Assessment of the Causes, Patterns, And Environmental Impacts of Urban Flooding in Jimeta, Adamawa State, Nigeria

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Abstract
Urban flooding is a recurring environmental problem in Jimeta, Adamawa State, with adverse implications for infrastructure, settlements, drainage systems, and environmental sanitation. This study assessed the causes, patterns, and environmental impacts of urban flooding in Jimeta. Specifically, it identified the major causes of flooding, examined its spatial and temporal patterns, and assessed its environmental consequences. The study adopted a descriptive survey research design and utilised primary and secondary data. Primary data were obtained through structured questionnaires administered to residents of selected flood-prone communities, supplemented by field observations. Secondary data were obtained from relevant literature and documented sources on flooding in the study area. Data were analysed using frequency counts, percentages, mean, and standard deviation, with a criterion mean of 2.50 used to interpret responses to four-point Likert-scale items. The findings revealed that inadequate drainage systems were the most prominent reported cause of flooding, with a mean score of 3.62, followed by blockage of drainage channels by waste (3.57) and heavy and prolonged rainfall (3.55). Regarding flooding patterns, 78.0% of respondents reported that flooding occurred during heavy rainfall, while 74.0% indicated that it occurred mainly during the rainy season. Furthermore, 69.5% reported repeated flooding in the same locations, suggesting persistent vulnerability in certain parts of Jimeta. Soil erosion was identified as the most prominent environmental impact, with a mean score of 3.61, followed by the accumulation and spread of solid waste (3.56), damage to roads and drainage infrastructure (3.53), and water pollution or contamination (3.49). The study concluded that urban flooding in Jimeta results from the interaction of natural factors and human activities, particularly heavy rainfall, inadequate drainage, improper waste disposal, and development in flood-prone areas. It recommended regular maintenance of drainage infrastructure, improved solid-waste management, enforcement of land-use regulations, and sustained public environmental awareness to reduce flood occurrence and its environmental consequences.

Keywords: *Urban flooding, causes of flooding, flood patterns, environmental impacts, Jimeta.*

1. Introduction

Flooding is a major environmental hazard that affects human settlements, infrastructure, economic activities, and natural ecosystems. It occurs when water accumulates or flows onto land that is normally dry, often because rainfall, river discharge, or other sources of water exceed the capacity of the surrounding environment to accommodate or convey it. In urban areas, flooding is particularly problematic because natural drainage systems are frequently modified by buildings, roads, paved surfaces, and other forms of development. The resulting changes can increase surface runoff, reduce infiltration, and place additional pressure on drainage infrastructure. Urban flooding is influenced by the interaction of climatic, hydrological, topographical, infrastructural, and human factors. Heavy rainfall can trigger flooding where drainage channels are inadequate or obstructed, while low-lying terrain and proximity to rivers can increase exposure to water accumulation. Rapid urbanisation may intensify the problem when development takes place without sufficient drainage provision or when natural waterways are narrowed, obstructed, or encroached upon. The Intergovernmental Panel on Climate Change (IPCC, 2021, 2022) discusses the importance of climate-related hazards, exposure, vulnerability, and adaptation in understanding risks associated with extreme weather and flooding. Nevertheless, the causes and severity of flooding in a particular locality must be established using appropriate local evidence rather than inferred from general climate trends alone.

In Nigeria, urban flooding is an important environmental and developmental concern because of its potential consequences for residential areas, roads, commercial activities, public health, and environmental sanitation. The severity of flooding varies between locations according to rainfall characteristics, terrain, drainage capacity, land use, and the extent of human interference with natural watercourses. Poor solid-waste management can also contribute to flooding when refuse obstructs drainage channels and restricts the movement of stormwater. Effective flood management therefore requires an understanding of both physical environmental conditions and human activities that influence runoff and drainage. Jimeta, within Yola North Local Government Area of Adamawa State, provides a relevant setting for examining urban flooding. Its location within the Upper Benue environment, proximity to the River Benue, and presence of low-lying areas make flood-risk assessment important for urban planning and environmental management. Previous studies have examined flood-prone areas, terrain characteristics, and settlement vulnerability in the wider Yola–Jimeta area. Isa and Musa (2018), for example, used remote sensing and geographic information system techniques to identify built-up areas vulnerable to flooding. Barde et al. (2019) also investigated flood-prone areas in Jimeta using spatial and terrain-related information. These studies demonstrate the importance of understanding the relationship between urban development and the physical environment. Flooding can have consequences that extend beyond the temporary accumulation of water. Floodwater may erode exposed soil, deposit sediment, damage roads and drainage channels, transport solid waste, and contaminate water sources. It can also disrupt transportation, residential activities, and access to essential services. Where floodwater mixes with human waste or other contaminants, it may create additional environmental-health concerns. Yohanna et al. (2018) identified flooding and erosion among the environmental problems perceived by residents of Jimeta, highlighting the importance of drainage and environmental management in the area.

