Journal of Advances in Chemical Sciences
ISSN 3121-6730
Volume 3, Number 1, 2026

Climate Change, Hydroclimatic Trends, and Flood Risk Mapping in the Ogun-Osun River Basin, Southwestern Nigeria

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Received 13th June**,** 2026 **Accepted** 17th June, 2026, **Published online** 25th June, 2026

Abstract

This study investigated the combined effects of climate change and land-use transformation on flood risk in the Ogun-Osun River Basin (OORB), Southwestern Nigeria, spanning from 2005 to 2024. Rainfall and temperature data from the Nigerian Meteorological Agency (NiMet) and NASA POWER were analysed using the Mann-Kendall trend test, Sen's slope estimator, Standardized Precipitation Index (SPI), and temperature anomaly analysis. Land use and land cover (LULC) change was mapped across five epochs using Landsat imagery and supervised Maximum Likelihood Classification. Flood susceptibility was modelled with eight conditioning factors weighted through the Analytical Hierarchy Process (AHP). Results indicate a statistically significant increasing rainfall trend (Mann-Kendall $\tau = +0.21$; $p < 0.05$), with annual rainfall rising 18.8% and basin-wide warming of 0.37 °C per decade. Extreme wet years (2012, 2017, 2022) that can be associated with significant floods have been identified by SPI, which supports the climate-flood connection. The rapid urban growth indicated by LULC analysis has increased the built-up areas twofold, with urban areas that have been built-up increasing by 16 to 32%, and the forest as well as wetland cover diminishing contributing to the rise in the amount of surface runoffs. Flood hazard mapping identified 14% of the basin as very high risk and 29% as high risk with hotspots being centered in Abeokuta, Osogbo, Isheri, Sango-Ifo, Ikire and Iwo. The model validation was good (ROC AUC = 0.84; SCC = 0.78). The results are critical in climate resilient spatial planning, early warning system and integrated watershed management.

Keywords: Ogun-Osun River Basin, flood risk, hydroclimatic trends, land-use change, Urbanization, GIS, AHP, Southwestern Nigeria

Introduction

Climate change, acting in concert with accelerated land-use change and decreasing wetland area, is driving a measurable intensification of flood risk in the Ogun-Osun River Basin (OORB) in southwest Nigeria. In the past, floodplains and wetlands in the basin were crucial sources of critical storage and attenuation to moderate flood peaks. However, recent remote-sensing studies show that, between 1999 and 2019, wetlands in the lower Ogun reaches experienced quantifiable shrinkage and growth of built and cultivated lands at the expense of buffering capacity and increased surface runoff [1]. Meanwhile, regional climate surveillance and trend projections show that there is an increasing spatial heterogeneity in the extreme precipitation, and multiple stations in the basin are becoming more responsive in short-duration maximum rainfall (e.g., Rx1day) and observing breaks in rainfall series, changes that augment the probability of flash floods and increased river discharges in severe storms [2]. These physical drivers act in combination with socio-economic exposure. Urban development surrounding cities like Abeokuta, Sagamu and Ifo has put large numbers of people and important infrastructure on to low floodplains, where informal settlements do not generally adapt well.

A review of national and basin-scale floods in Nigeria identifies human and environmental interactivity, which indicates that human activities and land-use have increased floods in recent decades, through urbanisation, inadequate drainage, and poor control of land-use [3]. Furthermore, the NiMet indicates in the short-term climate outlooks that there is an interannual variability in the timing and intensity of seasonal rains-data, which, when combined with land-cover changes data, can have a significant impact on flood-risk assessments and immediate preparedness [4] . On the international level, the evaluation by the Intergovernmental Panel on Climate Change (IPCC) confirms the fact that climate change is raising the rate and severity of extreme precipitation in most areas, which supports the necessity to consider flood risk as a climate-sensitive planning issue [5].

Despite these converging pressures, a critical knowledge gap persists: no existing study for the OORB integrates long-term land-cover change, station-based hydroclimatic trend analysis, and validated flood susceptibility mapping within a single analytical framework. Flood-risk mapping within the OORB can no longer afford to remain a single-factor investigation. Recent methodological innovations, integrating multi-criteria GIS predisposition mapping (slope, accumulation of flow, distance to channel, land cover), have been validated using remotely sensed flood footprints (Sentinel-1), and informed using station-level extreme-value analysis, provide a viable route towards the generation of operational hazard maps in data-constrained basins [6] Nonetheless, the previous uses within the area often do not include short-term weather forecasts or sub-regional exposure maps, which restricts their applicability in instant decision-making.

