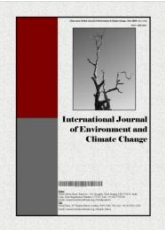

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# Flood Vulnerability Assessment of Settlements in the Niger-benue Trough, Central Nigeria

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***Authors' contributions***

*This work was carried out in collaboration among all authors. OOI designed the study, and wrote the protocol, and the first draft of the manuscript. PSUE contributed by handling the geospatial and statistical analyses as well as the final version of the manuscript, while NAI made special add-ups particularly on the livelihood asset survey deployed in the study, interviews with key informants as well as build the literature of the study. All authors read and approved the final manuscript.*

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## ABSTRACT

Flooding has become a household phenomenon, particularly for communities in close proximity or situated in floodplain areas, although only on extreme cases that serious alarms are given. The brunt of this study assessed the flood vulnerability levels of settlements located in the Niger-Benue Trough of Central Nigeria by considering their livelihood assets. Data were sourced via a random administration of questionnaire in 36 communities in the study area earmarked; water level and discharge data obtained; communities were mapped; and remotely sensed data (Spot 5 and the Shuttle Radar Topographic Mission (SRTM) data were retrieved and analyzed using ArcGIS 10.5 and the Statistical Package for Social Sciences (SPSS 25) software. The simulated worst-case scenario of flooding revealed 22 settlements were inundated in the 2019 flood between July – September, covering larger areas before the confluence with more than 50% of the area under the high and moderately high-risk zones. Natural and physical livelihood assets were vulnerable and seriously damaged with indices greater than 3.0, while human, financial and social assets were all below 3.0. Generally, vulnerability index computed for all communities was 2.82, indicating moderate vulnerability of the communities to the flood event of 2019. Also, the Pearson correlation

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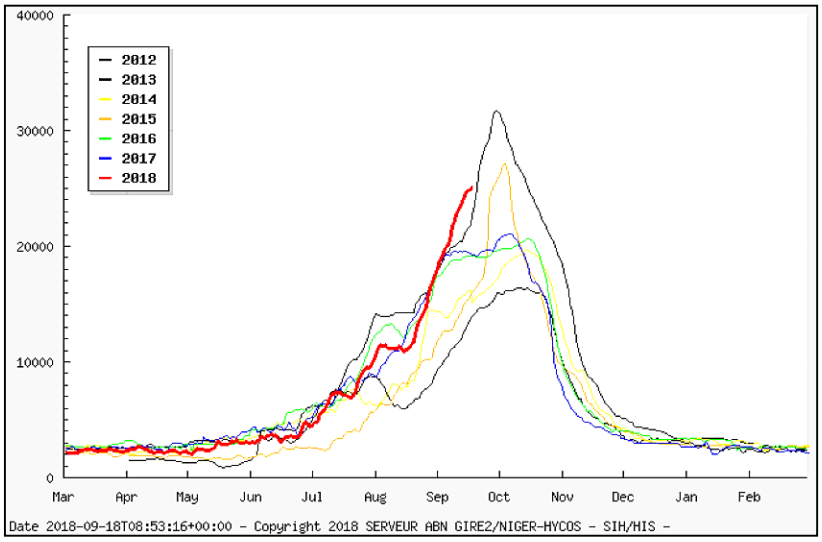
test revealed a strong, positive relationship (r = .769, α = .036) between the level of communities' flood vulnerability and the livelihood assets in the study. It was therefore recommended that yearly flood events are worth simulating to aid prioritization of decisions and development of a comprehensive flood management plan for the area.

*Keywords: Flood vulnerability; GIS; simulation; livelihood assets.*

## 1. INTRODUCTION

Water has always been a major determinant in the formation of settlements, however, with the rapidity of population growth and distribution in such areas, natural disaster such as flooding is imminent. Therefore, since man is inextricably tied to live with flood: reaping both burdens and joys, he must break-even (Ray et al., 2020, Malick et al, 2020), [1]. In as much as floods can cause deterioration of people's social and economic lives it can also go ahead to affect a nation's economy [2]. Flooding affects peoples livelihoods such that 80% of federal declared damage destructions in the US were attributed to flooding and around the world was responsible for an average of four billion dollars for annual property damages [3]. Nigeria is no exception in this outplay especially in recent time. Many communities have suffered huge losses due to the ravaging impact of flood. Notable ones occurred in Benin (1978), Ibadan (1980), Kano (1988), Jos (1995), Makurdi and Lokoja (2012), Niger-Delta [4] and in the Niger-Benue [5]. In 2012 Nigeria experienced one of the most devastating and most widespread floods in her history affecting about 19 of the 36 states of the Federation. In this flooding incident an estimated 365 people reportedly died and more than 2 million residents along the floodplains and coastal areas were displaced causing refugee problems that lasted several months. In addition, several properties, farmlands and merchandise worth millions of naira were washed away or irretrievably damaged by the flood. While the 2012 flood is not new, there are evidence that floods have occurred regularly and periodically in different parts of the country and even in the confluence town of Lokoja. Findings from the National Emergency Management Agency (NEMA) as summarized by the European Commission [9] indicated 12 states were affected by flood, 4 states declared to be under National Disaster (Niger, Kogi, Anambra and Delta), 441,251 people affected/displaced and 108 casualties reported. According to the report of the Commission, the floods were as a result of the high inflow from the upper part of the Niger and the subsequent increase in water released from the Kainji and Jebba dams located on the Niger. This again could have been worsened if the Lagdo Dam located upstream of Benue River reached its maximum retention capacity, thereby forcing and increase in its water discharge. In an event such as this, the hardest hit area will still be the Confluence of the two rivers: Niger and Benue. The figures below show the real-time hydrological measurements published by the Niger River Basin organization on their Niger-HYCOS system discharges.



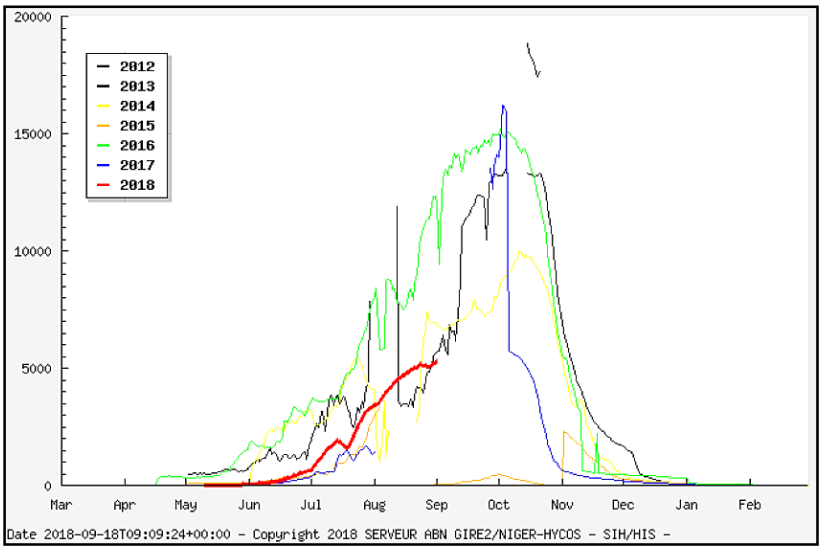



**Fig. 1. Hydrological observations at Lokoja at the Niger (top) and Umaisha at the Benue (bottom). Red hydrograph shows the measurements of 2018; black hydrograph shows reference flood in 2012**

From the Fig. 1, it is clear that a release from the Lagdo dam would have caused a reoccurrence of the 2012 flood event that was the most devastating in the Confluence. Meanwhile, it is germane to note that Dam operators in Cameroon gave an information that as at 19th September, 2018, water level was about 212 meters and had a capacity to accommodate 216 before releasing water into the Benue [6].

