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Mapping and Analysis of Seasonal Flooding in Benue State Nigeria using Remote Sensing and GIS Approach

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Abstract
This study aimed at assessing the impact of seasonal flooding in parts of Benue State using Remote Sensing and GIS. Its objectives were to delineate different risk levels of flooding in the study area, to determine the effect or impact of flooding on different land cover types and to produce flood risk map of the study area. The methodology involves data acquisition, data processing and reclassification and overlay analysis. This study has been able display the usefulness of remote sensing and GIS technologies in classifying and in identifying areas with high, moderate, low risk of flooding within the study area. The landuse/landcover distribution of Benue State in 2021 as shown in figure 4.5 and figure 4.6 indicate that forested area, accounted for the largest land cover/use of about 65.13% and an area of about 2039157 hectares. Grassland had 5.73% and a coverage area of 239423.9 hectares, farmland had 5.73% and a coverage area of 179424.5 hectares. Bare surface had 6.47% and a coverage area of 202653.6 hectares, rocky area had 4.98% and a coverage area of 153274.9 hectares, settlement had 9.19% with area coverage of 287964.3 hectares, while waterbody had 0.92 with area coverage of 28864.94 hectares. The results of the overlay analysis produced a layer showing three hazard zones; namely high risk, moderate risk and low risk in the study area. The results indicated that high-risk zone occupied 34.68% of the entire study area, covering an area of 10857.48km2, while moderate risk zone occupied 47.05%, covered an area of 14730.24km2. Low risk zone occupied 18.25% covering 5713. It is recommended that the results achieved in this research can be used as a base to help identify areas at risk of being flooded in the study area.

Keywords: Benue State, Flooding, GIS, Landcover/Landuse, Remote Sensing

1. Introduction

Flooding Seasonal flooding is a recurring environmental challenge in Benue State, Nigeria, significantly impacting the socio-economic development and livelihood of its residents. Floods disrupt agricultural activities, destroy infrastructure, and displace communities, necessitating effective flood risk management strategies. Recent advancements in remote sensing (RS) and geographic information systems (GIS) have provided new avenues for assessing and managing flood risks (Adeoye *et al*., 2009; Adelekan, 2011) [4, 3].

Benue State, located in the north-central region of Nigeria, experiences seasonal flooding primarily due to its geographical and climatic conditions. The state's riverine system, dominated by the Benue River and its tributaries, exacerbates the vulnerability to flooding (Adejumo & Adejumo, 2014) [2]. The frequent inundation affects not only the physical landscape but also the socio-economic fabric of the state, leading to substantial economic losses and human suffering (Aderogba, 2012) [5].

The integration of RS and GIS technologies has revolutionized flood risk assessment by enabling precise mapping, monitoring, and analysis of flood-prone areas. Remote sensing provides timely and accurate data on land cover, water bodies, and changes in terrain, while GIS facilitates the spatial analysis and visualization of flood hazards (Chowdhury & Al-Zahrani, 2013; Dewan, 2013) [6, 7]. This combined approach enhances the ability to predict flood events, assess risk levels, and plan mitigation strategies effectively (Egbinola *et al*., 2015) [8].

Several studies have highlighted the effectiveness of RS and GIS in flood risk management. For instance, Mmom and Aifesehi (2013) [11] demonstrated the application of these technologies in mapping flood-prone areas in the Niger Delta region. Similarly, Ologunorisa and Abawua (2005) [14] used GIS to assess flood vulnerability in Makurdi, Benue State.

These studies underscore the potential of RS and GIS in providing critical insights into flood dynamics and informing decision-making processes.

In Benue State, the need for a comprehensive flood risk assessment is underscored by the recurring flood events and their devastating impacts. The 2012 flood disaster, one of the worst in recent history, displaced thousands of residents and caused extensive damage to property and infrastructure (NEMA, 2013) [12]. The application of RS and GIS in this context can provide a systematic approach to understanding flood patterns, identifying high-risk areas, and implementing effective mitigation measures (Isioye *et al*., 2012; Abah, 2013) [9, 1].