This paper addresses these gaps by delivering a time-sensitive, validated flood-risk assessment of the OORB that combines land-cover change (1999-2019), hydrological predisposition indices derived by DEM, NiMet seasonal outlooks and station-based extreme-value trend tests and fine-scale exposure mapping (population and critical infrastructure). The objectives were: (1) map existing flood hazard via a multi-criteria GIS model calibrated and validated with Sentinel-1 flood footprints; (2) determine recent hydroclimatic trends and extreme-rainfall behaviour in the generation of floods in the basin; (3) determine socio-economic hotspots of exposure and vulnerability; and (4) propose actionable and climate-informed interventions to basin planners and local authorities. The significance of this work lies in its contribution of a temporally deep, spatially validated, and multi-factor flood-risk assessment that directly links observed climate change trends to flood hazard outcomes in a major West African river basin.

Materials and Methods

The Ogun-Osun River basin is situated between 6°30N and 8°30 N and 3°00E and 5°00E covering about 58,000 km^2 in Ogun, Osun, Oyo, Lagos as well as parts of Kwara and Ondo States in southwestern Nigeria. Its basin feeds into the Lagos Lagoon via the Ogun and Osun Rivers to create a complex hydrological system that supports agriculture, water, and power production [7]. It has a humid tropical climate with bimodal rainfall (the major one is in April-July and minor in September-October). Annual precipitation is 1,200 mm in the north and above 2,000 mm towards the coast [4]. The temperatures are 25 to 32 ℃ and it is humid throughout the year. In the north, the Precambrian Basement Complex rocks dominate the geology but in the south, the characteristics of infiltration and runoff are affected by the sedimentary formations [8]. The topography is undulating uplands (≈300-400 m a.s.l.) in the Osun headwaters and low-lying floodplains (<50 m a.s.l.) in the lower Ogun reaches around Lagos. Abeokuta, Sagamu, Osogbo and Ifo are some of the urban centres that are on the major tributaries and becoming more susceptible to flooding because of encroachment on the natural floodplains.

