



## GEOSPATIAL PROFILING OF FLOOD VICTIMS AND ASSOCIATED LOSSES OF LIVES AND PROPERTIES IN THE AFTERMATH OF 2022 FLOODS IN JIGAWA STATE, NORTHERN NIGERIA

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### ABSTRACT

Flooding is one of the natural disasters causing destructions in Jigawa state, Nigeria. Since 2018, flood has been claiming lives and properties across Jigawa. The real figures on loss of lives and properties have not been scientifically reported. The aim of this research is to conduct a geospatial profiling of flood victims and associated loss of lives and properties in the aftermath of 2022 floods in Jigawa. Fatality locations were determined through indexing and buffering using GeoEye, LandSat 8 and Shuttle Radar Topography Mission images. Extent of flooded areas in August, September and October, 2022 were determined using modified normalized difference water index. All analyses were done in ArcGIS 10.3 and SPSS. Out of the 27 Local Government Areas, 19 were affected. Areas with highest flooding were: Guri, Kirikasamma, Miga, Auyo and Ringim in descending order. Most of the flood prone areas were characterized by low elevation, proximity to water bodies and poor land use planning. Miga LGA recorded the highest number of deaths (20) followed by Kirikasamma (14) Birnin Kudu (13) Kafin Hausa (11) Jahun & Ringim (8) Birniwa (7) Auyo (6) Sule Tankarkar (4) Hadejia & Maigatari (3) Kaugama & Malammadori (2) Gagarawa & Taura (1). About 15 of the LGAs had buildings, farmlands and other structures affected. Causes of deaths were attributed to: building collapse (40%) water – borne diseases (20%) drowning in flood waters (15%) motor vehicle accidents (5) canoe – based accidents (5%) snake bites (5%) others (10%). Proper land use planning, resettlement, dredging and river trainings are recommended.

**Keywords:** Floods, Fatalities, River Training, Modified Normalized Difference Water Index, Local Government Areas

### INTRODUCTION

Flood has been the highest occurring natural hazard in Nigeria, causing severe damages to lives and properties (Alfa *et al.*, 2018). It has become an annual event in many regions of the country occurring in the form of coastal floods, river floods, flash floods and urban floods (Komolafe *et al.*, 2015). In 2018, floods affected more than 1.9 million persons across 12 states in Nigeria which caused the displacement of more than half a million from their households (WHO, 2018). The main causes of flooding were related to the inability of river channels to accommodate flood waters beyond its carrying capacity, which in most cases resulted in flooding a vast portion of lands (Alfa *et al.*, 2018). This is very similar to what obtains in Jigawa State, where inability of the two major rivers (rivers Hadejia & Iggi) to safely accommodate and discharge runoff during peak rainy seasons results in flooding vast hectares of agricultural lands and submergence of several communities along the river systems over the last decades (Iliyasu, 2017). Floods risk assessment, control, and management are crucial and are very challenging tasks because of the uncertainty of flood events which are due to many climatic, physiographic and land use factors of the watershed such as, rainfall intensity, topography, lithological settings, building types, etc. (Li *et al.*, 2019). Flooding effects are not only restricted to everyday livelihood but also the environment and the society at large, in terms of economic losses and damages (Vu & Ranzi, 2016). The management of flood risks can be achieved by either reduction of the hazard inflicted by floods or by reduction of the vulnerability of the exposed population (Komi *et al.*, 2016). Flood management strategies require early identification of flood prone areas for an effective early warning system, facilitation of quick response and reduction of the impact of possible flood events (Chakraborty & Mukhopadhyay, 2019).

According to Adger *et al.*, (2005), many low-income populations live in low lying areas at risk of flooding in large cities in Africa, and these are substantially areas with relatively higher records of fatalities than the uplands. In addition, results of focus group discussions conducted by Douglas *et al.*, (2008) over large cities across Africa: Lagos (Nigeria) Accra (Ghana) Maputo (Mozambique) and Nairobi (Kenya) linked flood disasters to problems with drainage systems, poor waste disposal approaches, urban planning, and planning policy implementation problems. Poor response time to distress calls, lack of or inadequate disaster response facilities, and poor warning systems are associated factors that increase flood fatalities (Douglas *et al.*, 2008; Abass *et al.*, 2022). In general, determination of flood fatalities in Africa is better hypothesized as a complex interplay of related factors, particularly climate, rapid and unplanned urban growth, poor waste management culture, and institutional ineptitude (Abbas, *et al.*, 2022) rather than a rainfall – stream discharge relationship that has been reported by most studies (Kundzewicz and Schellnhuber 2004; Di Baldassarre *et al.*, 2010; Trambly *et al.*, 2020).