This study aims to perform an impact assessment of seasonal flooding in Benue State using remote sensing and GIS technologies. The objectives include delineating different risk levels of flooding, determining the impact of flooding on various land cover types, and producing a flood risk map of the study area. By leveraging the capabilities of RS and GIS, this research seeks to contribute to the development of a robust flood management framework that can enhance the resilience of Benue State to seasonal floods (Jeb & Aggarwal, 2008; Nwilo *et al*., 2012) [10, 13].

2. Materials and Methods

Benue State is a centrally located state in Nigeria, boasting a population of approximately 4,253,641 as recorded in the 2006 census. Geographically, the state is situated between latitudes 6° 30' 00" N and 8° 0' 00" N and longitudes 7° 45' 00" E and 9° 45' 00" E (see Fig 1). This strategic location places Benue State within the Middle Belt region of Nigeria, an area known for its diverse cultural and ethnic composition.

The state is predominantly inhabited by three major ethnic groups: The Tiv, Idoma, and Igede peoples. The Tiv people, who speak the Tiv language, form the largest ethnic group in the state, predominantly occupying the central and western parts. The Idoma people, speakers of the Idoma language, are primarily located in the southern part of the state. Meanwhile, the Igede people, who speak the Igede language, reside mainly in the southeastern region.

Makurdi, the capital of Benue State, serves as the administrative and economic hub. It is a vibrant city situated on the banks of the Benue River, which plays a crucial role in the state's economy and daily life. The river is a significant waterway that supports agriculture, fishing, and transportation, making it an integral part of the state's socio-economic activities.

Benue State is often referred to as the "Food Basket of the Nation" due to its abundant agricultural resources. The fertile soil and favorable climatic conditions make it a prime area for the cultivation of various crops such as yam, rice, beans, maize, soybeans, and cassava. Additionally, the state is a leading producer of fruits and vegetables, including oranges, mangoes, and tomatoes. This agricultural wealth is central to the livelihoods of the inhabitants and the economic stability of the state.

Moreover, Benue State is rich in cultural heritage and traditions. The annual cultural festivals, traditional dances, and local crafts highlight the unique customs and practices of the Tiv, Idoma, and Igede peoples. These cultural expressions are not only a source of pride for the residents but also attract tourists, contributing to the state's cultural tourism sector.

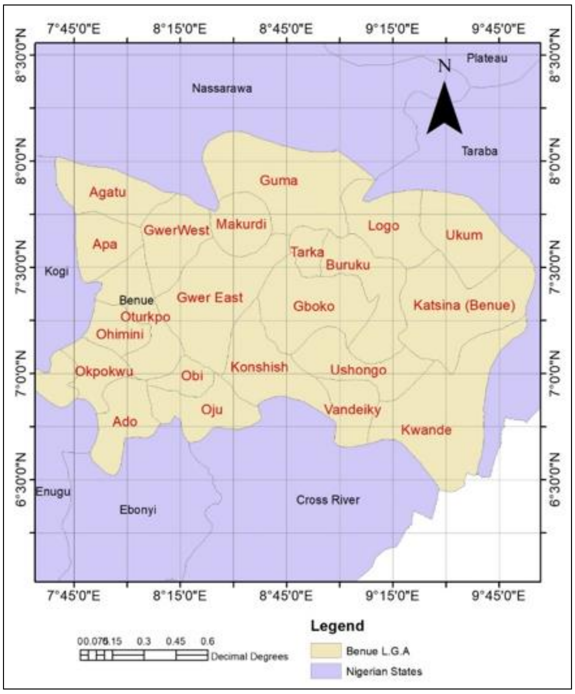

Fig 1: Map of Benue State

2.1 Method

The methodology for this research involved several stages. The data required included Sentinel imagery, Shuttle Radar Topography Mission (SRTM) data, and a shapefile of the boundary extent of Benue State. Data acquisition involved collecting primary datasets through field visits, including GPS coordinates for land cover/land use accuracy assessment and non-spatial attribute data describing the characteristics of the land cover/land use. Secondary datasets were obtained from existing sources, such as the shapefile of Benue State from the Department of Surveying & Geoinformatics at Nnamdi Azikiwe University, Awka, and Sentinel imagery and SRTM data from the Earth Explorer platform.

