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The Upshot of the 2012 Flooding on Structural Components and Fabrics of Buildings at Ogbaru, Anambra State Nigeria

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Abstract The study examined the effect of the 2012 flooding on structural components and fabrics of buildings at Ogbaru Local Government Area of Anambra State. It also examined the heights of the ground floors and foundations of the buildings respectively in relation to the height of the flood. Questionnaire survey on the selected households and physical examination on the building structures were carried out. The study revealed that most buildings in the area were either fully or partially submerged during the flood incidence. it further revealed that there no very severe damages on the structural components of the buildings, despite that most of the buildings have low ground floor levels (74%) and shallow foundations (68%) below 300mm. However, building fabrics and elements such as finishes and electrical fittings were severely damaged when the flood height rose 1 metre above the ground floor level. More so, the study revealed that the flood severely damaged both the structural components and fabrics of very old, weak and mud buildings. Based on this, the study recommended that building constructors in the area should raise the ground floor level of their building projects to at least 1 metre above the ground level. It also recommended suspension of buildings on plinths and use of deep stripe or raft foundation. The use water resistant materials and components such as paints, doors, windows and electrical fittings and incorporation of oversite concrete as floors while building new structures or refurbishing existing ones are also recommended.

Keywords: *buildings, building fabrics, built environment, flood disaster, Ogbaru, structural components*

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1. Introduction

Built environment bears the brunt of the damages from natural disaster of all kinds due to characteristic of constructed facilities, even when the disaster is accurately predicted [1]. Disaster according to Adedeji, Odufuwa and Adebayo [2] has been identified as a serious threat to sustainable development. Haigh [3] confirms that disaster has the ability to severally disrupt economic growth and hinders a person (or nation) ability to emerge from poverty. Haigh further posits that vital role of the built environment in serving human endeavours means that when the element of it is damaged or destroyed, the ability of the society to function economically and socially is severally disrupted.

Adedeji et al. [2] argue that flooding occurs due to human influence on the urban modification, and alteration in the urban space or area; and maintain that the disastrous consequences are dependent on the degree of human activities and occupancy in vulnerable areas. This human influence in urban modification can led to deltaic wetland losses either by direct destruction or rapid changes to the natural delta environment. This generally will reduce the adaptive capacity of the delta to cope with SLR (sea level rising) and other climate change impact [4].

The unprecedented rate of flooding in recent years implicate increasing rainstorm due to on-going global warning and climate [2]. To Schramn and Dries [5], dams and levee failures, torrential rains of hurricane, snow thaws, i.e. floes blocking a river and burst water main trigger off flooding. Nwilo [6] opinions that flood occurs when the carrying capacity of the water courses is exceeded and when there is blockage of the water course and drainage channels. However, the incidence of flood disaster has become so pronounced in Nigeria thereby causing a serious threat to sustainable development. In Nigeria today, flooding seems to be ubiquitous among the natural disasters being experienced in the country. This is because, it touches all regions and states in Nigeria.

Studies have also shown that disasters such as flooding could exacerbate environmental degradation leading to extensive loss of lives, particularly among vulnerable member of the community, economic losses hindering nations from achieving their developmental goals, destruction of the built and natural environment, an increase of vulnerability and widespread of disruption of local institution and livelihood disempowering of the local community [7,8].

In 2012, Nigeria recorded a nationwide flood disaster. The floods occurred due to excessive rainfall between May and October, 2012. This increased water supply from the Niger and the Benue and thereby causing an increase in river level along the Niger. In addition, 2012 flooding occurred due to the release of water from the reservoir behind the Lagio Dam in the Republic of Cameroon. The reservoir held 7.70km3 of water which was released to avoid the dam failure [9]. Also, in conformity with flow theory, the high water level in the brain channel of the Niger caused a damming of the outflow from the Anambra basin. It also caused a reflux and the subsequent damaging floods on the Anambra plains with water level rising up to 10 metres above the normal rainy season levels [10].