Kwari, *et al.*, (2015) used socio –economic assessment to study the causes and impacts of flooding on agriculture and socio-economic growth in Adamawa State of Nigeria, it was a cross case study analysis based on secondary data alone. Also, Kayode *et al.* (2017) used only socio –economic survey for a post – disaster assessment for riverine communities impacted by severe flooding in southern Nigeria. In a different approach, Dottori *et al.* (2016) used GIS for flood susceptibility and vulnerability analysis in complex flood scenarios, the methodology was based on a mathematical index, which considered local topography and basic information about the flood scenario to reproduce flooding processes in Northern Italy. Nkeki *et al.* (2013) too, used

geospatial techniques, only, for the assessment and analysis of flood risk along the Niger-Benue Basin in Nigeria. But in a more promising approach, Olaide *et al.* (2014) used a combination of geospatial and socio- economic approach to assess the 2012 Flood Disaster in Kogi State, Nigeria.

Despite the increasing frequency and severity of flooding events in northern Nigeria, particularly in Jigawa State, there remains a significant gap in scientifically validated and spatially explicit data on flood-related fatalities and associated losses of properties. Existing studies in Nigeria have largely focused on either socio-economic assessments or geospatial flood mapping in isolation, with limited integration of both approaches for comprehensive flood impact analysis. Furthermore, most available flood studies emphasize hydrological relationships (rainfall–runoff dynamics) without adequately capturing the spatial distribution of human vulnerability, fatality patterns, and infrastructure damage. This limitation constrains effective disaster risk reduction planning, especially in highly vulnerable riverine and low-lying communities. The 2022 flood event in Jigawa State represents one of the most devastating in recent history, yet there is no detailed geospatial profiling of victims, fatalities, and affected assets across Local Government Areas (LGAs). Such information is critical for:

- i. targeted disaster response,
- ii. evidence-based land use planning,
- iii. development of early warning systems.

Therefore, this study is justified in its attempt to integrate geospatial techniques (GIS and remote sensing) with socioeconomic data to provide a comprehensive spatial assessment of flood impacts, thereby filling an important knowledge and policy gap in flood risk management in Nigeria.

**Research Hypotheses**

**Null Hypothesis (H<sub>0</sub>)**

There is no significant relationship between flood occurrence (extent) and:

- i. elevation,
- ii. proximity to river channels,
- iii. and distribution of flood-related fatalities and property losses in Jigawa State.

**Alternative Hypothesis (H<sub>1</sub>):**

There is a significant relationship between flood occurrence (extent) and:

- i. elevation,
- ii. proximity to river channels,
- iii. and distribution of flood-related fatalities and property losses in Jigawa State.

This study is aimed at showcasing the impacts of floods on human and material losses in Jigawa state, northern Nigeria, using a combination of socio – economic and geospatial methods.

**MATERIALS AND METHODS**

**Study Area**

Jigawa state is located in the north-western part of Nigeria, between latitudes 11.00°N to 13.00°N and longitudes 8.00°E to 10.15° E. Kano and Katsina States border Jigawa to the west, Bauchi State to the east and Yobe State to the north-east. The State has an area of 23,154 km<sup>2</sup> and a population of 6,954,612 based on 2006 census and 3.5% projected growth rate (National Bureau for Statistics, 2020). The study area is the whole of Jigawa State that comprise of 27 Local Government Areas (LGAs)(Fig.1).They are: Auyo, Babura, Biriniwa, Birnin Kudu, Buji, Dutse, Gagarawa, Garki, Gumel,Guri, Gwaram, Gwiwa, Hadejia, Jahun, Kafin Hausa, Kaugama, Kazaure, Kirikasamma, Kiyawa, Maigatari, Malamadori, Miga, Ringim, Roni, Sule Tankarkar, Taura and Yankwashi.