The processing techniques included image sub-mapping, which involved clipping the Sentinel imagery and SRTM data using the shapefile of Benue State in ArcGIS 10.6 software. Class categories were defined before site visits using a level 1 classification scheme, identifying features like built-up areas, water bodies, vegetation, and open spaces. Ground truthing was then carried out to identify these features on the ground and collect sample points for accuracy assessment. Image classification was performed using the supervised classification method, involving steps like selecting the Signature Editor and applying the supervised classification method.

SRTM processing involved filling sinks in the elevation dataset using the spatial analyst tool in Arc Toolbox to ensure accurate flow direction calculations and continuous drainage networks. This step included elevation smoothing to reduce artificial depressions and generating classified elevation, slope gradient, flow accumulation, and drainage networks in preparation for Analytical Hierarchy Process (AHP) analysis. Finally, overlay analysis was conducted to create flood hazard zones by assigning weights of importance to the layers, overlaying the weighted layers, and performing a comparison intersect matrix to produce flood risk zones for the study area, with the final calculation executed using the ArcGIS raster calculator.

3. Results

The results of the overlay analysis produced a layer showing three hazard zones; namely high risk, moderate risk and low risk in the study area.

The results indicated that high-risk zone occupied 34.68% of the entire study area, covering an area of 10857.48km^2, while moderate risk zone occupied 47.05%, covered an area of 14730.24km^2. low risk zone occupied 18.25% covering 5713.64km^2. This is distribution is also represented in Table 1 and Fig 2.

Table 1: Flood hazard zone distribution

Class Name	Area (km^2)	Percentage (%)
High Risk	10857.48	34.68
Moderate Risk	14730.24	47.05
Low Risk	5713.64	18.25
Total	31301.36	100

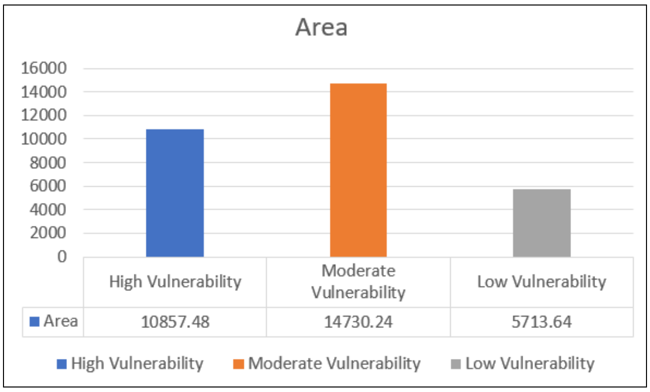

Fig 2: Histogram of flood risk distribution

a. Feature class at risk of Flooding

An overlay analysis was done, overlaying the flood hazard layer with the landcover/landuse layer to determine areas at risk. The results in shown in Fig 3.

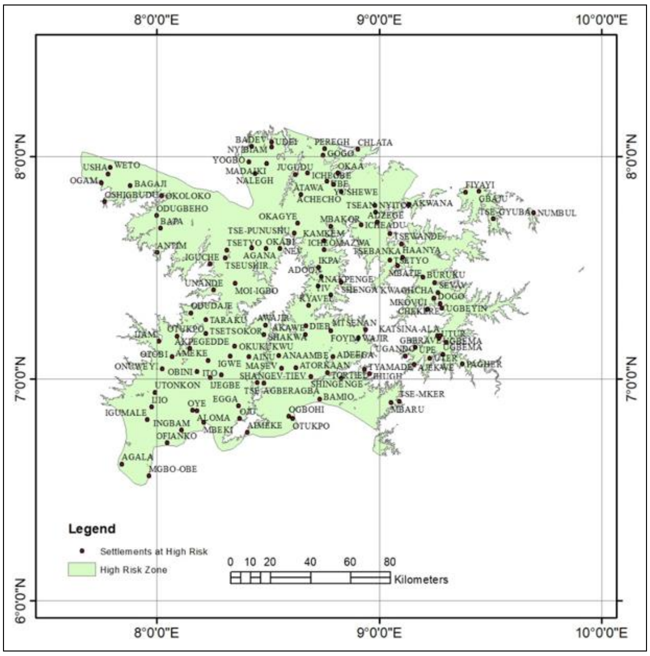

Fig 3: Feature class at high-risk flooding

The results showed that built up area occupied the largest area in high-risk flood zone with an area of 9059 km^2, followed by waterbody covering an area of 705 km^2. While water vegetation occupied 550 km^2. The distribution of settlements within the very high-risk flood zone is shown in Table 2.

