International Journal of Innovative Environmental Studies Research 14(2):120-128, April-June, 2026

 www.seahipublications.org **ISSN: 2354-2918**

doi:10.5281/zenodo.20027734

Application Of GIS And Remote Sensing In Flood Risk Mapping In Northwestern Yobe: A Case Study Of Gashua

Umar Mohammed Jambo[1] & Umar Ahmed Abubakar

Department of Geography,
Umar Suleiman College of Education Gashua, Yobe State, Nigeria
[1]Correspondance email address: jamboumar123@gmail.com

ABSTRACT
Identification of potential flood risk areas is crucial to reduce flood effects for the study area. The present study has prepared flood risk map for the flood-prone Gashua town using the weighted sum decision analysis along with the application of analytical hierarchy process (AHP) method. By utilizing ALOS PALSPAR DEM, three flood influential factors that included elevation, slope, and distance from streams were derived in GIS software. Sentinel 2 image was used to generate land use-land cover, while Worlclim was used to download precipitation data. These factors have been analysed to create a final risk map of the study area. The flood risk map is divided into five risk zones: very low, low, moderate, high, and very high. This study found that 65.3% area of the Gashua resides under the moderate to very high-risk zone of flooding. The risk map will guide government and non-governmental organizations to easily identify the vulnerable areas for flood risk and suitable areas for development activities necessary to attain sustainable development. It will also enable the Bade Local Government to restrict building permits in high-risk flood sites, as well as to enable NEMA and YOSEMA for relief distribution and evacuation of victims in the event of flooding.
Keywords: flood-prone, precipitation, natural hazards

1. INTRODUCTION

Floods are one of nature's most devastating disasters, impacting millions of people globally through infrastructure damage, property devastation, and fatalities (Guo, Guan, & Yu, 2021; Kumar, Sharma, Caloiero, Mehta, & Singh, 2023).

Flooding is one of the most destructive natural hazards globally, particularly in developing countries such as Nigeria where rapid urbanization, poor drainage systems, and climate variability increase vulnerability. Flood events lead to loss of lives, destruction of infrastructure, and environmental degradation (Eniola Onatay, Olumide Adelesi, 2021). Nigeria's flood situation has deteriorated into a serious humanitarian crisis, affecting 180 local government areas and 31 states. It has affected more than 1,083,141 people, resulting in houses and livelihoods being destroyed, many people being displaced, and fatalities. As a result of the floods, 285 people have died, 2,504 have been injured, and 641,598 have been displaced. 98,242 households have been impacted, causing destruction to farmlands, homes, and vital infrastructure (OCHA, 2024). In addition, over 5,865 shelters have been demolished in Yobe State alone. Waterborne disease risks have increased for the displaced. (SEMA, 2024) reported that in Yobe State, from 15th April to 19th August 2024, about 31, 855 individuals (11, 999 households) had been affected, 29 deaths were recorded, 274 persons were injured, and 20, 766 facilities (shelters and farms) were affected by flash floods and windstorm. DTM determined that 13,474 houses in seventeen (17) local government areas (LGAs) in Yobe State had 60,856 residents that were impacted by the floods (Reliefweb, 2025).