From the foregoing, it is clear that communities, including urban centres encapsulated in these corridors annually face different levels of flooding which in turn affect their livelihoods. Smart applications are therefore required using either structural measures by way of constructing flood retention walls, dykes, reservoirs and detention basins or the use of non-structural measures which include flood forecasting, flood mapping and proofing, as well as flood hazard zoning [7]. The structural option of flood control is time consuming, requires extensive field work, manpower and a wanton amount of financial resources, whereas for a confluence zone such as the Niger-Benue, chronically ravished by floods following predictions of more rainfall, climate change, and severe weather conditions as noted around the world, even the El Nino/La Nina-Southern Oscillation, the recent massive release of water from dams, requires not just monitoring on a regular basis [8] but a simulation of its occurrence, so as damages and other eventualities that ensue can be managed sustainably (Olayinka, *et al*. 2013).

Recent studies show that there has been a recent paradigm in the application of GIS-based simulation models in managing flood events even before they occur but as put forward by Bates and DeRoo [9], Drogue, *et al*. [10], Nwilo, *et al. [11]* and Musa, *et al. [11]*, this will rely hugely on high quality data, complex modelling and spatial analysis. Such therefore entails an empirical experiment and analysis of different scenarios of flooding before decisions are made and mitigation strategies are developed or updated. Other studies [12], National Research Council [13,14,15,16] have also emphasised on the application of Spatial Decision Support Systems (SDSS) for objective decision making. Hence, the effectiveness of any preparation to mitigate the impact of flood depends on how much we know about the flood characteristics: its frequency, duration, areal extent, spatial dispersion, and temporal spacing as well as its consequence on the people; their livelihood and activities and more critically responses and resilience.

Although, many studies [17], Nasiri & Shahmohammadi-Kalalagh [18,19,20,21], De Silva & Kawasaki [22,23], have embarked upon vulnerability of different groups to disasters, especially flooding, it is pertinent to note that Exposure (i.e. the predisposition of an area or individuals to flood event), Susceptibility (i.e. the

elements/livelihood assets exposed within the system, e.g. property, infrastructure, etc.) and Resilience (i.e. the capacity returning to normalcy), have social, economic, and environmental dimensions and/or components that can be measured in varying spatial scales [24]. This again is important as it can identify hotspots or communities or regions that may be hard hit and aid planners and/or policy makers in prioritizing interventions based on their varying degrees of vulnerabilities. It is therefore against this background that the thrust of this study hinged on the simulation of different flood risk scenarios; investigation of the varying levels of vulnerability in communities in the study area, the impact of flood on their livelihood assets and their relationship. These will go a long way into the development of an effective flood management policy framework for settlements in the Niger-Benue Trough, Central Nigeria.

## 1.1 The Study Area

The Niger-Benue trough of Kogi State abuts the confluence areas of Kogi State, located between 7°24'N to 8° 17' N and 6°28'E and 7°12'E, covering an area of 8,056.14 sq.km. This area comprises major Local Governments in the state: Kogi, Koton-Karfi, Bassa and Ajaokuta Local Government Areas of Kogi State. See Fig. I (A,B,C).