Moreover, before the incidence of the flooding, the Nigerian Meteorological Agency (NIMET) had predicted through its annual Seasonal Rainfall Prediction (SRP) that the seasonal rainfall for 2012 was expected to vary from 300-1100mm in the northern half of the country. In the South which the study area (Ogbaru, Anambra State) is part of, this will rapidly increase from 1200 – 2700mm, which may lead to high surface runoff and flash flooding [11]. This could be seen from Table 1 which shows the seasonal rainfall prediction in three MIMET stations in Anambra State. These cities lie within the study area.

Table 1. Extract of a Detailed Town -By-Town Results of Rainfall Onset, Cessation, and Length along with Total Seasonal Rainfall Expected in 2012 and their Margin of Errors

State	City	Longitude (Degrees)	Latitude (Degrees)	Onset date (Margin of error 1-6 Days)	Season end (Margin of error 1-9 Days)	Season Length Days (Margin of error 2-11 Days)	Season Rainfall mm (Margin of error 22-94 mm)
Anambra	Ihiala	6.30	5.30	11-Mar	8-Nov	250	2164
	Onitsha	6.78	6.15	8-Apr	9-Nov	215	1740
	Awka	7.07	6.20	23-Mar	11-Nov	235	1804

Source: [11].

Expectedly, effect of the flooding was devastating even beyond the imagination. To underpin this fact, the Nigeria's National Emergency Management Agency (NEMA) [9] reports that the 2012 flood disaster claimed 363 lives and displaced 2.3 million and affected 7 million people in different parts of the country with properties worth billions of naira destroyed. NEMA maintains that the level of water in the Kainji dam as a result of the flood was reported to be the highest in 29 years and the subsequent inundation along the River Niger is beyond imagination. Schramn and Dries [5] assert that flooding is number one natural disaster hazard that is becoming a greater threat than a constant or declining one.

Moreover, damage within each of these sectors can be divided into structural damage and content damage. Usually, damage to building contents results from collapsed structures (e.g. hurricane winds failing the building envelope and allowing rain to destroy the furniture inside the building). With regard to flooding, the damages on buildings contents can be direct and indirect [12] and often devastating; fast-flowing flood waters are capable of weakened structures; washing away entire buildings and communities; and could cause injury or even death [12,13].

Till date, flooding have continued to wreck most communities in Nigeria but none could be compare with 2012 flooding as 33 out of 36 states in Nigeria and Federal Capital Territory (FCT) Abuja were affected [9]. According to the report issued by NEMA, during the peak of the crisis more 597,476 houses/building were washed away by the flood nationwide [9,14]. The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) [14] state that Nigeria experienced the worst floods in the past 40 years in 2012.

Specifically in Anambra State, there was heavy rainfall between April, 2012 and October, 2012. Figure 1 shows the average monthly rainfall in Anambra State in 2012 as obtained from the station office of the Nigerian Meteorological Agency (NIMET) at Amawbia Awka Anambra State. It can be observed from Figure 1 that within this period of flooding (May – October), the average monthly rainfalls were very high with highest rainfall of 3635mm in August.

