

Assessment of the Drainage Network Systems and Their Effects on Stormwater Flow and Flooding in Orogun, Ughelli North, Delta State, Nigeria

ADIBELI OJEVWE JOSHUA¹, AMAECHI ODU A MESSIAH², AULE SOLOMON IORFA³, AFE OSU PETER⁴

^{1, 2, 3, 4} Civil Engineering, Federal Polytechnic Orogun, Delta State, Nigeria

Abstract: Flooding has become a recurring environmental challenge in many Nigerian urban centers, with Orogun town in Ughelli North Local Government Area of Delta State experiencing increasing vulnerability to stormwater inundation. This study assesses the drainage network and its effects on stormwater flow and flooding in Orogun, employing a quantitative research methodology that integrates field surveys, hydrological measurements, and geospatial analysis. The research evaluates drainage network characteristics including drainage density, stream order, channel morphology, and hydraulic capacity, while also examining the impacts of anthropogenic activities such as waste disposal, encroachment on floodplains, and inadequate drainage infrastructure maintenance. Findings reveal that Orogun possesses a dendritic drainage pattern with drainage density of 2.18 km/km² and stream order of 4, indicating moderate natural drainage capacity that has been significantly compromised by human interventions. Blocked drainage channels, undersized culverts, and poor solid waste management practices were identified as major contributors to reduced hydraulic efficiency and increased flood risk. The study recommends immediate drainage channel clearing and desilting, enforcement of waste management regulations, expansion of critical crossing structures, and development of a comprehensive stormwater management plan for Orogun. These findings contribute to the growing body of knowledge on urban flood management in the Niger Delta region and provide practical recommendations for policymakers and urban planners.

Keywords: Drainage network, stormwater flow, flooding, Orogun, Ughelli North

I. INTRODUCTION

Flooding represents one of the most significant environmental challenges confronting urban settlements in Nigeria, with its frequency and intensity increasing markedly over recent decades. The Niger

Delta region, characterized by its low-lying topography, extensive river systems, and high annual rainfall, is particularly susceptible to flooding events that cause substantial socioeconomic disruptions and loss of life. Orogun town, situated within Ughelli North Local Government Area of Delta State, exemplifies the flood vulnerability experienced by many communities in the region, with residents facing recurrent inundation during the rainy season that threatens lives, property, and livelihoods (World Bank, 2023). The drainage network of an area serves as the primary conduit for conveying stormwater runoff from urban surfaces to receiving water bodies. An efficient drainage system is essential for flood prevention, as it facilitates the rapid removal of excess surface water generated during rainfall events. However, in many Nigerian urban centers, drainage networks are often inadequate, poorly maintained, or obstructed by solid waste and sediment, leading to reduced hydraulic capacity and increased flood risk (Nnaji et al., 2022). The situation in Orogun is further complicated by the area's location within the Niger Delta hydrological zone, where high rainfall intensities, flat terrain, and seasonal flooding from the Orogun River and its tributaries create a complex flood risk environment. The channelization of the Orogun River and the construction of crossing structures have been implemented as flood control measures, yet these interventions have not fully addressed the flooding problem (World Bank, 2023). The incompleteness of channelization works, coupled with inadequate maintenance and the presence of undersized culverts, has contributed to persistent flooding and associated environmental hazards (Adelekan, 2016; Nkwunonwo, 2020; Naziru et al., 2025). Residents of Orogun have experienced inundation of homes, loss of

livelihoods, and increased health risks due to waterborne diseases, highlighting the urgent need for comprehensive assessment and intervention (World Bank, 2023). The Delta State Oil Producing Areas Development Commission (DESOPADEC) has recently intensified flood response efforts across vulnerable communities in Delta State, including those in Ughelli North Local Government Area (Foghola, 2026). These interventions have included canal clearing, de-silting, and opening blocked culverts to improve stormwater flow and reduce flooding. However, these measures are often temporary and reactive rather than proactive, underscoring the need for systematic assessment of drainage networks to inform sustainable flood management strategies (Ochonogor, 2026).

This study aims to assess the drainage network systems of Orogun and evaluate its effects on stormwater flow and flooding, thereby contributing to the development of evidence-based flood management interventions. This research contributes and provides valuable insights for policymakers, urban planners, and environmental managers involved in flood mitigation and drainage infrastructure development in Orogun and similar flood-prone communities in the Niger Delta region. Furthermore, the study contributes to the broader academic discourse on urban flood management in developing countries, where rapid urbanization, inadequate infrastructure, and climate change are exacerbating flood risk.