In recent years, flooding has emerged as a recurring and destructive challenge in Northwestern Yobe State, bringing with it a wide range of devastating consequences. Almost every year, intense rainfall (especially during July to September), flat and poorly drained terrain that leads to water stagnation, increasing risk from climate change, land degradation, and human settlement in floodplains make the region highly susceptible to flash floods, river flooding, and urban flooding due to poor or inadequate drainage systems (Mohammed Ibrahim, 2025). These factors among others trigger floods that result in the tragic loss of lives and severe damage to infrastructure. Roads and buildings are frequently destroyed or structurally displaced, cutting off communities and limiting access to essential services (IOM, 2024). Farmlands and crops, which are the backbone of the region's economy and food supply, are regularly washed away, leaving farmers in despair and threatening food security (Reliefweb, 2024). These floods also hinder economic activities and paralyze transportation networks, leading to shortages of goods and a slowdown in local commerce. Furthermore, stagnant water and poor sanitation contribute to the outbreak of waterborne diseases, posing serious health risks to already vulnerable populations. In the aftermath, thousands of people are displaced, often forced to take shelter in overcrowded public buildings such as schools. IPCC (2015) indicated that climate change will cause extreme precipitation events that are more intense and frequent in many regions, thus leading to greater flood risks. Hazards due to flood events cannot be prevented completely, however adopting some appropriate methods as the mitigation measures can help to reduce the intensity of disaster and its effects. Therefore, it is crucial for effective flood risk management to develop a tool that provides insight about flooding in the study area. Following a combination of environmental, climatic, and socio-economic factors in the northwestern Yobe State, flood risk mapping using GIS and remote sensing is crucial for better flood management. Remote sensing provides real-time and historical data through satellite imagery, which is essential for detecting flood extent, monitoring land use/land cover (LULC) changes, and identifying environmental factors contributing to flooding. In Akure South, satellite data such as Landsat 8 and SRTM DEM were integrated with rainfall and soil data to produce flood vulnerability maps (Ibrahim Olatunji Raufu , Ibrahim Mukaila , Kafayat Olaniyan, 2023). Remote sensing is particularly useful in areas with limited ground data, as it enables continuous monitoring and supports rapid assessment of flood events. GIS plays a central role in flood analysis by integrating spatial datasets (elevation, rainfall, soil, land use), performing spatial analysis (overlay, buffering, interpolation), and generating flood hazard maps. A study in Benin City applied GIS-based Analytical Hierarchy Process (AHP) to integrate six flood conditioning factors (slope, elevation, drainage density, flow accumulation, distance to rivers, and curve number). The results showed that over 26% of the area was highly susceptible to flooding (Okafor & Oriakhi, 2024).

Gashua is located within the Hadejia-Nguru Wetlands, it is a high-risk flood zone due to its flat topography and proximity to the River Yobe. In recent years Gashua has faced unprecedented inundation that destroyed hundreds of houses and submerged thousands of hectares of rice and vegetable farmlands. The fundamental problem is the lack of a spatially explicit flood hazard map. Without knowing the exact digital elevation levels and drainage bottlenecks, urban expansion continues into high-risk floodplains. There is an urgent need to use satellite-derived data to delineate those zones to prevent further socio-economic catastrophe. This research aim to develop a geospatial model for assessing flood risk and vulnerability in Gashua to enhance disaster preparedness and land-use planning through: analysis of satellite imageries to generate a digital elevation model (DEM) to identify low-lying areas and natural water-flow paths; to produce a flood risk ap using multi-criteria decision analysis; and to identify and quantify critical infrastructure (schools, clinics, markets) and residential areas currently situated in high-risk zones.

The findings of the research will be significant to the Bade Local Government to restrict building permits in high-risk flood sites; to enable NEMA and YOSEMA for relief distribution and evacuation of victims in the event of flooding; and to help farmers in the floodplains to know the safest periods and locations for planting to avoid seasonal washouts.

DATA AND METHODS

2.1 Study Area

Gashua is located in Yobe State, Nigeria, it is located between latitudes 12°48'30''N and 12°56'30''N, and longitudes 11°0'30''E and 11°6'15''E. The area is predominantly flat terrain with some elevated regions. Gashua has a tropical savanna climate (Köppen-Geiger classification Aw). The climate of Gashua is characterized by a distinct wet and dry seasons. The dry season is long and windy (May to October) while the wet season is short and hot. The migration of the Intertropical Convergence Zone (ITCZ) dominates the climate, concentrating intense, frequently convectional rainfall into a few months (June to September) (Tijjani Yahaya Abdullahi, Faiz Tijjani Ismail, Abba Bala Ibrahim, 2026).

The Yobe River flows near Gashua, playing a significant role in the area's hydrology. Seasonal flooding can occur due to river overflow during intense rainfall periods. The local economy is predominantly agricultural, with many residents relying on farming for their livelihoods.