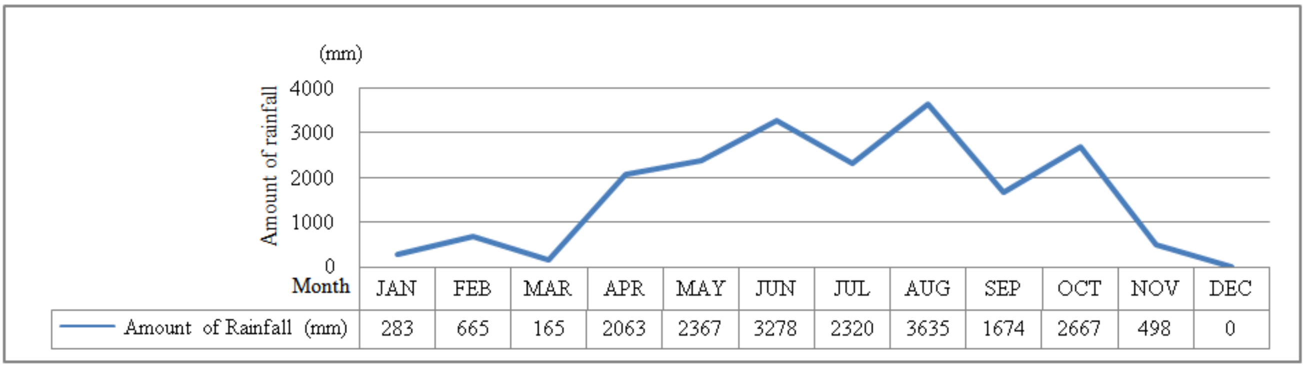

Figure 1. Average Monthly Rainfall Distribution in Anambra State in 2012 (Source: NIMET Station Office at Amawbia Awka Anambra State)

The raging 2012 national flood disaster submerged several communities in Anambra State. About 8 Local Government Areas were affected, including Ogbaru, Anyamelum, Anambra West Anambra East, Awka North, Onitsha North, Onitsha South and Ihiala LGAs, i.e. areas of the lower Niger River basin. The number of people displaced as a result of the flood ran into thousands with an estimated ten thousand (10,000) homes fully and partially submerged while lives were equally lost.

Anambra State Government (ANSG) [15] reports that at the peak of the crisis, a total of 125,000 people were internally displaced, numerous buildings and industries were fully or partially submerged for more than four (4) months, thus, putting the structural integrity of these buildings in jeopardy. In all these, it was reported Ogbaru Local Government Council of Anambra State was one of the council areas mostly hit by the disaster (Anambra State Emergency Management Agency ANSEMA) [16]. According to Ajaero and Mozie [10] about 96.70% of Ogbaru LGA was affected, 81.70% was very severely damaged and in about 36% the flood comes yearly and comes after a long spell of safety in about 64%.

Based on this, the study is aimed at examining the impacts of the 2012 flood disaster on the structural elements and fabrics of buildings at Ogbaru LGA of Anambra State with a view to recommending appropriate measures towards minimizing structural failure in new and reconstructed buildings in the area in case of future flood occurrence. According to Efobi and Anierobi [17] incidence of flooding can never be eliminated entirely, in practical terms, but the hazards or consequences of flooding can be properly mitigated by appropriate behaviours and actions.