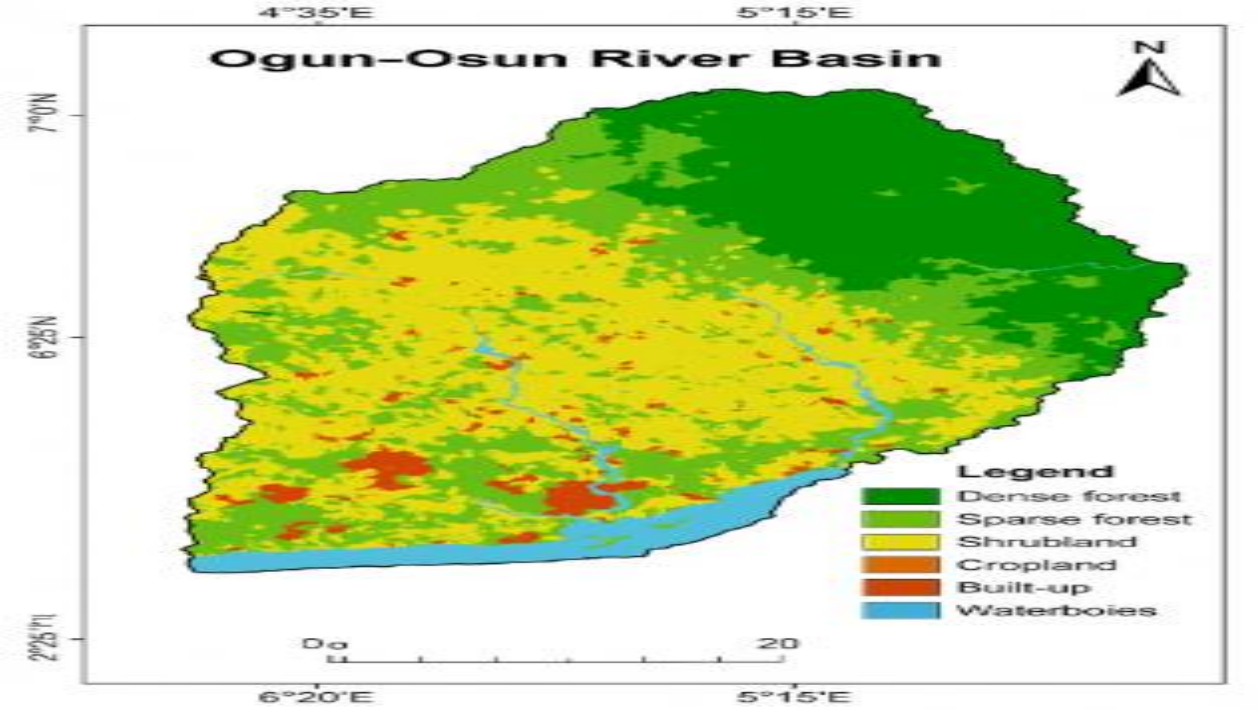

Figure 1: Study area map– *Ogun–Osun River Basin Hydrological Data and Catchment Boundaries (2023)* [7]

Flood risk can be defined loosely as the combination of hazard, exposure, and vulnerability, where the hazard is the physical phenomenon (e.g., inundation), exposure is the people/assets that are in the hazard areas, and vulnerability is the extent to which they can be damaged [8]. Applied to basin scale evaluations like the Ogun-Osun River Basin this triad should include other dimensions; land-cover change (wetland loss, urban growth), hydrometeorological change (rainfall intensity, frequency), and anthropogenic changes in infrastructure (drainage networks, floodplain encroachment). Wetlands and floodplains can act as natural buffers, which mitigate the peak of floods; transformation into built habitats or drained agricultural lands decreases storage capacity and amplifies the runoff and the size of floods [8]. Moreover, the hazard dimension is also enhanced in a changing climate scenario, which enhances increased rainfall variability, mainly in short-lasting extreme events [8]. Urbanisation process through growth of impermeable areas and obstruction of the natural drains increases the exposure and vulnerability, transforming what could have been moderate floods to a major disaster. Therefore, flood risk in OORB is the interaction between natural hydrological responsiveness and human alterations and climatic change- multi-dimensional analysis is needed.

The first lens is the hydrological theory of catchment response, which states that rainfall intensity and duration, antecedent moisture, soil infiltration rates, land cover, and channel network architecture all affect runoff generation, peak, and duration of floods. Indicators such as the Time of Concentration, Runoff Coefficient, Flow Accumulation, and Topographical Wetness Index (TWI) are operationalised by GIS flood-susceptibility models [8]. Changes in land cover (such as wetland loss and marsh drainage) immediately alter key hydrological characteristics in basins like the OORB, where upstream hills drain into wide floodplains.

The second prism is the vulnerability-exposure framework: a hazard does not imply damage, but it has to impact exposed and vulnerable systems. Multi-criteria decision-making (MCDM) techniques (e.g., AHP) are applied to combine physical risk hazard layers (slope, elevation, land cover) with exposure layers (population density, infrastructure) and vulnerability layers (poverty, adaptive capacity) into composite risk maps in flood-risk mapping [6]. This model highlights the fact that moderate hazard areas could still represent high risk in cases where vulnerability and exposure are large - especially in case of informal urban settlements in the OORB.

Through any change in the severity, seasonality, and frequency of extreme events, a third theoretical strand provides a connection between flood risk and climate change. Intense rainfall typically results in increased runoff, shorter lag periods, and higher peak flows in the same basin, according to empirical and theoretical research [8]. In urbanised or drained basins, relatively slight changes in rainfall intensity may result in disproportionately massive floods, suggesting a non-linear response to land-cover change.

Methodology

The methodological design is based on the following theoretical strands: (i) physical predisposition evaluated with hydrological measures, (ii) superimposition of exposure/vulnerability layers to map the risk, and (iii) the evaluation of the evolving context of hazard based on climate trends and projections. The study draws on three thematic bodies of empirical literature to contextualise the research findings: land-cover and wetland change, hydrometeorological trends and extremes, and flood-risk mapping methods in comparable basin settings.

Adeleke et al. [9] mapped marginal wetland loss in the lower Ogun River Basin over 1990-2017 and found that wetland contraction was largely due to agricultural and urban sprawl. The latter emphasize that the wetlands lost about 12-18 percent in major sub-basins, changing the nature of runoff responses and the natural flood mitigation capacity [9]. This is consistent with urban flood research in Lagos by Adelekan and Eze [9], which indicate that wetland and floodplain loss are major factors in urban flood intensity. Therefore, land-cover change serves as a flood hazard multiplier in the OORB format. Ojelabi et al. [2] analysed rainfall records from the OORB for trend breakpoints and directional change. Their analysis revealed non-uniform shifts in extreme rainfall indices (e.g., Rx1day) across stations, with shorter high-intensity event periods in downstream areas. This kind of spatial heterogeneity implies that hazard is accelerating more in lower parts of basins- which overlap with urbanised and flood prone regions. They also incorporated NiMet seasonal forecasts to indicate anticipated above-normal precipitation of the selected years. Combined, these results suggest that the hazard aspect of flood risk is rising and is also disproportionate throughout the basin.

