

Research Article

Flashflood Hazard Assessment in Yewa South Lga

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Abstract

In the bid to accomplish the Sustainable Development Goals, several attempts have been made in Yewa South LGA to accomplish environmental sustainability (SDG7) and reduce the adverse effects of climate change (SDG13). The area has witnessed recurrent flash floods with deleterious effect to lives and properties due to anthropogenic factors coupled with incessant torrential rainfall events which are the major drivers of flood vulnerability in the area. Previous studies have adopted the use of GIS, Remote sensing or an integration both techniques with associated challenges. This study adopts the use of Hydrologic Engineering Centre's Hydrologic Modelling System with Geographic Information Systems (HEC-GeoHMS) to evaluate the relationship between rainfalls, terrain characteristics, run off and stream flow as an alternative flood mitigation scheme. The catchment area was divided into forty-five sub basins over a 10m DEM, the run off hydrographs simulated and the hydrological characteristics modelled by using rainfall data between 1st June, 2022 – 31st May, 2023 as well as discharge data from Ogun-Osun River basin Development Authority (O-ORBDA). the model parameters were optimized for calibration and the calibrated model was thereafter validated using three statistical evaluation criteria which showed that there is a good simulation between the observed and estimated values (Rep = -2.24%, REv = 6.67%, NSE = 95.03%, and $R^2 = 0.83$). Further analysis of the results showed that the flash flood is induced mainly by hydrologic characteristics of the area. This work therefore proposes to mitigate flood in Yewa South Local Government Area of Ogun State by modelling how excess water runs on the terrain thereby creating flash floods. The model will serve as an input for putting mitigation measures in place to arrest flash floods.

Keywords

HEC-GeoHMS, Flashflood, Hazard, Mitigation, Hydrographs

1. Introduction

The growing population of Yewa and the increasing infra-structural development coupled with the incessant torrential rainfall events have increased the vulnerability of more lives and properties to flood disasters. Floods are caused by interaction of rainfall and the characteristics of the catchments.

How a catchment responds to rainfall under different physical characteristics such as soil properties, land use land cover, ground topography etc. [1-4], the aftermaths of which is a necessity to properly estimate the quantity of rainfall

runoff generated in a watershed. The study of the responses of the catchments to the rainfall, the amount of the rainfall and movement of underground water, are fundamentals to predict the hazards of pollution, flood and mitigation measures to protect these resources.

Floods according to Sherif et al., are the aggregations of hydrological, geomorphological, and meteorological conditions [5]. This have become an annual event in Yewa, occurring in the form of river flood, flash floods and urban flood.

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Flash floods are built up by specified geographical and physical factors that are mandatory for mitigation scheme. The mitigation schemes are based on various earth sciences which includes hydrology, geomorphology and meteorology [6]. Flash floods are special type of natural disasters that develops rapidly within a short duration. It is one of the most widespread environmental hazards in the world [6]. In the recent times, the flood events have greeted many states and cities.

Yewa communities like most communities in Nigeria have experienced severe flooding incidents [7-10]. It is on this premise that environmental activists some time ago called on the Federal Government to urgently declare a state of emergency on the environment to address issues relating to climate change as it spiraled into diseases and deaths thus, degrading the environment. This awareness is tagged world environment day and marked on every June 5 of the year.

Many researches have been conducted on flood risk assessment from diverse perspectives. The success of their outcome has been a function of the availability of qualitative data used, objectives of the flood risk assessment study and the expected results. The World Health Organization and the United Nations have both begun to emphasize that flash flood risk is becoming a growing concern in low-to-middle-income nations [11].

Olayinka & Irivbogbe applied the use of Remote Sensing, HEC-HMS, HEC-RAS and GIS to model and map flood in the adjoining areas of Lagos Island and part of Eti-Osa Local Government Areas of Lagos State [12]. Flood hazard map and 3D views of the flood model results were prepared and buildings that are prone to risk were assessed.