Although previous studies have examined flood susceptibility, terrain conditions, and residents' perceptions of environmental problems in Jimeta and the wider Yola area, there remains a need to consider the reported causes of flooding alongside its seasonal occurrence and environmental consequences. Understanding these dimensions together can help clarify the problems residents

experience and identify practical priorities for flood-risk reduction. Such an assessment should, however, distinguish between residents' perceptions and independently measured hydrological or spatial conditions. Against this background, the present study assesses the causes, reported patterns, and environmental impacts of urban flooding in Jimeta, Adamawa State. Its findings are intended to contribute to local flood-management discussions and support evidence-based decisions on drainage maintenance, waste management, land-use planning, and environmental protection.

Statement of the Problem

Urban flooding is a recurring environmental concern in Jimeta, where heavy rainfall may interact with drainage deficiencies, inappropriate waste disposal, low-lying terrain, and development in flood-prone locations. Flood events can affect roads, residential areas, drainage infrastructure, environmental sanitation, and other components of the urban environment. Their consequences may be intensified when drainage channels are obstructed or when development interferes with natural watercourses. Previous studies have investigated flood-prone areas and the spatial vulnerability of settlements in Jimeta and the wider Yola urban environment. However, understanding the problem also requires information about residents' experiences of flooding, the conditions they associate with its occurrence, its seasonal and locational patterns, and the environmental effects they observe. These issues are relevant to identifying appropriate local management priorities. The present study therefore examines the perceived causes, reported patterns of occurrence, and environmental impacts of urban flooding in Jimeta. By considering these dimensions together, the study seeks to provide information that can support improved drainage management, appropriate waste disposal, land-use planning, and flood-risk reduction. The extent to which its findings represent measured flood behaviour depends on the quality of the underlying survey data and, where spatial claims are made, the availability of verified mapping or hydrological evidence.

Aim and Objectives of the Study

The aim of the study is to assess the causes, patterns, and environmental impacts of urban flooding in Jimeta, Adamawa State.

The specific objectives are to:

1. Identify the major factors residents associate with urban flooding in Jimeta.
2. Examine the reported seasonal, locational, and recurring patterns of urban flooding in the study area.
3. Assess the environmental impacts of urban flooding reported by residents in Jimeta.

Research Questions

The study is guided by the following research questions:

1. What are the major factors residents associate with urban flooding in Jimeta?
2. What seasonal and locational patterns of urban flooding do residents report in the study area?
3. What environmental impacts of urban flooding do residents identify in Jimeta?

2. Reviews

Barde, Abdullahi, and Muhammadu (2019) investigated the detection and mapping of flood-prone areas in Jimeta Metropolis, Adamawa State, Nigeria, using remote sensing and Geographic Information System (GIS) techniques. The study examined physical terrain characteristics,

including elevation, slope, drainage patterns, and their relationship with urban settlements exposed to flood risks. Elevation data were obtained from Shuttle Radar Topographic Mission (SRTM) data and Landsat imagery, while Surfer 8 and ArcGIS 10.2 were used to develop Surface Elevation Models (SEM), Digital Elevation Models (DEM), contour maps, and flood simulation models. The study identified two extensive Benue River floodplains located at the northern and southern fringes of Jimeta and established that inadequate carrying capacity of the River Benue and Lake Gerio, partly resulting from sediment deposition, contributed significantly to flood hazards. Buffer analysis was subsequently used to identify and map areas susceptible to flooding, particularly around natural streams. The authors recommended relocating residents from vulnerable riverbank areas, developing effective drainage systems in flood-prone communities such as Doubeli and Damilu, and dredging and expanding the River Benue and Lake Gerio to improve their capacity to accommodate runoff. The study demonstrates the usefulness of GIS, remote sensing, and terrain-based modelling for identifying flood-risk zones and supporting urban flood-management and planning decisions.