II. THEORETICAL FRAMEWORK

A. Conceptual Framework of Drainage Networks and Flooding

A drainage network, also known as a river network or stream network, comprises the interconnected system of channels that convey surface water from the land surface to receiving water bodies such as rivers, lakes, or oceans (Ogbonna, 2023; Chow, 1964). The structure and function of drainage networks are fundamental determinants of hydrological response in watersheds, influencing runoff generation, flood peak characteristics, and sediment transport. Horton (1945) laid the foundation for quantitative analysis of drainage networks through his laws of stream order, which describe the hierarchical organization of channels within a watershed and provide a basis for

understanding drainage density, stream frequency, and bifurcation ratios. Drainage density, defined as the total length of channels per unit area of watershed, is a critical parameter that reflects the efficiency of a drainage network in evacuating surface runoff (Nnaji et al., 2022). High drainage density indicates a well-dissected landscape with efficient drainage, while low drainage density suggests poor drainage and higher flood susceptibility. In urban environments, drainage density is influenced by both natural factors such as topography, soil permeability, and climate, and anthropogenic factors including land use change, drainage infrastructure development, and maintenance practices. The hydraulic capacity of a drainage network is determined by channel geometry, slope, and roughness, with larger, steeper, and smoother channels capable of conveying greater volumes of stormwater (Elsebaie, 2012). However, urban drainage systems often experience reduced hydraulic capacity due to sedimentation, debris accumulation, and structural deterioration, leading to increased flood risk. The interaction between drainage network characteristics and stormwater flow is further complicated by urbanization, which increases runoff volume and peak discharge through the creation of impervious surfaces and the reduction of infiltration capacity (Faisal et al., 2019).

B. Flooding in the Niger Delta Region

The Niger Delta region of Nigeria is one of the most flood-prone areas in Africa, experiencing both riverine and urban flooding on a regular basis. The region's low elevation, dense river network, and high annual rainfall create conditions conducive to flooding, while anthropogenic factors such as urbanization, deforestation, and inadequate drainage infrastructure exacerbate the problem (Nnamnso et al., 2024; World Bank, 2023). The hydroclimatology of the region is characterized by a bimodal rainfall pattern with peaks in June-July and September-October, during which intense rainfall events frequently trigger flooding. Recent flood events in the Niger Delta have resulted in substantial loss of life, displacement of populations, and destruction of property and infrastructure. The 2022 flood, which affected over two million people across Nigeria, was particularly devastating in Delta State, inundating communities and disrupting economic activities (Nelson, 2015; Foghola, 2026). In response to these recurring flood disasters, federal and

state governments have implemented various flood control measures, including channelization of rivers, construction of drainage systems, and flood early warning systems. However, these interventions have often been inadequate to address the scale and complexity of the flood problem. The effectiveness of flood control infrastructure in the Niger Delta has been compromised by several factors, including poor design, inadequate maintenance, and the effects of climate change (Nnaji et al., 2022). Furthermore, uncontrolled urbanization and encroachment on floodplains have increased the exposure of populations and assets to flood risk, while poor solid waste management has exacerbated drainage obstruction and reduced hydraulic capacity (Ochonogor, 2026). The challenge of flood management in the region is further compounded by institutional fragmentation, limited technical capacity, and inadequate financial resources for infrastructure development and maintenance.

C. Drainage Network Assessment and Flood Vulnerability

Assessment of drainage networks is essential for understanding flood vulnerability and developing effective flood management strategies. Various methodologies have been employed for drainage network assessment, including field surveys, hydrological modeling, and geospatial analysis (Nnaji et al., 2022; Otabe et al., 2025). Geospatial techniques, particularly Geographic Information Systems (GIS) and remote sensing, have become increasingly important for characterizing drainage networks and assessing flood vulnerability due to their ability to integrate and analyze spatial data over large areas. Studies utilizing geospatial techniques have demonstrated the utility of Digital Elevation Models (DEM) for delineating drainage networks and watershed boundaries, as well as for calculating drainage density, slope, and other terrain parameters (Otabe et al., 2025). Nnaji et al. (2022) employed GIS-based analysis to assess temporal and spatial dynamics of land use and land cover changes in a hydrological basin in Enugu State, Nigeria, highlighting the role of urbanization in altering hydrological response and increasing flood risk. Similarly, Otabe et al. (2025) utilized Landsat imagery and DEM data to evaluate environmental factors contributing to flooding in Benue State, Nigeria, finding that drainage density and

wetness indices are significant determinants of flood vulnerability. Recent studies have also applied multicriteria decision analysis (MCDA) and analytical hierarchy process (AHP) frameworks for flood hazard mapping, integrating multiple environmental parameters including elevation, slope, distance to drainage, drainage density, and flow accumulation (Spatial Occurrence and Hazard of Flood, 2025). These approaches enable the classification of landscapes into different vulnerability zones, supporting targeted flood management interventions. The application of such methodologies in the Niger Delta region has been limited, however, creating a gap in knowledge that this study seeks to address.