Adewara & Olapeju integrated Rainfall, Soil, Land Use Land Cover (LULC), Digital Elevation Model (DEM), Normalized Difference Vegetative Index (NDVI), Topographic wetness Index (TWI) and Drainage Density to identify areas liable to flooding in Kogi State using ArcGIS and Spatial Multi-Criteria Decision Analysis (SMCDA) [13]. Weighted overlay was performed to produce Hazard map of the state reclassification of the data. Results showed that the study area is characterized by low NDVI, low elevation and high rainfall waters, thus rendering the area highly vulnerable to flood.

In another development, Hassan et al., examined how urbanization, land use, and drainage infrastructure changes over the years contributes to flood risks and posited that improved drainage infrastructure is a necessary component to future resilience [14].

Very few researches have attempted to study flash flooding in Yewa South LGA of Ogun State, all of which have not studied it from environmental engineering perspective. Very few have studied it from hydraulic and hydrologic points of view, which is the bases for this present effort. Hydrological modelling has shifted from generating stream flow hydrographs into estimating distributed surface and subsurface flows. This paradigm shift necessitates a holistic description of the basin topography and the distributed properties of the hydrological processes acting on it [15, 16]. This present study integrates varieties of hydrologic flood data into Hydrologic computer program such as HEC-HMS and ArcGIS and statistically evaluating the outcomes which is a shortfall perceived in previous studies.

2. Materials and Method

2.1. The Study Area

The average coverage area of Ilaro is 622.226 km². The main river traversing the study area is the Yewa river, travelling 25.748km long southwards from the Ogun river, cutting across major towns like Idogo, Ebute Erimi, Alapa, Ojete, Ibiwo, Ojumo, Oke-Odan among others. Approximately, about 40% of the towns in the LGA lie on flood plains. The river empties its content into the Atlantic Ocean through the Badagry waters. The river is mostly used for agricultural supports. The climate of Yewa is classified as Tropical wet and dry climate with temperatures between 88-99 degrees Celsius. Precipitation is highest in September and October with an average of 80mm according to Ogun Osun River Basin Development (O-ORBD). Predominantly, Yewa south is a relatively flat terrain, a factor which is attributable to its flood characteristics as indicated in Figure 1.

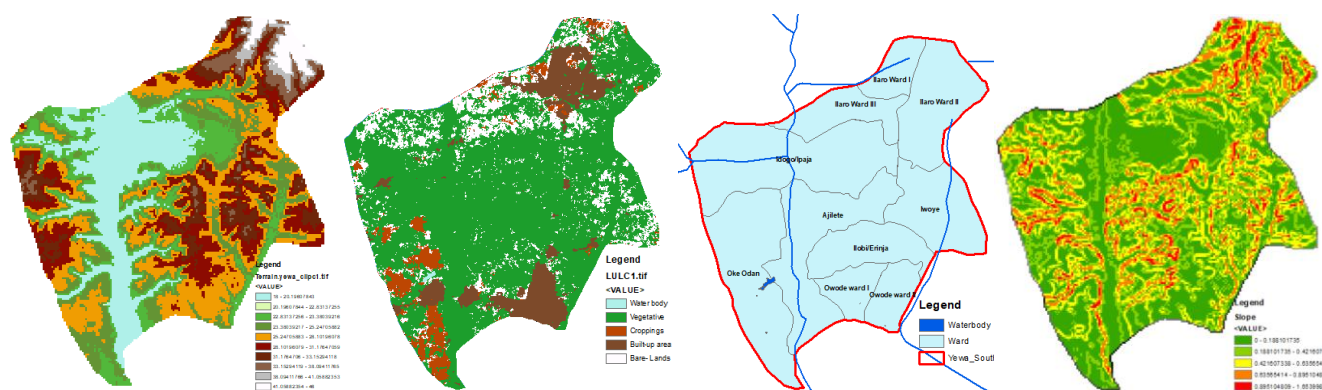


Figure 1. Elevation, Land Use Land Cover, Drainage Network and Slope maps of the study area.

2.2. Sources of Data

Several factors which demands research in details lead to the formation of flash floods: hydrometeorological, lithological and geomorphological, and anthropogenic factors [6]. Anthropogenic factors are not the main causes of flash flood

but they reinforce flash flood-producing forces. Lithological and geomorphological factors are precipitation, time of flow concentration, basin area etc while hydrometeorological factors are elevation within the basin, basin slope, land use land cover, rainfall, discharge flow data etc as shown in Figure 1 and Table 1.