1.1. Study Area

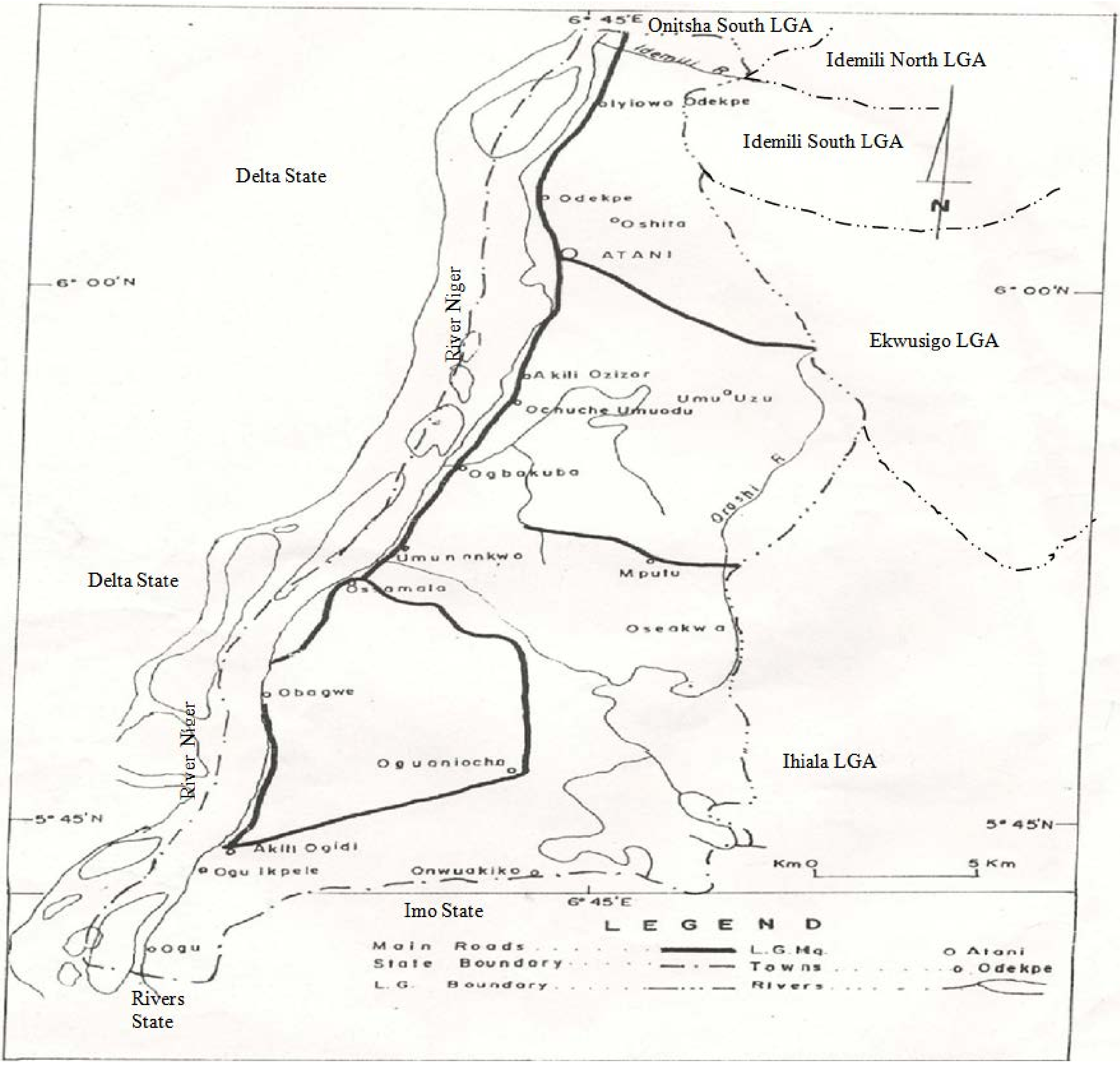

Figure 2. Map of Ogbaru Local Government Area Anambra State (Study Area)

Ogbaru Local Government Area of Anambra State is one of the 21 Local Government Areas that make up the State. It is located between latitudes 5° 42' N and 6° 08' N and longitudes 6° 42' E and 6° 50' E. The average climatic conditions are wet (from March to October) and dry (from November to February) seasons. The highest rainfall is recorded from June to September. The average annual rainfall ranges between 1800 mm and 2000 mm. The temperature pattern has mean daily and annual temperature as 30°C and 27°C respectively, while the average relative humidity ranges between 60-70% and 80-90% in January and July respectively [18,19].

The study area floods during the rainy season and dries up completely at dry seasons, though the flood remains for a number of times before receding. The plains suffered most of the floods on account of their relatively low and flat disposition with slope angles of 1º-3º [10]. Some of these communities are flooded for over 8 months of the year as a result of their low lying relief and location at the point where the River Niger seem to have one of its greatest discharge rates. The overflow of the river bank by the water from the river into the overlying plain is therefore an essential geographical feature of this location [20].

The relief is a plain land of heights ranging from 0 – 50m and characterized by swampy conditions as a result of its alluvial mud content. Its geology is mainly alluvium while the River Niger and Ulasi River which is its major tributary constitute the two major rivers in the area. However, there are local creeks and ponds all over its landscape. The vegetation is a mixture of fringing forests along the banks of the river Niger and guinea savannah in the hinterland [20].

