Urban Flood Event and Associated Damage in the Benue Valley, Nigeria

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Abstract

Flooding events in the Lower Benue valley of Nigeria are often associated with huge damage to properties and loss of life in the adjoining communities. Specific objective of this study is to evaluate the impact of 2017 flood event as typical of the study area. Method used was an integrated environmental approach that combines analysis of rainfall and discharge data with social surveys, remote sensing and geographical information system. Standardized Precipitation Index (SPI), Precipitation Concentration Index (PCI) as well as flood damage curves were analysed with landuse/cover change and soil data to establish the nature of the flood and its impacts. Result showed that the flood in the study area is essentially saturation overland flow, which is more associated with saturation-excess than infiltration excess flow, and that the flood events are recurrent and predictable. 85% of the affected residents are however poor, earning an equivalent of US $4.3 daily, and live in non-reinforced concrete masonry (64%) and wooden buildings (24%). Many of the affected communities lived within flood plain and most buildings were structurally deficient. Victims received no compensation, and the properties were generally uninsured. The study recommends extensive flood control policy for the area and similar flood-prone communities.

Keywords: Recurring flood disasters, Flood damage, Poor and vulnerable communities; Response strategies

1. Introduction

1.1. *Background*

Flood, inundation or overflow of water resulting from different overland flow mechanisms, is associated with frequent disastrous effects (Barredo, 2007; Berz, 2020; Yin, 2020; Zeleňáková et al, 2020), including causing essential damages to livelihoods, properties, and some cases, deaths. Overland flow mechanisms such as infiltration-excess, saturation-excess and preferential flows become dominant in different soil and vegetation environment; largely impervious or loosely vegetated but dry surfaces, near-stream humid and vegetated surface as well as areas characterised by natural or artificial mole or pipes, respectively (Beven, 1986; Hussaini & Khan, 2020). Floods generally result from the interaction of physical processes, including certain hydrological pre-conditions, meteorological or climate factors, runoff generation processes and river routing at different scales (Nied et al., 2014). While floods are initiated by precipitation excess or dam failure (Kunkel et el., 1999; Ologunorisa, 2001; Ologunorisa & Tersoo, 2006; Adelekan, 2015; Albright & Crow, 2019; Tei et al., 2020), the effects are largely exacerbated by blocked drainage systems and poorly planned settlements, among other urban planning problems (Costa, 1985; Brown & Graham, 1988; Adelekan, 2011; Atufu & Holt, 2018; Asiedu, 2020; Latrubesse et al, 2020).

Studies have shown that floods are not always disastrous; especially in areas such as parts of the agricultural areas of sub-Saharan Africa, Asia and South America where deposited alluvial plains in many flood-prone watersheds have accounted for productive farmlands (Fairbairn, 2005; Sommer et al., 2020). Floods also inundate wetlands with fresh wastes and nourish lakes and streams with nutrients, among some other positive impacts (Ponnamperuma, 1984; Bai et al., 2020. Firth et al., 2020). The impact (destructive or non-destructive) of flood is often dependent on the strength (intensity and stretch) of rainfall and the environmental responses (coping, adaptation or resilience) (Baker et al., 1988; Hu et al., 2019). Floods may also result into direct or indirect fatalities (Janerich et al, 1981; Jonkman & Kelman, 2005; Davis et al, 2019; Knighton et al., 2020). The effects include 40% - 47% of all weather-related disasters, loss of livelihoods of about 2.3 billion people and 242,000 deaths between 1995 and 2015 (United Nations Office for Disaster Reduction, UNISDR, 2015). The indirect effects include psychological and mental illness of victims of flood-related losses. Alderman et al. (2012) indicated that flood in many densely and poorly planned settlements may significantly correlate with increased risk of disease outbreaks, increased mortality and prolonged psychological distress.

Di Baldassarre et al (2010) argued that flood-related losses and fatalities have dramatically increased in Africa since about half of the century and that there is a growing global concern on the need to identify the causes for the increased amount of damages. According to the United Nations (2009) over 600,000 people were either displaced or suffered significant economic loss across the West Africa in September 2009, and about over 500 deaths occurred in flood-linked disasters in 2007. In general, fatalities due to flood appear to be an annual occurrence, probably due to poor understanding of the flood disasters alongside poor settlement planning system (Di Baldassarre et al., 2010). In Nigeria, coastal and urban floods have been linked to numerous disasters, such that the National Emergency Management Agency (NEMA) documented that flood events occurrence in four months (June – September) in 2012 directly caused more than 363 human deaths with displacement of at least 1.2 million people. Only in the state (Oyo State)'s capital of Ibadan in the southwestern Nigeria, more than a million people were severely affected by the 'Ogunpa flood' disasters in 1980 (Smit and Parnell, 2012; Nwala, 2017). Life and properties worth millions of dollars have also been lost to flood events in different parts of the countries, including the Niger Delta (Ologunorisa, 2001; Ologunorisa, 2004; Ologunorisa and Adeyemo, 2005), Lagos (Adelekan, 2016a, Olanrewaju et al, 2019), Ibadan (Adelekan, 2016b), Akure (Eludoyin et al., 2007), Abuja (Adeleye et al, 2019), Chad basin (Oyebande, 1991) and Yobe (Goes, 2002).

Efforts have emerged through the Ecological Fund initiative of the federal government of Nigeria. The Ecological Fund was founded in 1985 through the Federation Account Act of 1981 with the prime aim of funding ecological projects to mitigate serious ecological problems that include flooding and soil erosion (www.ecologicalfund.gov.ng). Despite the efforts through the initiatives and other efforts of non-governmental agencies, the menace of flooding and associated soil erosion has become a recurrent problem in almost all parts of the country, suggesting that the initiatives are probably not working. Records of flood-related fatalities (Di Baldassarre et al., 2010) revealed an increase in flood-related deaths in Nigeria and the entire African region since the preceding 50 years. A review of recent studies on possible factors that might link to increased fatalities during flood events revealed poor modeling or use of non-validated models (Bernhofen et al, 2018), changing climatic conditions and anthropogenic factors, such as poor land use management and urbanization that are capable of exacerbating the impact (Ekeu-wei, 2018).