Table 1. Data used for the study.

SN	Data	Purpose	Source
1	10m DEM	Data support for Hydrologic computations & modelling	NASA (https://urs.earthdata.nasa.gov/oauth/authorize?response_type=code&client_id=OLpAZIE4HqIOMr0TYqg7UQ&redirect_uri=https%3A%2F%2Fd53njncz5taqi.cloudfront.net%2Furs_callback&state=https%3A%2F%2Fsearch.earthdata.nasa.gov%2Fdownloads%2F5915390643%3Fee%3Dprod)
2	LULC	To estimate manning's value at each river cross section	Sentinel-2 10m Land Use/Land Cover Time series Downloader (https://www.arcgis.com/apps/instant/media/index.html?appid=fc92d38533d440078f17678ebc20e8e2)
3	Drainage Network details	Hydrographic data	Office of Surveyor General of the Federation (OSGOF)
5	Discharge, flow	Hydrologic modelling	Ogun-Oshun River Basin Development Authority, O-ORBDA Abeokuta, Ogun State, Nigeria
7	Monthly rainfall data	Hydrologic modelling	Ogun-Oshun River Basin Development Authority, O-ORBDA Abeokuta, Ogun State, Nigeria
8	Soil	Run off Curve Number determination	Harmonized World Soil Database

Source: Authors compilation

2.3. HMS Data Input

Hydrometeorological, lithological and geomorphological, and anthropogenic parameters serve as inputs to HMS. They are assigned using the sub-basin parameters option in HEC-HMS. SCS for Loss Method was selected to get excess rainfall from total rainfall and the SCS unit hydrograph for Transform Method was chosen to convert excess rainfall to direct runoff. The loss models in HEC-HMS normally calculate the runoff volume by computing the volume of water that is intercepted, infiltrated, stored, evaporated, or transpired and subtracting it from the precipitation. In this study, the Soil

Conservation Service Curve Number loss method was selected to estimate direct runoff from a specific or design rainfall as also adopted in [17].

3. Results

The ability of the simulated data to adequately match observed data is a function of acceptability of the result outcomes. Rainfall events were classed into 6 events as seen in table 2 below. Four rainfall events were selected for calibration while two rainfall events were selected for validation.

Table 2. Rainfall events selected for Calibration & Validation.

Events	Start date	Start time	End date	End time	Selection
Event 1	Jun 10 th 2022	0:00	Jul 24 th 2022	0:00	Calibration
Event 2	Aug 25 th 2022	0:00	Aug 31 st 2022	0:00	Calibration

Events	Start date	Start time	End date	End time	Selection
Event 3	Sept 4th 2022	0:00	Sept 11th 2022	0:00	Calibration
Event 4	Oct 9 th 2022	0:00	Oct 14 th 2022	0:00	Calibration
Event 5	Jan 24 th 2023	0:00	Jan 31 st 2023	0:00	Validation
Event 6	Apr 4 th 2023	0:00	May 19 th 2023	0:00	Validation

3.1. Catchment Delineation

HEC-HMS was used to hydrologically discretize the region into sub-catchments for homogenous analysis of land-use, soil type, etc. in order to address the spatial distribution of catchment features.



Figure 2. Hydrologically Connected Sub-Basin.

Table 3. Loss parameters.

	CN	l (Km)	Basin slope	Area (sqkm)	S = (1000/CN)-10	Y (%)	Tc	Lag (min)	Innitial Abstraction =0.2S
Subbasin-1	62	6.55294	0.01209	13.70213	6.129032	1.209	90.62141	3262.371	1.225806
Subbasin-10	62	5.24796	0.00404	3.758467	6.129032	0.404	131.2492	4724.972	1.225806
Subbasin-11	62	3.82998	0.00711	7.073021	6.129032	0.711	76.89842	2768.343	1.225806

