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The Physiognomy of Flooding and Flood Disasters in Nigeria: Stakeholders' Perception of Flooding Events of Ogbaru in Anambra State

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Authors' contributions

This work was carried out in collaboration between all authors. Author FOE initiated the idea, designed, carried out literature search and compiled the first draft of the manuscript. Author KCO was responsible for supervising every stage of the research, and proof reading while authors AIA carried out the data acquisition and analysis. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Aim: This study evaluates and establishes the nature and characteristics of flooding and flood disaster in Ogbaru.

Study Design: It was a survey research, where questionnaires were distributed to heads of the selected households and building practitioners in the study area. Likewise, physical observations were carried out to substantiate the findings of the questionnaire survey.

Place and Duration of the Study: The study was conducted in Ogbaru Local Government Area, Anambra State, Nigeria for a period of 2 years.

Methodology: Data were collected through structured questionnaire administered to the selected

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building construction practitioners and occupants in Ogbaru. In addition, interviews and direct observation survey were conducted to substantiate the validity of the questionnaire. Accordingly, a total of three hundred and eighty-four (384) questionnaires were distributed and a total of two hundred and ninety-three (293) questionnaires were completed and returned. This corresponds to a response rate of 76.3%. Data collected were analyzed using mean score, standard deviation and t-test.

Results: The survey found that flooding is a regular phenomenon for the last five years in Ogbaru with a depth ranging from medium to shallow and not more than 1.8 m deep. The velocity of flow is either laminar or moderate but not up to 3m/s in nature while the intensity of flow & destruction significantly varies across the local government area. The flood disaster lasts for more than a month in most areas and moves with floating debris lowering the ground surface and removing refilled earth of the foundation of buildings. Over 90% of the residents of Ogbaru had experienced flood hazards which have affected their houses and those of their neighborhood.

Conclusion: The study concluded by recommending that the nature and characteristics of flooding in the study area should be thoroughly examined and considered before any construction/ mitigation action will be deployed in Ogbaru.

Keywords: Flood; flood characteristics; flood disaster; Ogbaru; Anambra State.

1. INTRODUCTION

Flood is a water induced disaster that leads to a temporary overflow of water into an area that is normally dry thereby causing inundation and harm to plants and animals, including man [1-4]. Accordingly, [5], [6] suggested that flooding is an extreme hydrological event, where there is excess of water as a result of temporary rise in level of stream, river, lake or sea which may have devastating effect on the immediate environment. It therefore constitutes a risk factor to human beings and their immediate environment [5]. Generally, flooding is the most common of all environmental hazards and regularly claims over 20,000 lives per year and adversely affects around 75 million people world-wide [4]. In many parts of the world, according to [5], [7-11] flooding seems to be ubiquitous and becomes a disaster when it occurs in areas that is inhabited [3]. Due to recent changes in climate, the number of flood disasters recorded globally have increased tremendously over the past few decades, growing from no fewer than 100 events in 1975 to more than 400 in 2005 [12]. This figure has even doubled in recent times. Flood alone according to [13,14], account for about 40 -50% of water related disasters globally. Likewise, it accounts for 26% of total disaster occurrences in Africa between 1971 and 2001 [14].

In Nigeria, at least 20 percent of the population is at risk from one form of flooding to another [15, 16]. Hence, flood has gradually become a regular phenomenon in most communities in Nigeria, particularly, in riverine areas. Each rainy season in most Nigerian communities comes with its own flood events, ordeals and traumas. However, the most prominent devasting among recurrent flood events are the 2012 floods which destroyed over 500,000 buildings and other properties in Nigeria [8,10,11,17-19].

Since 2012, extreme flood event haves been regular phenomenon within riparian communities of Ogbaru, Anambra East, Anambra West and Ayamelum local council area of Anambra state. Records of flooding in Anambra state indicate that the intensity of flood events in these areas are similar but the extent of the destruction in terms of infrastructural, agricultural and socio-cultural activities differs [11]. This situation has caused widespread devastation and destruction of properties worth billions of naira. Subsequently, flood disaster in Ogbaru have continued to wreak havoc every rainy season though many of these incidences were unreported. Given the above scenario, the 2012 flood and subsequent flooding in Ogbaru have continually reinforced the need for urgent actions. These actions require a detailed data on the nature/characteristics of floods in Ogbaru which is currently insufficient. This research therefore attempts to evaluate and establish the nature and characteristics of flooding and flood disaster in Ogbaru local administrative area as a means of addressing this need.