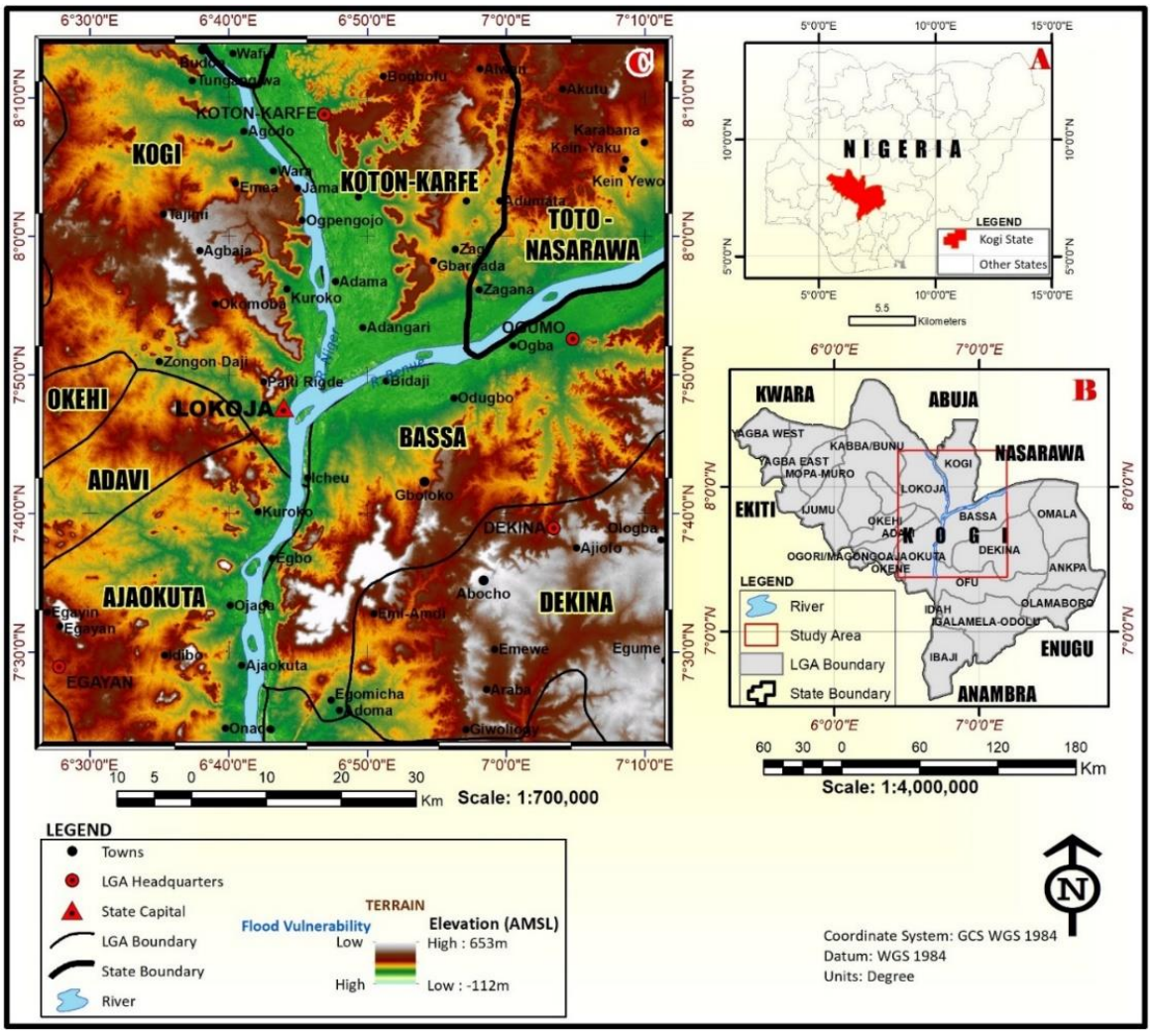



**Fig. I. A- Nigeria showing Kogi State; B- Kogi State showing the Study Area; C- Relief of the study area**

*Source: GIS Laboratory, Kogi State University, Anyigba (2019)*

Most parts of the study area are situated in the valley and floodplains of the Niger-Benue River confluence, surrounded by a ring of hills and ranges of plateau as shown on the relief map of the study area. Prominent of these is the Patti ridge in Lokoja. Generally, the Niger-Benue Trough enjoys cool weather during the raining season when the temperature drops from June and remain relatively low till January because of the harmattan before it rises again. Most of the precipitations are recorded between the month of May and October while the months of December to April receive very little precipitation. The rainy season is the period when risk of flood hazard is high for settlements situated within the floodplains. This happens every year at varying degrees, thus, provides opportunity for the study of floods in the Niger-Benue Trough. The Niger and Benue rivers, the two largest rivers in Nigeria join forces together in Lokoja to form an extensive floodplain. This floodplain is inhabited and (massively) cultivated by the people in the region [20]. The erosional and transportation force of Niger is enhanced by the Benue River in Lokoja and together they flow into the Atlantic Ocean forming an extensive delta and floodplains in the Niger Delta region of the country. Major urban areas and prominent settlements in the trough include Koton-Karfe, Adangari, Ogba, Odugbo, Bidaji, Ajaokuta, Itobe, Gboloko and Lokoja, the state capital which alone is home to about 290,000 persons as estimated from the 2006 Census figure and projections (2008, 2009 and 2010) presented and made respectively by the National Bureau of Statistics [25].

## 2. METHODOLOGY

Data for the study were sourced to cover the physical and human environment affected by flooding in the Niger-Benue floodplains particularly for settlements in the area, and complemented with measurements and recorded information of selected parameters along the flood plains. Data on water level and discharge were obtained from the National Inland Waterway Authority (NIWA) office in Lokoja, Kogi State; Global Positioning System (GPS) survey campaign was carried out to map settlements in the earmarked area while satellite remotely sensed data was downloaded from the United States Geological Survey (USGS) website (https://earthexplorer.usgs.gov/). These include the Shuttle Radar Topographic Mission (SRTM) elevation data and Spot-5 imagery obtained from the GIS Laboratory of the Department of Geography and Environmental Studies, Kogi State University, Anyigba. Three-dimensional (3-D) surface of the Niger-Benue trough was modelled in ArcScene 10.5 environment upon which inundation areas were simulated for low, moderate and high flow regimes so as to reveal areas that may be flooded, based on elevation data obtained from USGS website. The data was then preprocessed and reclassified into five categories, from low to high vulnerabilities, same as applied by Gigovi´c, *et al.* [26] and Ogato, *et al.* [27].

Data was also sourced randomly from household heads in 36 communities and towns located in the floodplain area via a random administration of a well-structured questionnaire using a sample size determined using Krejcie and Morgan [28] table. Out of the 600 copies of questionnaire administered, only 578 were retrieved and analyzed. Respondents' opinions were analyzed using a Likert weighting scale from 1 – 4, i.e. from no damage, little damage, serious damage to very serious damage; and based on level of agreement: strongly disagree, disagree, agree and strongly agree. Contacts were also made through focused group discussions and interviews with community heads and other individuals who were reported to have lost their livelihoods, particularly during the 2019 flood event in the earmarked communities via observations and interviews. The Statistical Package for Social Sciences (SPSS V.25) was utilized to analyze the data obtained from the field which were then presented using simple descriptive tables and charts. Furthermore, the Pearson Correlation test statistic was used to test the hypothesis that there is *no significant relationship between the level of the communities' vulnerability and the impact of flood on their livelihood assets.*

## 3. RESULTS AND DISCUSSION

Preliminary investigation and interview with the locals revealed that the main cause of flooding in the area was due to excess inflow of water released from the dams located up the Niger River or Benue River or a combination of both, for settlements down the confluence. Although the flood event of 2012 is said to be one of the worst in recent time, that of 2018 affected different areas and displaced over 100,000 persons (European Union, 2018). This is in agreement with the 3D model generated in the study, shows the physical terrain of the study area. See Fig. 2.

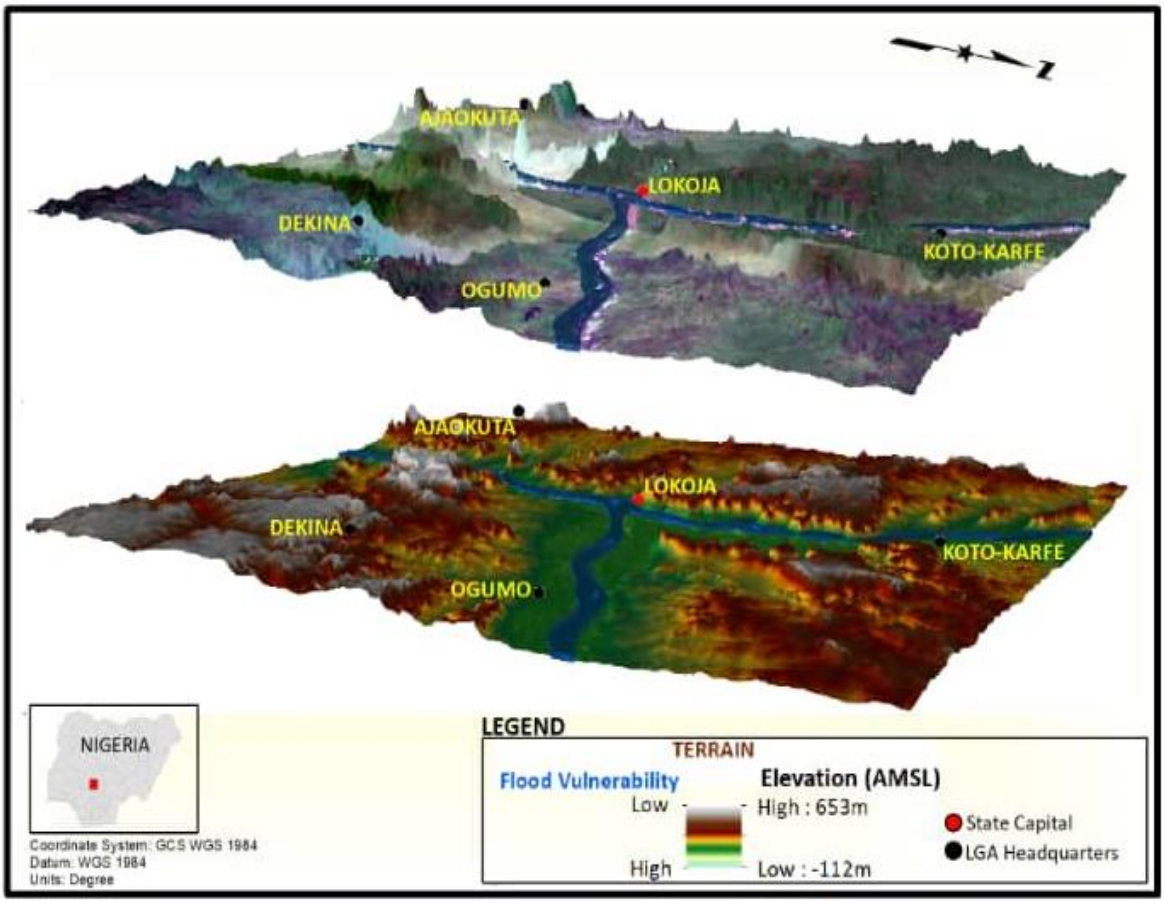



**Fig. 2. 3D Model of the study area**

**Table 1. Settlements at risk to flooding in the year 2019**

| Months | Discharge/Volume (Cu.m/Sec) | Inundated area ($km^2$) | Settlements at risk |
|---|---|---|---|
| July | 175,052.34 | 256 | 10 (21.3%) |
| August | 312,673.23 | 367 | 21 (44.7%) |
| September | 402,123.54 | 509 | 35 (74.5%) |