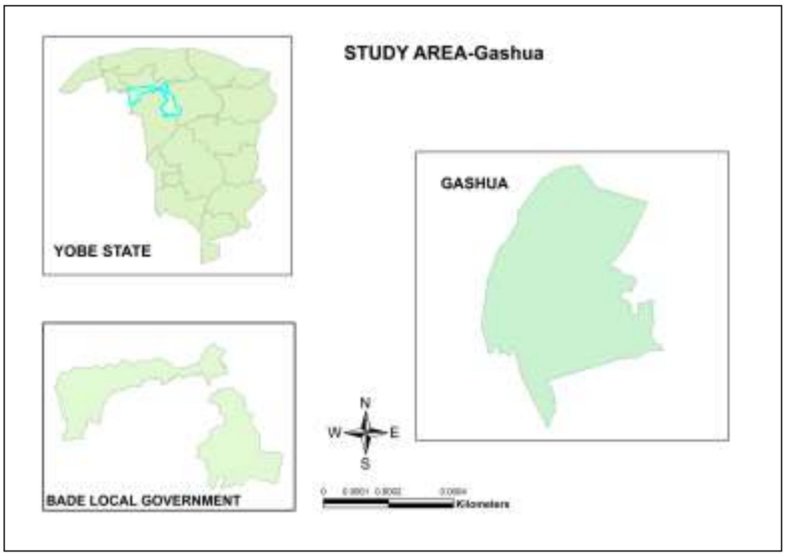

Figure 1: Study Area

2.2 Data Collection and Preparation

The sets of data used for this research are from secondary sources. First of all, the study area boundary/shape file is extracted through digitization using Arc GIS software. A high resolution (12.5) digital elevation model of the area is obtained from ALOS PALSPAR satellite in Earth Data site (https://search.asf.alaska.edu). The DEM was analyzed in Arc GIS software to generate other flood risk influential factors. A high resolution (10m) Sentinel 2 image was downloaded from ESA's Copernicus program (https://dataspace.copernicus.eu) to generate landuse landcover raster layer for the study area. Moreover, precipitation data was obtained from Worlclim site (worldclim.org). The data set selected was for the month of August because it is the month with the peak amount of rainfall usually recorded in the study area. Sentinel-2 images was used to derive land use cover, SNAP 8.0 software (European Space Agency) was used to pre-process the S2 images, including radiometric calibration and atmospheric correction.

2.3 **Assigning weights to the factors**

In order to estimate the flood-risk of Gashua town, flood risk influential factors identified based on the opinions of the experts in the field. The factors used for this research work include slope, distance from the stream, land use, precipitation, and elevation ….. All of these variables were georeferenced and reprojected to projected coordinate system, WGS_1984_UTM_zone_32N to march coordinate system of the study area. Moreover, after analyzing each of these factors, each of them is reclassified into five classes for suitability analysis in order to make them unique and suitable for overlay analysis. Also, each of these reclassified factors (layers) is a assigned a class value that include 10, 8, 6, 4, and 2 which correspond to very high, high, moderate, low, and very low flood risk suitability respectively. Thematic maps of each of the factor are produced.

Each of these factors is then assigned a weighted value based on its significance in influencing flood risk. The summation of all the values equals to one. The resulting map of flood risk areas includes the combination of the five variables which are related directly to flood event that occurs in the area of study, specifically, the five maps that were developed after the classification method were combined using a weighted sum combination approach in a GIS environment, according to this technique, each factor is multiplied by its assigned weight and the summation of all factors yields the final map of risk areas.

The formula is given as:

$$S = \sum_{i=1}^{n} w_i x_i$$

Where: S = weighted sum (final flood risk map), x_i = each data point in the dataset (rate of a factor i), w_i = weight assigned to each data point (weight of factors i), and n = total number of data points. The final map is then reclassified into five classes using natural break in Arc GIS environment, the classes were then labeled very high, high, moderate, low, and very low flood risk areas respectively.

RESULTS AND DISCUSSION

1.1 Elevation

Elevation influences flood, areas with lower elevation is more susceptible to flood than those with higher elevation, because water always flow from locations on higher elevation to those on lower elevation. The elevation of the study area ranges from 348 to 382 meters above the mean sea level as shown in figure 2. The area may be described as low land, the northern part of the area has high elevation compared to the southern part. Meanwhile, some portion in the middle part of the area has higher elevation than the remaining parts. Therefore, the southern part of the study area is more susceptible to flood than the northern part.