Table 2: Settlements at high-risk flooding

NAME	LGA	EASTING (NTM)	NORTHING (NTM)
ODUGBEHO	APA	615568	412787
YOGBO	GUMA	661294	439232
OGAM	APA	588350	429088
OSHIGBUDU	APA	589765	419654
USHA	APA	591432	433339
WETO	APA	592544	436729
AGALA	ADOR	598059	289161
BAGAJI	APA	602604	427475
IGUMALE	ADOR	610859	311210
MGBO-OBE	OHAUKWU	611574	283221
IJIO	ADOR	612903	317483
UTONKON	ADOR	614529	324813
ANTIM	OTUKPO	615751	394249
IJAMI	OTUKPO	616647	350230
BAPA	APA	617499	406328
OKOLOKO	APA	618101	422689
ONUWEYI	OTUKPO	618213	336479
OFIANKO	OHAUKWU	620688	299660
OTOBI	OTUKPO	623087	342624
OTUKPO	OTUKPO	625600	352801
INGBAM	ADOR	627725	305987
AKPEGEDDE	OTUKPO	631845	346552
ODUDAJE	GWER	632650	364276
OYE	OJU	633344	315793
ALOMA	OJU	635454	315718
OBINI	OJU	635479	335124
MBEKI	OJU	638871	309895
TARAKU	GWER	639885	360875
TSETSOKOR	GWER	639932	354084
AMEKE	OJU	641094	340718
IJEGBE	OJU	642073	332089
IGUCHE	GWER	642189	388579
UNANDE	GWER	643868	375590
ITO	OJU	647525	333415
TSEUSHIR	GWER	649444	391610
TSETYO	GWER	650409	395534
IGWE	GWER	651877	342780
OKUKUKWU	GWER	654262	347616
MOI-IGBO	GWER	654441	379007
EGGA	OJU	655974	318022
OJU	OJU	656489	311649
AIMEKE	OJU	660519	304949
AINU	GWER	661246	342428
BADEV	GUMA	662576	446964
AGANA	GWER	662663	396502
NALEGH	GUMA	664314	433706
SHANGEV-TIEV	OJU	665514	329481
TSE-AGBERAGBA	KONSHISHA	668585	329227
SHAKWA	KONSHISHA	668773	353496
AWAJIR	KONSHISHA	669409	358230
OKABI	GWER	669728	396280
MADAIKI	GUMA	669989	438524
UDEI	GUMA	672435	449348
NYIBIAM	GUMA	672508	446857
ANAAMBE	KONSHISHA	675995	343178
NEV	GWER	676705	396177
MASEV	KONSHISHA	677417	336862
OGBOHI	YALA	681065	312810
OTUKPO	YALA	682999	311849
TSE-PUNUSHU	GWER	683836	404003