1.2. *Research Problem*

Owing to heavy rain, settlements in the Nigerian Benue trough suffered flooding between August and September, 2017. Within the Niger trough, residents of Lokoja and Makurdi, the administrative capital of Kogi and Makurdi States in the western and eastern flange of the middle belt of Nigeria have suffered severe flooding over the years (Onuigbo et al., 2017; Brooks et al., 2020; Lawal, 2020). The flooding events of August-September, 2017 resulted in the displacement of over 10,000 people, and the situation was described as being ‘in dire need of humanitarian intervention’ and ‘desperately pathetic’ (Davies, 2017). The disturbing level of the impact of flood on the mid-belt environment of Nigeria in 2017 is not unique; such is representative of the situation in many flood prone communities in the sub-Saharan Africa, including coastal and urban settlements (Douglas et al., 2008; Hula & Udoh, 2015; Kanu &

Imatari, 2016; Nkwunonwo et al., 2020; Plänitz, 2020). According to Nkwunonwo et al. (2020), sub-Saharan African countries, including Nigeria are challenged by poorly understood and under-studied flood hazards. Existing studies on disaster management have equally revealed problems with flood management, preparedness as well as coping strategies (Adeleye, 2019); many of the studies have linked the inadequate management of flood hazards to limited development control (designing and implementing sustainable policy for ensuring efficient regulations) of physical development (Ahmed and Dinye, 2011; Lekwot *et al.*, 2013). Douglas et al (2008) posited that residents of low to middle economic settlements bare most burdens of flood hazards because disaster response and mitigating facilities are generally poor.

This study has focused on determining the impact of flood events on affected on communities in the Benue trough of Nigeria. Objectives were to analyse temporal characteristics of rainfall, the effects of the flood events as well as the perception of the residents on the causes and effects of flood hazards in the selected communities in the Benue trough of Nigeria. The study is based on the hypothesis of suggested by Lovett (2000) that the ability to combine data from different sources is adequate for effective environmental management. Consequently, the study is aimed at strengthening the importance of freely available satellite imageries, especially Landsat image data to complement climate and survey data for better decision for flood control development in the region. The hypothesis is supported by the argument by Douglas et al (2008) that flooding is related to heavy rainfall, extreme climatic events and changes in the built-up areas. The extent to which this hypothesis is true is determined in this study from an integrated perspective of climate analysis, remote sensing, social and field surveys, with geographical information system.

2. Materials and Methods

2.1. *Study Area*

The study area, Makurdi, situated at the narrow end of the River Benue lying on both sides of the riverbanks, is the administrative headquarter of Benue State (Figure 1). It is situated inside the floodplain of the Lower River Benue valley with a physiographic stretch of about 73 m – 167 m above sea level, and is often drained by River Benue which partitions it into Makurdi North and South banks. Apart from River Benue, tributaries and headwater channels that drain the communities in Makurdi include Kpege, Adaka, Asase, Idye, Urudu, and Demekpe streams; the dense drainage system usually makes the area susceptible to inundation in the wet season.

Insert Figure 1

Dominant climate in the area is the Tropical Guinea Savanna, classified as Koppen's *Aw* climate. The Guinea belt occupies the limits of tropical rainforest climate, and extends to the central part of Nigeria where it forms a boundary with Sudan savanna climate, exhibiting a well-marked single peak rainy season and a dry season. The 1951-2009 average minimum, mean and maximum temperature values are 22.3±2.5 ºC, 27.8±1.8 ºC and 33.3±2.6 ºC, respectively while mean relative humidity for same period is 69.8±14.2% (Eludoyin et al, 2014). Mean annual rainfall is about 1200 mm, with double peaks and little dry season; the rainy season lasts from April to October, while dry season occurs between November and March. Geological underlain is primarily sedimentary, with micaceous and feldspathic sandstone in some portions of the area, and shale in some low-lying areas (Nyagba, 1995). Main soil types are hydromorphic soils that developed on alluvium sediments along River Benue coastline, as well as red ferasols away from the coastline (Nyagba, 1995). Given the influence of good drainage, rich soil and grassland that makes cultivation relatively easier than what obtains in the rainforest belt, over 60% of the indigenous people are small-scale or indigenous farmers, and many of the farmers are also fishermen, depending on their locations. Other residents are either government workers or commercial workers, but a number of the residents combine at least two occupational activities. The population density as at 2016 was estimated at 405,000 and projected to be about 600,000 by 2021, based on the 1991 Nigerian Population Commission's estimated growth of 3.05% per year, and net migration. Prior to the flood episode of August/September 2017, the study area (Makurdi) has experienced flooding in many years, and significant damages were reported in newsprints in 1996, 1999, 2000, 2002, 2004, 2005, 2007, 2008, 2012 and 2017 (Ologunorisa and Tersoo, 2006; Shabu and Tyonum, 2013), especially as River Benue overflows its banks, due to either heavy and prolonged rainfall or dam failure, such as the Lagdo dam failure in 2012, which caused displacement of over 500 people and inundation of about 300 buildings (Ocheri and Okele, 2012). The 2017 flooding event was next to that of 2012 in magnitude (Davies, 2017), hence its selection for this study.

2.2. ***Data***

Data used for this study include remotely sensed imageries of Shuttle Radar Topography Mission, SRTM, and Landsat 8 Operational Land Imager (OLI, released on 15th of January, 2017; spatial resolution = 30m), which were used to derive essential topographical characteristics, such as slope and drainage network (SRTM), as well as the land use/cover over the study area. Both the Landsat and SRTM imageries for the study area were downloaded from the archive of the United States of America's Geological Survey (USGS). Data also included 57 (1960 – 2017) daily rainfall and runoff data, as well as daily evaporation data for 36 years (1980 – 2017) that were obtained from the office of the NigerianMeteorological Agency (NiMet) and Nigerian Hydrological Service Agency (NiHSA) in Abuja Nigeria, respectively. Furthermore, soil data and geological data were extracted from the Harmonised World Soil Database (HWSD)

Nigerian Geological Survey Agency, respectively. In addition, 400 residents of the study area were selected using a systematic sampling procedure for administration of a set of semi-structured questionnaire. Contents of the questionnaire were grouped into personal and socio-economic attributes of respondents, perception on vulnerability to flood disasters and coping strategies.

2.3. ***Data analysis***

The remote sensing data were first corrected for geometric and radiometric corrections as required for standard remote sensing imageries for quality enhancement and assessment (Burrough, 1996). The imageries were thereafter georeferenced in ArcGGIS software (version 10.5) by merging the coordinates of known points that were obtained from the existing topographical maps of the area, and confirmed with the use of global positioning system (GPS, Germin etrex version) on the physical structure as described by Stopher et al. (2015). Also, the Landsat 8 imagery was classified using supervised classification (based on Maximum likelihood Classification algorithm) into different dominant landuse system following Anderson (1976)'s scheme for landuse/land cover classification. All the imagery data as well as soil and geological data were analysed following the principles of remote sensing and geographical information system in ArcGIS software as described in previous studies and the software's manual (Hillier, 2005; Crosier et al., 2006). The climate and discharge data were also investigated for non-climatic heterogeneity and instrumental errors as advised by the World Meteorological Organisation (1989) before analysed. The data were analysed for time series, dispersion using standard extreme rainfall indices, mainly, Standardized Precipitation Index (SPI) and

Precipitation Concentration Index (PCI). The PCI was determined based on the recommendation of Oliver (1980) and De Luis et al. (2011) (equation 1)

$$PCI = \frac{\sum_{i=1}^{12} {P_i}^2}{\left(\sum_{i=1}^{12} P_i\right)^2} \times 100 \qquad (1)$$

Where: P_i = the rainfall amount of the *i*th month. PCI less than 10% indicates low precipitation concentration; 11 – 15% is interpreted as moderate and 16 and above is high.