The aquifers are quite shallow with average elevation of 25m above sea level. The climate lies within the tropical rainy climate zone {AF} in accordance within Koppens climate classification and under the influence of tropical continental (CT) and tropical maritime (MT) air masses with the convergence zone (ITCZ) shifting seasonally with pressure belts and isotherms.

According to the 2006 national census, the LGA has a population of 221,879 [21]. The area is surrounded by the River Niger in such a way that most of the communities are located at the bank of the River (see Figure 2). The towns that make up the Local Government include Atani, Akili-Ogidi, Akili-Ozizor, Amiyi, Mputu, Obaogwe, Ohita, Odekpe, Ogbakugba, Ochuche Umuodu, Ossomala, Ogwu-aniocha, Umunankwo, Umuzu, Okpoko, and OgwuIkpele with headquarters at Atani. To the north, the study area is bounded by Onitsha South Idemili LGAs in Anambra state, to the south it is bounded by Imo and Rivers States, to the east it is bounded by Ekwusogo and Ihiala LGAs in Anambra and to the west it is bounded by River Niger and Delta State.

2. Research Methodology

The population of this study constitutes the people, buildings and other facilities affected by the 2012 flooding in the study area. But in line with the objective of this study, the focus of this study was on the impacts of the flooding on building an d its components.

According to the National Census 2006, the population of Ogbaru LGA of Anambra State as at 2006 was 221,879 [21]. At the time of this study, the population of the area would have been grown more than the census figure in 2006. Therefore, using a population growth rate of 3.2% as recommended by National Population Commission, for Anambra State, the population of Ogbaru LGA in 2014 would be 278,680. Therefore, the population of this study is 278,680peoples.

Cochran's sample size calculation procedure was employed to determine the appropriate sample size in this study. To do this, Cochran's return sample size formula is first determined using the formula presented below [22]:

$$n_0 = \frac{\left(t^2\right) \text{x} \left(p\right)\left(q\right)}{\left(d^2\right)} \qquad (1)$$

Where t = value of selected alpha level usually 0.025 in each tail of a normal distribution obtained as 1.96 (the alpha level of 0.05 indicating that the risk the researcher is willing to take that the true margin of error exceed the acceptable margin of error is 5%).

(p)(q)= this is the estimate of variance given as 0.5

d= acceptable margin of error for proportion being estimated given as 0.05 (this is the error level the researcher is willing to expect)

Hence after calculating the Cochran's return sample size $\boldsymbol{n_o}$ (see Equation 1) we shall employ the Cochran's correction formula to obtain the appropriate or final sample size and the formula is given as;

$$n_1 = \frac{n_o}{\left(1 + n_o / _{\text{population}}\right)} \qquad (2)$$

However, to obtain the sample size using the procedure discussed, we shall calculate $\boldsymbol{n_o}$ first as given:

$$n_o = \frac{\left(1.96^2\right) \text{x} \left(0.5\right)\left(0.5\right)}{\left(0.05^2\right)} = 384$$

Thus, the Cochran's correction for population of 278,680 was given as:

$$n_1 = \frac{384}{(1 + 384/_{278680})} = 383$$

However, multi-stage sampling technique was employed in choosing the population frame. In this case, samples are selected in stages (i.e. selecting the towns to be studied first and then the households). First, 10 out of the sixteen towns that make up the council area were purposefully selected based on their proximity and ease of access. 38 households were selected through the same process from each of the 10 selected towns with 3 towns having additional 1 each. Due to the nature and terrain of the study area, it was very difficult to access the entire communities. As can be seen from the map (Figure 1), accessing some these communities at the time of the survey was very difficult. This is one of the challenges and limitations of this study. Meanwhile, multi-stage sampling is particularly useful with clusters that are homogeneous with respect to the target variable.

Data were collected through structured questionnaire administered to the heads of the selected households or their representatives. This is in addition to physical observation of the buildings in the selected households, and some photographs were taken to substantiate the validity of the result of this study. Accordingly, a total of 383questionnaires administered to the selected respondents within the chosen households and only about 241 were completed, returned and found useful. This corresponds to response rate of 62.92%. Being a descriptive research, tables, line -chart and histogram were used for data presentation.