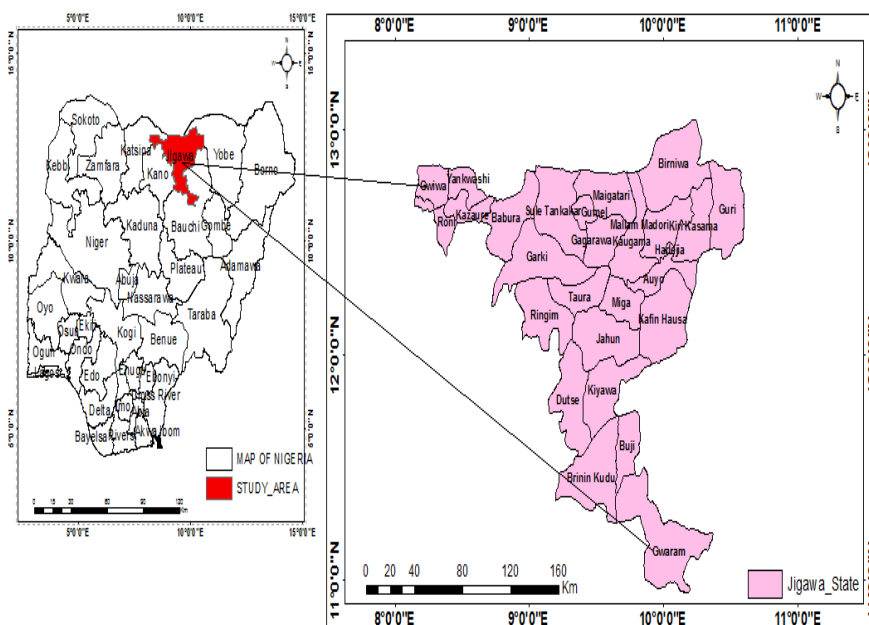


Figure 1: Map of the Jigawa State Showing LGAs



Landsat 8 band 3) and the SWIR (SWIR- Landsat 8, band 6) wavelength bands were used where the SWIR band is subtracted from the green band before being normalized by the sum of the two bands as in Equation (1)

$$MNDWI = (GREEN-SWIR) / (GREEN+SWIR) \text{ equation.... (1)}$$

Where: Green = reflectance in Green wavelengths, 0.525-0.600nm (Landsat8 band 3) SWIR = reflectance in SWIR wavelengths, 2.100-2.300nm (Landsta8 band 6) Like the NDWI, the MNDWI also produces an index of values ranging between -1 and +1 where water features are denoted by higher positive values. An index threshold value of zero was used once again to distinguish non-water from water features in the MNDWI images.

**Mapping of Flood Extent**

The Modified Normalized Difference Water Index (MNDWI) was applied to Landsat 8 images to accurately detect flood extent. Previous studies (Memon et al., 2015, Gosh & Swades, 2023 and Asif, et al. 2023) have confirmed that MNDWI outperforms the NDWI in mapping water features (Xu, 2006). This approach enabled the detection of flood extent for three major flood events.

The MNDWI was calculated for each Landsat 8 image using the formula:  $MNDWI = (Green - SWIR) / (Green + SWIR)$ , equation 1. This calculation allowed for the differentiation between water and non-water features. The resulting MNDWI images provided a clear representation of the flood extent. Each MNDWI image was then recoded into binary thematic layers, where '1' represented flooded areas and '0' represented non-flooded areas. This binary recoding enabled the creation of clear and concise flood extent maps. The resulting binary maps showcased the full extent of flood inundation for each period.

Three flood extent maps were generated for each month, illustrating the spatial distribution of floodwater. The area covered by floodwater was calculated for each LGA in Jigawa state, providing valuable insights into the extent of flooding in each LGA. These calculations enabled the assessment of flood risk and the identification of areas most affected by flooding.

The final output consisted of thematic maps displaying the flood extent for each period, accompanied by tables illustrating the area covered by floodwater in each local government.