The SPI is typically determined as probabilities, based on the likelihood of recorded measure of precipitation; zero indicates the median precipitation amount and negative values represent dry spell while positive values indicate wet condition over a period of at least 30 years (McKee et al., 1993; Cheval et al., 2014). SPI was determined using equation 2.

$$SPI = \frac{X - \bar{x}}{SD} \qquad (2)$$

Where: $(X - \bar{x}\ )$ = the rainfall anomaly and SD = standard deviation of the mean of the series.

In this study, monthly SPI were calculated for the period 1980 to 2017, using the rainfall data obtained from the Makurdi station of the Nigerian Meteorological Agency; the body responsibly for obtaining and keeping such records in the country. Also, the Mann – Kendall (MK) trend test, a non-parametric test for determination of monotonic trends in a series of data was adopted to assess statically significant trend of rainfall over the study period. The MK test is less affected by the outliers than other tends' procedure (Birsan et al., 2005). The MK test statistic 'S' is calculated based as described by Yue et al. (2002) (3)

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i) \qquad (3)$$

Where:

$$Sgn\ (x_j - x_i) = \begin{Bmatrix} +1if(x_j - x_i) > 0 \\ 0if(x_j - x_i) = 0 \\ -1if(x_j - x_i) < 0 \end{Bmatrix}$$

X_i and X_j are the annual values in years i and j (j > i) respectively.

Perceptions of residents were analysed using frequency/percentage distribution analysis. The study area was also visited for visual assessment of flood damage after one of the occurrences in 2017.

3. Results

3.1. *Rainfall and discharge characteristics*

Some mean monthly characteristics of daily rainfall within the selected period are provided in Table 1. Rainfall averagely increased from March and peaked in August before it rescinded in September and October. The generally low rainfall from November to March characterizes the months as dry period. Coefficients of variation were higher in the dry period than in the other months (wet or rainy season). The results of the M-K test and Sen's slope that were used to examine monotonic trend and its magnitude indicate that while there is no monotonic trend in rainfall pattern between November and February, the period between April and July showed negative trend.

Insert Table 1

In general, mean monthly rainfall pattern reveals a continuously increasing pattern and probable soil water surplus in the wet season (due to reduced evaporation) that is capable of generating high proportion of overland flow, either as infiltration-excess or saturation-excess (Figure 2a) in the area. The assumption of saturation-excess flow becomes evident with the pattern of measured discharge at the Makurdi station of River Benue, which correspondingly increased with rainfall (Figure 2b). Whereas rainfall has relatively increased over the studied years (y = 2968 + 4.876x, $R^2 = 0.01$), mean annual discharge has relatively declined (y = 109.9 - 0.329x, $R^2 = 0.08$). Increased rainfall has been depicted as hazardous as more communities become vulnerable to flood, and more communities in the study area have become notoriously vulnerable to flooding, and the community and government have appeared to possess no solution or control for years (Ologunorisa and Tersoo, 2006; Ajon et al., 2017). Reduced discharge may be linked with landuse and land cover change (Eludoyin et al., 2017).

Insert Figure 2

Analysis of the return period for flood incidence reveals that peak discharge in 24 out of the 46 years investigated occurred in September while peaks occurred in November in 20 times, and at only one time did discharge peaked in November. Furthermore, the observed low and statistically insignificant correlation that occurred in annual total rainfall between 1980 and 2017 (Figure 3a), and the wavelet transform result (Figure 3b) reveal low level of similarity in spectral signals (rainfall occurrences) in the area. The low similarity level in the signal reveals the presence of extreme rainfall cases in the wet season. Existing studies showed that the study area experiences wet season whose prevalence is associated with the movement of south westerlies over the Atlantic Ocean (Odekunle & Eludoyin, 2008). Also, studies (Hula and Udoh, 2015; Agada and Nirupama, 2015) documented that areas in the guinea savanna of Nigeria, including the present study area experience floods more in the wet period. Such documentation will easily associate flood with rainwater overflow due to infiltration-excess or saturation-excess.

Insert Figure 3

Infiltration-excess flow occurs when the soil infiltration capacity or where when flood is generated due to low infiltration capacity (the maximum rate at which a given soil can absorb precipitation as it falls; Beston, 1964) or where soil storage capacity is extremely low, including poorly vegetated, rocky, paved and concrete surfaces, cultivated and heavily grazed areas (Ziegler et al, 2004; Bilotta, et al., 2007; Kechavarzi, et al., 2010). Saturation-excess flow, on the other hands, prevails at near-stream areas and expansion of small, locally variable water table, during storm condition (Chappell, et al., 2006).

3.2. *Extreme rainfall events*

Results of the SPI indicate alternating wet and dry sequences over the study period; with only 13.5% of the years exhibiting extreme wetness, and 54.1% were wet (near normal to very wet) and 32.4% were dry (Figure 4). In addition, the PCI was 13 – 19.8 units in 2016 and 1982, respectively; indicating moderate-to-high rainfall concentration. Given the SPI and PCI, it is safe to characterize rainfall as being between 'moderately irregular' and 'highly irregular'. Iskander et al. (2014) described areas that are characterised by irregular PCI as that which possesses tendency for high flood potential and consequentially high erosion-potential. The PCI during the 2017 flood event in Makurdi was 18.9 unit, indicating 'highly irregular', and suggesting that flood can be linked with saturation overland flow; flood occurring when the soil is saturated due to rainfall or moisture surplus (see also Olaniran, 1983).

Insert Figure 4

Also, the number of consecutive rain days peaked between August and September, when the hazardous flood events occurred. Existing studies on Niger-Benue trough and few others settlements in the country confirmed that most hazardous floods occurred in the wet season (Ologunorisa and Tersoo, 2006; Taiwo, 2008), and are therefore triggered by saturation excess flow, rather than the more spontaneous infiltration excess flow, which probably occurred in local dominance in highly urbanised settlements.