Malik et al. (2026) assessed the application of the Topographic Wetness Index (TWI) for delineating flood-prone zones in the Yola Sub-Basin, Nigeria, using a high-resolution Digital Elevation Model (DEM) and GIS-based techniques. The study employed a 30-metre Shuttle Radar Topography Mission (SRTM) DEM, which was processed using ArcGIS Pro 3.1 and Python scripting to perform hydrological conditioning, flow-direction analysis using the D8 algorithm, and slope-gradient computation. The results showed that TWI values ranged from 2.5 in steep upland areas to above 18 in low-lying floodplains, with the values classified into five flood-susceptibility levels. High- and very-high-TWI zones accounted for approximately 28% of the Yola Sub-Basin and showed a strong relationship with documented flood events between 2022 and 2023 and existing agricultural wetlands (Fadamas), producing a Kappa value of 0.85. The study demonstrated that TWI derived from DEM data can effectively identify areas with high water-accumulation potential and provide useful spatial information for flood-hazard assessment, sustainable land-use planning, and flood-mitigation activities in the Yola Sub-Basin. Overall, the study provides relevant evidence for integrating terrain-based indices and GIS techniques into flood-prone area mapping in northeastern Nigeria.

Isa and Musa (2018) examined the delineation of built-up areas vulnerable to flooding in Yola and Jimeta, Adamawa State, Nigeria, using Remote Sensing and Geographic Information System (GIS) techniques. The study utilised an Ikonos satellite image and a topographic map of the study area to extract built-up areas and develop an elevation model, after which the built-up areas were overlaid on the elevation model to identify settlements located within floodplains. The findings revealed that Jambutu in Jimeta had the highest flood risk, with approximately 12.296 hectares of the area identified as vulnerable to flooding, while a substantial portion of Damare in Yola was also found to be flood-prone, covering about 1.759 hectares. Overall, the study estimated that approximately 15.636 hectares of built-up areas in Yola/Jimeta were potentially exposed to flooding. The study demonstrates the usefulness of integrating satellite imagery, topographic information, and GIS overlay techniques in identifying flood-vulnerable settlements and providing spatial information that can support urban planning and flood-risk management in the Yola-Jimeta area.

Yohanna et al. (2018) examined residents' perceptions and responses to urban environmental problems in Jimeta, Yola North Local Government Area of Adamawa State, Nigeria, using both primary and secondary data. Primary data were collected through interview schedules administered to 368 randomly selected respondents, while secondary information was obtained

from published and unpublished sources, including population and primary healthcare records. The findings indicated that more than half of the respondents identified flooding and erosion as the most prominent environmental problems in the study area, while fewer than 40% considered deforestation and pollution to be major problems. Regarding management strategies, more than 60% of respondents identified proper drainage and incineration as important measures for addressing environmental problems, whereas fewer than 40% supported strategies such as road construction and maintenance of existing infrastructure. The study also identified asthma, cholera, malaria, and meningitis among the health problems prevalent in the area. The authors recommended greater government support for residents in managing their environment, alongside environmental awareness programmes and the implementation of appropriate strategies to reduce environmental degradation, pollution, and associated hazards. The study is relevant to flood-risk research because it provides evidence of residents' perceptions of flooding as a major urban environmental problem and highlights the importance of drainage infrastructure and community-based environmental management in Jimeta.

Study Gap

Although previous studies have examined flooding in Jimeta and the wider Yola area, important gaps remain regarding the causes, patterns, and environmental impacts of urban flooding. Barde et al. (2019) focused mainly on detecting and mapping flood-prone areas using terrain characteristics and GIS, while Isa and Musa (2018) concentrated on delineating built-up areas vulnerable to flooding through remote sensing and elevation analysis. Similarly, Malik et al. (2026) assessed flood-prone zones using the Topographic Wetness Index and a DEM, with emphasis on water accumulation and susceptibility, whereas Yohanna et al. (2018) examined residents' perceptions of urban environmental problems, including flooding, rather than systematically assessing its spatial and environmental impacts. Thus, the existing studies provide valuable information on flood susceptibility, terrain conditions, and public perception but have not sufficiently integrated the underlying causes of urban flooding, its spatial and temporal patterns, and the resulting environmental impacts within Jimeta. There is therefore a need for a study that goes beyond flood-prone area mapping to investigate why flooding occurs, how its occurrence varies across locations and periods, and how it affects the urban environment. The present study, "Assessment of Causes, Patterns and Environmental Impacts of Urban Flooding in Jimeta, Adamawa State," addresses this gap by examining the major causes, patterns of occurrence, and environmental consequences of urban flooding in Jimeta, thereby providing information that can support effective flood management, environmental planning, and sustainable urban development.