2. LITERATURE REVIEW

2.1 Physical characteristics of flooding

Critical physical characteristics of flooding are:

2.1.1 Flood depth

The most noticeable characteristic of any flood is water depth. The depth of flooding is generally influenced by storm strength, tidal cycle, storm duration, land elevation, and the presence of waves. Flood depth is a crucial factor in building design and construction because the flood forces acting upon the building elements are directly related to depth [20]. Generally, flood depth is measured from the floodwater surface to the adjacent ground level, while flood elevation is measured against an established standard datum [21]. The depth of flooding affecting a structure can be calculated by determining the height of the flood above the ground elevation at the building site [21]. Floodwater can impose hydrostatic forces on buildings; Hydrostatic forces increase linearly as the depth of water increases [21]. Flood depths greater than 1 meter above floor level are likely to result in structural damages of buildings [22]. If the building is well-built and flooding depths is less than 900mm, it is possible that unequaled hydrostatic forces may not cause significant damages [21]. Flood depth and its impacts on building elements are given in Table 1.

2.1.2 Flood Duration

Duration is related to rates of rise and fall. The longer the duration of flooding, the more extensive the damage will be [22]. Consequently, [21,23] observed that long periods of inundation cause greater damage to building fabric and lead to structural problems. In terms of the costs of damage, a limit of 12 hours can be used to differentiate between short and long floods [24]. For long duration of flooding, a strategy to keep water (i.e. dry flood-proofing) out at the building level may not be a viable option because, chance of seepage and failure are caused by prolonged exposure to floodwater [21,23]. Conversely, mitigation measures may only delay the time before water enters a building to enable ground floor contents to be moved [23]. For building design, duration is important because it affects access, building usability, saturation and stability of soils, and selection of building materials [20]. Table 2 shows different flood duration along with potential sources

2.1.3 Velocity

Velocity refers to the speed of the mass movement of floodwater across an area [21]. This speed is normally expressed in terms of feet/meter per second (ft/sec or m/sec). Flood velocity ranges from extremely high (i.e. 10 feet or 3m) per second or more) to very low or nearly stagnant [20]. Floodwater velocity depends primarily on the slope and roughness of the ground surface [21]. As velocity of the flooding increases, hydrodynamic forces imposed by moving water are added to the hydrostatic forces from the depth of still water, hence increasing the chances of structural failure [21]. Velocity is important in site planning considering erosion and other related events. In structural design, velocity is a factor in determining the

Table 1. Flood depth and its impacts on building elements

Depth of floodwater	Damage to the building elements
Below ground floor level	▪ Minimal damage to the main building. ▪ Floodwater may enter basements, cellars and voids under floors. ▪ Possible erosion beneath foundations.
Up to half a metre above ground floor level.	▪ Damages internal finishes, such as wall coverings and plaster linings. Therefore, wall coverings and linings may need to be stripped to allow walls to dry. ▪ Floors and walls will become saturated and will require cleaning and drying out. ▪ Damp problems may result. ▪ Chipboard flooring likely to be replacement. ▪ Damage to internal and external doors and skirting boards.
More than half a metre above ground floor level.	▪ Possible structural damage/failure/collapse

Source: ODPM, (2013)

Table 2. Different flood duration along with potential sources

Flood duration	Potential sources
Hours	Infrastructural failure Overland
Days	Rivers & water courses Sea Drainage systems
Months	Ground water

Source: Tezak, Low, Reeder (2009)

hydrodynamic (i.e., moving water) loads and impact loads (which is the force of moving water or the force of flood-borne debris hitting a building) [20]. High-velocity floods can sweep people away before emergency services are able to reach them [25].

Moreover, velocity is a major factor in aggravating structural and content damages in buildings. Generally, the higher the flow velocity of floodwater, the greater the probability (and extent) of structural damages [26]. Thus, [26] suggested high velocities create greater danger of foundation collapse and forceful destruction of building contents. Equally, [27] state that a velocity of 3 m/s acting over a 1m depth will produce a force sufficient to exceed the design capacity of a typical residential building.

2.1.4 Wave action

Waves contribute to erosion, scour and loads exerted on buildings. Hence, it must be considered in site planning along coastal shorelines [20]. Waves on top of storm surges may be as much as 50 percent higher than the depth of the surge. The height of waves varies with flood zone: V zone (i.e. the zone closest to the water, subject to "coastal high hazard flooding) wave heights can exceed 900mm, while Coastal A zone (i.e. coastal flood hazard areas within medium flood risk areas) wave heights are between 0.45m and 0.9m [28].