	CN	l (Km)	Basin slope	Area (sqkm)	S = (1000/CN)-10	Y (%)	Tc	Lag (min)	Innitial Abstraction =0.2S
Subbasin-12	62	6.14985	0.00264	15.15225	6.129032	0.264	184.3252	6635.706	1.225806
Subbasin-13	60	6.57634	0.00353	8.404761	6.666667	0.353	176.9694	6370.9	1.333333
Subbasin-14	62	7.68589	0.008	8.819081	6.129032	0.8	126.5626	4556.253	1.225806
Subbasin-15	62	6.05414	0.00351	3.610496	6.129032	0.351	157.8641	5683.108	1.225806
Subbasin-16	22	6.23839	0.00676	8.227196	35.45455	0.676	365.1611	13145.8	7.090909
Subbasin-18	81	4.09055	0.00916	4.468729	2.345679	0.916	42.05234	1513.884	0.469136
Subbasin-19	81	6.2618	0.00496	8.404761	2.345679	0.496	80.33987	2892.235	0.469136
Subbasin-2	81	6.16714	0.00685	13.82051	2.345679	0.685	67.53585	2431.29	0.469136
Subbasin-20	22	6.16102	0.01098	9.144617	35.45455	1.098	283.6748	10212.29	7.090909
Subbasin-21	21	5.86482	0.00767	12.72552	37.61905	0.767	339.7354	12230.47	7.52381
Subbasin-22	81	5.02807	0.01153	9.914067	2.345679	1.153	44.20984	1591.554	0.469136
Subbasin-23	21	4.51198	0.007	5.238179	37.61905	0.7	288.3231	10379.63	7.52381
Subbasin-25	81	10.14216	0.00883	14.20523	2.345679	0.883	88.5598	3188.153	0.469136
Subbasin-26	81	8.01266	0.00384	17.19425	2.345679	0.384	111.2163	4003.786	0.469136
Subbasin-27	21	5.2001	0.00528	10.44676	37.61905	0.528	371.9008	13388.43	7.52381
Subbasin-28	22	14.96004	0.00546	26.07252	35.45455	0.546	817.9931	29447.75	7.090909
Subbasin-29	81	4.20355	0.00762	7.635311	2.345679	0.762	47.12247	1696.409	0.469136
Subbasin-30	21	2.88634	0.0071	3.462525	37.61905	0.71	200.2551	7209.182	7.52381
Subbasin-31	62	3.61009	0.00743	5.504527	6.129032	0.743	71.74886	2582.959	1.225806
Subbasin-32	62	3.82998	0.00367	6.362759	6.129032	0.367	107.0334	3853.201	1.225806
Subbasin-33	22	5.3365	0.0101	6.895456	35.45455	1.01	263.66	9491.761	7.090909
Subbasin-34	62	3.12963	0.00572	4.735077	6.129032	0.572	72.9443	2625.995	1.225806
Subbasin-35	62	3.82386	0.01079	3.166583	6.129032	1.079	62.34274	2244.339	1.225806
Subbasin-36	81	3.36681	0.0067	3.314554	2.345679	0.67	42.07751	1514.791	0.469136
Subbasin-37	21	3.30777	0.00677	3.551308	37.61905	0.677	228.7013	8233.246	7.52381
Subbasin-4	81	4.33995	0.01123	7.191398	2.345679	1.123	39.82085	1433.55	0.469136
Subbasin-40	81	5.55639	0.007	7.132209	2.345679	0.7	61.46073	2212.586	0.469136
Subbasin-42	81	4.5181	0.00958	5.859658	2.345679	0.958	44.52403	1602.865	0.469136
Subbasin-43	22	7.56783	0.00695	11.71932	35.45455	0.695	420.3243	15131.67	7.090909
Subbasin-45	81	5.61542	0.00768	6.451542	2.345679	0.768	59.17493	2130.298	0.469136
Subbasin-49	81	7.69811	0.01034	14.82671	2.345679	1.034	65.63865	2362.991	0.469136
Subbasin-5	62	7.06291	0.00363	12.34079	6.129032	0.363	175.6017	6321.66	1.225806
Subbasin-50	61	4.74916	0.00674	8.108819	6.393443	0.674	96.23428	3464.434	1.278689
Subbasin-54	81	4.31655	0.01141	5.59331	2.345679	1.141	39.335	1416.06	0.469136
Subbasin-57	62	5.68668	0.00652	5.682092	6.129032	0.652	110.1687	3966.073	1.225806
Subbasin-6	21	3.30777	0.00889	3.018611	37.61905	0.889	199.5777	7184.798	7.52381
Subbasin-64	62	9.69121	0.00658	12.25201	6.129032	0.658	167.9904	6047.654	1.225806
Subbasin-69	81	5.52687	0.00469	5.238179	2.345679	0.469	74.76693	2691.61	0.469136