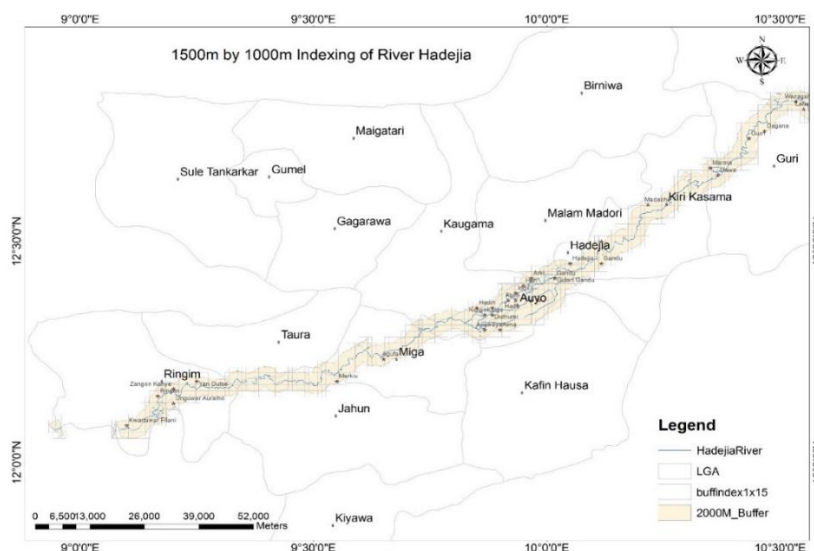


Figure 3: Indexing of River Hadejia

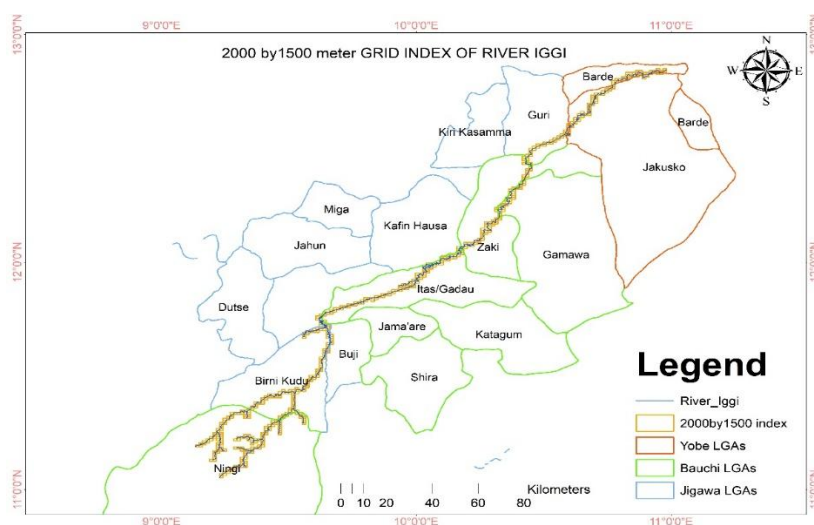


Figure 4: Indexing of River Iggi

**Socio – Economic Survey**

Two thousand structured questionnaires were administered to the affected communities within the sampled Index Sheets (64 index sheets) so as to get very reliable and accurate information on the flood related deaths and associated losses of properties. Only one thousand five hundred were retrieved and used for the analysis. Focus group discussions were done in two locations in each of the LGAs affected, in order to validate the questionnaires. After retrieving the questionnaires, SPSS was used to profile all deaths that were attributable directly or indirectly to the flood events, and the damages caused to the infrastructure (agriculture and other facilities) in the study area.

**RESULTS AND DISCUSSION**

**Socio – Economic Characteristics of the Respondents**

The study used socio- economic survey to study the causes and impact of floods on the livelihoods of the people in the affected areas (as done by Kwari et al., 2015 and Kayode et al., 2017). Most of the respondents were farmers (55.4%) and very few were civil servants (4.3%). Traders constituted 18.3%, while 21.8% of the respondents engage in other forms of livelihoods. About 73% of them had access to flood information. Majority (95%) of the respondents experienced flooding in the last 10 years. Some 50% of the respondents

had family sizes of 6 – 10; 32.3% had 1 – 5 family members, 16% were 11 – 15 while those with >16 members in their families constituted only 1.7%. From the respondents’ points of observations, causes of deaths in the aftermath of the 2022 floods were: building collapse (40%) water – borne diseases (20%) drowning in flood waters (15%) motor vehicle accidents (5) canoe – based accidents (5%) snake bites (5%) others (10%).

**Flood Related Deaths from August – October 2022**

Out of the 27 Local Government Areas, 19 were affected in either loss of lives or properties in the aftermath of 2022 floods. Most of the flood prone areas were characterized by low elevation, proximity to water bodies, poor land use planning and environmental conservation measures. From table 2, the total lives lost were one hundred and three (103). No fatalities were recorded in August, since the flood waters have not gathered momentum at that time. Miga LGA recorded the highest number of deaths (20) which was attributed to its low elevation, followed by Kirikasamma (14) Birnin Kudu (13) Kafin Hausa (11) Jahun & Ringim (8) Birniwa (7) Auyo (6) Sule Tankarkar (4) Hadejia & Maigatari (3) Kaugama and Malammadori (2) Gagarawa and Taura, 1 each. These figures are depicted in table 2 and figure 5 below.

**Table 2: Flood Related Deaths in 2022**

S/no	Months	LGAs	Deaths
1	October	Auyo	6
2	September	Birnin Kudu	13
3	September	Birniwa	7
4	September	Gagarawa	1
5	October	Hadejia	3
6	September	Jahun	8
7	October	Kafin Hausa	11
8	September	Kaugama	2
9	October	Kirikasamma	14
10	September	Maigatari	3
11	September	MallamMadori	2
12	September	Miga	20
13	October	Ringim	8
14	September	Sule Tankakar	4
15	October	Taura	1
<b>Total</b>			<b>103</b>

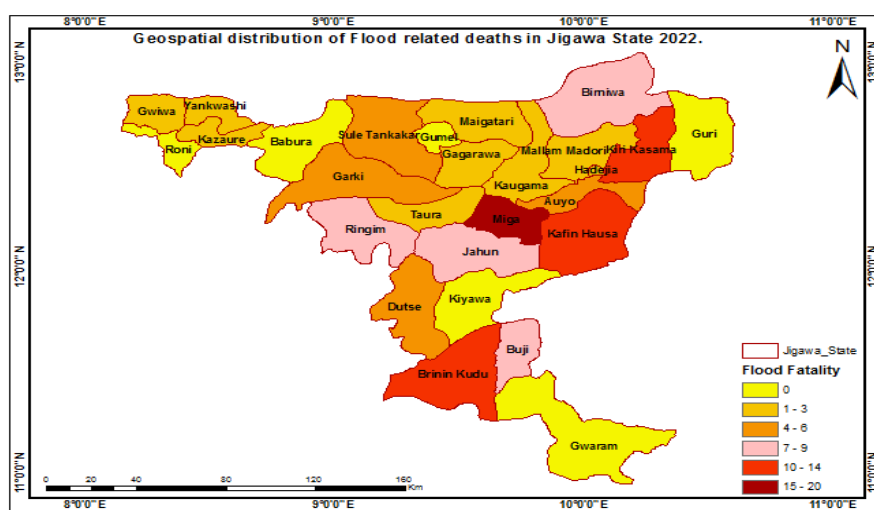


Figure 5: Map of Jigawa State Showing Distribution of Flood Related Deaths per LGA