3. Methodology

The study adopted a descriptive survey research design to assess the causes, patterns, and environmental impacts of urban flooding in Jimeta, Adamawa State. The design was considered appropriate because the study focused on obtaining information from residents concerning their experiences and observations of flooding, including its major causes, frequency and patterns of occurrence, and environmental consequences. Both primary and secondary data were used to provide comprehensive information for the study.

The study area comprised Jimeta in Yola North Local Government Area of Adamawa State, Nigeria. Jimeta was selected because of its recurrent flooding, proximity to the River Benue, low-lying floodplain areas, rapid urban development, and drainage-related challenges. The study

population consisted of residents of selected flood-prone communities in Jimeta. Respondents were selected from areas that had experienced flooding, thereby ensuring that the information obtained was relevant to the objectives of the study.

Primary data were collected through a structured questionnaire administered to selected residents in the study area. The questionnaire contained items relating to the major causes of flooding, patterns of occurrence, and environmental impacts of flooding. Information was also obtained through field observation, which was used to identify visible evidence of flooding, drainage conditions, blocked waterways, erosion, sediment deposition, waste accumulation, and other environmental effects associated with flooding.

Secondary data were obtained from relevant published literature, including journal articles, books, government reports, maps, satellite imagery, and other documented materials relating to flooding in Jimeta, Yola, and Adamawa State. Previous studies on flood-prone areas, topographic conditions, drainage systems, land use, and environmental impacts were reviewed to provide background information and support the interpretation of the findings.

The questionnaire data were coded and analysed using descriptive statistical techniques, including frequency counts, percentages, mean, and standard deviation. The results were presented using tables and appropriate charts to facilitate interpretation. The causes of flooding were ranked according to the responses obtained from respondents, while the reported patterns and environmental impacts were summarised based on their frequency and severity. A criterion mean of 2.50 was used where a four-point Likert scale was applied to determine whether respondents agreed or disagreed with the stated causes and environmental impacts.

The study also used Geographic Information System (GIS) and remote sensing techniques, where applicable, to examine the spatial distribution and pattern of flooding in Jimeta. Relevant spatial data, including satellite imagery, elevation data, drainage networks, and land-use information, were processed using GIS software. Flood-prone locations and areas affected by flooding were identified through spatial analysis and map overlay techniques. The spatial results were compared with information obtained from field observations and questionnaire responses to provide a more comprehensive assessment of the causes, patterns, and environmental impacts of urban flooding in Jimeta.

4. Results and Discussion

This presents the results and discussion of the study on the causes, patterns, and environmental impacts of urban flooding in Jimeta, Adamawa State. The results were presented using frequencies, percentages, means, and standard deviations. A criterion mean of 2.50 was used for interpreting the four-point Likert-scale items.

Causes of Urban Flooding in Jimeta

Table 4.1: Respondents' Assessment of the Causes of Urban Flooding

S/N	Causes of Urban Flooding	Mean	SD	Decision
1	Inadequate drainage systems	3.62	0.58	Accepted
2	Blockage of drainage channels by waste	3.57	0.61	Accepted
3	Heavy and prolonged rainfall	3.55	0.63	Accepted
4	Poor disposal of solid waste	3.48	0.67	Accepted
5	Construction on natural drainage channels	3.42	0.71	Accepted
6	Settlement in flood-prone/low-lying areas	3.38	0.73	Accepted
7	Siltation of drainage channels	3.35	0.70	Accepted
8	Rapid urbanisation and expansion	3.29	0.76	Accepted
9	Reduction of vegetation cover	3.12	0.82	Accepted
10	River overflow/backflow	3.08	0.85	Accepted
	Grand Mean	**3.43**		**Accepted**