JUGUDU	GUMA	684151	433164
ATORKAAN	KONSHISHA	684530	337085
OKAGYE	GWER	685270	408872
ATAWA	GUMA	686916	423119
AKAWE	GBOKO	689160	353493
DIEB	GBOKO	689382	357742
ICHEGBE	GUMA	690379	433784
KYAVEL	GBOKO	690944	367882
SHINGENGE	KONSHISHA	691927	332555
ANAKPENGE	GBOKO	695560	377498
IKPA	GBOKO	695765	386847
BAMIO	KONSHISHA	696382	321445
ADOON	GBOKO	697067	382154
GOGO	GUMA	698076	442579
ICHEOMAZWA	GBOKO	698403	395776
KAMKEM	GBOKO	698522	400194
PEREGH	GUMA	698683	445880
UBE	GUMA	699789	429769
TORTIEL	KONSHISHA	700179	334558
FOYIM	GBOKO	701733	355411
TIV	GBOKO	701817	373185
MBAKOR	GBOKO	701897	407327
ADEEGA	USHONGO	702842	342455
YUSHEWE	GUMA	703236	428012
OKAA	GUMA	705206	433874
ACHECHO	GUMA	706902	424501
SHENGA	GBOKO	707079	379620
TYOGBENDA	KONSHISHA	707172	331805
CHLATA	GUMA	715233	445562
WAJIR	USHONGO	715546	351882
ICHEADU	BURUKU	716841	408122
TYAMADE	USHONGO	718501	336304
MTSENAN	USHONGO	719057	355850
IHUGH	VANDEIKYA	721075	334066
NYITOR	GUMA	723597	417806
TSEAN	GUMA	724031	414394
ADZEGE	GUMA	724786	409488
TSETYO	BURUKU	731006	390427
TSEWANDE	GUMA	731125	403693
MBARU	VANDEIKYA	731782	319891
MBATIE	BURUKU	734937	387810
TSE-MKER	VANDEIKYA	735816	320429
TSEBANKA	BURUKU	736798	398644
HAANYA	BURUKU	737337	392038
UGANDO	USHONGO	738712	342944
AKWANA	WUKARI	740415	417981
AJEKWE	USHONGO	743150	338573
UPE	BURUKU	743807	347123
BURUKU	BURUKU	747588	382201
MKOVUI	BURUKU	749647	366074
UTER	USHONGO	751020	341813
DOGO	BURUKU	753079	371574
SEVAV	BURUKU	753364	379226
UTUR	BURUKU	754587	352955
KWAGHCHA	BURUKU	755027	374416
UGBEMA	BURUKU	755431	351782
CHEKERE	BURUKU	755983	368963
KATSINA-ALA	BURUKU	756153	352924
UGBEYIN	BURUKU	757016	366755
UGBEMA	USHONGO	757472	343798
GBERAVE	USHONGO	759033	349674
PAGHER	KWANDE	767188	339010
FIYAYI	WUKARI	768493	424496
GBAJU	WUKARI	775023	424819
TSE-GYUBA	UKUM	782343	411276
NUMBUL	UKUM	802266	414233

b. Features at risk of Moderate flooding

The overlay results showing feature class at Moderate risk is shown in Fig 4.

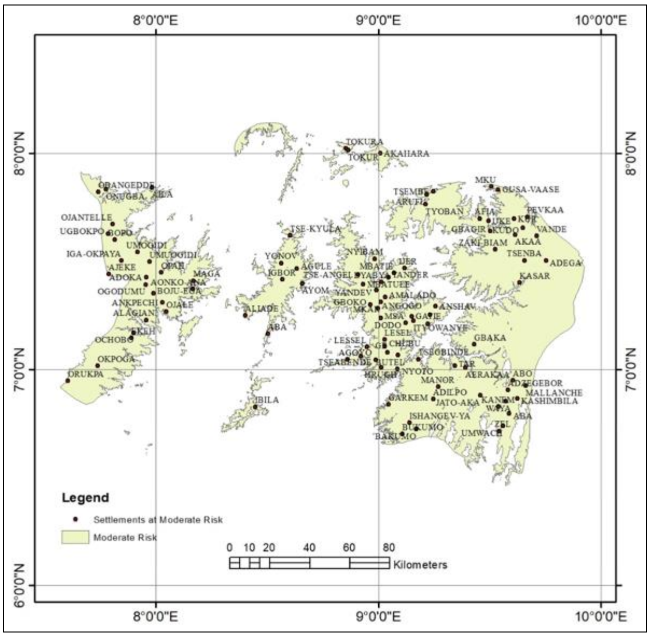

Fig 4: Feature class at moderate risk flooding

The results fig 4.6 indicates that built up area occupied the largest area in moderate risk flood zone with an area of 13097 km^2, followed by open space covering an area of 1500 km^2. While water body and vegetation occupied 1101 and 1041 km^2 respectively. The settlements within the moderate risk flood zone is shown in Table 3.