2.1.5 Impacts from debris

Debris imposed load on building in form of floating objects by moving water. Floating debris contributes to the loads that must be considered in the structural design. These loads are influenced when the building is located in the potential debris stream [29]. Debris impact can destroy most flood measures as well as the structure itself [21]. Also, it's capable of destroying unreinforced masonry walls, light wood frame construction, and small-diameter posts and piles (and the components of structures they support) [28]. Based on this, recent building codes require that building foundations be designed such that it resists the impact of flood-borne debris [20]. Factors that affect debris impact load include size, shape, and weight of the waterborne object; flood velocity; velocity of the waterborne object compared to the flood velocity; duration of the impact; portion of the building to be struck; depth of flooding; and blockage upstream of structure.

2.1.6 Erosion and scour

Erosion refers either to the lowering of the ground surface as a result of a flood event or the gradual recession of a shoreline as a result of long-term coastal processes. Scour on the other hand, refers to a localized lowering of the ground surface due to the interaction of currents and/or waves with structural elements (such as pilings). Scour occurs around the object itself, such as a pile or foundation element, and contributes to the loss of support provided by the soil [28]. Soil characteristics influence an area's susceptibility to scour. Hence, erosion and scour may affect foundation stability and the maintaining of filled areas by removing all support from beneath a foundation, resulting in possible structural damage or building collapse [20]. Therefore, determination of the potential scour is critical in design of coastal foundations to ensure that failure does not occur as a result of loss in either bearing capacity or anchoring resistance of the building foundation [29].

3. METHODOLOGY

The sample population used for this study constitutes local/residents, construction professionals, disaster management agencies and building development control units (Anambra State Physical Planning Board -ANSPPB) in the study area. According to the 2006 National population and housing census, the population of persons in Ogbaru LGA of Anambra State was 223,317while the number of households in the area were 49,501 [30]. Using a population growth rate of 2.83% as recommended by National Population Commission for Anambra State [30], the population of Ogbaru LGA in 2017 was 303, 559.

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 was first determined using the formula presented in the equation below [31].

$$n_o = \frac{(t^2) \times (p)(q)}{(d^2)} \quad (1)$$

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) (0.5) = 0.25
- d= acceptable margin of error for proportion being estimated given as 0.05 (this is the error level the researcher is willing to expect).

Thus, after calculating the Cochran's return sample size number (see Equation 1), the study employed the Cochran's correction formula to obtain the appropriate or final sample size and the formula is stated as given in equation (2):

$$\frac{N_o}{N_1 = (1 + n_o/\text{Population})} \quad (2)$$

However, to obtain the sample size using the procedure discussed, equations 1 and 2 were applied. Applying both equations resulted in sample size of 384 as presented equation in 3 and 4 respectively

$$n_o = \frac{(1.96^2) \times (0.5)(0.5)}{(0.05^2)} = 384 \quad (3)$$

Fromequation 3: N_O = 384, Population = 303,559

$$N_1 = \frac{384}{1 + 384/\ (303{,}559} \quad (4)$$

Thus, the sample size for this study is 384. In choosing the population frame of the respondents, purposeful sampling technique was employed. 10 town (i.e. Atani, Akili-Ozizor, Mputu, Ohita, Odekpe, Ogbakugba, Ossomala, Ogwu-aniocha, Umunankwo and Okpoko) out of the sixteen towns that make up the council area were purposefully selected because other towns could not be easily accessible as at the time of carrying out the field survey; and must have been flooded in the past five years. 30 households and 8 professionals were randomly selected from each of the 10 selected towns while Atani, Umunnankwo, Akili-ozizor and Okpoko got additional 1 each. Meanwhile, 38 copies of questionnaires were administered to the head of each household or their representative and construction practitioners in each of the selected town, on issues regarding the nature and characteristics of flooding in the area.

Data were collected using structured questionnaires administered to the selected building construction practitioners and occupants in Ogbaru. In addition, few interviews and direct observation were conducted to substantiate validity of result of this study. In total, three hundred and eighty-four (384) questionnaires were distributed to the building occupants and practitioners in Ogbaru. Out of this total, two hundred and ninety-three (293) questionnaires were completed and returned. This corresponds to a response rate of 76.3% (See Table 3). Data collected were analyse using mean score, standard deviation and t-test.