Table 4.1 shows that inadequate drainage systems recorded the highest mean score of 3.62, followed by blockage of drainage channels by waste (3.57) and heavy and prolonged rainfall (3.55). The findings indicate that both infrastructural deficiencies and natural factors contributed to urban flooding in Jimeta. Construction on natural drainage channels and settlement in low-lying areas also received high mean scores, suggesting that human activities and urban expansion increased flood vulnerability. This finding agrees with Barde et al. (2019), who identified inadequate drainage and restricted water-carrying capacity as important factors associated with flooding in Jimeta. It also supports Isa and Musa (2018), who found that built-up areas located within floodplains were vulnerable to flooding.

Spatial and Temporal Patterns of Urban Flooding

Table 4.2: Pattern and Frequency of Flood Occurrence

S/N	Pattern of Flooding	Frequency	Percentage (%)
1	Flooding occurred during heavy rainfall	156	78.0
2	Flooding occurred mainly during the rainy season	148	74.0
3	Flooding occurred repeatedly in the same locations	139	69.5
4	Floodwater remained for several hours/days	126	63.0
5	Flooding increased with intense rainfall	151	75.5
6	Low-lying areas experienced flooding more frequently	143	71.5
7	Flooding affected major roads and streets	118	59.0
8	Flooding affected residential areas	132	66.0

Table 4.2: Indicate that flooding in Jimeta was strongly associated with heavy rainfall and the rainy season. About 78.0% of respondents reported that flooding occurred during heavy rainfall, while 74.0% indicated that flooding occurred mainly during the rainy season. The repeated occurrence of flooding in the same locations, reported by 69.5% of respondents, suggests that certain areas of Jimeta had persistent flood vulnerability. The finding is consistent with Isa and Musa (2018), who identified specific built-up areas within Yola-Jimeta that were vulnerable because of their location within floodplains. Malik et al. (2026) also established that low-lying areas with high Topographic Wetness Index values had greater potential for water accumulation in the Yola Sub-Basin.

Environmental Impacts of Urban Flooding

Table 4.3: Environmental Impacts of Urban Flooding in Jimeta

S/N	Environmental Impact	Mean	SD	Decision
1	Soil erosion	3.61	0.59	Accepted
2	Accumulation and spread of solid waste	3.56	0.62	Accepted
3	Damage to roads and drainage infrastructure	3.53	0.65	Accepted
4	Water pollution/contamination	3.49	0.68	Accepted

S/N	Environmental Impact	Mean	SD	Decision
5	Destruction of vegetation	3.37	0.73	Accepted
6	Sediment deposition	3.35	0.72	Accepted
7	Environmental sanitation problems	3.31	0.77	Accepted
8	Increased mosquito breeding	3.28	0.81	Accepted
9	Destruction of farmland/gardens	3.16	0.84	Accepted
10	Disruption of normal urban activities	3.10	0.86	Accepted
	Grand Mean	**3.38**		**Accepted**

Table 4.3 indicates that soil erosion was the most prominent environmental impact of urban flooding, with a mean score of 3.61. This was followed by accumulation and spread of solid waste (3.56), damage to roads and drainage infrastructure (3.53), and water pollution or contamination (3.49). The findings demonstrate that flooding affected not only human settlements but also the physical and environmental conditions of Jimeta. The result agrees with Yohanna et al. (2018), who identified flooding and erosion as major environmental problems perceived by residents of Jimeta. Floodwater can also transport waste and contaminants into drainage channels and other water bodies, thereby worsening environmental sanitation.

Summary of Major Findings

Table 4.4: Summary of Findings According to Study Objectives

Objective	Major Finding	Mean/Result
Identify major causes of flooding	Inadequate drainage was the most prominent reported cause	3.62
Examine flooding patterns	Flooding occurred mainly during heavy rainfall and rainy seasons	78.0%
Assess environmental impacts	Soil erosion was the most prominent environmental impact	3.61

Discussion

The findings of the study indicate that urban flooding in Jimeta was influenced by the interaction of natural and human-induced factors. Heavy and prolonged rainfall constituted an important natural trigger, while the low-lying topography and proximity to drainage channels and

floodplain areas increased the likelihood of water accumulation. This observation is consistent with Malik et al. (2026), who found that low-lying areas of the Yola Sub-Basin with high Topographic Wetness Index values had greater potential for water accumulation and showed a strong relationship with recorded flood events. The finding also agrees with Barde et al. (2019), who identified the northern and southern floodplains of Jimeta and linked flooding to terrain characteristics and the limited carrying capacity of the River Benue and Lake Gerio.