*Source: NIWA (2019)*

The terrain model shown above reveals the floodplains, hills, plateaus and ranges around the confluence and the major towns in the region, as well as their proximity to the rivers. The major communities found within the altitudes of 50 meters above sea level (MASL) and 120masl with sizeable population of over 1,000 people are Koton Karfe, Lokoja, Gboloko and Ajaokuta. These communities are flood prone. The study of [20] in Lokoja indicated that areas ranging from 35 – 133MASL are very vulnerable to flooding. This is also in line with the submission of Mayomi, *et al*. [29] who opined that flood intensities depend on the proximity of any location to a major waterbody but which can only be reduced by the influence of topography. But away from topography, the two major Rivers (Niger and Benue) are mostly responsible for the morphology of the study area's landscape as the study area is dissected in to three parts and the flow or discharge of the two rivers differs during any flood year. During the field survey, the study carried out by European Union (2018) was confirmed – that flooding in the area is characterized by the volume of water released from the Dam(s) at the upper stream, or partly due to increased precipitation. Furthermore, the inundation levels (20 – 100masl) as generated from the SRTM elevation data and the data from NIWA showed the settlements at risk of flood at different months based on the varying levels of discharges in

cubic meters per seconds (Cu.m/sec). See Table 1.

From the data obtained from NIWA it was observed that in July, August and September – the peak periods of rain during the double maxima regime, 10, 21 and 35 settlements were completely inundated, respectively. Meanwhile, it is worthy to note also that the settlements at the lower Niger (after the confluence) were most inundated in the month of September. It was found that within the study area, the floodplain was estimated to be 289km$^2$. This implies that in the month of July, when the full potential of the rivers had not been actualised, as a result of silting and other depositional characteristics, settlements that took advantage by encroaching and converting part of the plains for economic and/or agricultural activities were inundated. The expansion of the flood water in the month of August showed an extension over the flood plains and in September, affecting infrastructure and economic activities outside the flood plains.

As noted earlier, since the cause of flooding in the area was noted to be caused, majorly by the release of water from Dams in the region than from discharges from other lower order rivers in the area or from precipitation, there was need to simulate the volume of flow with respect to the water level as observed by NIWA (2019). The simulation was for different scenarios: high (above 400,000 cu.m/sec and a water level of 50masl), mid flow (300,000 cu.m/sec and a water level of 35m) and low flow (200,000 cu.m/sec and a water level of 20 masl) events. The result of this can be seen in Fig. 3.

The simulation of expected flood event was direct since there is almost a complete absence of flood barriers and functional drainage systems, except for Lokoja town where some concretized flood barriers have been constructed. Again, the result shows the impact floods are envisaged to ripple on the communities along its course. The number of settlements inundated for different scenarios as simulated and extracted from ArcScene environment can be seen in Table 2.

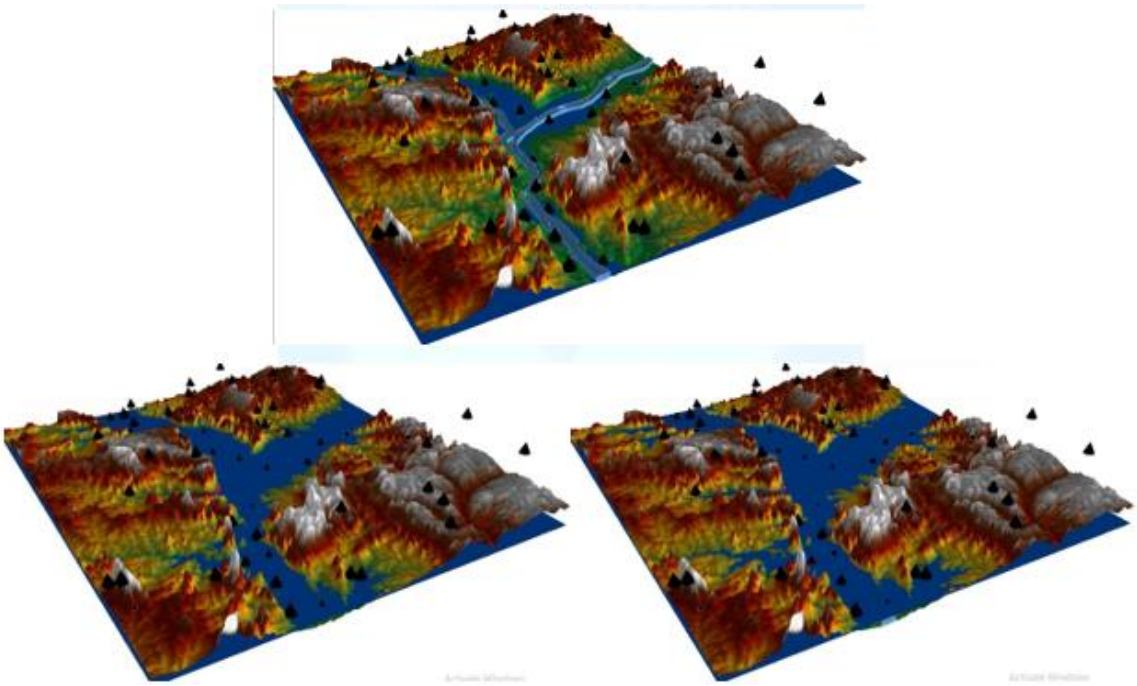


**Fig. 3. Flood simulation result – top: low; bottom left: Mid flow; bottom right: High flow**

**Table 2. Flood risk zone simulation**

| S.No. | Flow Scenario | Cumulative No. of Settlements | Cumulative Percentage (%) |
|---|---|---|---|
| 1. | Low level | 12 | 18 |
| 2. | Mid-level | 34 | 52 |
| 3. | High level | 66 | 100 |