Table 3. Population distribution of questionnaire and percentage response

Categories	Number of questionnaires distributed	Number of questionnaires received	Percentage (%)
Professionals	256	185	72.3
Households	128	108	84.4
Total	384	293	76.3

Source: Field Survey (2017)

4. RESULTS AND DISCUSSION

This section presents the results, analysis, discussions and findings of the data collected. Table 4 discussed personal flood experience among respondents while Table 5 discussed flood characteristics of the study area.

The likert scale result in Table 4, presents the extent of personal flood experiences among respondents in the study area. Result indicated, a total of 180 representing 97.3% of total respondents agreed that they had experienced flooding hazards over the last five decades; none disagreed while 5 respondents representing 2.7% could neither agree nor disagree to such experience

In response to the cause of the flood, 180 respondents representing 97.3% agreed that the flood was as a result of heavy rainfall while 5(2.7%) stood without taking a decision; a total of 165(89.2%) asserted the cause of floods to emanate from rising damp/soil saturation. 12 respondents representing 6.5%disagreed whilst 8 respondents representing (4.3%) could not take either side. In the same vein, a total of 75 respondents (40.5%) said flood occurred as a result of dam spillage.

Responding to the adverse impacts of flooding in the study area, 180 respondents representing 97.3% agreed to have been affected by more than one flood event over the last five years. They further opined that their houses were damaged due to flooding. The remaining 5 respondent representing 2.7% could not decide. In the same vein, a total of 177 respondents, representing 95.7% asserted that their entire neighborhood was flooded while the remaining 8(4.3%) could not assert to this experience.

Generally, the respondents agreed (with a cluster mean value of 4.49 > 3.00(likert average) and a cluster standard deviation of 0.652 < 1.581(likert standard deviation) that they have experienced flood hazard for the past five (5) years which has affected their houses and those of their neighborhood.

The table (Table 5), depicts characteristics of floods in Ogbaru. Flood characteristics were categorized into depth, velocity/flow rate, duration, debris, and erosion and scour (with cluster mean value of 3.35 and standard deviation of 1.160). Particularly, the households agreed that depth of flood in the area for the past five years (with strata mean values of 3.37 and 4.14 > 3.00 respectively) are shallow (less than 0.9m/3feet) or medium (0.9m to 1.8m or 3feet to 6feet).The professionals were of the view that depth of flood in the area over the past five years (with strata mean value of 3.55 > 3.00) were shallow (less than 0.9m/3feet).

On the velocity/flow rate of flood in the area, the households agreed that floods velocity in the area are either slow or moderate normally but often fast whenever it rains. While the professionals were specific that the flow rate of flood in the area is moderate. More so, the households agreed that floods in the area often last for about a week or more than a month but the professionals specifically said that flood in Ogbaru lasts for more than a month. The two parties agreed that flood water moves with floating debris lowering the ground surface and removing refilled earth of the foundation.

Comparing the results of the two groups, the researcher employed independent sample t-test presented in Table 6.

The t-test result (with t-stat. = 1.171; p-value = 0.258>0.05) indicates that there is no significance difference in opinions of the two groups (professional and households) which approves a cluster evaluation of the results (see Table 6). Therefore, the flood in Ogbaru local government area in Anambra State is characterized by the following:

i. Depth: The depth of flooding in Ogbaru ranges from medium to shallow. This in essence means that the flood depth is not more than 1.8m (see plate 1,2 & 3)
ii. Velocity/flow rate: The speed of flow of the flood in the study area is moderate. Comparing this finding to observations made by [20] “flood velocity ranges from extremely high (i.e. 10 ft/s or 3m/s or more) to very low or nearly stagnant.” This means that velocity of flow in Ogbaru is less than 3m/s.
iii. Duration: The flood disaster lasted for more than a month in most area of Ogbaru in of form of riverine flooding this is due to the increase in volume of water in River Niger and the overflow of water from River Niger onto the adjacent floodplain of Ogbaru.
iv. Debris and erosion and scour: flood water moves with floating debris lowering the ground surface and removing refilled earth of the foundation (See Plates 4 & 5)