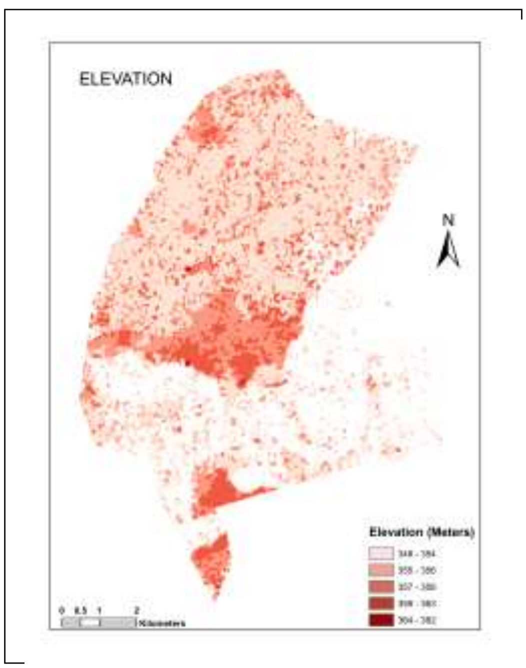

Figure 2: Elevation of the study

1.2 Distance from Streams

Places that have close proximity to the water bodies are likely to be more affected by flooding due to the overflow of the water bodies. The study area is dominated by a number of water bodies that include streams and their tributaries, as well as ponds. Most parts of the study area are closer to one or more water bodies, so in the event of flooding, many parts of the study area may be affected. As shown in figure 3.

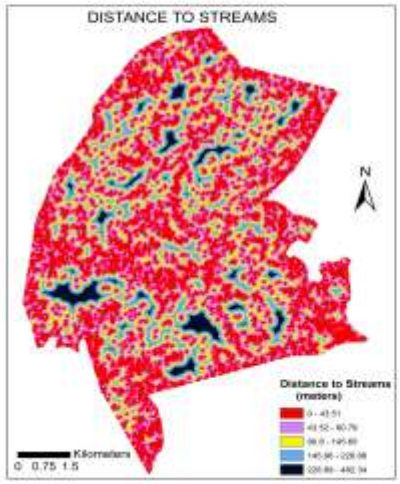

Figure 3: Distance to streams

1.3 Slope

Water flow is also regulated by slope; places with the gentle slope have the higher chance of flooding than those with steep slope. The slope of the study area varies from 0 to 26.5 (Fig. 4). From the map, the study area is said to have nearly flat terrain because almost all the area belongs to the first two classes. Meanwhile, the northern part has more distribution of moderate to high slopes.

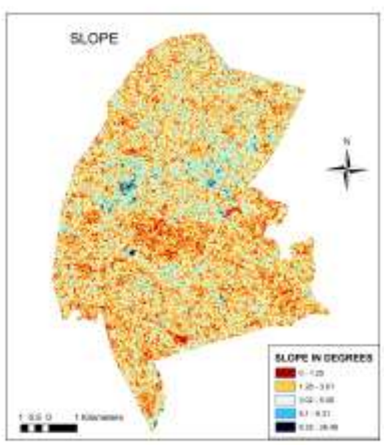

Figure 4: slope

1.4 Precipitation

Precipitation is an important factor in causing flood, heavier precipitation has the tendency of causing flood. The precipitation map of the study area showed that rainfall intensity was high in the southern part of the study area as compared to the northern part as shown in figure 6.

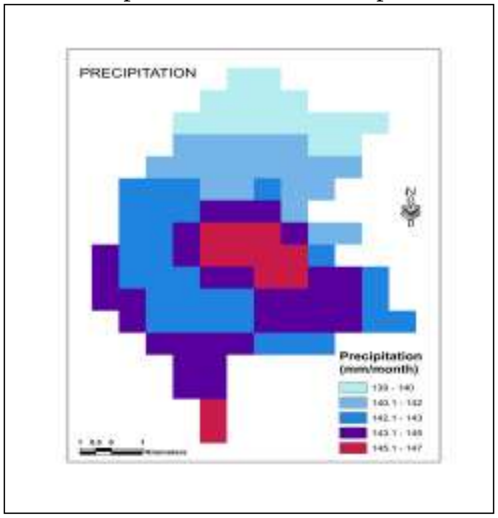

Figure 6: Precipitation

1.5 Land use

Land use and nature of land cover are also key factors responsible for flood incidence, Land use is the surface cover of the earth in a specific location (e.g., vegetation type, an artificial structure…). Different types of land use and land cover contributes differently to the occurrence of flood. Land use influences infiltration rates, the interrelationship between surface and groundwater as well as debris flow.