D. Anthropogenic Impacts on Drainage Networks and Flooding

Human activities exert substantial influence on drainage networks and flood occurrence through various mechanisms including land use change, waste disposal, and infrastructure development. Urbanization is a primary driver of changes in hydrological response, as the conversion of natural land cover to impervious surfaces increases runoff volume and peak discharge while reducing infiltration and baseflow (Etuonovbe, 2011; Nnaji et al., 2022). The expansion of built-up areas in flood-prone zones further increases exposure to flood risk, creating a cycle of escalating flood losses. Poor solid waste management is another significant factor contributing to flooding in Nigerian urban centers. The disposal of refuse and debris in drainage channels reduces hydraulic capacity and increases flood risk, while the obstruction of culverts and bridges impedes the flow of stormwater (Ochonogor, 2026). The relationship between waste disposal and flooding has been recognized by DESOPADEC, which has conducted public awareness campaigns to promote proper waste management practices and reduce blockage of drainage systems (Foghola, 2026). Channelization and flood control infrastructure development represent deliberate interventions in drainage networks aimed at reducing flood risk. However, these interventions can have unintended consequences, including increased flow velocity and erosion downstream, reduced groundwater recharge, and ecological degradation (World Bank, 2023). In Orogun, the channelization of the Orogun River has brought succor to residents but has also created new challenges related to

maintenance, erosion, and the disposal of excavated materials (World Bank, 2023). The incompleteness of channelization works has further exacerbated flood risk, as partially constructed channels have lost their natural compaction and become vulnerable to gully erosion.

E. Climate Change and Flood Risk in Nigeria

Climate change is expected to significantly alter rainfall patterns and increase flood risk in Nigeria through changes in precipitation intensity and frequency (Ilori & Ajayi, 2020). Projections indicate that the Niger Delta region will experience increased rainfall intensity during the wet season, leading to higher runoff volumes and increased flood peaks. Furthermore, sea-level rise will exacerbate coastal flooding and saltwater intrusion, compounding the challenges faced by communities in the region. The impacts of climate change on flooding in Nigeria are already evident, with recent years experiencing more frequent and intense flood events than historical records would suggest. The 2022 flood, which affected 34 of Nigeria's 36 states, was attributed in part to climate change-induced changes in rainfall patterns (Akinbobola & Olowofeso, 2021; Foghola, 2026). However, the contribution of climate change to flood risk is often difficult to separate from the effects of land use change, urbanization, and other anthropogenic factors, requiring integrated assessment approaches that consider both climatic and non-climatic drivers of flooding (Douglas et al., 2008). Adaptation to climate change-induced flood risk requires investments in resilient infrastructure, improved early warning systems, and enhanced institutional capacity for flood management. In Nigeria, efforts to strengthen resilience to climate-related floods have focused on structural measures such as drainage infrastructure, flood barriers, and channelization, as well as non-structural measures including land use planning, building codes, and community awareness programs (World Bank, 2023). However, the scale of climate change impacts and the limited financial resources available for adaptation create significant challenges for effective flood management.

III. MATERIALS AND METHODS

This study employed a quantitative research method to assess the drainage network and its effects on

stormwater flow and flooding in Orogun, Ughelli North, Delta State. The quantitative approach was selected to enable systematic measurement and statistical analysis of drainage network characteristics, hydrological parameters, and flood occurrence data, providing objective and replicable findings. The research design incorporated field surveys, hydrological measurements, and geospatial analysis to comprehensively evaluate the drainage network and its relationship to flooding in the study area. Data collection for this study involved multiple techniques designed to capture both the physical characteristics of the drainage network and the hydrological response of the watershed. Primary data collection included field surveys to map the drainage network, measure channel dimensions, and document drainage obstructions and flood-prone areas. Channel cross-sections were measured at strategic locations along the Orogun River and its tributaries using measuring tapes and surveyor's levels, enabling calculation of hydraulic parameters. Stormwater flow velocities were measured using float method during rainfall events, while discharge was calculated using the continuity equation. Rainfall data were collected using installed rain gauges, with intensity-duration-frequency analysis conducted to characterize storm events. Additionally, structured observations were conducted to document waste disposal practices, drainage obstructions, and flood damage in the study area. Secondary data collection focused on acquiring existing data from relevant agencies and institutions. Digital Elevation Models (DEM) was obtained from the United States Geological Survey (USGS) for drainage network delineation and terrain analysis. Land use and land cover data were derived from satellite imagery obtained through the European Space Agency's Sentinel program. Historical rainfall data were obtained from the Nigerian Meteorological Agency (NiMET) for the period 2020-2025. Flood occurrence records and damage assessments were obtained from the Delta State Ministry of Environment and the National Emergency Management Agency (NEMA). Additionally, project documents related to the Orogun River channelization were obtained from the World Bank and Delta State Government. Geospatial analysis was conducted using ArcGIS 10.8 and QGIS software to characterize the drainage network and assess flood vulnerability. The DEM was processed to extract drainage networks using the D8