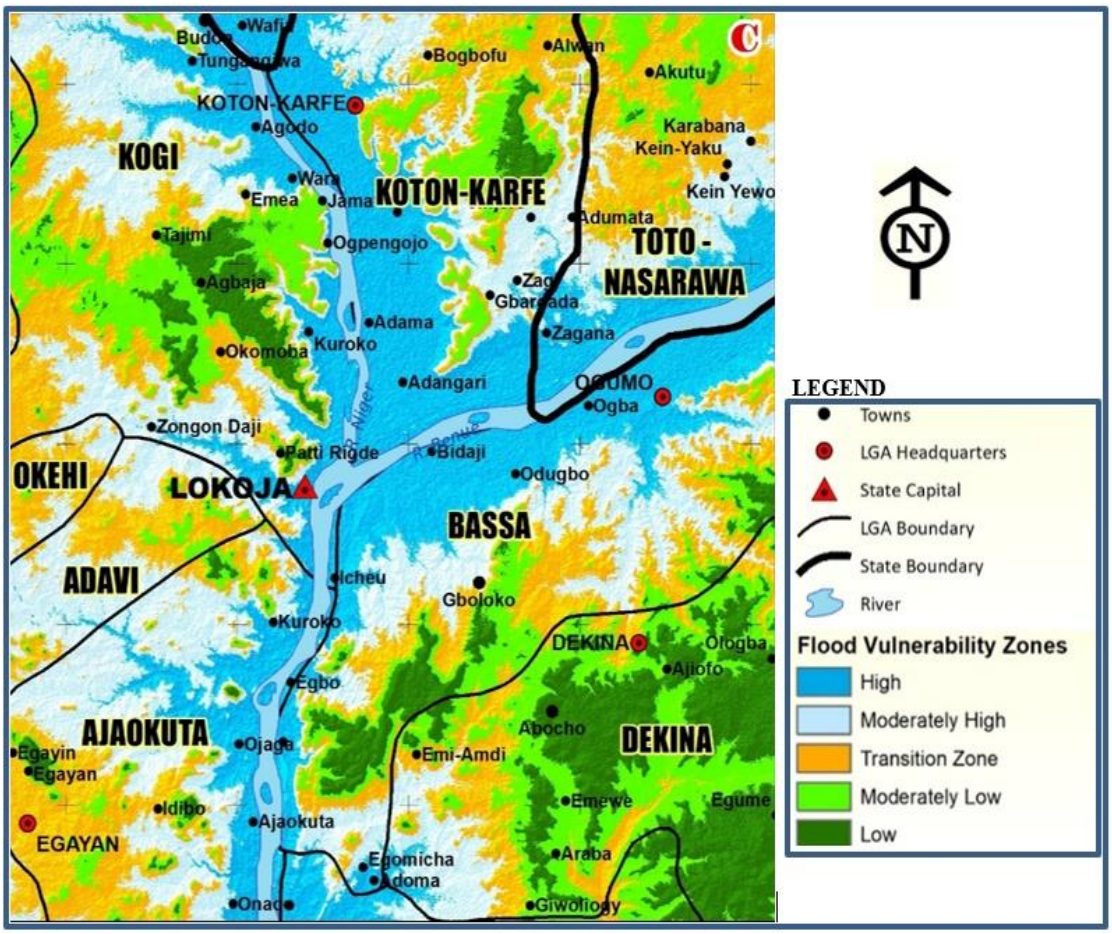



**Fig. 4. Worst case scenario and Flood risk zones in the study area**

**Table 3. Flood risk zones of the study area**

| Count | Risk Zone | Area (sq.km) | Percentage |
|---|---|---|---|
| 1 | High | 1,280.62 | 15.90 |
| 2 | Moderately High | 2,836.00 | 35.20 |
| 3 | Transition Zone | 2,354.12 | 29.22 |
| 4 | Moderately Low | 1,111.95 | 13.80 |
| 5 | Low | 473.46 | 5.88 |
| | Total | 8,056.14 | 100 |

Even the low flow scenario of the model simulated in the study reveals about 12 communities (18%) affected by flooding. However, it was gathered during fieldwork that most of these communities in this category are fishing communities and usually tend to relocate to other areas when the flood increases. Besides, it was observed during fieldwork that most of the people built close to the river or in unplanned areas. This is same with a related study by De Silva and Kawasaki [23] who revealed that households in Sri Lanka were scattered everywhere without city planning; lands privately owned and people choose where they live based on affordability, therefore tend to be more exposed to the ravaging impact of floods. Also, from Table it is obvious that when water exceeds 300,000 cu.m/sec and a water level of 35masl, more than half of the communities along the floodplain and particularly after the confluence are expected to be inundated. Hence, a benchmark such as this will go a long way in preparing for floods in the area. Thus, in any event it was observed after the first phase of the study that parts of prominent towns in the trough (including Lokoja, Zango Daji, Kuroko, Jama, Wara, Koton-Karfe, Adangari, Bidaji, Ogumo, Adama and Ajaokuta) are exposed and located

in highly vulnerable flood zone. This and other zones can be seen in the map presented in Fig. 4.

Fig. 4 is an estimation of the worst-case scenario of flooding in the study area (with reference to that of 2012) and it shows the different flood risk zones. It should be noted however, that the areas before the confluence have wider areas in the high-risk zone (especially along the Benue River) than after the confluence. This is as a result of the upland ranges after the confluence – around Lokoja, Kuroko, Egbo and Ajaokuta towns that makes the valley system relatively narrower as also shown in the study of Onuigbo, *et al. [20]*. Also related to this is the fact that community vulnerability is shaped by biophysical impacts of flood disasters which is inextricably tied to the social vulnerability of inhabitants [19]. See Table 3.

From the Table 3, it is very important to note that more than 50% of the area earmarked for this study is either highly or moderately high-risk zone of flooding. From the simulation, it is evident too that only in high risk flood zones that buildings can be completely submerged while the severity or impact of flooding reduces down the trend. Again, it should be noted that the simulation done here is in an event that there is an increased precipitation in the study area and that the dams up the Niger and Benue are released too as in the case of the 2012 flood occurrence. Although this will be very impactful to the livelihood of communities in the affected areas as it is expected to take different tolls on their livelihood assets.

### 3.1 Vulnerability of Livelihood Assets

The inundation during any flood events has grave implications on settlements especially on the assets that define the livelihood of the inhabitants. The economic cost of any flood events and its implications are always unending in resolving or accounting. To this end, the Livelihood assets of the study area were analysed for their extent of damages in the flood event of 2019. The result is presented in Table and discussed in the subsequent sub-sections.

### 3.2 Natural Assets

Natural assets in this study refers to the natural resources found in the areas which include the soil, water, air, fish, forest and other services derived from them to make a living. A high percentage (88%) of the respondents rely mainly on natural resources for their livelihood, especially (crop and fish) farming. The position of the natural assets to maintain their base quality during and after the occurrence of flooding is a major one, however, the opinion of the respondents on the impact of the 2019 flooding on their natural assets was assessed using a Likert scale and this can be seen in Table 2.

The result of the Likert scale shows that all the natural assets in the communities experienced moderate to serious damages but overall, moderate damage (3.3) during the 2019 flood event. Their farmlands and crop output experienced serious damages (3.7) especially as they are closely related. Studies [30], Onuigbo, *et al.* [20,31] carried out in the region show that the people are predominantly farmers and engage in serious modification of the surrounding land cover and as such can be closely linked to their livelihood. This implies that the soil quality and nutrient that must have affected farmlands in the area translated into affecting the crop yield as compared to previous years. Domestic water sources also were faced with serious damage (3.5) due to the pollution brought about from unhygienic sources. Livestock and vegetal cover are shown to have moderate damages and as such, some of the livestock farmers indicated that animals were mildly affected during the period as they were exposed to unchecked or polluted feeds and water sources but little or no deaths were recorded during the period.

### 3.3 Physical Assets

Physical assets which have to deal with the reproducible goods owned by the communities under investigation were also assessed. Table reveals that the most impactful threat of the 2019 flood event was on drainage facilities and roads as they were filled or blocked (in some cases) with solid waste products and/or debris from other areas. Some of the roads during the period became un-motorable while cost of transportation increased as well. Also, some electrical installations were damaged or affected during the period, thus the respondents indicated serious damages.