3.3. *Physical characteristics influencing flood recurrence*

The remote sensing–based analysis of relevant physical characteristics of the study area indicated that the communities in Makurdi are within River Benue basin, and are characterized by varying slope; relatively higher in the built-up area than other areas. The northern part of the study area is largely drained by Plinthic Luvisols and fluvisol, while the southern part is dominated by Ferric Acrisols. Both Fluvisols and Plinthic Luvisols are young, weak and poorly drained soils (Batjes, 1997). The soils have derived from the largely sedimentary geology of the crystalline basement rocks (Ofoegbu, 1983). Ofoegbu (1983) noted that part of Makurdi is geologically underlain by three categories of geological composition, namely; alluvium, basalts, trachyte and ryolite as well as shale and limestone. The satellite imagery used in the study also revealed the dominance of alluvium and sandstone in the area (Figure 5d). Alluvium and associated alluvial soil are very productive (Boettinger, 2005), and are therefore vulnerable to pressure for tillage as population increases. In addition, analysis of land cover reveals that a significant portion of the built-up area are concentrated around the River Benue (Figure 5e).

Insert Figure 5

Studies (including O’Connell et al, 2007, Konrad, 2016) have established causative links between agriculture intensification, urbanization activities and flooding. In the study area Acha and Aishetu (2018) reported construction and livelihood activities within the Benue floodplain and along waterways. Consequently, the flood vulnerability analysis of the area classified about

37.3% (representing 307.5 sq. km or 34.1% of the entire built up area) of the entire land area as medium to high hazard zone (Figure 6).

Insert Figure 6

3.4. *Flood damage: case study of the 2017 event*

Analysis of some socio-economic variables across randomly selected responses from the study area indicates that the residents of the most affected (flooded) communities in the flood event were relatively poor people (Table 2). Majority of the affected people were working class (aged 25 – 45 years), who's income was at most NGN 600, 000 (US $1, 520) per annum; about 74.8% of the respondents have lived for at least 4 years before the flood event and 95% have experienced flooding events in the study area before the 2017 event. Residential houses with concrete frame and unreinforced masonry was less damaged (damage percentage = 1.8%) than residential unreinforced masonry buildings (22.4%). The unreinforced masonry structure therefore incurred more damages than concrete frame with unreinforced masonry wall structures (Table 3).

Insert Table 2

Insert Table 3

The two indices of flood damage reveal that the unreinforced building and commercial building types were more damaged than the concrete frame buildings. Furthermore, the results of flood vulnerability or depth-damage curves are presented as Figure 7. Figure 7 were generated for dominant building uses (residential and commercial) and type or make-up (Unreinforced Masonry Building or UMB and Concrete Frame with Unreinforced Masonry Building (CFUMB) types). Values of R^2 (Coefficient of Determination, Wheeler et al, 2013) was low, generally less than 50%; suggesting that water or flood depth is not a significant predictor of damage to the building and residential contents. Escarameia *et al.* (2012) argued that other flood characteristics such as duration, velocity as well as variations in building structure and material and responses of affected communities are other factors. Also, damage whereas became obvious at UMB at 20 cm flood depth, it was at 40 cm with CFUMB and 23 cm with the commercial buildings. This is probably because since the floor elevation is first vulnerable (submerged by flood), buildings with higher floors such as the CFUMB were not as damaged as those with lower floor elevation structure.

Insert Figure 7

In general, only 3.6% of the total damages occurred with the CFURMB, while the URMB and Commercial Building type experienced 40% and 34% damage ratios, respectively (refer to Table 3). Observations from the 2017 flood occurrence reveal that the commercial building type comprises a general set of old or abandoned residential buildings as well as wooden structures that were converted to economic uses. Such wooden and unorganized structures are normally expected to incur high damage ratio at any flood event (Komolafe et al., 2018). Also, 81.9% of the respondents noted that the depth of flood water that displaced the study area between August and September, 2017, was in excess of one meter above the ground level, and the heavy rainfall lasted roughly four days. An average of eight hundred and eleven thousand (NGN 811,814.97 or US$ 2, 127.96) was lost by residents whose income (of 86.7%) was at most NGN 600,000 or US$ 1572.74 per annum.

3.5. *Impact of flood warning system*

At least 64.3% of the respondents claimed to be forewarned about the likelihood of a flood event by the Nigerian Meteorological Agency and the Nigerian Association of Hydrological Science but were not sure of the magnitude. Duru (2017) noted that the Benue State Commissioner for Water Resources and Environment noted that they '*were actually aware that there would be flooding but it was the magnitude we (that they) did not know'*. With such warning, a youth organization typically embarked on campaign to sensitise the vulnerable communities on cleaning of many blocked drainage channels (Plate 1) that have been implicated for preventing free runoffs, and consequently aggravating flooding.

Insert Plate 1

Also, 73.1% of respondents argued that construction of more drainage channels could prevent the flooding problem but only 59% claimed to have received any assistance from the State Government while 12.3% noted that relatives have provided some aid. However, 81% of the affected people argued that the responsibility to manage flood disaster in the area is governments' and not residents'.

4. Discussion and conclusion

The study area is typical of communities that are vulnerable to flood in the wet season or during any course of extreme rainfall event, due to their closeness to water bodies. The entire Niger-Benue region, Niger Delta and coastline of the Atlantic Ocean are vulnerable to flood in Nigeria as many near-stream communities in the world (Ologunorisa & Adeyemo, 2005; Lindersson et al., 2020). Consequently, flood-related hazards have been referred to as 'natural hazard' even when studies across urban areas in the country (e.g. Omiunu, 1981; Oguntala & Oguntoyinbo, 1982; Olaniran, 1983; Oriola, 1994; Rashid et al., 2007; Adelekan, 2016a, b) and many others in other parts of the world (Wens et al., 2019; Lindersson et al., 2020) have argued that flood is fundamentally an anthropogenic disaster with strong societal links involving drivers, impacts and feedback mechanisms. A report of the UNISDR (2015) referred to population growth and socio-economic development in flood-prone areas as the main driver of past decades' flood damages. It is obvious in the study area that the communities are flood prone due to their near-river (River Benue) location and seasonal heavy rainfall. The seasonal heavy rainfall between June and October of every year suggests that the recurring flood disasters are predictable. The perception of early warning by the Nigerian Meteorological Agency is shared by the respondents on the 2017 flood disaster suggests that the effects can be reduced or avoided, with right responses. When compared with records of flood events in many other areas, it can be assumed that occurrence of flood disasters in many near-stream communities, especially in developing are recurrent and not unexpected but the preventive strategies are either weak or unavailable. Ologunorisa & Adeyemo (2005) recounted that persistent victims of flood in the Niger Delta are quite aware of the causes of the hazards to include heavy, prolonged rainfall and river overflow but decided to tolerate the hazard for economic reasons (mainly occupational).