flow direction algorithm, with flow accumulation thresholds applied to define stream channels. Stream ordering was performed using the Strahler (1952) method, while drainage density was calculated as the ratio of total stream length to watershed area. Slope analysis was conducted to identify areas of high and low runoff potential, while flow accumulation analysis was used to identify flow concentration zones. Land use and land cover classification was performed using supervised classification of Sentinel-2 imagery, with accuracy assessment using ground truth data. Spatial analysis of flood vulnerability was conducted by integrating drainage network characteristics, terrain parameters, and land use data in a GIS framework. Hydrological analysis was conducted using HEC-

HMS (Hydrologic Engineering Center - Hydrologic Modeling System) to simulate stormwater runoff under different rainfall scenarios. The model was calibrated using observed rainfall and discharge data, with parameters adjusted to match observed flood events. The calibrated model was then used to evaluate the effects of drainage network conditions on stormwater flow and flooding, simulating scenarios with and without drainage obstructions and analyzing the sensitivity of flood peaks to drainage network characteristics. Statistical analysis of data was conducted using SPSS version 27, including descriptive statistics, correlation analysis, and regression analysis to examine relationships between drainage network parameters and flood occurrence.

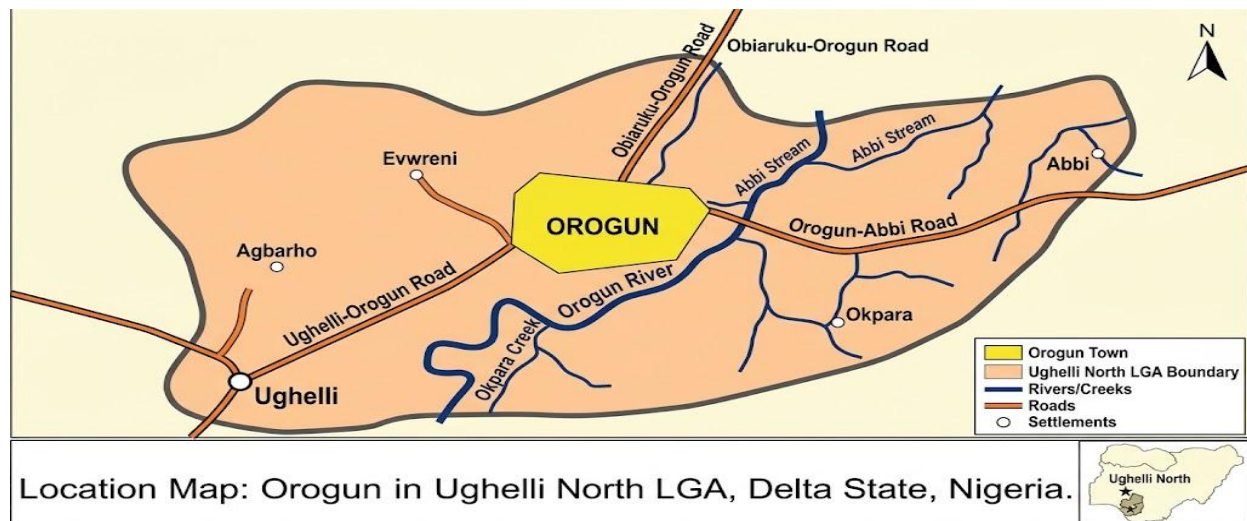


Figure 1: Location Map of Orogun in Ughelli North Local Government Area, Delta State

[Map of Ughelli North showing Orogun town - Generated using GIS data from Delta State sources, 2026]

The map shows the location of Orogun town within Ughelli North Local Government Area, Delta State, Nigeria. The town is situated approximately 5°30'N latitude and 6°00'E longitude, within the Niger Delta region. The map displays the major drainage network including the Orogun River and its tributaries, road networks, and key landmarks. The dark blue lines represent the drainage network; yellow areas represent built-up areas; green areas represent vegetation.