**Geospatial Analysis of floods in Jigawa State**

After the socio – economic analysis, the study employed geospatial analysis (as used by Dottori et al., 2016 and Nkeki at al., 2013). The latter involved flood extent and elevation analyses.

**Flooded Areas from August to October 2022**

Out of the 23,154 km<sup>2</sup> of the entire Jigawa State, 1099.028 km<sup>2</sup> were flooded as of August 2022 (Fig. 6). A total of nineteen LGAs have experienced flooding, while 8 LGAs didn't experience any (table 3). This is attributable to the fact that they are very far away from the two main rivers and are on relatively higher elevations. Miga, with an elevation of 377m above mean sea level (a.s.l.), had the highest flooding (145.97 km<sup>2</sup>) followed by Auyo with elevation of 363 a.s.l. (91.41 km<sup>2</sup>) then Guri with the lowest elevation of 349 (table 6), had a total of 83.02 km<sup>2</sup> flooded. The remaining areas only experienced mild flooding in August. This is most likely because the flood waters have not gathered enough momentum at this early period of the rainy season. In

September, 2022, Miga again had the highest floods, followed by Auyo, Kirikasamma, Guri and Kafin Hausa (164.04, 160.23, 131.30 and 118.99km<sup>2</sup>) respectively. Apart from Ringim that was a bit high with 109.19 km<sup>2</sup> (Ringim is on relatively higher elevations (392m), but very close to River Hadejia) the remaining LGAs had only mild levels of flooding. Babura, Birniwa, Gagarawa, Garki, Gumel, Gwiwa, Maigatari and Sule Tankarkar didn't get any floods (table 4). In the month of October, twenty out of the twenty-seven LGAs were now flooded. Guri, which has the lowest elevation (table 5) and the terminal end of river Hadejia to the north – eastern part of Jigawa State, had the highest flooding (400.96km<sup>2</sup>). Guri was followed by Kirikasamma (195.73km<sup>2</sup>). Miga was the third with 159km<sup>2</sup>, then Auyo (135.64). Ringim was the last among LGAs with highest levels of flooding (110.96km<sup>2</sup>). Interestingly, Roni and Yankwashi that had some few areas flooded in August and September (tables 2 & 3) were among the LGAs that didn't get any flooding in October (table 5). The flooded areas are here depicted in figure 8.