Other components that experienced (more) serious damages are houses (3.6), market places (3.8) which were flooded, water facilities and installations (3.8), poor electricity supply and damage to related infrastructures (3.5). This was also the case for market places, as some of the local markets were shifted with rippling effects to traders both in affected areas and those who

**Table 4. Status of damages impacted on livelihood assets**

| Livelihood Assets | Facility/Components | Rating Scale | | | | Total | Total Score | Mean Score | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 3 | 2 | 1 | | | | |
| Natural Asset | Farmland | 428 | 124 | 21 | 5 | 578 | 2131 | 3.7 | Serious Damage |
| | Crop output | 439 | 126 | 10 | 3 | 578 | 2157 | 3.7 | Serious Damage |
| | Livestock | 217 | 209 | 91 | 61 | 578 | 1738 | 3 | Moderate Damage |
| | Domestic water sources | 356 | 187 | 26 | 9 | 578 | 2046 | 3.5 | Serious Damage |
| | Vegetation and tree cover | 201 | 139 | 130 | 108 | 578 | 1589 | 2.7 | Moderate Damage |
| | Remark = | | | | | | | 3.3 | Moderate Damage |
| Physical Assets | Road Infrastructure | 407 | 87 | 49 | 35 | 578 | 2022 | 3.5 | Serious Damage |
| | Electricity Infrastructure | 398 | 101 | 56 | 23 | 578 | 2030 | 3.5 | Serious Damage |
| | Motor Park | 68 | 106 | 227 | 177 | 578 | 1221 | 2.1 | Little Damage |
| | Housing | 415 | 117 | 30 | 16 | 578 | 2087 | 3.6 | Serious Damage |
| | Market Place | 479 | 78 | 15 | 6 | 578 | 2186 | 3.8 | Serious Damage |
| | Vehicles | 12 | 45 | 275 | 246 | 578 | 979 | 1.7 | Little damage |
| | Water Infrastructure | 497 | 45 | 27 | 9 | 578 | 2186 | 3.8 | Serious Damage |
| | Communication Infrastructure | 5 | 7 | 288 | 278 | 578 | 895 | 1.5 | Little Damage |
| | Drainage Infrastructure | 461 | 67 | 39 | 11 | 578 | 2134 | 3.7 | Serious Damage |
| | Remark = | | | | | | | 3 | Moderate Damage |
| Social Assets | Sport Centres | 14 | 48 | 259 | 257 | 578 | 975 | 1.7 | Little Damage |
| | Banks | 5 | 16 | 60 | 497 | 578 | 685 | 1.2 | No Damage |
| | Cooperative Building | 118 | 137 | 169 | 154 | 578 | 1375 | 2.4 | Little Damage |
| | Cultural heritage | 324 | 189 | 34 | 31 | 578 | 1962 | 3.4 | Serious Damage |
| | Church | 34 | 67 | 216 | 261 | 578 | 1030 | 1.8 | Little Damage |
| | Mosque | 12 | 29 | 225 | 312 | 578 | 897 | 1.6 | Little Damage |
| | Hotels | 21 | 37 | 215 | 305 | 578 | 930 | 1.6 | Little Damage |
| | Remark = | | | | | | | 1.9 | Little Damage |
| Human Assets | Public Schools | 38 | 59 | 218 | 263 | 578 | 1028 | 1.8 | Little Damage |
| | Private Schools | 23 | 45 | 251 | 259 | 578 | 988 | 1.7 | Little Damage |
| | School activities by pupils/students | 252 | 216 | 78 | 32 | 578 | 1844 | 3.2 | Moderate Damage |
| | Public examinations (SSCE/GCE) | 67 | 79 | 189 | 243 | 578 | 1126 | 1.9 | Little Damage |
| | Access to health facilities | 37 | 101 | 218 | 222 | 578 | 1109 | 1.9 | Little Damage |
| | Health facilities | 41 | 75 | 227 | 235 | 578 | 1078 | 1.9 | Little Damage |
| | No of Health personnel after the flood | 67 | 78 | 189 | 244 | 578 | 1124 | 1.9 | Little Damage |

| **Livelihood Assets** | **Facility/Components** | **Rating Scale** | | | | **Total** | **Total Score** | **Mean Score** | **Remarks** |
|---|---|---|---|---|---|---|---|---|---|
| | | **4** | **3** | **2** | **1** | | | | |
| | Severity of any epidemic | 441 | 125 | 9 | 3 | 578 | 2160 | 3.7 | Serious Damage |
| | Remark = | | | | | | | 2.3 | Little Damage |
| Financial Assets | Owned land | 395 | 105 | 56 | 21 | 577 | 2028 | 3.5 | Serious Damage |
| | Residential building | 418 | 127 | 28 | 5 | 578 | 2114 | 3.7 | Serious Damage |
| | Valued assets owned | 405 | 167 | 6 | 0 | 578 | 2133 | 3.7 | Serious Damage |
| | Remark = | | | | | | | 3.6 | Serious Damage |
| Composite | Overall Remark | | | | | | | 2.82 | Moderate Damage |

usually bring their goods from neighbouring areas. During the same period, communication infrastructure, vehicles and motor parks had little damages with mean scores of 1.5, 1.7 and 2.1, respectively, implying that movement of people, goods and services were not completely cut-off. Hence, although the overall extent of damage to physical assets were moderately serious (3.0), it is important to note that when movement of people from one region to another is mildly affected, the economy of such a place may not be as vibrant as expected.

### 3.4 Social Assets

At the household and individual levels, social assets can be best described as the value of people's social network and personal relations, such that households that may be poor but with friends, families or financial institutions (cooperative bank, mortgage facilities, etc.) may not be as vulnerable as one without. It is revealed in the study that apart from cultural heritages, all other social capitals in the communities experienced little or no damage. Some include damages of some artefacts in the communities such as sculptures, civic or community centres, etc. This aspect again indicates that the resilience of the communities during the 2019 flood event was high and therefore, on this (social assets), one could conclude that the communities in the region were less vulnerable or experienced little or no damage, but again, this may not be the case for all assets. From the findings of Saldajeno, *et al*. [17], rural upland communities usually have limited social organizations and members associated to such organizations except for family and friends, hence damages to such assets will definitely be little. Again, on an overall scale, it could be deduced from the table that social assets in the Niger-Benue trough experienced little damages (1.9), and this could be attributed to the unavailability or dearth of these assets in most of the communities under investigation.

### 3.5 Human Assets

The human assets are as important as other assets mentioned in the study but it is pertinent to note that the enhancement of this asset may as well go a long way to improve upon the index of other assets. It is obvious from the field survey (as presented in Table 4) that all components of human asset experienced at least some form of little to serious damage. Public and private schools only had little damages (1.8 and 1.7, respectively) but it is worthy to note that this was not the case for school activities during the same period as moderate damage (3.2) was opined by the respondents. Another striking score obtained was for the severity of any disease outbreak which was noted to be serious (3.7) as many of the respondents indicated the prevalence of some waterborne diseases such as cholera, typhoid and other skin irritations. Furthermore, it is seen from Table 7 that the impact of the flood on the access to school engagements (such as examinations), healthcare facilities as well as the state of the facilities too and the number of healthcare personnel affected during and after the flood was only little (1.9). In general, it is obvious that the human assets of the communities in the confluence experienced little damages (2.3), but given the fact that they could relate closely to other assets, they must be held seriously and monitored.

### 3.6 Financial Assets

The financial or economic component determines the individual's vulnerability in terms of household's economic status and this also predisposes them to the extent of their individual vulnerabilities or as a group, could be impactful. Financial assets in this study only focused on the ownership of land, residential buildings and assets owned. Table  reveals the extent of damage caused by the flood event of 2019 and indicates that all financial assets were seriously damaged. As mentioned earlier, documents/credentials, households' properties, etc. which include valued assets were seriously damaged. As sudden as it was, residential buildings including fences, low-base structures, and other poorly constructed fittings were seriously damaged. Although, the respondents pointed out that the damages caused by the flood could be repaired, but was not to be in the nearest future, except again if they could access funds from other ventures or their cooperative societies as few of them indicated. This however is similar to the findings of Dulal et al. *[32]* in Nepal where he concluded that communities in developing countries have no government supported insurance team or other microfinance services and cannot independently and quickly deal with the sudden unset of climate-related events, such as flooding. So in an event as this, i.e. where financial foundation of communities is affected with little or no support from the government, except for palliatives received from closed families or friends, pulling through is difficult and in some cases impossible.