Table 4: Personal flood experience among respondents

Personal flood experience	SA (%)	A (%)	U (%)	D (%)	SD (%)	Mean	Std.
You have experienced flood hazard in the last 5 years	140(75.7%)	40(21.6%)	5(2.7%)	0(0.0%)	0(0.0%)	4.73	0.503
The flood was as a result of:							
i. Heavy rainfall	135(73.0%)	45(24.3%)	5(2.7%)	0(0.0%)	0(0.0%)	4.70	0.514
ii. Rising damp/soil saturation	125(67.6%)	40(21.6%)	8(4.3%)	8(4.3%)	4(2.2%)	4.48	0.927
iii. Release from dam	25(13.5%)	50(27.0)	40(21.6%)	40(21.6%)	30(16.2%)	3.00	1.298
You have been affected by more than one flood event in the past 5 year	160(86.5%)	20(10.8%)	5(2.7%)	0(0.0%)	0(0.0%)	4.84	0.437
Your house/personal effects were damaged due to flooding	161(87.0%)	19(10.3%)	5(2.7%)	0(0.0%)	0(0.0%)	4.84	0.434
The entire neighbourhood was flooded	169(91.4%)	8(4.3%)	8(4.3%)	0(0.0%)	0(0.0%)	4.87	0.448
Cluster mean and Std. deviation						**4.49**	**0.652**

Source: Field Survey (2018)

Table 5. Flood characteristics of ogbaru

Flood characteristics	Households		Professionals		$\overline{\overline{X}}$	$\overline{Std}$
	Mean	Std	Mean	Std		
Depth						
Shallow (Less than 0.9m/3feet)	3.37	1.576	3.55	1.080	3.46	1.328
Medium (between 0.9m-1.8m/3ft-6ft)	4.14	1.192	2.94	1.066	3.54	1.129
Deep (Above 1.8m/6ft)	1.86	1.138	2.56	1.403	2.21	1.271
Velocity/Flow rate						
Laminar (Slow)	3.10	1.381	3.56	1.285	3.33	1.333
Moderate	3.81	1.270	3.20	0.758	3.51	1.014
Turbulent (Fast)	4.03	1.197	2.62	1.213	3.33	1.205
Duration						
Less than one hour after rain	2.29	1.180	2.69	1.027	2.49	1.104
A day	2.43	1.370	2.80	1.066	2.62	1.218
Not more than one week	3.06	1.309	2.98	1.311	3.02	1.310
More than a month	4.75	0.433	3.60	1.367	4.18	0.900
Debris						
The flood water moves with floating debris	4.78	0.675	3.83	1.457	4.31	1.066
Erosion & Scour						
There is lowering of ground surface due to the interaction between current/wave with structural elements	4.26	0.806	3.56	1.113	3.91	0.960
Removal of refilled earth of the foundation	3.86	1.199	3.51	1.286	3.69	1.243
Cluster Mean & Std. deviation	**3.52**	**1.133**	**3.18**	**1.187**	**3.35**	**1.160**

Source: Field Survey (2018)

Table 6. Independent sampling T-Test value

		Independent Sampling T-Test								
		Levene's Test for Equality of Variances		T-Test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Mean ratings	Equal variances assumed	7.518	.011	1.171	24	.253	.33385	.28502	-.25441	.92210
	Equal variances not assumed			1.171	17.106	.258	.33385	.28502	-.26722	.93491

Source: Field Survey (2018)

Plate 1. Flood mark on wall depicting the maximum flood depth in Ogbaru

Plate 2. Flood mark on wall depicting the maximum flood depth in Ogbaru

Plate 3. Flood mark on wall depicting the maximum flood depth in Ogbaru

Plate 4. Removal of the refilled earth of the foundation by flood in Ogbaru

Plate 5. Exposure of the Foundation

5. CONCLUSIONS

Flooding is a regular phenomenon in Ogbaru, lasting for more than a month with a depth not more than 1.8m otherwise termed as either medium to shallow. The flood moves with floating debris lowering the ground surface and removing refilled earth of the foundation with the speed of flow either being laminar or moderate but not more than 3m/s depending on the location. Almost all residents in Ogbaru had experienced flooding event affecting several livelihoods and personal properties. The intensity of floods significantly varies across the local government area. This is due individual communities 'proximity to River Niger bank coupled with soil conditions and rainfall patterns. Consequently, the nature and characteristics of flooding highlighted in this study should be thoroughly examined and considered as mitigation measures before undertaken any project regardless of its nature and magnitude in the study area. Existing buildings should be made flood resilient considering the nature and characteristics of flood established in this study. Furthermore, government should intensify efforts towards flood predications, early warning systems and sensitization to help minimize the extent of flood damages. Flood walls and other structural flood resilient measures should be built along the River Niger bank or incorporated into the existing building respectively considering the flood characteristics established in this study to help protect the existing communities against flood disaster.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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