3. Results and Discussions

3.1. Results

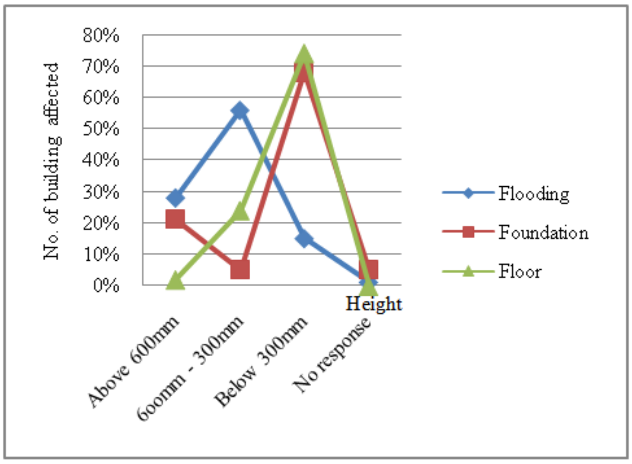

Figure 3. Height of Flooding and Depth of Foundation

From Figure 3, about 68% of the buildings have foundations depths of 300mm or less (see also plate 1). Likewise, more than 74% of the buildings have ground floor level height of 300mm or less. Figure 1 also showed that during the 2012 flooding, about 56 % of the buildings showed flood depth mark of between 300-600mm, 28% showed flood depth mark of more 600mm. It further revealed that this depth increased significantly during the flooding and got to a depth of more than 1m. With the water rising above the floor level and coming into contact with internal finishes, it left most of the fittings and fabrics damaged.

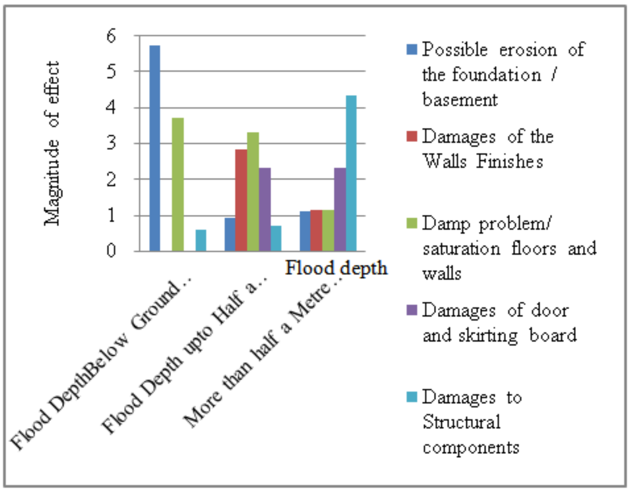

Figure 4. Effects on Structural Components and finishes

Figure 4 revealed that when flood level was below the ground level, erosion of the foundation/basement was pronounced. When the flood came up to haft a metre above the ground floor level, walls finishes, Damp problems/saturation of floor and walls, and damage of door and skirting became common. But when the flood depth was more than haft a metre above the ground floor level, damages to structural components of buildings ensued.

Figure 5 revealed that at when flood level was below ground level, basement fittings were more vulnerable. When the flood came up to haft a metre above the ground floor level, damages of downstairs electricity, floor covering and kitchen were common. But when the flood depth was more than haft a metre above the ground floor level, damage of higher units/electrical services and appliances were severely affected.