One striking attributes victims of flood and other disasters in the sub-Saharan Africa is that they are poor and their properties are largely uninsured (NEST, 1991; Odemerho, 1993; Omodanisi et al, 2014) unlike what ensures in many developed countries (Martínez-Gomariz et al, 2020). Like Ologunorisa & Adeyemo (2005) observed for victims of flood in the Niger Delta, most of the flood victims in the study area were not compensated or given any relief. Also, many of the affected buildings were actually within the floodplain of River Benue or its tributary; analysis of the landuse/cover suggest that about 34% of the built-up in Makurdi are within the floodplain of the river. These places easily become submerged with increase in the volume of the river.

Furthermore, properties damaged in the 2017 flood hazard were relatively (to the income of the residents) high, and given unreliable/poor insurance policy in the country, poor planning policies and increased rate of land exposure due to urban growth, more records of hazards is predicted. Coping or/and adaptive responses are largely are largely individualistic, and as such, the poor (86.8% who earn at most US $ 4.3; NGN 600,000 by 360 days; Table 2) will be unlikely able to cope, except with government intervention. The huge impact of the 2017 flood disaster after many blocked drainage channels have been cleared in the affected communities suggests that the response was inadequate. In general, the study concluded on the need for an extensive flood control policy for the affected area and similar flood-prone communities. The policy will be strengthened by inclusion of plan for structural control, including channelization, canalization, dredging, building of flood walls and embankments, as well as monitoring and enforcement of the set-back rules to water bodies.

Declarations

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Conflicts of interest/Competing interests: There are no competing interest by the authors

Availability of data and material: Data are available in repository with the Federal University of Technology, Akure, Nigeria

Code availability: Not applicable

Ethics approval: Approval to conduct social surveys was obtained through the Federal University of Technology, Akure, Nigeria

Consent to participate: All the participating authors agree to participate in the research.

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Figures

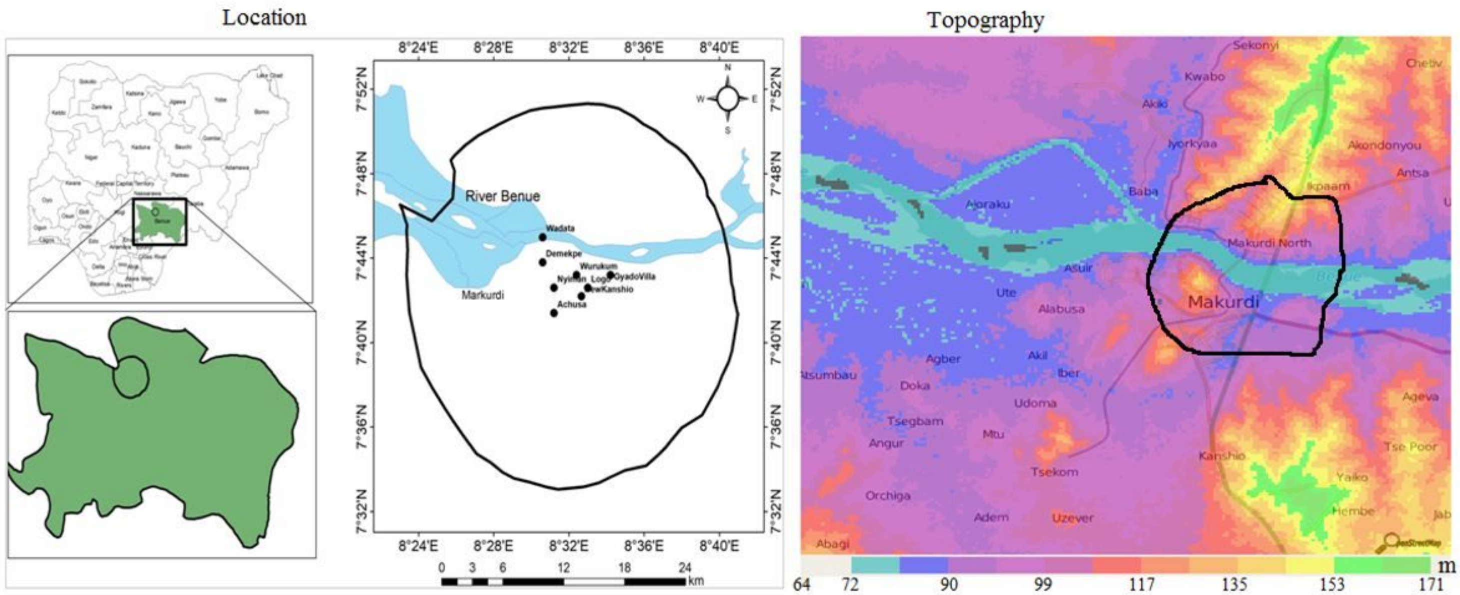

Figure 1

Location and topography of the study area, Makurdi in Benue State, Nigeria Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