Table 3: Settlements at risk of Moderate risk flooding

NAME	LGA	EASTING (NTM)	NORTHING (NTM)
UMUOGIDI	OTUKPO	612619	386658
ORUKPA	OGBADIBO	571931	325841
OKPOGA	OGBADIBO	586591	333398
OBANGEDDE	APA	587174	422387
ONUGBA	APA	590890	423690
UGBOKPO	APA	592124	401096
AJEKE	OTUKPO	592371	380355
OJANTELLE	APA	594318	405808
BOPO	APA	595266	397936
IGA-OKPAYA	APA	598457	387288
EKEH	OTUKPO	603330	347796
OCHOBO	OTUKPO	604674	350334
UMOGIDI	OTUKPO	606452	391670
OGODUMU	OTUKPO	610654	375006
ADOKA	OTUKPO	610874	378654
ALAGIANI	OTUKPO	610978	356867
AILA	APA	613820	424687
BOJU-EGA	OTUKPO	614494	370610
OPAH	OTUKPO	618259	381185
ANKPECHI	OTUKPO	618794	365762
OJALE	OTUKPO	620740	361149
AONKO-ANA	GWER	633921	372680
MAGA	GWER	634039	376895
ALIADE	GWER	659925	359156
IBILA	OJU	664803	312384
ABA	KONSHISHA	671142	349816
YONOV	GWER	677793	385936
IGBOR	GWER	678127	377627
TSE-KYULA	GWER	682038	400137

AGULE	GBOKO	685445	383171
AYOM	GBOKO	688157	375525
TOKURA	GUMA	709813	444595
AGOYO	USHONGO	710495	336706
TOKUR	GUMA	710723	443787
TSE-ANGEL	GBOKO	715649	380013
CHIA	USHONGO	717137	338309
MBATULE	GBOKO	718383	375235
LESSEL	USHONGO	720260	343026
GBOKO	GBOKO	721789	364801
NYIBAM	GBOKO	723907	388152
TSEABENDE	USHONGO	724583	336568
YANDEV	GBOKO	724882	372104
ANGOGO	GBOKO	725628	362912
AKAHARA	GUMA	726564	442115
MKAR	GBOKO	727044	365995
MSA	GBOKO	727088	357786
BYABYA	GBOKO	727392	376203
HRUGH	VANDEIKYA	727412	332721
LESEL	USHONGO	729004	346877
CHUBU	USHONGO	729059	343644
AMALADO	GBOKO	729113	368529
GE	USHONGO	730227	340249
TANDER	GBOKO	730755	378805
GARKEM	VANDEIKYA	730845	313673
MBATIE	GBOKO	733645	380918
NYOTO	VANDEIKYA	735372	331772
BUTEL	USHONGO	735539	339006
BUKUMO	VANDEIKYA	737737	298545
IJER	BURUKU	738647	383420
DODO	BURUKU	739301	355502
ISHANGEV-YA	VANDEIKYA	741467	304434
GATIE	BURUKU	742347	358817
ITYOWANYE	BURUKU	743252	356477
BAKUMO	KWANDE	744789	301078
TSEGBINDE	USHONGO	745636	336851
TYOBAN	WUKARI	749192	416121
ARUFU	WUKARI	749648	420997
ABWA	BURUKU	750280	354834
TSEYUMA	BURUKU	751287	359472
TSEMBE	WUKARI	753021	422636
ADILPO	KWANDE	753263	316425
ANSHAV	BURUKU	754082	363897
MANOR	KWANDE	755590	322825
TAR	KWANDE	763846	333485
AERAKAA	KWANDE	768876	332532
GBAKA	KWANDE	773279	344436
AFIA	UKUM	775981	408873
JATO-AKA	KWANDE	776396	318457
UKE	UKUM	780301	407608
GBAGIR	UKUM	781203	402380
MKU	UKUM	781566	425111
ZAKI-BIAM	UKUM	783732	393115
GUSA-VAASE	UKUM	785053	423682
KANEM	KWANDE	785413	312664
ZEL	KWANDE	785781	300214
UMWACH	KWANDE	787813	302778
WAYA	KWANDE	788964	315516
ADZEGEBOR	KWANDE	790215	321134
ABA	KWANDE	790840	309079
ABO	KWANDE	792531	326142
KUR	UKUM	792869	408786
AKAA	UKUM	793573	400670
KASHIMBILA	KWANDE	794847	316850
KASAR	UKUM	795890	376128
KUDO	UKUM	797330	404194
TSENBA	UKUM	798337	387496
MALLANCHE	KWANDE	798922	323510
PEVKAA	UKUM	799385	409752
VANDE	UKUM	804093	399978
ADEGA	UKUM	808846	387455

c. Features at low-risk flooding

The results for feature class at low-risk flooding indicate that built up area occupied the largest area in low-risk flood zone with an area of 4140 km^2, followed by open space covering an area of 70 km^2. While water body and vegetation occupied 60 and 40 km^2 respectively. The distribution of settlements within the low-risk flood zone is shown in Table 4.