Ogundolie et al. [6] applied AHP-based multicriteria analysis in the Osun River Basin (hydrologically close to areas of OORB) to outline flood-vulnerable areas. Their output maps established based on the recent footprint of the floods and validated against it define high-risk regions as low-lying, high-rainfall, and high-drainage density, which are the downstream edge of the OORB [6]. The paper highlights the fact that AHP-MCA techniques come in handy in data-scarce areas like southwestern Nigeria. The replicability of the approach is supported by similar approaches in other basins in Nigeria [11]. Indicatively, the study of the Hadejia Basin integrated hydro-geomorphic indices and socio-economic layers to map flood risks to 43 percent of the basin surface ([11]).

The synthesis of these findings creates a number of insights: Firstly, OORB is experiencing a significant change in land-cover (a decrease in wetlands and urbanization) which decreases the natural ability to mitigate floods. Second, hydrometeorological data shows that there is a trend of growing higher extremes of rainfall, especially in downstream urbanised areas, which increases the risk of floods. Third, methodological developments (AHP-MCA, Sentinel-1 footprint validation) demonstrate that even in the data-sparse situations, flood-hazard and risk mapping can be successful. More importantly, such studies point to spatial heterogeneity of hazard and vulnerability- high risk is being focalized at the point of land-cover change, intense rainfall and high human exposure. This implies that the management of flood-risks needs to be spatially focused as opposed to homogenous.

Although the research on flood-risk in Nigeria is on the increase, there are still gaps that are significant. A lot of the studies are standalone-they take one land-cover image or fail to incorporate the climate-change projections and the changing extremes of precipitation. Hazard maps validation with real inundation footprints (e.g. Sentinel-1) is also uncommon in the OORB context. Informal settlements, critical infrastructure, adaptive capacity Socio-economic exposure layers are usually coarse or absent, which constrains prioritisation of interventions. Moreover, there is a dearth of studies that directly combine long-term land-cover change, trends of rain-extremes, and exposure with the intent of generating a near-term, operational flood-risk map to support the making of decisions at a municipal and basin scale. The current research aims to address these gaps by incorporating the land-cover change (1999-2019), climate/ outlook data, created by NiMet, a high-resolution DEM-based hydrological predisposition layers, and the latest exposure / infrastructure data to create a validated flood-risk map of the OORB

Rainfall and temperature data were obtained both through the Nigerian Meteorological Agency and NASA POWER which allowed cross-validation and bridging gaps in time. The Landsat 5 (TM) was used to acquire the Land Use and Land cover (LULC) data in 2005, Landsat 8 (OLI/TIRS) in 2010, 2015 and 2020, and Landsat 9 image in 2024. A 30-m SRTM Digital Elevation Model (DEM) contained elevation, slope, hydrological flow accumulation and drainage density extraction. Primary data was collected through retrieving river discharge and water-level records at the Ogun-Osun River Basin Development Authority (OORBDA), and flood inventory data, such as the existing flood points and the loci of inundation and emergency response data, were collected at NEMA, field GPS survey between 2018 and 2024, and supporting media archives. The analysis involved the broad use of climatic and hydrological data, geospatial and socio-environmental data of twenty years between 2005 and 2024. The base variables on which climatic characteristics were analyzed were monthly rainfall series, daily maximum, and daily minimum temperatures.

The non-parametric Mann-Kendall (MK) test was used to test rainfall and temperature trends because it is highly used in hydroclimatic time-series analysis because it is not sensitive to non-normality. Slope estimator that was created by Sen measured the scale of monotonic climatic change. Along with these trend measures, the Standardized Precipitation Index (SPI) was to be determined as the measure of the meteorological drought and wetness intensities during the period of the study. To further indicate inter-annual rainfall variability Rainfall Anomaly Index (RAI) was used. The temperature abnormalities were calculated against a 2005-2010 baseline, and the rates of warming were compared in terms of Tmax and Tmin, and further heat indices were computed on annual basis.