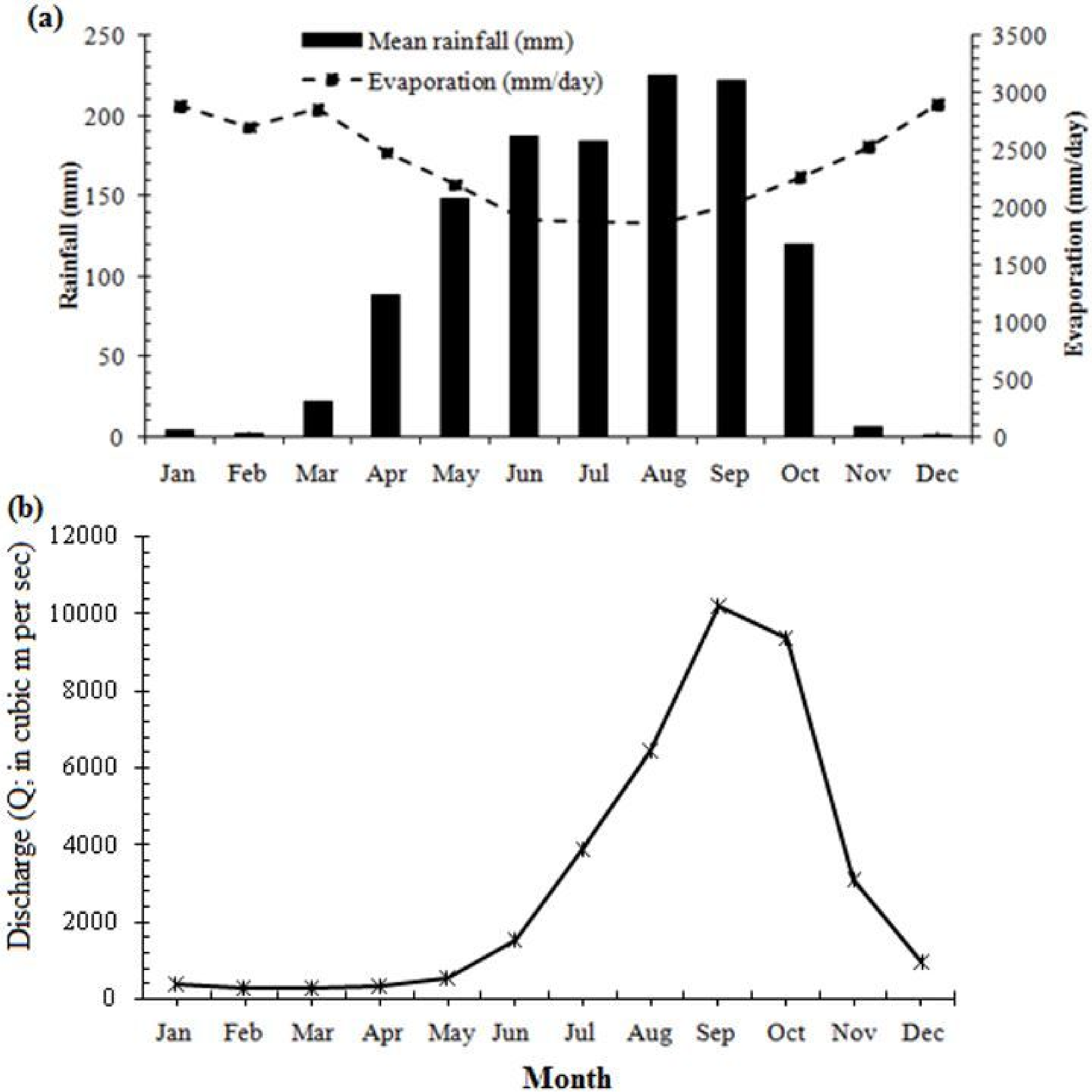

Figure 2

Monthly mean rainfall, evaporation and corresponding discharge of River Benue at Makurdi, Nigeria