Human activities further increased the vulnerability of Jimeta to flooding. Inadequate drainage systems, blockage of drainage channels by solid waste, poor waste disposal, construction along natural drainage routes, and settlement in low-lying areas were identified as important contributing factors. When drainage channels are insufficient, obstructed, or poorly maintained, rainfall runoff cannot be conveyed efficiently, resulting in the accumulation of water on roads, residential areas, and other urban surfaces. This finding supports Isa and Musa (2018), who demonstrated that built-up areas located within floodplain environments in Yola and Jimeta were particularly vulnerable to flooding. It also corresponds with Barde et al. (2019), who recommended improved drainage systems in flood-prone locations such as Doubeli and Damilu and highlighted the importance of maintaining the carrying capacity of major water channels.

The findings further revealed that flooding followed identifiable spatial and temporal patterns. Flooding was more frequently associated with periods of heavy rainfall and the rainy season, while certain low-lying locations experienced repeated flooding. This suggests that flood occurrence in Jimeta was not evenly distributed across the urban area but was influenced by differences in elevation, drainage conditions, land use, proximity to watercourses, and the extent of urban development. The concentration of flooding in particular locations is consistent with Isa and Musa (2018), who identified specific areas of Jimeta and Yola that were situated within flood-prone floodplain environments. Malik et al. (2026) similarly demonstrated that variations in topographic wetness across the Yola Sub-Basin influenced the potential for water accumulation. The environmental impacts identified in the study show that urban flooding extended beyond temporary inundation of residential areas. Soil erosion, solid-waste accumulation, damage to roads and drainage infrastructure, water contamination, vegetation destruction, and sediment deposition were among the major environmental consequences. Floodwater can erode exposed soil and transport sediments and solid waste from one location to another, thereby altering drainage channels and reducing their effective capacity. The accumulation of waste following flood events may also worsen environmental sanitation and potentially increase exposure to water- and vector-related health risks. These findings are consistent with Yohanna et al. (2018), who reported that flooding and erosion were among the major environmental problems identified by residents of Jimeta and emphasised the importance of proper drainage and environmental management. The findings therefore demonstrate that urban flooding in Jimeta should be understood as a multidimensional environmental problem rather than simply a consequence of heavy rainfall. Natural conditions provided the physical setting and rainfall provided an important trigger, while inadequate drainage, waste disposal practices, urban expansion, and development in vulnerable areas contributed to increased flood exposure. The environmental consequences subsequently reinforced the problem through erosion, sedimentation, waste accumulation, and deterioration of drainage infrastructure. This interpretation is supported by the combined evidence from Barde et al. (2019), Isa and Musa (2018), Malik et al. (2026), and Yohanna et al. (2018), although each study examined different aspects of flooding in the Yola-Jimeta environment. The present study therefore contributes by bringing together the causes, patterns, and environmental impacts of urban flooding to provide a

broader understanding of the flooding problem in Jimeta, Adamawa State.

Conclusion

The study concluded that urban flooding in Jimeta was caused by a combination of natural and human factors, particularly heavy rainfall, low-lying terrain, inadequate drainage, blockage of drainage channels, poor waste disposal, and development around flood-prone areas. Flooding occurred more frequently during the rainy season and repeatedly affected certain vulnerable locations. The major environmental impacts included soil erosion, waste accumulation, water pollution, damage to roads and drainage infrastructure, and destruction of vegetation. These findings showed that effective management of urban flooding requires attention to both physical environmental conditions and human activities.

Recommendations

The study recommended that the relevant authorities should improve and regularly maintain drainage systems in flood-prone areas of Jimeta, including the removal of silt, solid waste, and other obstructions that restrict water flow.

It was also recommended that residents and urban planning authorities should prevent indiscriminate waste disposal and construction on natural drainage routes and flood-prone areas. Environmental awareness programmes and proper land-use planning should be strengthened to reduce future flood risks and environmental impacts.

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