	CN	l (Km)	Basin slope	Area (sqkm)	$S = (1000/CN)-10$	Y (%)	Tc	Lag (min)	Innitial Abstraction =0.2S
Subbasin-7	22	4.66061	0.00516	4.40954	35.45455	0.516	331.0009	11916.03	7.090909
Subbasin-71	62	4.85604	0.00452	4.113598	6.129032	0.452	116.6142	4198.113	1.225806
Subbasin-8	81	4.37558	0.0069	6.777079	2.345679	0.69	51.1348	1840.853	0.469136
Subbasin-9	61	8.78932	0.00867	16.27683	6.393443	0.867	138.842	4998.313	1.278689

Source: Authors results

3.2. Model Calibration

The model was calibrated and result of calibration is shown in figures 2 & 3. The Nash–Sutcliffe Efficiency (NSE) in equation 4 was used to test calibrated model to confirm that the hydrograph of observed values matches with the simulated values [18].

Table 4. Observed and simulated values before and after optimization.

Events	Observed	Peak Discharge (m³/s)			Total Volume (mm)					R²
		Simulated			Simulated					
		Bopt	Aopt	REp	Observed	Bopt	Aopt	REv	NSE	
Event 1	18.37	31.8	19.6	-0.067	315.83	362.83	337.02	-0.067	0.958	0.741
Event 2	114.68	345.2	122.7	-0.070	156.13	142.01	166.3	-0.065	0.968	0.940
Event 3	230.21	205.8	248.6	-0.080	150.85	142.31	176.43	-0.170	0.829	0.623
Event 4	18.70	211.9	17.2	0.080	332.64	253.31	355.12	-0.068	0.965	0.709
Mean	95.49	198.68	102.03	0.03	226.188	218.02	243.034	0.079	0.940	0.800

Bopt = Before optimization, Aopt=After optimization, Rep = Relative Error of Peak Discharge, REv = Relative Error of Total volumes

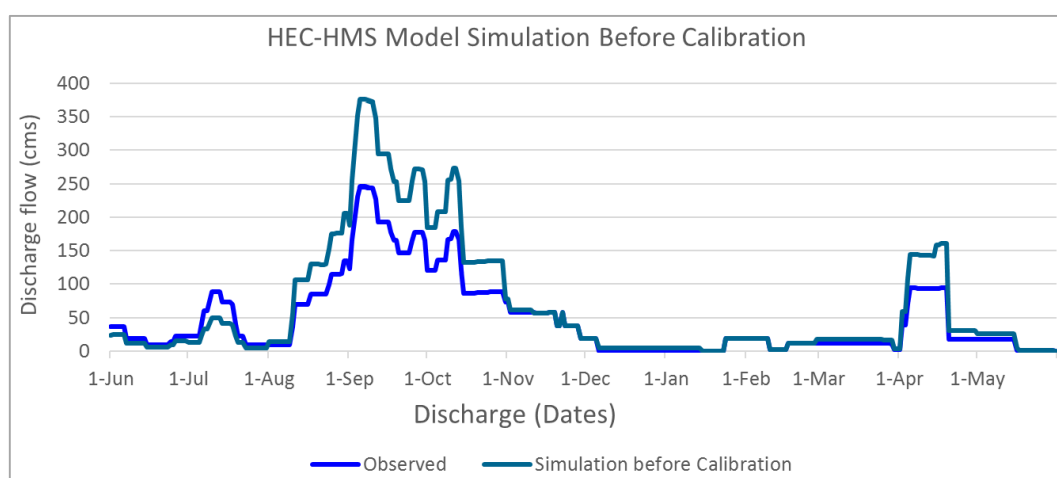


Figure 3. Model Simulation before Calibration (Authors results).

$$NSE = 1 - \frac{\sum_{t=1}^T (Q_o^t - Q_m^t)^2}{\sum_{t=1}^T (Q_o^t - Q_o^-)^2} \quad (1)$$

Where;

Q_o^- = mean of observed discharges (m^3/s), and

Q_m = modeled discharge (m^3/s), and

Q_o^t = observed discharge (m^3/s) at time t .