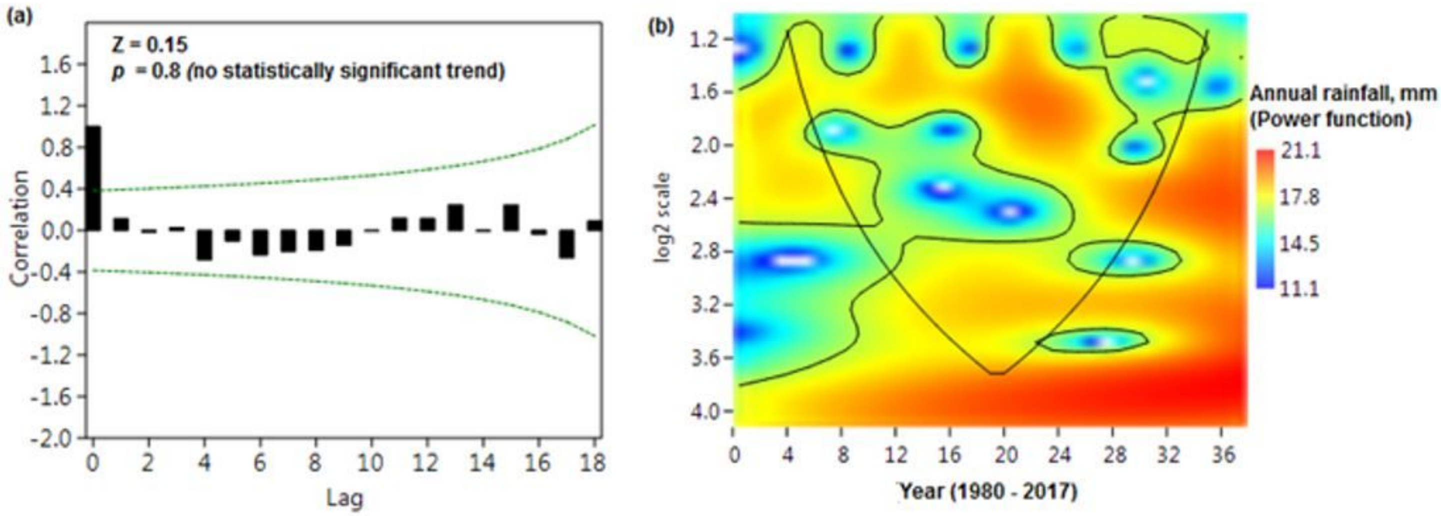

Figure 3

Time-rainfall relationship and variability

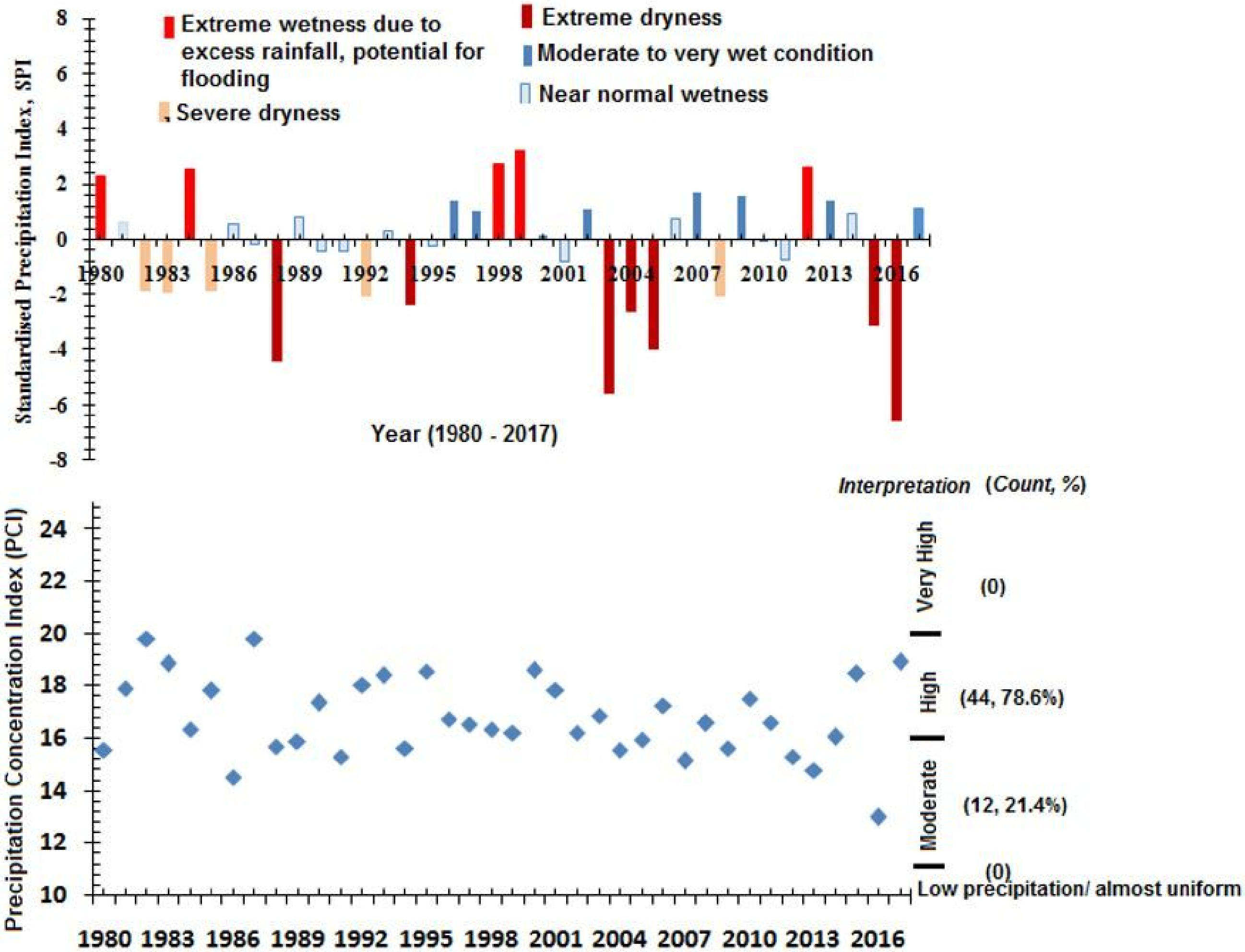

Figure 4

Results of SPI and PCI

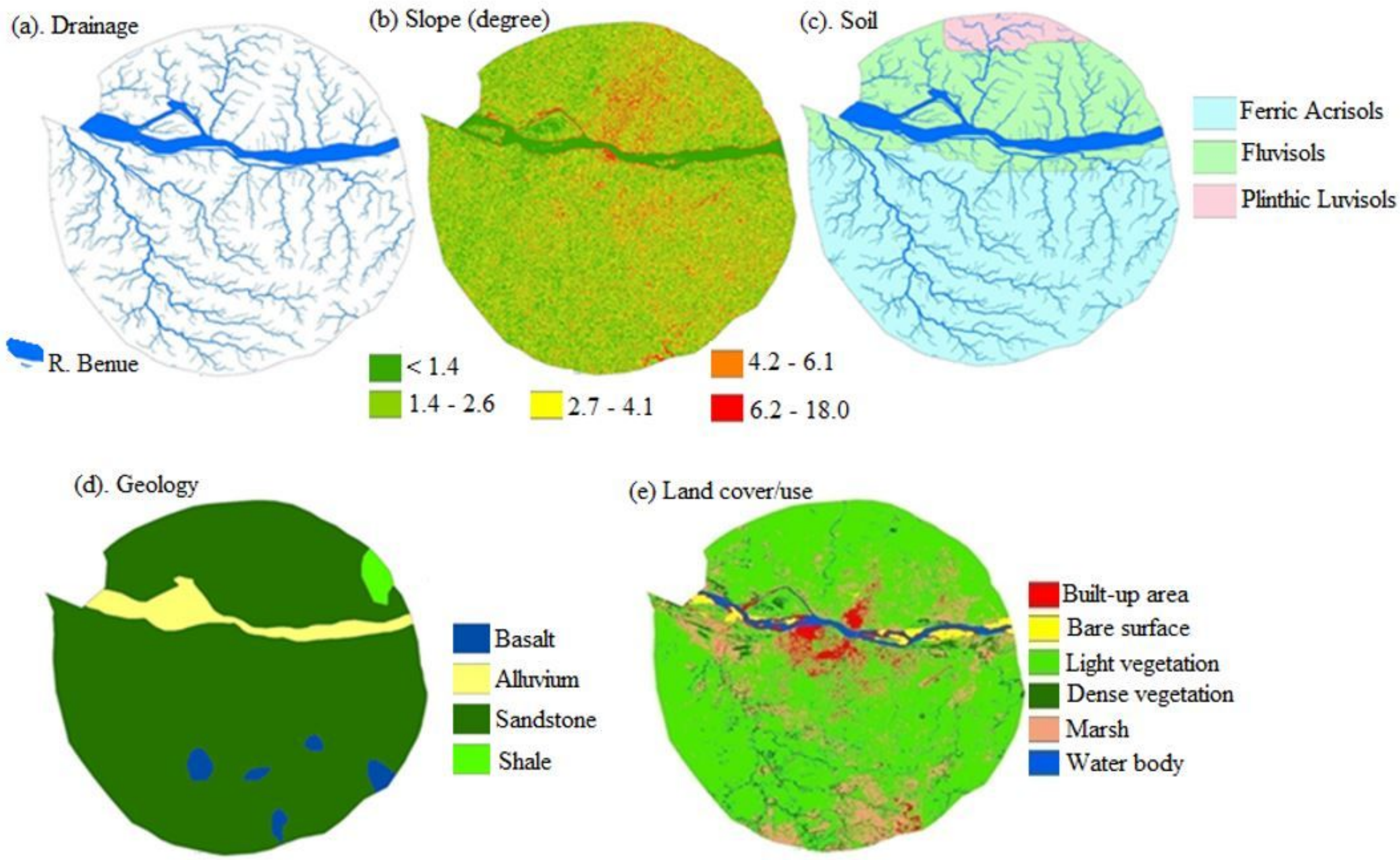

Figure 5

Some characteristics of Benue Basin around Makurdi, the study area