Table 4: Settlements at Low-risk flooding

NAME	LGA	EASTING	NORTHING
GESA	KWANDE	781322	284562
SUSU	KWANDE	785417	273104
KANDEV	KWANDE	797734	310064

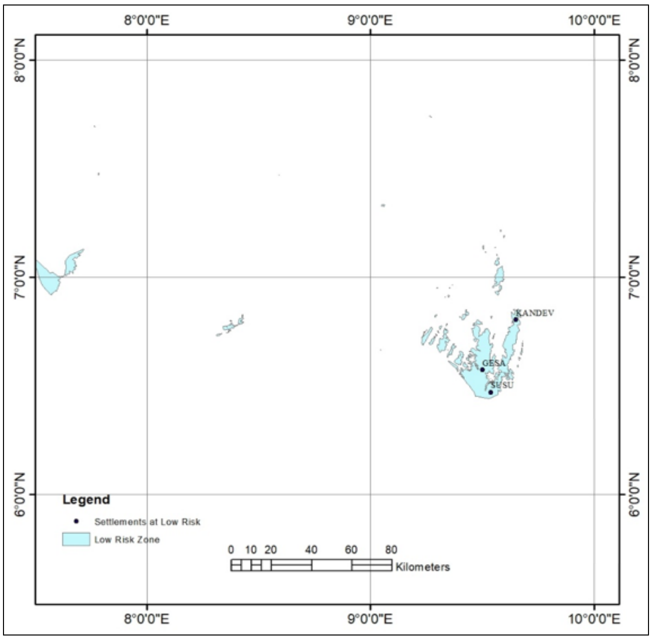

Fig 5: Settlements at low-risk flooding

3. Discussion of Results

The results of this study indicated that the high-risk flood zone occupied 34.68% of the entire study area, covering 10,857.48 km². The moderate-risk zone occupied 47.05% of the study area, covering 14,730.24 km², while the low-risk zone covered 18.25%, or 5,713.64 km². This distribution is also represented in Table 1 and Fig 2.

High-Risk Zone: The built-up area occupied the largest portion, covering 9,059 km², followed by water bodies at 705 km², and water vegetation at 550 km². This suggests that densely populated and urbanized areas are most vulnerable to flooding. The distribution of settlements within this very high-risk flood zone is shown in Table 2.

Moderate-Risk Zone: Built-up areas also dominated here, covering 13,097 km², followed by open spaces at 1,500 km². Water bodies and vegetation covered 1,101 km² and 1,041 km², respectively. The distribution of settlements within the moderate-risk flood zone is shown in Table 3.

Low-Risk Zone: Built-up areas again occupied the largest portion, covering 4,140 km², followed by open spaces at 70 km². Water bodies and vegetation covered 60 km² and 40 km², respectively. The distribution of settlements within the low-risk flood zone is shown in Table 4.

The significance of these findings lies in their potential to inform flood risk management and urban planning in Benue State. The high percentage of built-up areas in both high and moderate-risk zones highlight the urgent need for targeted flood mitigation strategies in urban regions. This information can aid policymakers and urban planners in prioritizing areas for intervention, improving flood defences, and developing evacuation plans.

The implication of these results is profound for local communities, as they provide a clear identification of areas most susceptible to flooding, which is crucial for disaster preparedness and resilience building. For instance, resources can be allocated more efficiently to reinforce infrastructure in high-risk zones, while low-risk areas might be considered for future development.

This study contributes to scientific knowledge by providing a detailed spatial analysis of flood risk using remote sensing and GIS technologies. The methodology and results demonstrate the value of integrating multiple data sources to produce comprehensive flood risk maps, which can be replicated in other regions facing similar challenges. Additionally, the study offers a framework for assessing the impact of flooding on different land cover types, contributing to the broader understanding of flood dynamics in the context of urban and regional planning.