LULC component adhered to conventional remote-sensing processes. Cloud-filtered to less than 20 percent cloudiness, all the Landsat images were used. The LEDAPS and USGS ARD processing tools were used to perform atmospheric correction to minimize atmospheric scattering and enhance the quality of radiometrics. The maximum Likelihood Classifier (MLC) which is supervised classification was adopted because of its good performance in mixed landscapes characteristic of southwestern Nigeria. The mapping of land-cover included 6 classes that included built-up areas, forest, farmland, wetlands, water bodies and bare surfaces. Assessment of accuracy was done through confusion matrices and kappa coefficient obtained on ground-truth data and high-resolution Google Earth images. Changes in LULC were determined by post-classification comparison between the five temporal epochs (2005, 2010, 2015, 2020 and 2024).

Eight conditioning factors were employed in flood hazards evaluation based on literature-based and hydrological theory: rainfall intensity, slope, elevation, land-cover class, soil type, and distance to river channels, flow accumulation, and drainage density. Analytical Hierarchy Process (AHP) permitted systematic weighting by the use of matrices of pairwise comparisons resulting in normalized weights and consistency ratio ($CR < 0.10$). A weighted linear combination was used to model flood risk and it was as described: $FRI = \Sigma (Wi \times Xi)$ where Wi is the weight of the criterion and Xi is the standardized raster layer.

Results and Discussion

Climate Change Signal in Hydroclimatic Data

The rainfall and temperature pattern analysis over the two-decade study period (2005-2024) revealed statistically significant climatic changes within the Ogun-Osun River Basin, consistent with the climate change trajectory projected for West Africa by the IPCC [5]. The increasing tendency of rainfall was statistically significant and the Mann-Kendall t value is +0.21 and the slope of Sen is +6.5 mm/year as summarized in Table 1. There was also an increase in the rainfall of 1330 mm in 2005 to 1580 mm in 2024, an 18.8 percent increase. The Standardized Precipitation Index (SPI) also indicated years of recorded basin-wide flooding of 2012, 2017, and 2022, indicating three extreme wet years. On the other hand, there were extreme dry anomalies in 2009, 2016 and 2021, highlighting the increasing climatic variability in the area.

Table 1: Summary of Rainfall Trends (2005–2024)

Parameter	Result	Interpretation
Mann–Kendall τ	+0.21	Increasing rainfall trend
Sen's Slope	+6.5 mm/year	Progressive rise in annual rainfall
Mean Annual Rainfall (2005)	1330 mm	Baseline year
Mean Annual Rainfall (2024)	1580 mm	+18.8% increase
Wet SPI Years	2012, 2017, 2022	Extreme wetness; major flood years
Dry SPI Years	2009, 2016, 2021	Meteorological drought periods

Source: Authors, 2025

The pattern on temperature was along similarly growing lines. The maximum temperatures rose at an average of +0.34degC/decade whereas minimum temperatures rose faster at +0.41degC/decade. The average warming rate of the basin-wide (0.37degC/decade) is in tandem with the regional forecasts, whereas the years of 2023 and 2024 were the years with the highest temperature anomalies (Table 2).

Table 2: Temperature Trend Summary (2005–2024)

Parameter	Result	Interpretation
Tmax Trend	+0.34 °C/decade	Warming of daytime temperatures
Tmin Trend	+0.41°C/decade	Stronger nighttime warming
Mean Warming Rate	0.37 °C/decade	Basin-wide temperature rise
Hottest Years	2023, 2024	Peak heat anomalies
Temperature Baseline	2005–2010	Reference period

Source: Authors 2025

Land Use and Land Cover Change (2005-2024).

The analysis of the land-cover showed that the basin experienced a significant metamorphosis. The urban space, which had increased to 16 percent, had increased to 32 percent and forest cover had reduced to 15 percent. Wetlands decreased by 4 percentage points, and bare areas expanded of 3 to 8 percentage points (Table 3). These results reveal high rate of urbanization, deforestation, loss of wetlands and land degradation-processes that have significant consequences on the hydrology of the basin, infiltration, and runoff production.

Table 3: Land Use/Land Cover Change (2005–2024)

LULC Class	2005 (%)	2024 (%)	Change (%)	Key Interpretation
Built-up	16	32	+16	Rapid urban expansion, increased impervious surfaces
Forest	28	15	–13	Deforestation and land conversion
Farmland	38	33	–5	Pressure from urban encroachment
Wetlands	10	6	–4	Loss of natural flood buffers
Water Bodies	5	6	+1	Minor expansion in reservoir/river area
Bare Surface	3	8	+5	Increased land degradation and soil exposure

Source: Authors, 2025

The analysis of weighted overlay with AHP provided four hazard zones on the basin. The weights developed (Table 4) had the highest weight on the intensity of rainfall (0.18), slope (0.15) and elevation (0.14). The last hazard classification (Table 5) indicated that 14% of the basin is in the category of the very high level of risk, and 29% is that of high level, 31% is medium level, and 26% is low level.