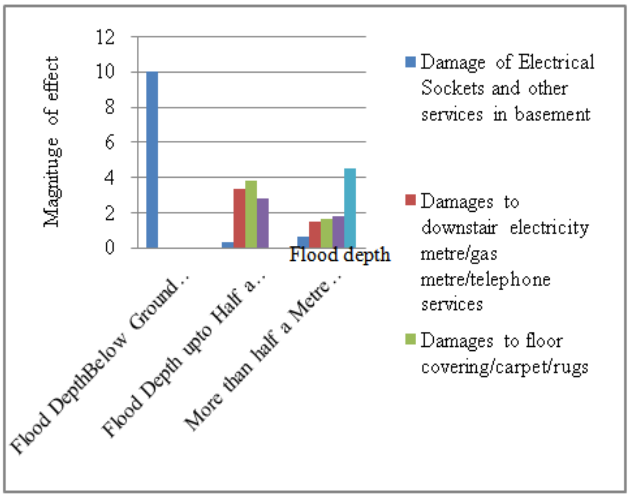

Figure 5. Effects on building Services and Fittings

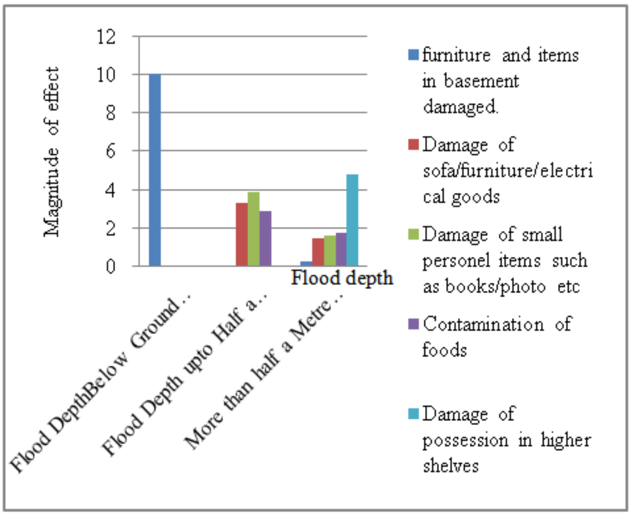

Figure 6. Effects on furniture and items in the buildings

Figure 6 revealed that at when flood level was below ground level, personnel possession and furniture at basement were severely affected. When the flood came up to haft a metre above the ground floor level, damages of downstairs sofa, books and contamination of foods were more common. But when the flood depth was more than half a metre above the ground floor level, damage of possession at higher selves were severely affected.

From Table 2, 59% of the respondents indicated that the foundation and plinth of their buildings were negligibly and slightly damaged, 25% showed that theirs were moderately damaged, 12% pointed out that theirs were substantially and heavily damaged while only 4% showed that theirs were very heavily damaged. It was also observed that 66% of the walls, columns and beams of the buildings were negligibly and slightly damaged, 23% were moderately damaged, 9% were substantially and heavily damaged, while only 2% were very heavily damaged.

Table 2. General Assessment on Building Components

Building Component	Negligible to slight damage	Moderate damage	Substantial / heavy damage	Very heavy damage	Total (%)
Foundation and Plinth	59%	25%	12%	4%	100
Wall, Columns and Beams	66%	23%	9%	2%	100
Floors	63%	28%	7%	2%	100
Doors and Windows	13%	54%	21%	12%	
Roof	89%	11%	0	0	100
Finishes	15%	44%	32%	9%	100

Likewise, 63% of the respondents disclosed that the floors of their buildings were negligibly and slightly damaged, 28% indicated that theirs were moderately damaged, 7% showed that theirs were substantially and heavily damaged and 2% indicated that theirs were very heavily damaged. 13% of the respondents revealed that the doors and windows of their buildings were negligibly and slightly damaged, 54% indicated that theirs were moderately damaged, 21% showed that theirs were substantially and heavily damaged and 12% indicated that theirs were very heavily damaged.

Furthermore, 89% of the respondents indicated that the roofs of their buildings were negligibly and slightly damaged, while 11% showed that theirs were moderately damaged. For the finishes, especially the wall and floor finishes, 15% of the respondents indicated that the finishes of their buildings were negligibly and slightly damaged, 44% showed that theirs were moderately damaged, 32% pointed out that theirs were substantially and heavily damaged while 9% showed that theirs were very heavily damaged during the flood disaster.