4. Conclusion

This study aimed to assess flood risk in parts of Benue State using remote sensing and GIS. The objectives were to delineate different flood risk levels in the study area, determine the impact of flooding on various land cover types, and produce a flood risk map. The methodology included data acquisition, data processing, reclassification, and overlay analysis. This study demonstrated the effectiveness of remote sensing and GIS technologies in classifying and identifying areas with high, moderate, and low flood risks within the study area.

The land use/land cover distribution of Benue State in 2021 indicated that forested areas accounted for the largest land cover, comprising about 65.13% (2,039,157 hectares). Grassland covered 5.73% (239,423.9 hectares), farmland also covered 5.73% (179,424.5 hectares), bare surfaces covered 6.47% (202,653.6 hectares), rocky areas covered 4.98% (153,274.9 hectares), settlements covered 9.19% (287,964.3 hectares), and water bodies covered 0.92% (28,864.94 hectares).

The results of the overlay analysis produced a layer showing three hazard zones: High risk, moderate risk, and low risk. The high-risk zone occupied 34.68% of the study area, covering 10,857.48 km². The moderate-risk zone occupied 47.05%, covering 14,730.24 km². The low-risk zone occupied 18.25%, covering 5,713.64 km². These findings underscore the importance of remote sensing and GIS in flood risk assessment and land management.

5. References

1. Abah RC. An application of geographic information system in mapping flood risk zones in a north central city in Nigeria. African Journal of Environmental Science and Technology. 2013; 7(6):365-371.
2. Adejumo O, Adejumo T. Climate change and agricultural productivity in Nigeria: Implications for achieving food security. Journal of Earth Science & Climatic Change. 2014; 5(8):234-245.
3. Adelekan IO. Vulnerability assessment of climate-induced natural disasters in Nigeria: Case study of Nigerian coastal communities. Natural Hazards. 2011; 56(1):237-263.
4. Adeoye NO, Ayanlade A, Babatimehin O. Climate change and menace of floods in Nigerian cities: Socio-economic implications. Advances in Natural and Applied Sciences. 2009; 3(3):369-377.
5. Aderogba KA. Qualitative studies of recent floods and sustainable growth and development of cities and towns in Nigeria. International Journal of Academic Research in Economics and Management Sciences. 2012; 1(3):1-25.
6. Chowdhury RK, Al-Zahrani M. Characterizing water resources and trends of sector wise water consumptions in Saudi Arabia. Journal of King Saud University - Engineering Sciences. 2013; 25(2):81-90.
7. Dewan AM. Floods in a Megacity: Geospatial Techniques in Assessing Hazards, Risk and Vulnerability. Springer Science & Business Media, 2013.
8. Egbinola CN, Olaniran HD, Amanambu AC. Flood management in cities of developing countries: The example of Ibadan, Nigeria. Journal of Flood Risk Management. 2015; 10(4):461-471.
9. Isioye OA, Onwuka OS, Salami AT. Geospatial analysis of flood disaster in Kogi State, Nigeria. Journal of Environmental Sciences and Resources Management. 2012; 4(1):43-52.
10. Jeb DN, Aggarwal SP. Flood inundation hazard modelling of the River Kaduna using remote sensing and geographic information systems. Journal of Applied Sciences Research. 2008; 4(12):1822-1833.
11. Mmom PC, Aifesehi PE. Vulnerability and resilience of Niger Delta coastal communities to flooding. Journal of Coastal Research. 2013; 29(3):704-712.
12. NEMA. Annual Flood Report 2012. National Emergency Management Agency, Abuja, Nigeria, 2013.
13. Nwilo PC, Badejo OT, Olayinka DN. Sea level rise and Nigeria's coastal resources: Development, climate change and migration scenarios. Marine Geodesy. 2012; 35(1):86-101.
14. Ologunorisa TE, Abawua MJ. Flood risk assessment: A review. Journal of Environmental Management. 2005; 27(1):52-59.
15. Thomson MC, Hardin K. Remote sensing of vegetation and land-cover change in the Sahel. Geographical Journal. 2000; 166(3):311-320.