline in vegetation has led to a significant reduction in infiltration rates from 629 mm in 1994 to 368 mm in 2024, underscoring the critical role of vegetation in supporting natural water absorption and replenishing groundwater. Despite improvements in stormwater management, the reduced infiltration capacity has increased the susceptibility of several areas to surface runoff and waterlogging. The study identified eight (8) communities: Central, Gardere, Westminster, Oak Hills Place, Baton Rouge, Denham Springs, Monticello, and Merrydale as having especially low infiltration rates, making them more vulnerable to hydrological issues such as flooding and surface water pollution. These findings underscore the need for targeted interventions, such as reforestation and green infrastructure, to enhance infiltration capacity and reduce runoff in these areas. Continued monitoring through satellite remote sensing is essential to manage vegetation and hydrological changes adaptively. The study calls for urgent action to restore vegetation and enhance water resilience across East Baton Rouge Parish to ensure long-term hydrological stability and safeguard against future environmental challenges.

Acknowledgements

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