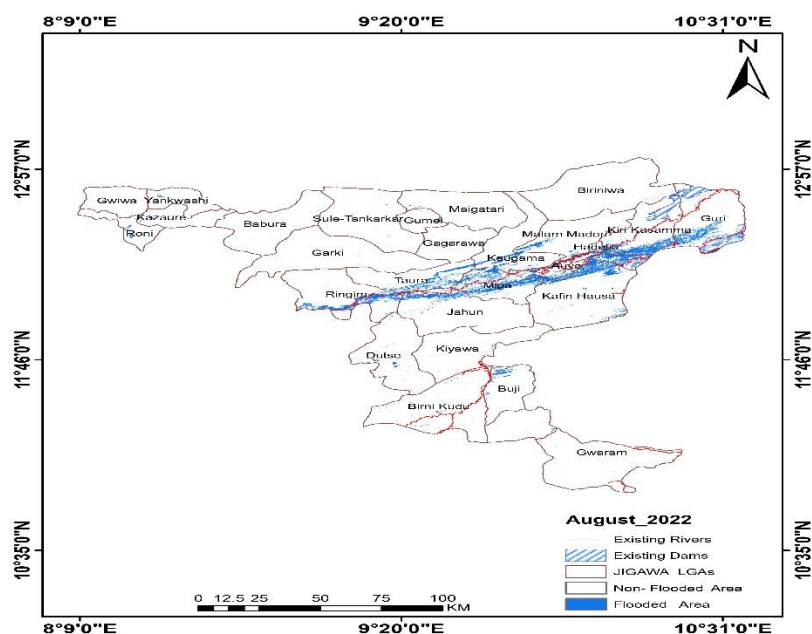


Figure 6: Flood Extent in August 2022

**Table 3: Flooded Area Extent per LGAs in August 2022**

LGAs	Land Area(km <sup>2</sup> )	Flooded Area (km <sup>2</sup> )	Flooded Area (%)
Auyo	423.848	91.41	12.46
Babura	1001.182	3.42	0.47
Birnin Kudu	1402.56	9.9	1.35
Birniwa	1592.059	0.13	0.02
Buji	568.401	29.7	4.05
Dutse	1028.417	3.9	0.53
Gagarawa	582.401	0.19	0.03
Garki	1408.224	2.58	0.35
Gumel	227.248	0.09	0.01
Guri	1063.956	83.02	11.32
Gwaram	1857.667	9.4	1.28
Gwiwa	451.249	0.12	0.02
Hadejia	32.218	2.2	0.30
Jahun	1245.081	53.9	7.35
Kafin Hausa	1370.461	48.9	6.67
Kaugama	816.802	29.47	4.02
Kazaure	381.86	2.57	0.35

LGAs	Land Area(km <sup>2</sup> )	Flooded Area (km <sup>2</sup> )	Flooded Area (%)
Kirikasamma	829.543	60.46	8.24
Kiyawa	1030.758	6.4	0.87
Maigatari	963.881	0.14	0.02
MalamMadori	806.195	31.83	4.34
Miga	568.703	145.97	19.90
Ringim	1020.137	64.9	8.85
Roni	303.986	1.21	0.16
Sule Tankarkar	1231.64	0.4	0.05
Taura	655.251	49.4	6.74
Yankwashi	337.822	4.32	0.59
Total	23,154	733.35	100

**Table 4: Flooded Area Extent per LGAs in September 2022**

L.G. A	Land Area (km2)	Flooded Area (km2)	Flooded Area (%)
Auyo	423.848	160.230078	14.57
Babura	1001.182	0	0
Birniwa	1592.059	0	0
Birnin Kudu	1402.560	9.762214	0.888
Buji	568.401	22.135496	2.014
Dutse	1028.417	4.20019	0.382
Gagarawa	582.401	0	0
Garki	1408.224	0	0
Gumel	227.248	0	0
Guri	1063.956	128.745208	11.71
Gwaram	1857.667	5.94977	0.541
Gwiwa	451.249	0	0
Hadejia	32.218	5.107237	0.464
Jahun	1245.081	73.18579	6.659
Kafin Hausa	1370.461	118.986581	10.82
Kaugama	816.802	41.286648	3.756
Kazaure	381.860	2.576775	0.234
Kirikasamma	829.543	131.29498	11.946
Kiyawa	1030.758	5.14234	0.467
Maigatari	963.881	0	0
MalamMadori	806.195	34.902349	3.175
Miga	568.703	164.041155	14.92
Ringim	1020.137	109.188	9.934
Roni	303.986	0.934919	0.085
Sule Tankarkar	1231.640	0	0
Taura	655.251	78.7378	7.164
Yankwashi	337.822	2.62032	0.238
Total	23,154	1099.028	100

**Table 5: Flood Area Extent in October, 2022**

Jigawa L.G. A	Land Area (Km2)	Flooded Area October 2022	Percentage (%)
Auyo	423.848	135.643	9.19
Babura	1001.182	10.511	0.71
Birniwa	1592.059	0	0
Birnin Kudu	1402.560	20.930	0.38
Buji	568.401	39.563	2.68
Dutse	1028.417	8.524	0.58
Gagarawa	582.401	6.335	0.43
Garki	1408.224	8.722	0.59
Gumel	227.248	0.922	0.06
Guri	1063.956	400.959	27.17
Gwaram	1857.667	0	0
Gwiwa	451.249	0	0
Hadejia	32.218	3.296	0.22
Jahun	1245.081	73.484	4.98

Jigawa L.G. A	Land Area (Km2)	Flooded Area October 2022	Percentage (%)
Kafin Hausa	1370.461	92.437	6.26
Kaugama	816.802	45.191	3.06
Kazaure	381.860	5.102	0.35
Kirikasamma	829.543	195.732	13.26
Kiyawa	1030.758	18.608	1.26
Maigatari	963.881	0	0
MalamMadori	806.195	30.289	2.05
Miga	568.703	159.001	10.77
Ringim	1020.137	110.957	7.52
Roni	303.986	0	0
Sule Tankarkar	1231.640	4.398	0.30
Taura	655.251	72.159	4.89
Yankwashi	337.822	0	0
Total	23,154	1442.763	100