Table 4. AHP-Generated Weights for Flood Conditioning Factors

Flood Conditioning Factor	Weight (Wi)	Influence on Flooding
Rainfall Intensity	0.18	Strongest climatic driver
Slope	0.15	Controls runoff velocity
Elevation	0.14	Determines inundation potential
Distance to River	0.13	Proximity increases risk
LULC	0.12	Affects infiltration vs. runoff
Soil Type	0.10	Influences permeability
Flow Accumulation	0.10	Concentrates runoff
Drainage Density	0.08	Facilitates rapid flooding

Table 5: Flood Hazard Zonation (AHP–Weighted Overlay)

Hazard Class	Area Coverage (%)	Characteristics
Very High	14%	Low elevation, flat terrain, high flow accumulation
High	29%	Densely settled, near rivers, altered land cover
Moderate	31%	Transitional areas with mixed elevation and LULC
Low	26%	High elevation, forested or permeable surfaces

Source: Authors, 2025

The low-lying floodplains and high-speed urbanizing areas were the biggest concentration points of high- and very- high-risk zones, mainly in Abeokuta, Osogbo (Erinle axis), Isheri-OPIC, Ifo-Sango, Ikire, and Iwo (Table 6). Table 7 demonstrates that the model performed well when validated through NEMA flood points, Sentinel-1 images, and field GPS with a strong model performance (AUC 0.84; SCC 0.78).

Table 6: High-Risk Settlements Identified (2005–2024)

Location	**State**	**Key Drivers of Flooding**
Akin-Olugbade, Ijaye (Abeokuta)	Ogun	River proximity, rapid urban growth
Isheri & OPIC	Lagos–Ogun	Low elevation, urban expansion
Osogbo (Erinle Axis)	Osun	River overflow, upstream accumulation
Ifo–Sango	Ogun	High population density, poor drainage
Ikire & Iwo	Osun	Alluvial plains, agricultural encroachment

Source: Authors, 2025

Table 7. Flood Map Validation Metrics

Validation Method	**Result**	**Interpretation**
ROC AUC	0.84	High predictive accuracy
SCC	0.78	Strong spatial agreement with observed floods
Validation Data Used	NEMA flood points, Sentinel-1 flood extent, Field GPS	Multi-source reliability

Source: Authors, 2025

The findings show that there is a distinct climatological aggravation during the research period. This high growth in the amount of rainfall, in addition to warming trends, is consistent with the results of Adefisan et al [12] and Oguntunde et al. [19], who reported an elevation in variability of rainfall and temperature in southwestern Nigeria. The positive change in the trend of rainfall, complemented by the wet extremes of the SPI, claiming the existence of hydrometeorological extremes of rainfalls is justified by the fact that the warmer the air, the more the water vapor it contains which results in heavier events of rainfalls according to the Clausius-Clapeyron principle, according to which, the warmer the air, the greater the amount of water it holds. The warming rates observed in the basin are in line with results of climate data in Africa conducted by Niang et al. indicating that the heat extremes would only intensify in West Africa [13]. Higher temperatures boost evapotranspiration, however, intensify convective rainfall, which increases stormwater floods and flash floods. Moreover, the presence of severe wet SPI episodes (2012, 2017, 2022) in recorded floods supports the direct correlation between climatic conditions and floods. It is consistent with the theory of hydroclimatic teleconnections, in which local precipitation abnormalities are linked with more global climatic processes, including the Atlantic Nino and the West African monsoon interactions.

The trends of urbanisation towards the southwest of Nigeria show by the study align with previous findings of high urbanisation rates in the region [14,15]. The acreage of built up areas had developed by 16 percent that significantly increased impervious areas and diminished the capacity of soil to absorb water. Such a change is also in line with the theory of urban runoff, according to which, rises in impervious cover multiply the flood peaks exponentially despite a relatively insignificant increase in rainfall. Deforestation (-13%) and wetland (-4%) losses have a serious hydrological impact. Forests promote evapotranspiration and surface retention and wetlands cushion floodwaters. Their decrease enhances the velocity of runoff and the channel discharge. These results resemble the results of Oguntunde et al. [16], who found that land-cover change was a significant predictor of the severity of floods in Nigeria.