According to Nash–Sutcliffe, model efficiency ranges from infinity to 1.

$E = 1$ implies that there is a perfect match between modeled discharge and the observed data.

$E = 0$ implies that the predictions of model are as accurate as the mean of the observed data, $E < 0$ implies that the observed mean is a better predictor than the model.

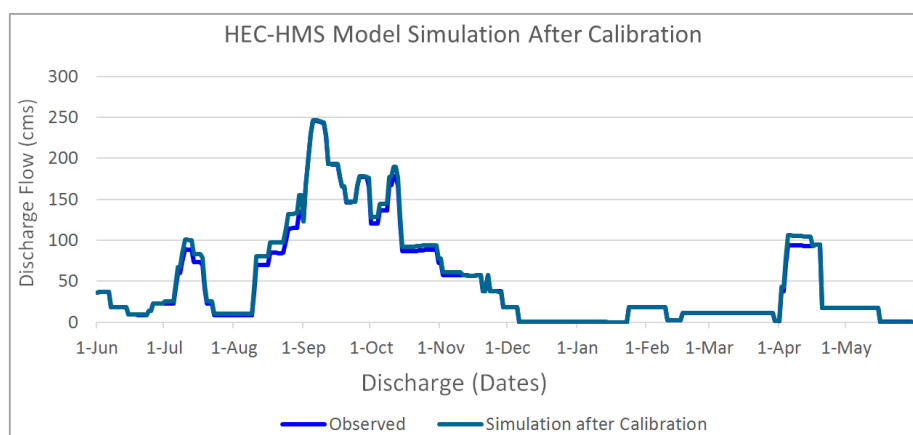


Figure 4. Model Simulation after Calibration (Authors results).

3.3. Model Validation

The calibrated model result was further subjected to validation where two extreme events, events 5 and 6 shown in Table 4 within the 12 months rainfall data that are different from the four extreme rainfall events were used for the model validation.

Table 5. Observed and simulated values before and after optimization.

Events	Observed	Peak Discharge (m³/s)			Total Volume (mm)				R²	
		Simulated			Simulated					
		Bopt	Aopt	REp	Observed	Bopt	Aopt	REv		NSE
Event 5	166.92	227.2	157.1	0.060	175.49	189.93	180.3	-0.027	0.983	0.987
Event 6	71.05	49.2	75.1	-0.060	144.79	178.08	145.45	-0.005	0.999	0.999
Mean	118.98	138.2	116.1	0.001	160.14	184.001	162.88	-0.016	0.992	0.993

Bopt= Before optimization, Aopt=After optimization, REp= Relative Error of Peak Discharge, REv = Relative Error of Total volumes
Three statistical evaluation criteria were used in this study and they showed that there is a good simulation between the observed and estimated values (REp= 0.001%, REv = -0.016%, NSE=0.992%, and $R^2= 0.993$).

Table 6. Sub Basin Characteristics.

Hydrologic Elements	Area_sqkm	Peak Dis-charge (m^3/s)	Loss Volume (mm)	Excess Vol-ume (mm)	Direct Runoff Volume (mm)	Town
Subbasin-4, 18 & 22	21.57419379	4.5	144.96	585.52	585.38	Ilobi/Erinja