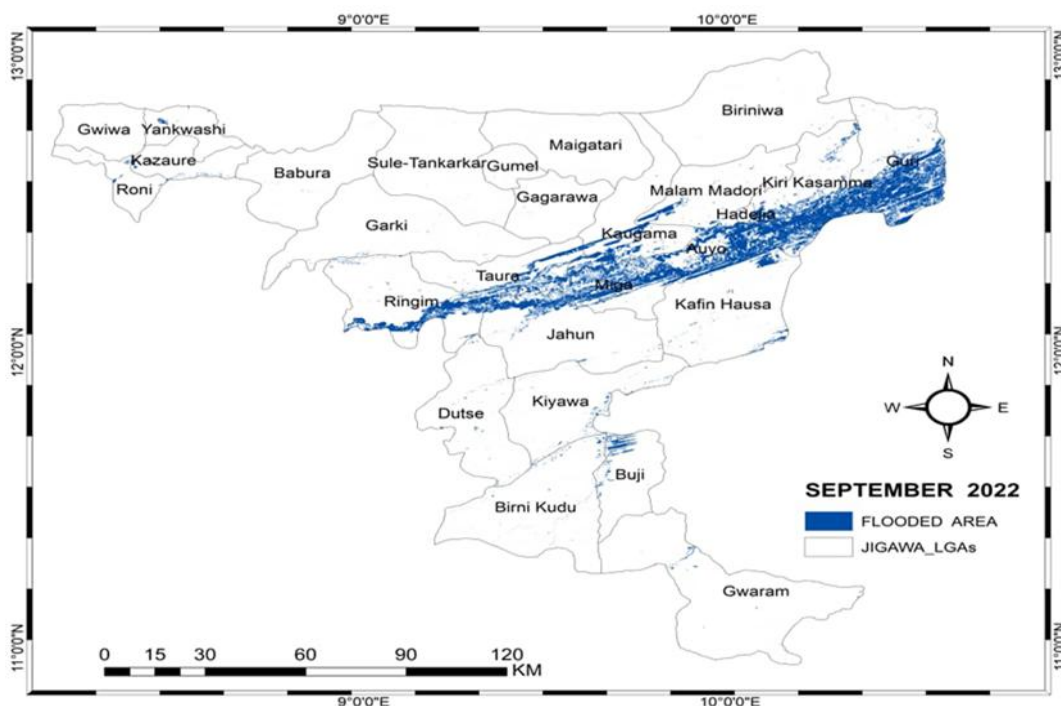


Figure 7: Map of Jigawa State Showing Flood Extent in September 2022

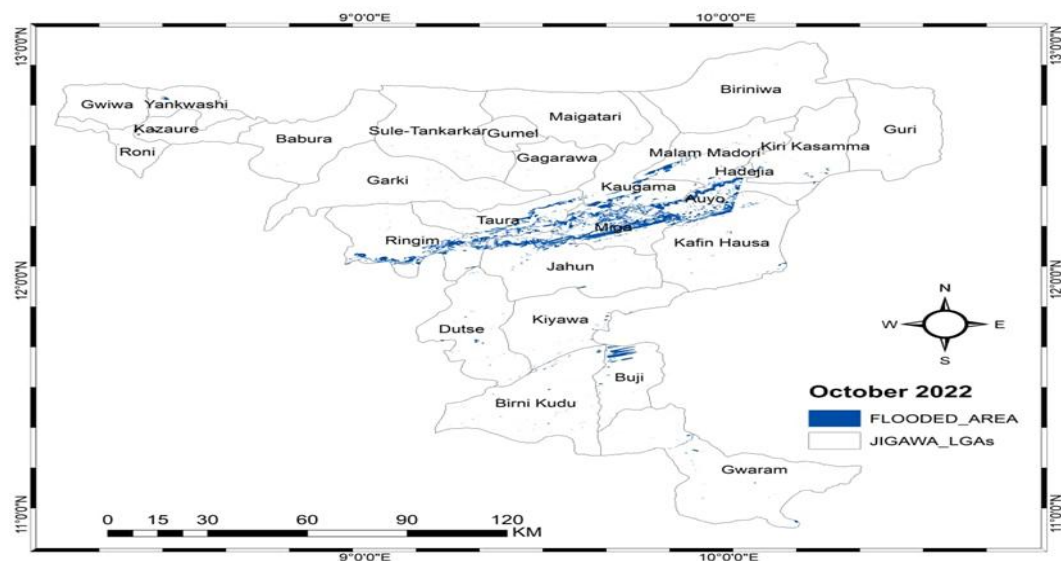


Figure 8: Map of Jigawa State Showing Flooded Areas in October 2022

Relief of Jigawa State

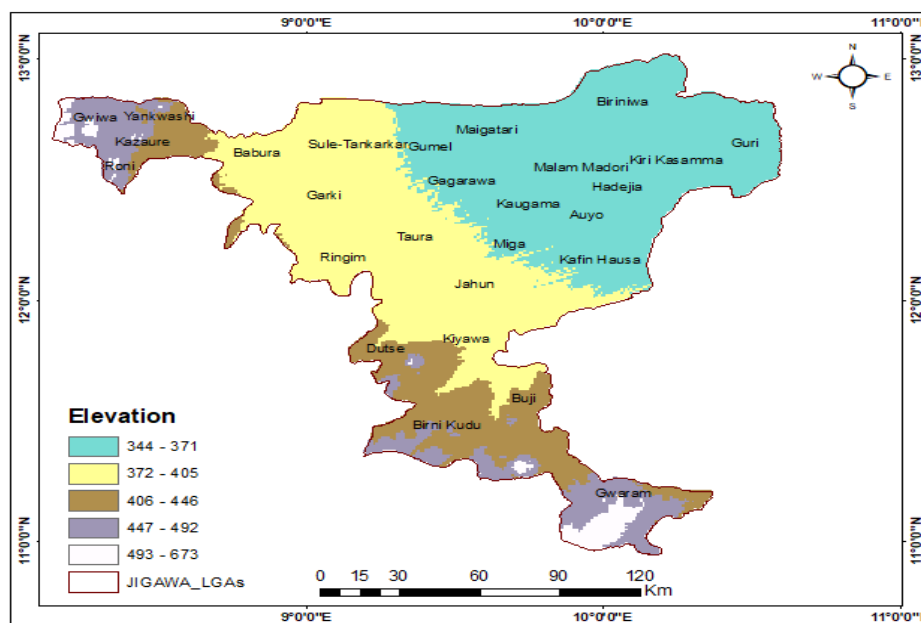


Figure 9: Elevation Map of Jigawa State

The state has four categories of elevations: very low (344 – 371m,a.s.l) in the north eastern corner of the state; low (372 – 405m,a.s.l.) in the middle parts of the state; moderate (406 – 446m) in the north - western and southern tips of the state; high (447 – 492m) in the southern and north – western parts, and very high (493 – 673m) scattered around Gwiwa and Roni LGAs in the north west as well as Gwaram in the southern tip

of the state. From table 5, LGAs with highest elevations include Roni, Gwiwa, Gwaram and Kazaure in ascending order. Guri, Hadejia, Birniwa and Kirikasamma are those with the lowest elevations, also in descending order. The other nineteen (19) LGAs fall within moderate elevations across the state.

Table 6: Elevations of LGAs (Above Mean Sea Level)

Jigawa_LGAs	Land area(km2)	Elevation(m)
Auyo	423.848	363
Babura	1001.182	396
Birnin kudu	1402.56	451
Birniwa	1592.059	353
Buji	568.401	423
Dutse	1028.417	415
Gagarawa	582.401	367
Garki	1408.224	378
Gumel	227.248	369
Guri	1063.956	349
Gwaram	1857.667	469
Gwiwa	451.249	493
Hadejia	32.218	357
Jahun	1245.081	380
Kafin Hausa	1370.461	365
Kaugama	816.802	366
Kazaure	381.86	436
Kirikasamma	829.543	355
Kiyawa	1030.758	402
Maigatari	963.881	370
Malamadori	806.195	361
Miga	568.703	377
Ringim	1020.137	392
Roni	303.986	506
Sule Tankarkar	1231.64	380
Taura	655.251	379
Yankwashi	337.822	432

**Properties Affected**

Many public and private owned properties were affected by the 2022 floods across Jigawa state. They include: roads,