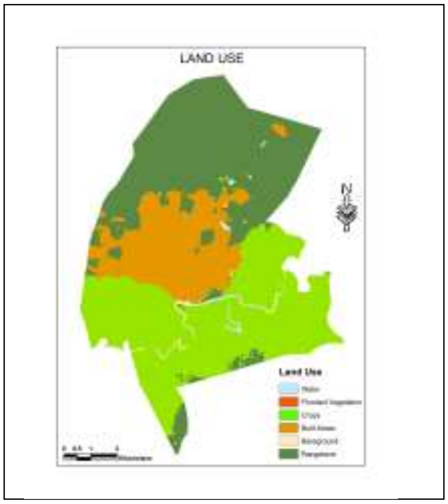

Figure 7: Land use

In this study, five different types of land cover had been identified from the Sentinel 2A image. These land cover types were water bodies, cropland, flooded vegetation, built areas, rangeland and bare ground as shown in figure 7. Among the six land cover types, cropland covers most part of the study area, followed by rangeland, and built areas.

3.6. Flood Risk Map

The flood risk map of the study area map of the study area is shown in figure 8, the area is divided into five classes of flood risk that include very low, low, moderate, high and very high.

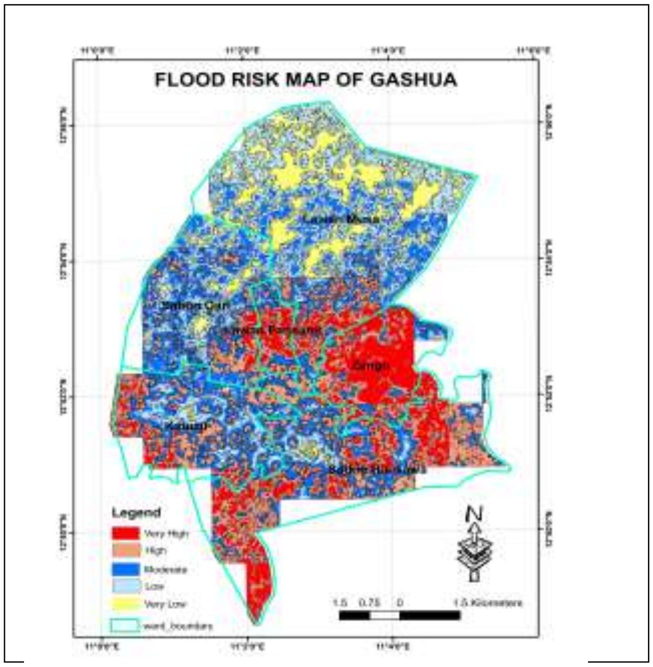

Figure 8: flood Risk of Gashua

Table 1: Distribution of flood risk in Gashua by area and percentage

s/n	Class	Area (km^2)	Percentage (%)
1	Very low	8.250809	11.5
2	Low	16.69291	23.2
3	Moderate	18.944875	26.3
4	High	16.937016	23.6
5	Very High	11.072044	15.4
	TOTAL	71.897654	100

The table 1 above shows the total area and their respective percentages covered by different classes of flood risk in the study area.

2. DISCUSSION

The present study aimed to determine the flood risk distribution across the flood-prone Gashua town. In the event of flooding in the study area, Zango Ward may highly be affected than any other ward, this is because most of its area falls under very high and high flood risk. After Zango, the next ward to be affected is Lawan Fannami as most of its area also falls under very high and high flood risk. The next ward to be affected is Sarkin Hausawa Ward, because greater parts of its area fall under very high, high to moderate flood risk. The western and southern parts of Katuzu Ward also have high to very high susceptibility to flooding. South easthern parts of Sabon Gari Ward may also be affected because they fall under the zones of high to very high flood risk. Moreover, there are some places at the western border of the Ward that fall under the zone of high flood risk. Lawan Musa Ward is the safest among the wards because most of its area fall under the zones of very low, low and moderate flood risk. However, some portion of its southern part fall under the zones of high and very high flood risk. All these are shown in figure 8 above.

The area covered by each class of flood risk and their respective percentages are given in the table 1 above. From the table, the study area has a total area of 71.897654 sq. km out of which, moderate class of flood risk has the highest value (18.944875 sq. km) covering about 26.3% of the total area of Gashua, high class occupies 16.937016 sq. km which is about 23.6% of the total area of the study area, low class occupies 16.69291 sq. km which is about 23.2% of the total area of the study area, very high class occupies 11.072044 sq. km which is about 15.4% of the total area of the study area, and finally very low class occupies 8.250809 sq. km which is about 11.5% of the total area of the study area. This shows that the study area has high susceptibility to flooding

3. CONCLUSION

In conclusion, Multi-criteria decision analysis was incorporated with geospatial techniques to produce flood risk maps for Gashua town. Based on the findings of the study, the study area is very susceptible to flooding because about 65.3% of the total area of the study area has tendency to flooding. Moreover, in the event of flooding in Gashua town, Zango ward may be hit most while Lawan Musa ward may be affected least.