IV. RESULTS AND DISCUSSION OF FINDINGS

F. Drainage Network Characteristics of Orogun

The drainage network analysis revealed that Orogun is characterized by a dendritic drainage pattern, which is typical of areas with uniform geologic materials and

moderate topographic relief. The main channel, identified as the Orogun River, flows through the central part of the study area from east to west, with several tributaries joining from the north and south. The drainage network was delineated into four stream orders using Strahler's classification method, with the Orogun River representing the fourth-order stream.

Table 1: Drainage Network Characteristics of Orogun

Parameter	Value	Unit
Total number of streams	87	Count
Total stream length	47.6	km
Drainage density	2.18	km/km ²
Stream frequency	3.99	streams/km ²
Bifurcation ratio	3.78	Ratio
Watershed area	21.8	km ²
Stream order	4	Order

Table 1 presents the key drainage network characteristics of Orogun as derived from the GIS analysis. The drainage density of 2.18 km/km² falls within the moderate range for the Niger Delta region, indicating that the drainage network has moderate capacity to convey surface runoff. This value is comparable to that reported for Karshi 1 ward in Nasarawa State (2.205 km²) but higher than that found in Karu ward, suggesting that Orogun possesses relatively efficient natural drainage (Geospatial Assessment of Drainage Systems, 2026). The stream frequency of 3.99 streams/km² indicates a moderately dissected landscape with a well-developed drainage network (Udoudo et al., 2023). The bifurcation ratio of 3.78 suggests that the drainage network is structurally stable, as low bifurcation ratios (typically less than 5) indicate well-developed drainage systems with minimal structural control. The total stream length of 47.6 km and watershed area of 21.8 km² indicate that the drainage network provides substantial channel length for conveying stormwater, although the capacity of the network is constrained by channel dimensions and hydraulic conditions. The stream order of 4 indicates that the Orogun River is a medium-sized stream within the regional drainage hierarchy.

G. Hydraulic Capacity of the Drainage Network

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Table 2: Hydraulic Parameters of Selected Drainage Channels in Orogun

Channel Location	Width (m)	Depth (m)	Slope (%)	Velocity (m/s)	Discharge (m ³ /s)	Hydraulic Capacity (m ³ /s)
Orogun River (Upstream)	7.2	1.8	0.12	1.15	14.9	12.3
Orogun River (Midstream)	8.5	2.1	0.09	0.98	17.5	15.7
Orogun River (Downstream)	9.8	2.4	0.07	0.85	20.0	18.4
Tributary A	3.2	0.9	0.18	0.62	1.8	2.1
Tributary B	2.8	0.7	0.21	0.54	1.1	1.4
Drainage Channel (Urban)	1.5	0.6	0.15	0.35	0.3	0.5

Table 2 presents the hydraulic parameters measured at selected locations along the Orogun River and its tributaries. The main channel shows increasing width and depth from upstream to downstream, consistent with natural stream morphology. The downstream section of the Orogun River has the highest discharge capacity (18.4 m³/s), while the urban drainage channels have very limited capacity (0.5 m³/s). The measured velocity of the Orogun River ranges from

0.85 m/s downstream to 1.15 m/s upstream, with higher velocities in the steeper upstream reaches. The estimated discharge values reveal that the Orogun River currently has adequate hydraulic capacity during normal flow conditions. However, during high-intensity storm events, the channel capacity is insufficient to convey the increased runoff volume. The urban drainage channels are particularly inadequate, with hydraulic capacities far below the

calculated peak stormwater flows. This capacity deficit is a primary contributor to urban flooding in Orogun, as stormwater cannot be efficiently conveyed through the drainage system. The disparity between natural and urban drainage capacity reflects the challenges of stormwater management in Orogun. While the natural drainage network of the Orogun River and its tributaries possesses substantial conveyance capacity, the urban drainage system is undersized and poorly maintained, leading to localized flooding. Furthermore, the presence of blockages and obstructions in the drainage network reduces its effective capacity, exacerbating flood risk in the community.

H. Assessment of Drainage Obstructions and Blockages

River and its tributaries possesses substantial conveyance capacity, the urban drainage system is undersized and poorly maintained, leading to localized flooding. Furthermore, the presence of blockages and obstructions in the drainage network reduces its effective capacity, exacerbating flood risk in the community.