culverts, bridges, schools and hospitals on the side of the public properties. Others include: farmlands and houses, on the parts of the privately-owned structures (table 7).

**Table 7: Houses, Farmlands & Other Structures Affected by Floods in Jigawa State**

S/No	LGA	No Houses Affected	Farmlands Affected (ha)	Others
1	Auyo	365	1340	Submerged schools & hospitals
2	Ringim	1104	2354	Broken culverts & submerged road
3	Birnin Kudu	427	511	
4	Dutse	354	290	Broken bridge
5	Guri	549	347	
6	Hadejia	316	760	
7	Jahun	230	215	Broken roads
8	Kafin Hausa	500	795	Broken roads, bridges & culverts
9	Kirikasamma	433	400	Broken culverts
10	Kiyawa	734	675	Submerged road and bridge
11	Miga	593	630	Broken roads and culverts. Submerged markets, schools and hospitals
12	Kaugama	332	300	Broken road and bridge
	<b>Total</b>	<b>5937</b>	<b>8617</b>	

**CONCLUSION**

In Jigawa state, floods have been more common in September and become more severe in October. The floods come with attendant loss of properties and sometimes loss of lives too. This study used a combination of socio – economic and geospatial analyses to study the impact of floods as was done by Olaide et al., (2014). However, the study added losses of lives and properties in the aftermath of 2022 floods in Jigawa State. From the months of August to October, a total of 103 deaths and loss of several properties were recorded across 15 LGAs of the state following the 2022 floods. Areas with low elevations had the highest flood incidence, while areas with high elevations that have no proximity to rivers recorded lowest flood incidences. The study recommends enhancing a more free water movement in the river channels (dredging, river training and diking) as well as ensuring proper town and land use planning and establishing a robust flood early warning system.

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