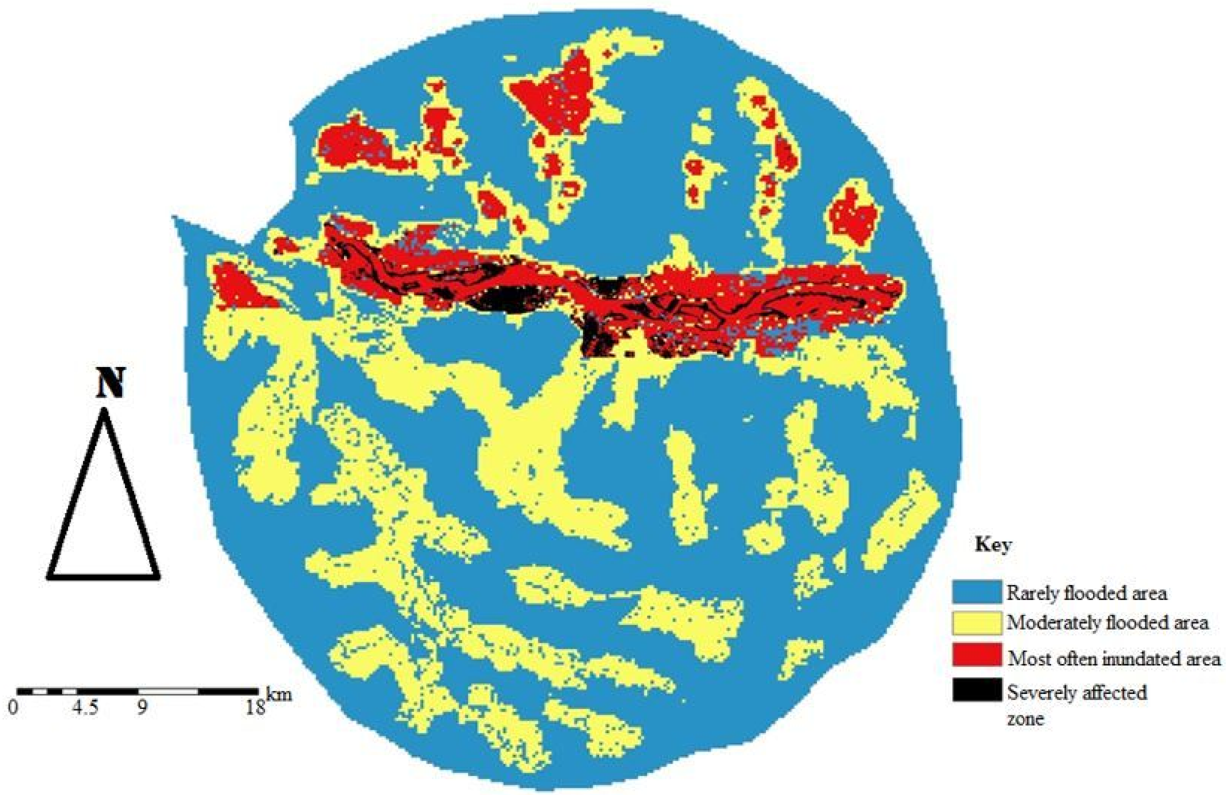

Figure 6

Vulnerability of the study area to flood hazards

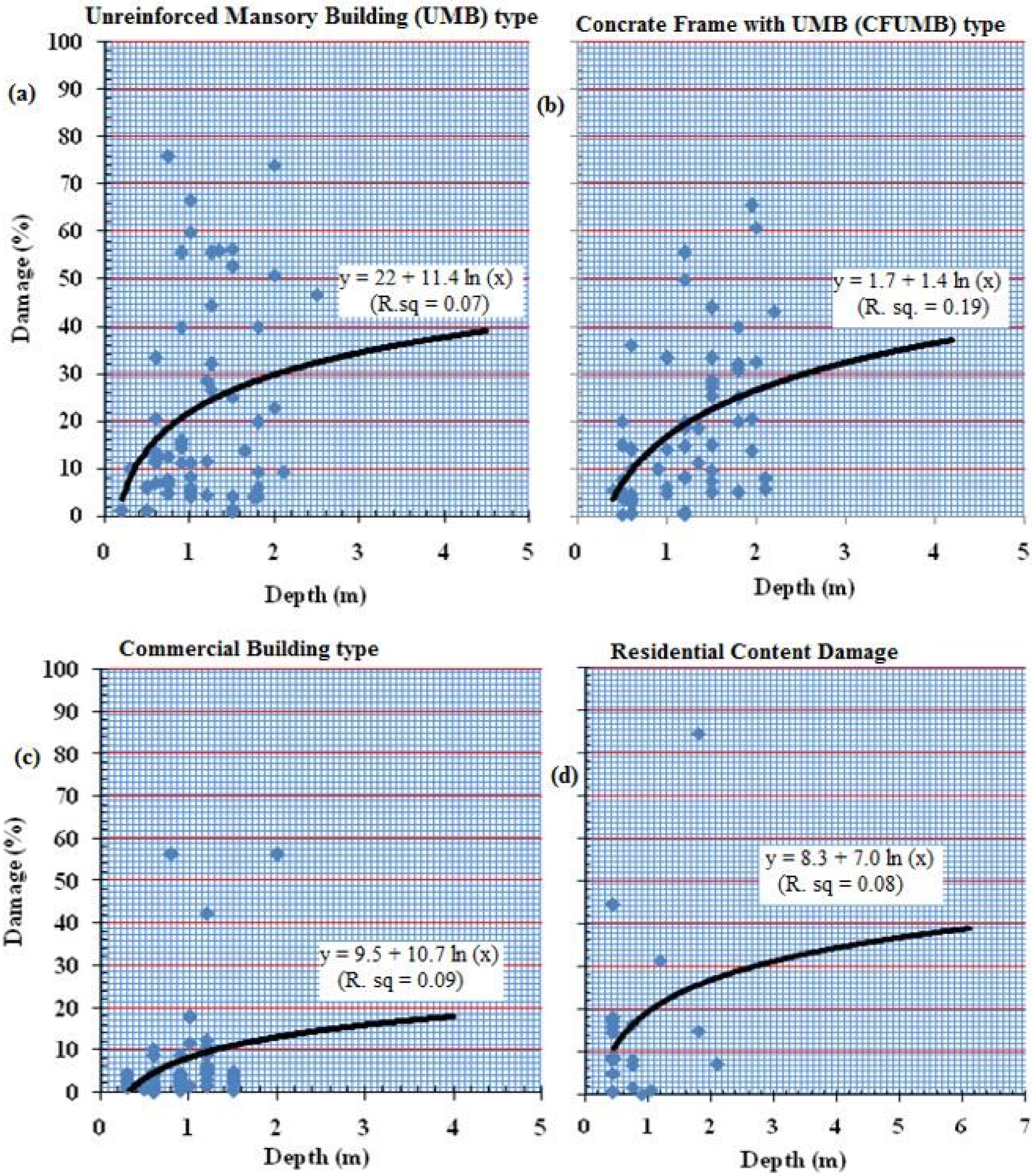

Figure 7

Flood vulnerability or depth-damage curves for different building types in the study area

Supplementary Files

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- Plate1.jpg