The geomorphological and hydrological concepts are in correspondence to the spatial distribution of high flood hazard zones. Flat low areas of the Ogun and Osun rivers are naturally endowed with water because of their low slope and dense drainage systems. Based on the concept of topographic wetness index (TWI), they possess high flow convergence; hence, high flood susceptibility. The regions of high flow accumulation (e.g., Isheri, Abeokuta floodplain) coincide with the predicted risk areas by the model, proving the predictive ability of hydrological terrain analysis. Besides, the saliency of newly urbanized regions in high-risk regions portrays the exposure aspect of Pressure-and-Release (PAR) model, which underscores how social-environmental pressures exacerbate natural hazards. The AHP method, which is proven by good ROC indicators, is compatible with the proven reliability of the multi-criteria decision analysis used in the flood modeling process, as shown in the works by Tehrany et al. [17] and Abebe et al. [18].

Previous studies in Nigeria have shown the same samples of climate and flood patterns. As an example, Oguntunde et al. observed the rise in the frequency of rainfall and increases in the levels of floods in Ogun State [19]. As Adelekan et al. noted, unplanned urbanization increases flood risk in Lagos and Ogun [14]. [20] found that the frequent flooding along the Ogun river was common especially in Isheri and OPIC. Odufuwa et al. related the growth of settlements and floods exposure in southwest Nigeria [21]. The current results are comparable to these studies but they give more quantitative information with respect to time and space with the multi- sensor remote sensing and AHP based modeling. The combination of 20 years of climate and five epochs of land-cover mapping adds to the existing knowledge and supports the predictive understanding.

Conclusion

This study set out to: (1) map flood hazard in the OORB using a multi-criteria GIS model validated with Sentinel-1 flood footprints; (2) determine recent hydroclimatic trends and extreme-rainfall behaviour; (3) identify socio-economic hotspots of exposure and vulnerability; and (4) propose climate-informed interventions for basin planners. All four objectives were addressed. Multi-criteria AHP modelling, validated against NEMA flood inventory data, Sentinel-1 satellite imagery, and field GPS records, confirmed that 43% of the basin falls within high to very high flood hazard zones, with ROC AUC of 0.84 and SCC of 0.78 indicating strong predictive reliability. Hydroclimatic analysis established a statistically significant increasing rainfall trend (Mann-Kendall $\tau = +0.21$; $p < 0.05$) and basin-wide warming of 0.37°C per decade, with SPI-identified extreme wet years (2012, 2017, 2022) corresponding to major flood occurrences. LULC mapping documented a doubling of built-up area and a combined 17-percentage-point loss of forest and wetland cover, reducing the basin's natural flood buffering capacity. Socio-economic hotspots were identified in Abeokuta, Isheri, Osogbo, Ifo-Sango, Ikire, and Iwo, where high physical hazard converges with dense settlement on natural floodplains. Together, these results confirm that escalating flood risk in the OORB is driven by the compounding of intensifying climate extremes and unsustainable land-use change, and they provide a spatially explicit evidence base for climate-resilient planning and early warning system development.

Recommendations

- Implement early warning by real-time rainfall, water level and satellite surveillance.
- Impose the land-use planning regulations to prevent construction in floodplains and wetlands.
- Build and repair drainage systems particularly in Abeokuta, Ifo and Isheri.
- Rehabilitate deteriorated wetlands to enhance natural flood storage.
- Create climate-sensitive agriculture in the upstream farmlands to minimize soil erosion.

References

[1] Tobore, A. & Bamidele, S. (2022). Wetland change prediction of Ogun-River Basin, Nigeria: Application of cellular automata-Markov and remote sensing techniques. Watershed *Ecology and the Environment*, 4, 158–168. https://doi.org/10.1016/j.wsee.2022.01.002

[2] Ojelabi, O., Eze, C. & Abayomi, O. (2023). Hydroclimatic trends and extreme rainfall patterns in the Ogun River Basin, West Africa. *Water Practice and Technology*, 18(9), 1817–1832. https://doi.org/10.2166/wpt.2023.112

[3] Umar, N. & Gray, E. (2023). Flooding in Nigeria: review of occurrence and impacts. *International Journal of Water Resources Development*, 39(5), 739–769. https://doi.org/10.1080/07900627.2022.2135730