Generally, it was observed that there were not much structural damages on buildings that were either fully or partially submerged by the flood in 2012 in the study area except for those buildings that were old and weak, under construction and built with red mud.

3.2. Discussions

From the physical observations of the buildings under study, it was observed that most buildings had columns and beams but were lying on a very shallow foundation, with low ground floor level. No building was built with plinth (see plates1 - 3).

The study confirmed that the entire study area was prone to flooding even before 2012 flooding. The usual depth of flooding was between 300mm – 600mm and takes weeks/months for it to subside. Also, the study observed that heights of the ground floor of the buildings above the natural ground level were mostly 300mm or less. Very few buildings have high elevated ground floor level and not even a single building studied was built with plinth.

The study also observed that the impact of the 2012 flooding was so enormous that the entire buildings and roads within the study area were either fully or partially submerged. As a result of this, buildings within the study area sustain different kinds and degrees of damages.

At Flood depth below ground floor level, for instance, damages sustained were mainly foundation and basement including fittings and personal possession in basement but at Flood depth up-to half a metre above the ground floor level, walls finishes, door and skirting and dampness were more significant. However, structural damage and damages of electrical fittings and furniture at upper parts of building were observed at a flood depth more than half a metre above the ground floor level.

Consequently, greater percentages of the buildings with very heavy structural damages were building that were not properly reinforced (buildings lacking columns and beams), buildings with very shallow foundation, low ground floor level, mud houses, old and weak buildings and buildings under construction.

Plate 1. Building on low ground floor level and shallow foundation with arrows showing the depth of 2012 flooding

Plate 2. Building without columns and beam

Plate 3. Mud house

4. Conclusion

The structural components and fabrics of buildings in the flood ravaged areas may likely suffer some damages if the flood persists for a long period of time. Therefore, the 2012 national flood disaster in Nigeria which devastated the entire nation and lasted for months may not have gone without leaving scars on the integrity of building structure in the affected areas.

Ogbaru Local Government Council of Anambra State was one of the local government councils in Nigeria that was grievously hit by the disaster. Based on this, the need to assess the effect of the disaster on the structural components and fabrics of buildings affected by the flood in the Local Government Council became imperative and this study has critically examined that.

The study had revealed that there were more damages on the fabrics and fittings of the affected buildings such as floor and wall finishes and doors and windows than on their structural components such as foundation, wall, beams and columns, roof and floors. This was due to the inflow of floods into the buildings as a result of the rising level of flood above the ground floor level of the buildings which were mainly very low.

It was also revealed that majority of the buildings which suffered structural damages were very old and weak buildings, mud houses, buildings with shallow foundations and buildings under construction. Though it was confirmed that the study area is flood prone which usually occur on yearly basis, most building in the area were with low ground floor level and none were constructed with plinth which may have aided in elevating the buildings above the perennial flood level.

As residents and households are battling to erect new building structures, reconstruct and refurbish the damaged ones through individual efforts and various government interventions, there is need to seek alternative methods of building construction in the study area. This study has therefore provided a platform for making more enquiries into new method of building construction in flood prone areas like Ogbaru LGA of Anambra State. The result would guild the residents, prospective house owners, government agencies, international aids agencies and professionals in building industry in choosing the appropriate building techniques and materials for the areas.

Moreover, the study has added to the growing body of knowledge since most studies on the 2012 flood disaster in Nigeria were focused on the environmental, economic, social and urban planning effects.

To this end and based on the outcome of this study, professional, residents and prospective house owners who wish to erect new buildings should raise the ground floor level of the buildings to at least above 1 metre, the foundation depths of the buildings in the area should also be made at least 1 metre or the buildings should be suspended on plinths to allow the easy flow of flood water as the case may be.

More so, water-resistant building components and materials should be used especially for the finishes and wood which deteriorate easily when a building is under water. Buildings in the area should also be built with oversite concrete as floors so as to minimise the rate of rising damps. These are in addition to the adherence to the early warning signs from the Nigerian Meteorological Agency (NiMET) and other relevant agencies.

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