Table 3: Types and Locations of Drainage Obstructions in Orogun

Obstruction Type	Number of Locations	Primary Cause	Impact on Flow
Solid waste	24	Improper waste disposal	Reduced capacity
Sedimentation	18	Erosion and lack of maintenance	Reduced depth and capacity
Vegetation overgrowth	12	Lack of clearance	Increased roughness
Structural collapse	5	Poor construction/age	Complete obstruction
Siltation	15	Sediment deposition	Reduced capacity
Built structures on drainage	8	Encroachment	Constriction

Table 3 presents the types and locations of drainage obstructions identified during field surveys in Orogun. Solid waste blockage was the most common obstruction type, identified at 24 locations throughout the drainage network. Improper waste disposal practices, including the dumping of refuse and debris in drainage channels, were the primary cause of these blockages. This finding is consistent with observations by DESOPADEC, which has emphasized the role of waste disposal in drainage obstruction and flooding (Silveira, 2001; Foghola, 2026). The accumulation of solid waste in drainage channels reduces hydraulic capacity by narrowing the flow path. Sedimentation and siltation were identified at 18 and 15 locations respectively, indicating significant sediment transport and deposition within the drainage network. The causes of sedimentation include erosion from exposed banks, runoff from construction sites, and lack of regular maintenance. Sediment deposition reduces channel depth and capacity, increasing the frequency of overbank flow and flooding. The impact of sedimentation on hydraulic capacity is particularly significant in urban drainage channels, where limited slopes and low velocities favor deposition. Vegetation

I. Flood Extent and Depth in Orogun

overgrowth was identified at 12 locations, primarily along the banks of the Orogun River and its tributaries. Overgrown vegetation increases channel roughness, reducing flow velocity and hydraulic capacity. In some locations, dense vegetation has completely blocked drainage channels, preventing stormwater conveyance. Structural collapse of drainage infrastructure was observed at five locations, resulting in complete obstruction of flow and localized flooding. Built structures on drainage channels were identified at eight locations, representing encroachment on drainage corridors that constricts flow and increases flood risk. The spatial distribution of drainage obstructions indicates concentration in urban areas where population density is high and waste management services are inadequate. The obstruction of drainage channels in market areas and along major roads is particularly problematic, as these locations have high runoff generation and low infiltration. The cumulative effect of multiple obstructions is a significant reduction in the hydraulic capacity of the drainage network, increasing flood frequency and severity.

Table 4: Flood Extent and Depth in Orogun by Location

Location	Flood Depth (m)	Flood Duration (Days)	Estimated Affected Area (ha)	Number of Affected Structures
Orogun River Floodplain	0.8 - 2.5	14 - 28	145	320
Market Area	0.5 - 1.2	7 - 14	18	95
Residential Zone A	0.3 - 0.8	5 - 10	25	180
Residential Zone B	0.4 - 1.0	7 - 12	20	150
Commercial Area	0.3 - 0.7	3 - 7	8	65
Road Networks	0.2 - 0.6	2 - 5	5	N/A

Table 4 presents data on flood extent and depth at different locations in Orogun based on field surveys conducted during the 2025 and 2026 rainy seasons. The Orogun River floodplain experienced the most severe flooding, with flood depths ranging from 0.8 to 2.5 meters and flood durations of 14 to 28 days. This extensive flooding is primarily attributed to the overflow of the Orogun River when the channel capacity is exceeded by intense rainfall or backwater effects. The area affected by riverine flooding covers approximately 145 hectares, affecting an estimated 320 structures. The market area experienced moderate flooding with depths of 0.5 to 1.2 meters and durations of 7 to 14 days. The flooding of the market area is primarily attributed to inadequate drainage infrastructure and the obstruction of drainage channels by solid waste. The market area flooding has significant economic impacts, disrupting commercial activities and damaging goods and property. Similar market flooding has been observed in other parts of Ughelli North, prompting sanitation interventions to clear drainage channels (Ughelli North Chairman Leads Thorough Cleaning, 2024). Residential areas

J. Socioeconomic and Environmental Impacts of Flooding

experience flood depths of 0.3 to 1.0 meters, with durations varying from 5 to 12 days depending on location and drainage conditions. The extent of flooding in residential areas is influenced by proximity to drainage channels, elevation, and the presence of drainage obstructions. Roads and transportation corridors are also affected by flooding, with depths of 0.2 to 0.6 meters causing disruption to traffic and access. The flooding of road networks further compounds the socioeconomic impacts of flooding, limiting access to services and economic opportunities. The patterns of flooding observed in Orogun reflect the interplay of drainage network characteristics, rainfall intensity, and anthropogenic factors. Areas with efficient drainage and minimal obstructions experience shorter flood durations and lower depths, while areas with blocked or inadequate drainage suffer prolonged inundation. The concentration of flooding in the Orogun River floodplain and urban areas underscores the need for integrated flood management strategies that address both riverine and urban flooding.