From the forgoing, it is important to standardize the result of the individual livelihood assets so as to get a deeper insight to the current status of vulnerability of the affected communities impacted by flood, particularly for a flood that is not as disastrous as that recorded in 2012. The result of the Status of Vulnerability Index (SVI) can be seen in Fig. 5.

The overall status of damage to all livelihood assets on a scale of 0 – 4 is 2.82 which invariably translates to a moderate vulnerability index, however, a look at the radar chart on Fig. 5 indicates that the 2019 flood event was more impactful to the financial, natural and physical assets with mean scores of 3.6, 3.3 and 3.0, respectively, than how it affected human and social assets with scores of 2.3 and 1.9 obtained, respectively. In fact, the findings of this study is in sharp agreement with the studies of Park, *et al.* (2009) and Saldajeno, *et al. [17]* who suggested that the high vulnerability of natural assets or resources was due to the heavy dependence by community dwellers upon which their livelihoods are based.

### 3.7 Determinants of Flood Vulnerability

To ascertain further, the factors that contributed to make the study area vulnerable to flooding with regards to assessing the perception of residents of the selected communities, the result for this is shown in Table 5.

From Table 5 it is clear that all the determinants that predisposes the communities to be vulnerable to flood are present majority of the respondents indicated a level tending towards agreement (i.e. Agree) of the listed factors to be responsible for the vulnerability of their respective communities. It is also important to note that Poverty and communities located in flood-prone areas are the main reasons or determinants for the current flood vulnerability recorded in the study as this was also identified by the terrain analysis performed

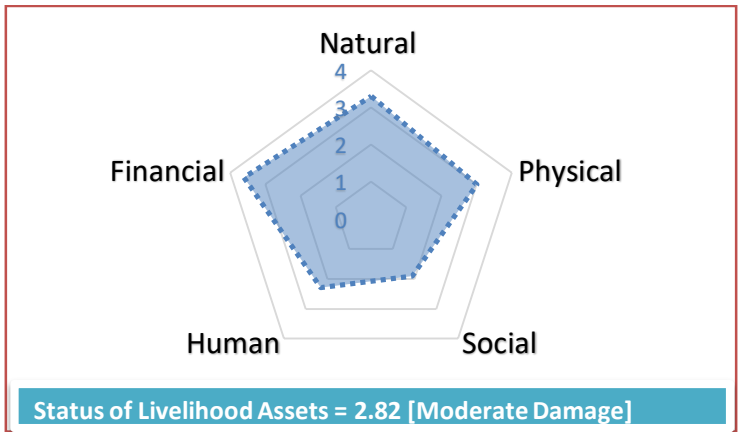



**Fig. 5. Status of livelihood asset in the Niger-Benue trough**

**Table 5. Determinants of flood vulnerability in the Niger-benue trough**

| S/N | Responses | Rating Scale | | | | Total Response | Total Score | Mean Score | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 3 | 2 | 1 | | | | |
| i. | Community is a flood prone area | 247 | 256 | 65 | 10 | 578 | 1896 | 3.3 | Agree |
| ii | Poverty | 276 | 223 | 71 | 8 | 578 | 1923 | 3.3 | Agree |
| iii | Lack of early warning | 174 | 157 | 145 | 102 | 578 | 1559 | 2.7 | Agree |
| iv | Alternative livelihood | 211 | 192 | 101 | 74 | 578 | 1696 | 2.9 | Agree |
| | | | | | | Mean Score | | 2.8 | Agree |

**Table 6. Correlation test result**

| | | | Livelihood Asset | Flood Vulnerabilities |
|---|---|---|---|---|
| **Pearson, *r*** | **Livelihood Asset** | Correlation Coefficient | 1.000 | .769* |
| | | Sign (2-tailed) | | .036 |
| | | N | 6 | 6 |
| | **Flood Vulnerabilities** | Correlation Coefficient | .769* | 1.000 |
| | | Sign (2-tailed) | .036 | |
| | | N | 6 | 6 |

**Table 7. Coping strategies in the Niger-benue trough**

| S/N | | Responses | | | |
|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** |
| 1 | Income Loss | Selling of Assets | Borrowing from formal/Informal Financial Institution | Alternative Employment | Remittances/Support from Relatives |
| | | 54(16.2%) | 73(21.9%) | 149(44.7%) | 110(33.0%) |
| 2 | Health Challenges | Access to available free healthcare | Personal hygiene | Drink clean water/sanitation | Sleeping under bed nets (ITN/LLTN) |
| | | 94(28.2%) | 243(73.0%) | 122(36.6%) | 153(46.0%) |
| 3 | Livelihood | Alternative Employment | Investing Savings | Finding another livelihood | Depending on Government/organization intervention and remittances |
| | | 159(47.8%) | 53(15.9%) | 102(30.6%) | 139(41.7%) |

in this very study. Most of the communities were located within the Niger-Benue trough, hence predisposes the people to floods. Again, poverty on the other hand tells more on the human and social assets of the people as hitherto discussed. Perhaps, if people have alternative streams of income or alternative jobs or a vibrant community structure in-place, etc., incidence of flooding in the area will not be as pronounced, especially when the 2012 flood is held in view.

Furthermore, it is important to test the hypothesis of this study which states that there is no significant relationship between the level of the communities' vulnerability and the impact of flood on their livelihoods. This test was performed using Pearson correlation statistic and the result is given in Table 6.

The Pearson correlation coefficient, $r_s$, is .769 and also seen to be statistically significant ($p$ = 0.36). This implies that there exist a significantly strong, positive relationship between level of communities' vulnerability and the impact of flood on their livelihoods in the entire Niger-Benue Trough. To add to this, the study of De Silva and Kawasaki [23] also noted that economic and financial loss due to floods, especially for non-poor households in Rathnapura, Sri Lanka was directly affected by inundation depth. Also, it was noted by De Silva and Kawasaki [23] that households located far from the river and at higher elevations, better living conditions, educated, that depended little on the natural assets tend to be less vulnerable to flood disasters or climate-related disasters. Also, the study of De Silva and Kawasaki [22] in another Sri Lankan community, faced with drought and flood had a positive correlation between disaster damage, poverty and vulnerability, as the author maintained that poor households often depend solely on agriculture to make a living; have no capacity to cope with or resist and recover (quickly) from the impact of hazards. Thus, in any event, it is obvious from the foregoing that if livelihood assets are strengthened or robust, it will go a long way to reduce the vulnerability levels of communities to flooding in the study area. Meanwhile, it is also important to note that the livelihood assets in this study are linked and in themselves, impactful.

### 3.8 Community Coping Strategies

Part of the objectives of the study was to find out how the respondents coped and the strategies they deployed, particularly in the flood event of 2019, especially as regards to their shortage or

outright loss of income, health challenges and their livelihood too. The result is shown on Table 7.