Hydrologic Elements	Area_sqkm	Peak Dis-charge (m ³ /s)	Loss Volume (mm)	Excess Vol-ume (mm)	Direct Runoff Volume (mm)	Town
Subbasin-2, 12 & 36	32.2873051	3.9	192.64	537.74	531.71	Igbobe
Subbasin-1, 6, 16, 20, 28, 33 & 50	75.16934461	3.1	1170.93	533.29	486.30	Ilaro
Subbasin-26, 32 & 71	27.6706052	3	240.32	490.06	485.56	Idogo/Ipaja
Subbasin-29 42	13.49496895	2.7	96.64	390.38	390.23	Okuta
Subbasin-19 & 25	22.60999184	3.3	96.64	390.38	389.05	Erimi-Oguntade
Subbasin-8, 27 & 34	21.95891878	2.1	341.06	389.32	380.44	Ajelete
Subbasin-31 & 57	11.186619	1.2	192	294.92	293.27	Erimi-Ebute
Subbasin-5, 30, 37, 43	31.07394167	1.2	683.8	290.04	267.68	Owode
Subbasin-23 & 45	11.68972091	1.2	245.06	241.86	235.92	Ajilete
Subbasin-54	5.5933095	1.2	48.32	195.24	195.13	Oju-Ota
Subbasin-40	7.132209469	1.1	48.32	195.14	194.99	Iwoye
Subbasin-49	14.82670931	2.4	48.32	195.24	194.93	Alagbe
Subbasin-69	5.238178738	0.8	48.32	195.14	194.76	Araromi
Subbasin-14 & 21	21.54459956	1	292.74	194.18	184.57	Oke-Odan
Subbasin-35	3.166582627	0.4	96	147.46	147.32	Oke-Erinja
Subbasin-11	7.073021008	0.9	96	147.46	147.09	Ipake
Subbasin-10	3.75846723	0.3	96	147.46	145.1	Irogun-Akere
Subbasin-15	3.61049608	0.3	96	147.46	143.53	Ayekoshe
Subbasin-64	12.25201129	0.9	96	147.46	142.86	Ipaja
Subbasin-9	16.27682659	1.3	98.49	144.97	142.22	Elemuren
Subbasin-13	8.404761366	0.6	100	142.48	137.34	Kakanfo
Subbasin-7	4.409540294	0.1	194.32	49.14	41.6	Iweke

Source: Authors results

Table 7. Flash Flood Susceptibility Threshold.

Class	Susceptibility Threshold
500-600	Extremely High
400-500	Very High
300-400	High
200-300	Medium
100-200	Low
0-100	Very low

Source: Authors analysis

4. Discussion

The catchment was subdivided into 45 sub basins as shown in Figure 4 which were categorized into different CN based on the LULC as seen in Table 5. The LULC in Figure 1 showed that the area is dominated by crops, herbaceous grasslands, herbaceous wetlands, and Built-up areas (High/Low intensity Residential), which significantly contribute to the economic importance of the area.

4.1. Calibration and Validation

An NSE of 0.94 was obtained, thus indicating that the model and its parameters are very reliable since this value fall within NSE efficiency range from infinity to 1 according to Nash–Sutcliffe.

The model results with respect to observed data, NSE and

Coefficient of determination (R^2) shows the peak discharge and its relative errors as well as the total volume and its relative errors) in Table 3.

The simulated results of the peak discharge, total volume and their relative errors with respect to the observed data as well as the NSE and Coefficient of determination (R^2) were validated using events 5 and 6 (Table 4 & Figure 3), implying that there is close semblance between the simulated and observed values (Table 4) for all the events. The average relative percentage error between observed and simulated peak flow values is -0.001% while average relative percentage error between observed and simulated total volume is -0.016%. A Coefficient of determination ($R^2 = 0.992$) was obtained, showing that there is also a close agreement between the observed and simulated peak flow values. Using the NSE evaluation criteria, a better NSE value of 99.2% was obtained between the observed and simulated values.

These findings conform with the results of [19-21], and also gives acceptability to the overall model performance. A comparison of the model result with historical flood events data from O-ORBDA was performed which showed that the area is susceptible to flood at varying degrees, thus trusting the validity of the model, hence, a good reflection of ground reality as observed in [22-24].

4.2. Elevations

The slope of the catchment is divided into five classes, viz. very flat (0– 0.188 degrees), Gentle (0.188–0.421 degrees), Moderately gentle (0.421– 0.635), Gentle steep (0.635–0.895 degrees) and Steep (0.895 - 1.654 degrees), as shown in Figure 1. The maximum precipitation in the study area is usually from July to October, leading to increased devastating floods at these period. While 75% of flash floods occur in August, September and October (According to authors' analysis).