[4] NiMet. (2023). Seasonal climate outlook bulletin 2023. Nigerian Meteorological Agency. https://nimet.gov.ng/ (Accessed: Oct. 8, 2025)

[5] IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/ (Accessed: Oct. 7, 2025)

[6] Ogundolie, O. I., Olabiyisi, S. O., Ganiyu, R. A., Jeremiah, Y. S. & Ogundolie, F. A. (2024). Assessment of flood vulnerability in Osun River Basin using AHP method. *BMC Environmental Science*, 1(9), 54–67. https://doi.org/10.1186/s43170-024-00265-6

[7] NIHSA. (2024). Annual flood outlook 2024: Hydrological zones and flood predictions. Nigerian Hydrological Services Agency. https://nihsa.gov.ng/ (Accessed: Oct. 7, 2025)

[8] Rahmati, O., Falah, F. & Melesse, A. M. (2021). Flood hazard modelling using GIS-based AHP in semi-arid environments. *Natural Hazards*, 106(2), 1341–1363. https://doi.org/10.1007/s11069-021-04513-6

[9] Adeleke, B. O., Orimoogunje, O. I. & Ekanade, O. (2020). Assessing marginal wetland loss to agricultural expansions in the lower Ogun River Basin of Southwest Nigeria. *Journal of Wetlands Ecology*, 14, 1–14. https://doi.org/10.3126/jowe.v14i0.32657

[10] Ologunorisa, T. E., Ojo, A. O. & Nwankwoala, H. O. (2024). Integrating climate adaptation and land use management in Nigeria’s flood-prone basins: A systems perspective. *Journal of Flood Risk Management*, 17(1), e12971. https://doi.org/10.1111/jfr3.12971

[11] Aliyu, M., Ahmad, L., Adigun, H. A. & Jega, R. M. (2022). Flood risk assessment and mapping in the Hadejia River Basin, Nigeria, using hydro-geomorphic approach and multi-criterion decision-making method. *Water* 14(22), 3709. https://doi.org/10.3390/w14223709

[12] Adefisan, E. A., Abatan, A. A. & Abiodun, B. J. (2015). Trends in rainfall and temperature extremes in the Niger-Southwest Nigeria. *Theoretical and Applied Climatology*, 122(1–2), 1–17. https://doi.org/10.1007/s00704-014-1283-1

[13] Niang, I., Ruppel, O. C., Abdrabo, M., Essel, A., Lennard, C., Padgham, J. & Urquhart, P. (2014). Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Cambridge University Press.

[14] Adelekan, I. O. (2016). Flood risk management in the coastal city of Lagos, Nigeria. *Journal of Flood Risk Management* 9(3), 255–264. https://doi.org/10.1111/jfr3.12179

[15] Oloukoi, G., Bobadoye, A. & Subair, S. (2014). Land use change and urban flooding: Implication for sustainable development in Akure, Nigeria. *Environmental Management and Sustainable Development*, 3(2), 127–142. https://doi.org/10.5296/emsd.v3i2.6107

[16] Ologunorisa, T. E. & Adeyemo, A. (2005). Public perception of flood hazard in the Niger Delta, Nigeria. *Environmentalist* 25(1), 39–46. https://doi.org/10.1007/s10669-005-3094-5

[17] Tehrany, M. S., Pradhan, B. & Jebur, M. N. (2014). Flood susceptibility analysis and its validation using AHP and GIS. *Hydrological Processes* 28(6), 2765–2790. https://doi.org/10.1002/hyp.9975

[18] Abebe, Y., Kabir, G. & Tesfamariam, S. (2020). Assessing urban flood risk using GIS-based multi-criteria analysis. *Journal of Hydrology*, 590, 125236. https://doi.org/10.1016/j.jhydrol.2020.125236

[19] Oguntunde, P. G., Abiodun, B. J. & Lischeid, G. (2017). Rainfall trends and variability in the Ogun River Basin, Nigeria. *Hydrology Research*, 48(3), 1–13. https://doi.org/10.2166/nh.2016.197

[20] Aderogba, K. A. (2012). Qualitative studies of recent floods and sustainable growth and development of cities and towns in Nigeria. *International Journal of Academic Research in Economics and Management Sciences*, 1(3), 1–25.

[21] Odufuwa, B. O., Adedeji, O. H. & Oladesu, J. O. (2012). Floods of fury in Nigerian cities. *Natural Hazards*, 64(3), 1443–1455. https://doi.org/10.1007/s11069-012-0315-2