In the event that income of the respondents was lost, 44% of the respondents indicated that sorting for alternative employment or other petty jobs and 33% of them were more at ease to expect support from relatives or other remittances from friends and families working in urban centres. While about 22% of the respondents resulted to formal and/or informal financial institutions for loans, only about 16% of them resorted or opined that selling some of their valuable assets was a good strategy. It should also be noted that some of them deployed more than one strategy, but in any event the most deployed strategy by respondents in the communities was in engaging in other forms of employment or a complete switch to other occupations, perhaps until after the floods receded. As earlier noted, if the people have access to financial aids, they will be able to finance themselves when floods ensue, thereby reduce their vulnerability and increase their resilience and adaptive capacity [32].

Again, based on health challenges brought about by the flood, about 73% of the respondents opined that personal hygiene was the best, cheapest and widely adopted measure to avoid the outbreak of diseases: cholera, typhoid, etc. They also indicated that during the floods, mosquitos and other parasites were high, thus, 46% of them indicated that they made use of insect treated and/or bed nets. Meanwhile, it should be noted that based on cost, accessibility and availability, the utilization of Insect Treated Nets (ITNs) or bed nets is complex [30]. On the other hand, it is worrisome to note that low percentages were recorded for respondents who had access to clean water/sanitation (36.6%) and free healthcare services (28.2%). These issues, i.e. healthcare and clean water are expensive to access and afford, especially in areas where the government has no facility or utility on ground. Lastly, in maintaining their livelihood, respondents opted for alternative employments (47.8%) and some (41.7%) indicated that they had rather wait or depend on government or non-governmental organizations palliatives or relief materials. Finding another means of livelihood and investing or saving for flood periods were suggested by 30.6% and 15.9% of the respondents, respectively. Hence, apart from settling for other secondary or alternative employments or relying on governments, the respondents in the communities make only little savings and have a low drive in sorting for other forms of livelihood.

### 3.9 Discussion of Findings

The realities of climate change and its resultant effects are worthy to consider in flood management or modelling, at different scales, particularly in urban areas [18]. Understanding flood vulnerability is not only vital for the existence of the exposed societies to extreme floods, but also for their adaptation to climate change through the protection of their key livelihood assets. The vulnerability of communities (both in urban and rural settings) located within or along the floodplain area of the confluence region in the country is a major issue of concern as they are situated at the epicentre of the excesses of Rivers Niger and Benue. As noted earlier, due to the water that may be released from the Dams located upstream, disasters may ensue and it is important to reiterate that whatever is felt upstream is doubled at the confluence, as aptly noted by Nwilo, *et al.* [5], Mayomi, *et al*. [29], According to the European Union (2018) report, Kogi State was among the worst-hit states of the 2012 floods and the most affected region in 2018, respectively. Meanwhile, it is important to note that it is not only when a flood reaches a more destructive category that people are affected. With every slight flood, impacts are felt at different levels and different livelihoods are altered, if not lost completely. For instance, NEMA situation Report No. 2 of September 2018, as cited by European Union (2018) indicated that the 2018 floods (which was relatively lighter compared to the 2012 floods) affected a total of 441,251 persons from 12 states with 118,199 (about 27%) persons coming from Kogi State.

It was revealed in the study that there are at least ten (10) major towns/communities (Lokoja, Ganaja, Ajaokuta, Banda, Oguma, Itobe, Zango-Daji, Sheria, Shintaku, and Kotonkarfe) within the floodplain area of the confluence and are highly prone to prone to flooding – located in low altitudes. Notable towns affected in the 2019 floods are in parts of Koton Karfe, Lokoja, Gboloko and Ajaokuta and caused mainly by the release of water from the dam up the Niger, discharge from main river into other subsequent streams or rivers and also increase in the amount of rainfall [6]. Consequently, with a discharge of about 402,123cu.m/sec an area of 509sq.km or more may be inundated as shown by the flood simulation model developed in the

study. It is vital at this point to appreciate the role of GIS and remote sensing technologies in planning for flooding and visualizing the simulation results carried out as this provides the best potential to analyze and provide results required for spatial planning and for prompt and effective decision-making on floods even before they occur [33]. Hence, using this information together with the impacts on their livelihood assets was the dimension of this study.

Again, with the uncertainties caused by the large dams and complex hydrology of the confluence area, it is difficult if not impossible to make precise decisions of the river flow at the confluence of both rivers as noted by European Commission [6] and also explain the levels of vulnerabilities for the communities affected. It was therefore pertinent to go beyond the terrain assessment used by Nwilo, *et al. [5]* and Mayomi, *et al*. [29] etc. to include the work of Balica, *et al*. [24] as suggested by Nur & Shrestha [19]. From the study, it is obvious that natural assets, followed by physical and social assets rendered the people more vulnerable than human and financial assets damaged. The people depend heavily on natural assets and the physical assets are often times exposed to the feedbacks gotten from the damages done to natural resources which in turn affect the social basis of the people. Although, the SVI values for all assets put together indicates moderate vulnerability of the community to flooding and SVI values for human and financial assets of the communities are below 2.8, it should be noted that where the people are better educated, employed in industries that do not depend on natural resources and labouring in farms will suffer less impact on their natural, physical and social resources as their resilience will be more robust [23]. On the other hand, poor households who are faced with flooding tend to be much more vulnerable: recouping properties and assets is more difficult from a position of financial hardship [23,19]. The survey responses given by respondents equally indicated alternative livelihood and poverty as the major reason why they tend to be moderately vulnerable to 2018 flooding (which off course may have been worse in the flood event of 2012). Hence, there is a need to look into the alternative livelihood of people in the area, so as to raise their standard of living and resilience to flood and in a holistic manner, relocate their key assets to less flood-prone areas thereby invariably reduce their exposures to the hazard. This again is important as there exist a strong, positive relationship between communities' vulnerability levels and their livelihood, especially as more than 47% of the respondents indicated alternative employments or jobs would go a long way to help them, although about 41% noted their full dependence on government and/or NGOs for relief materials and funds. To this end, a diverse but integrative approach will be a better approach since diversity is closely related to flexibility of individuals, guarantee their resilience and stability.

## 4. CONCLUSION AND RECOMMENDATION

This study is an assessment of the vulnerability levels of communities located in the flood-prone zones of the confluence area of Rivers Niger and Benue, with particular reference on the livelihood assets: physical, natural, financial, cultural, social and human capitals. It is an indication that given any degree of flooding, livelihoods assets are affected at varying magnitudes. It is worthy to note that the flood vulnerability indices obtained in this study can be used in combination with other decision-making tools in developing a good flood hazard management plan, create awareness for improving livelihoods and preparedness for the region rather than for different cities or communities, since issues of flooding and other environmental hazards do not follow politico-administrative boundaries.

Hence, this research will be of much value to policy makers and can serve as a reference for spatial planning in the region, such that will improve resilience level of the communities and given any/varying degrees of flood occurrences, prioritizing mitigation measures or identifying areas to roll-out relief materials. Hence, the social dimension of flood events or its impact ought to be stressed. Also, in order to mitigate or completely eliminate the annual (flash) floods experienced in the confluence area of Niger and Benue Rivers, there is an ardent call to develop a flood management plan for the region and revisit the construction of dams at the upstream and for state governments to invest in underground water storage facilities, such that can support agricultural activities throughout the year. There is also need to suggest that governmental and non-governmental agencies create avenues to partner with financial service providers through the integration of a comprehensive climate adaptation and flood management system that can offer greater livelihood options, improve adaptive capacity and resilience of flood-prone communities, both in the confluence and beyond.

There is need to also restrict the construction of settlements in flood-prone areas through the provision of concessionary rates or by allowing payments for suitable lands to be made in instalments. This will go a long way to reduce economic losses as well as help protect livelihood assets [23].

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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