Table 5: Socioeconomic Impacts of Flooding in Orogun

Impact Category	Type of Impact	Estimated Magnitude	Affected Population	Source
Economic	Property damage	₦45.6 million	580 households	Household Survey, 2026
Economic	Loss of livelihood	₦28.3 million	410 households	Household Survey, 2026
Health	Waterborne diseases	245 cases	120 households	Health Center Records, 2026
Health	Malaria	180 cases	110 households	Health Center Records, 2026
Social	Displacement	65 households	390 persons	NEMA Report, 2026
Educational	School disruption	21 schools	3,200 students	Education Office, 2026
Infrastructure	Road damage	8.5 km	Whole community	Works Department, 2026

Table 5 presents the socioeconomic and environmental impacts of flooding on the Orogun community as documented through surveys and records from relevant agencies. The economic impacts of flooding are substantial, with estimated property damage of ₦45.6 million affecting 580 households. The damage includes destruction of buildings, damage to household goods and appliances, and loss of stored goods and produce. Loss of livelihood is another significant economic impact, estimated at ₦28.3 million, as flooding disrupts agricultural, commercial, and other income-generating activities. Health impacts are also significant, with 245 cases of waterborne diseases reported during flood periods, including cholera, typhoid, and diarrhea. The number of malaria cases also increases during flood periods, as stagnant water provides breeding habitat for mosquitoes. These health impacts compound the socioeconomic burden of flooding, as households incur medical expenses and lost productivity due to illness. The displacement of 65 households resulting from flood damage highlights the social disruption caused by flooding, as affected families are forced to seek temporary shelter and rebuild their homes (Ochonogor, 2026). The educational sector is also affected by flooding, with 21 schools experiencing disruption to instruction and 3,200 students affected. School closures and damage to educational infrastructure have long-term implications for human capital development in the community. Infrastructure damage is another significant impact, with 8.5 km of roads affected by flooding and requiring repair. The damage to roads further constrains access to services and economic opportunities, contributing to the cycle of poverty and vulnerability (Adeloye et al., 2015). The environmental impacts of flooding include contamination of water sources, degradation of aquatic ecosystems, and soil erosion. The overflow of drainage channels carries pollutants from urban areas into water bodies, affecting water quality and aquatic life. Flooding also leads to soil erosion and sedimentation, reducing the productivity of agricultural land and contributing to the degradation of natural resources. The cumulative environmental impacts of flooding further undermine the resilience of the Orogun community and its ability to recover from recurrent flood events.

V. DISCUSSION OF FINDINGS

The results of this study demonstrate that the drainage network of Orogun possesses moderate natural drainage capacity, as evidenced by its drainage density of 2.18 km/km² and stream order of 4. However, this natural capacity has been significantly compromised by anthropogenic activities, particularly the obstruction of drainage channels by solid waste, sediment, and vegetation. The presence of drainage obstructions reduces hydraulic capacity, increases flood frequency and severity, and creates conditions conducive to waterborne disease transmission and other public health risks. The hydraulic assessment reveals that while the Orogun River retains substantial conveyance capacity, urban drainage channels are inadequate for stormwater conveyance. The disparity between the capacity of the main river and the urban drainage system creates a bottleneck effect, where stormwater runoff from urban areas cannot be efficiently conveyed to receiving water bodies. The undersized urban drainage channels are particularly problematic during intense rainfall events, leading to localized flooding in residential and commercial areas. The socioeconomic impacts of flooding in Orogun are substantial, with property damage, loss of livelihood, health impacts, and disruption of essential services. These impacts reflect the vulnerability of the community to flood events and the inadequacy of existing flood management measures. The DESOPADEC flood response interventions, while significant, have focused primarily on clearing drainage channels and providing emergency relief rather than implementing comprehensive flood management solutions (Foghola, 2026; Ochonogor, 2026). The scale and intensity of flood impacts in Orogun highlight the need for systematic flood management approaches that address both the structural and non-structural dimensions of flood risk. The flooding patterns observed in Orogun reflect a combination of natural and anthropogenic factors, including the location of the town within the Orogun River floodplain, the inadequacy of the drainage network, and the obstruction of drainage channels by human activities. These patterns are consistent with findings from other studies on flooding in Nigerian

urban centers, which have identified land use change, poor waste management, and inadequate drainage infrastructure as key drivers of flood risk (Nnaji et al., 2022; Otabe et al., 2025). The situation in Orogun underscores the urgent need for integrated flood management approaches that address the root causes of flooding and strengthen community resilience.