4. RECOMMENDATIONS

The researchers make the following recommendations;

1. A further research should be conducted to identify the people and the infrastructures to be affected in Gashua in the event of flooding
2. Government shoud establish evacuation points in the identified areas for emergency responses in the event flood occurs.

ACKNOWLEDGEMENT

The authors thank Tetfund for their support in carrying out the research

REFERENCES

Eniola Onatay, Olumide Adelesi, and O. A. (2021). Geospatial assessment of flood vulnerability using remote sensing and GIS. *International Journal of Science and Research Archive*. https://doi.org/10.30574/ijsra.2021.4.1.0198

Guo, K., Guan, M., & Yu, D. (2021). Urban surface water flood modelling – a comprehensive review of current models and future challenges. *Hydrology and Earth System Sciences*, *25*(5), 2843–2860. https://doi.org/10.5194/hess-25-2843-2021

Ibrahim Olatunji Raufu , Ibrahim Mukaila , Kafayat Olaniyan, Z. A. (2023). Application of Remote Sensing and Geographical Information System (GIS) in Flood Vulnerability Mapping: A Scenario of Akure South, Nigeria. *International Journal of Environment and Geoinformatics*. https://doi.org/https://doi.org/10.30897/ijegeo.1073697

IOM. (2024). *NIGERIA FLOOD SITUATION REPORT — YOBE STATE*. Retrieved from https://dtm.iom.int/dtm_download_track/63446?file=1&type=node&id=42876

Kumar, V., Sharma, K., Caloiero, T., Mehta, D., & Singh, K. (2023). Comprehensive Overview of Flood Modeling Approaches: A Review of Recent Advances. *Hydrology*, *10*(7), 141. https://doi.org/10.3390/hydrology10070141

Mohammed Ibrahim, A. B. I. A. I. A. & M. A. (2025). Modelling Flood Scenarios in Northeast Nigeria: Simulations, Vulnerabilities and Implications. *African Journal of Earth and Environmental Science, 3(2).* Retrieved from https://ajeesbuk.com.ng/index.php/journal/article/view/112

OCHA. (2024). *Nigeria: Flood Overview, As of 17 September 2024*.

Okafor, G. U. and, & Oriakhi, O. (2024). Flood Susceptibility Modelling Using GIS-Based Analytical Hierarchy Process (AHP) in Benin City, Nigeria. *NIPES-JOURNAL OF SCIENCE & TECHNOLOGY RESEARCH*. https://doi.org/https://doi.org/10.5281/zenodo.13937655

Reliefweb. (2024). *West Africa Key Message Update July 2024: Inflation and flooding are driving food insecurity of vulnerable households*. Retrieved from https://reliefweb.int/report/nigeria/west-africa-key-message-update-july-2024-inflation-and-flooding-are-driving-food-insecurity-vulnerable-households

Reliefweb. (2025). *Nigeria: Joint Post-Flood Situation Report - Yobe State (31 December 2024)*. Retrieved from https://reliefweb.int/report/nigeria/nigeria-joint-post-flood-situation-report-yobe-state-31-december-2024

SEMA. (2024). *2024 Yobe Windstorm, Heavy rain & Flash flood: Flash Update #3 Yobe State, Nigeria.* Damaturu. Retrieved from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://fscluster.org/sites/default/files/2024-08/2024 Yobe Windstorm Heavy rain_ Flash flood _Flash Update.pdf

Tijjani Yahaya Abdullahi, Faiz Tijjani Ismail, Abba Bala Ibrahim, and A. H. (2026). ASSESSING LONG TERM VARIABILITY OF RAINFALL INGASHUA TOWN BADE LOCAL GOVERNMENT AREA OFYOBE STATE 1990-2024. *Wudil Journal of Earth and Environmental Sciences,*. Retrieved from https://www.researchgate.net/publication/403781573_ASSESSING_LONG_TERM_VARIABILITY_OF_RAINFALL_IN_GASHUA_TOWN_BADE_LOCAL_GOVERNMENT_AREA_OF_YOBE_STATE_1990-2024/figures?lo=1