The most destructive type of floods are flash floods in smaller basin areas. The smaller a basin the faster is the flood wave that is formed. For instance, the time it takes water to travel in Sub-basin 1 (13.7km²) is 3,262 minutes while the lag time in a smaller basin (sub-basin 35) with 3.166km² area is 2,244 minutes as seen in Tables 5 and 6.

4.3. Sub Basin Areas and Runoffs

Data analysis demonstrated that the flash floods in Ilaro, Owode, Oke-Odan, Ajelete, Igboke, Idogo, Olute, Akere, are more extreme having sub-basin coverage between 3.0km² and 5.0km² with corresponding lag times between 2,691 minutes and 7,185 minutes respectively as indicated in Table 5 & Table 6.

Based on the run off volumes in Table 6, the study area has been classified into six (6) flash flood susceptibility thresholds (Table 3): Extremely high (Ilobi/Erinja and Igboke), Very high (Ilaro and Idogo/Ipaja), High (Okuta, Erimi-Oguntade

and Ajelete), Medium (Erimi-Ebute, Owode and Ajilete), Low (Oju-Ota, Iwoye, Alagbe, Araromi, Oke-Odan, Oke-Erinja, Ipake, Irogun –Akere, Ayekoshe,, Ipaja,, Elemuren and Kakanfo) and Very low (Iweke) respectively.

5. Conclusion

The small nature of spatial and temporal scale of flash flood events makes its study to be complicated. Its main factors being hydrological and meteorological, lithological and geomorphological, as well as anthropogenic.

Beyond the conventional flood depth and hazard maps preparations, other flood triggering characteristics can be generated by integration of GIS, HEC-HMS numerical modelling approach and statistical analysis of the output hydrological characteristics.

Water levels from the drainage networks have dropped between 2020 and 2022 in Yewa. However, the duration of flooding continues to increase.

6. Recommendations

As historical records showed that the periods of floods keep increasing, there is high probability that these tendencies, according to climate change scenarios will persist in the future. To keep abreast of this tendency requires stepping up the existing methods of approaches to addressing flood issues by embracing the adopted method in this study. Successful flow rate data simulation of Yewa South LGA through rainfall-runoff modelling using HEC-HMS can be used for further hydrological analysis. To adopt this method in other areas, this present study envisaged establishment of gauging stations in catchment areas in Nigeria to have a more refined data since the quality of data output is a function of the input data.

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Abbreviations

O-ORBDA Ogun-Osun River Basin Development

	Authority
NASA	National Aeronautics and Space Administration
OSGOF	Office of Surveyor General of the Federation
LULC	Land use Land Cover
DEM	Digital Elevation Model
HEC-HMS	Hydrological Engineering Center Hydrological Modelling Systems
HEC-RAS	Hydrological Engineering Center River Analysis Systems
HEC-GeoHMS	Hydrological Engineering Center Geospatial Hydrological Modelling Systems
ESRI	Environmental System Research Institute
GIS	Geographical Information Systems
CN	Curve Number
SCS	Soil Conservation Service
NDVI	Normalized Difference Vegetative Index
TWI	Topographic Wetness Index
SMCDA	Spatial Multi-Criteria Decision Analysis
SDG	Sustainable Development Goal

Declarations

Ethical Approval

The research is in conformity with the ethical soundness of project execution.

Consent to Participate

Authors declare that there is agreement among the research teams to be participative in the project.

Consent to Publish

Express permission is hereby given to Journal of Environmental Modelling and Software by all authors to publish the manuscript.

Author Contributions

Adebayo Adedokun: Conceptualization, Data curation, Formal analysis, Methodology, Writing original draft, Supervision

Monsur Adewara: Conceptualization, Data curation, Formal analysis, Methodology, Writing original draft, Investigation, Model calibration & validation, Writing review and editing

Oluwayemisi Adaradohun: Data curation, Writing review and editing, Investigation

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Conflicts of Interest

The authors declare no conflicts of interest.

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