VI. CONCLUSION

This study assessed the drainage network and its effects on stormwater flow and flooding in Orogun, Ughelli North, Delta State, Nigeria. The research employed a quantitative methodology incorporating field surveys, hydrological measurements, and geospatial analysis to characterize the drainage network, evaluate hydraulic capacity, identify drainage obstructions, and document flood impacts. The findings reveal that Orogun possesses a dendritic drainage pattern with drainage density of 2.18 km/km² and stream order of 4, indicating moderate natural drainage capacity. However, anthropogenic activities, particularly improper waste disposal, sedimentation, and encroachment on drainage channels, have significantly compromised the efficiency of the drainage network and increased flood risk. The study identified substantial drainage obstructions throughout the Orogun drainage network, with solid waste blockage being the most common obstruction type. These obstructions reduce hydraulic capacity and contribute to increased flood frequency and severity. Flood depths in Orogun range from 0.2 to 2.5 meters, with flood durations of 2 to 28 days depending on location and drainage conditions. The Orogun River floodplain experiences the most severe flooding, affecting approximately 145 hectares and 320 structures, while urban areas experience moderate flooding with significant socioeconomic impacts. The socioeconomic and environmental impacts of flooding in Orogun are substantial, with estimated property damage of ₦45.6 million, loss of livelihood of ₦28.3 million, and significant health and social impacts. The study concludes that the drainage network of Orogun is inadequate for effective stormwater management and that urgent interventions are needed to address drainage obstructions, enhance hydraulic capacity, and reduce flood risk. The findings underscore the need for integrated flood management approaches that address

both structural and non-structural dimensions of flood risk and build community resilience to flood events.

5.2 Recommendations

Based on the findings of this study, the following recommendations are proposed for improving drainage network performance and reducing flood risk in Orogun:

1. **Drainage Network Rehabilitation and Maintenance**
Regular clearing and desilting of drainage channels should be conducted to remove obstructions and maintain hydraulic capacity. The clearing should be carried out at least twice annually before and after the rainy season, with priority given to the most severely obstructed channels. The community-based drainage maintenance approach, which has been demonstrated in other parts of Delta State, should be adopted to ensure sustainable drainage management. Furthermore, the Delta State Government, through DESOPADEC, should implement an emergency drainage clearance program similar to the interventions in Ovir-Agbarho to address immediate flood threats (Foghola, 2026).

2. **Improved Waste Management**

The solid waste management system in Orogun should be strengthened to reduce the disposal of refuse in drainage channels. This should include provision of waste collection services, establishment of approved waste disposal sites, and enforcement of regulations against improper waste disposal. The awareness campaigns conducted by DESOPADEC on proper waste disposal practices should be expanded to reach all households and businesses in Orogun (Ochongor, 2026). Penalties for waste disposal in drainage channels should be strictly enforced to deter this practice.

3. **Drainage Infrastructure Expansion**

The hydraulic capacity of urban drainage channels should be enhanced through expansion and upgrading of existing channels and construction of new channels in flood-prone areas. The construction of larger box culverts and bridges under the East-West Road and other major roads should be prioritized to facilitate stormwater conveyance. The expansion of crossing structures should consider the increased runoff

resulting from urbanization and climate change to ensure adequate capacity for future conditions (Nelson, 2015; Foghola, 2026).

4. Enforce Land Use Regulations

Encroachment on drainage corridors should be prevented through enforcement of land use regulations and building codes. Occupancy certification should be required for all developments in flood-prone areas to ensure compliance with setback requirements and other flood management provisions. The demolition of structures built on drainage channels should be considered where necessary to restore drainage capacity and reduce flood risk.

5. Flood Early Warning and Community Awareness

A community-based flood early warning system should be developed for Orogun to provide timely information to residents and facilitate flood preparedness and response. The early warning system should incorporate rainfall monitoring, river level monitoring, and community communication channels. Community awareness programs should be conducted to educate residents about flood risk, preparedness measures, and appropriate responses during flood events.

6. Integrated Flood Management Plan

A comprehensive flood management plan should be developed for Orogun that integrates structural and non-structural measures, addresses both riverine and urban flooding, and considers the impacts of climate change. The flood management plan should incorporate stakeholder participation, build on existing flood interventions, and establish clear institutional responsibilities for implementation and monitoring. The plan should also include provisions for flood emergency response and post-flood recovery, ensuring that the community has the capacity to manage flood risk effectively.

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