KIU Journal of Social Sciences Copyright©2022
Kampala International University ISSN: *2413-9580*; 8(4): 87–98

Variability in Flood Sensitivity: A Household-Based Perception Study in Lagos Metropolis, Nigeria

OLUWAFEMI MICHAEL ODUNSI, OLANREWAJU TIMOTHY DADA,
TEMITOPE MUYIWA ADEBARA, SURAJUDEEN OLUSEYI MOMODU
Olabisi Onabanjo University, Ago-Iwoye, Nigeria

MARGARET EMEM OGUNBIYI
Bells University of Technology, Ota, Ogun States, Nigeria

Abstract. Climate change has severe impact and one of such is incessant flooding with complex and far-reaching consequences on humans, the natural and built environment. While different flood types and impact are evident in many countries, little is known about the impact of each flood type on households. Based on this gap, this study seeks to understand the variation in flood sensitivity at household level in Lagos metropolis, Nigeria. This evolved a question of whether statistically significant variations exist in pluvial, fluvial and coastal flood sensitivity in Lagos Metropolis, Nigeria by delineating spatial zones based on different flood types. Stratified random and systematic sampling techniques are used for data collection through questionnaire survey from 512 selected households. The data collected were analysed using Analysis of Variance (ANOVA) with the Levene Statistic serving as a pre-test of homogeneity of variance and the Tukey HSD of multiple comparison as a post hoc test. Findings showed that the sensitivity to flood was higher in males than females and the low income earners in all the flood zones. Observing similar flood exposure, the aggregate results indicate no statistically significant difference in flood sensitivity across the zones as the p-values are greater than the significant level of 0.05. It is concluded that households that have experienced surface, river and surge flood expressed similar perception of impact to these flood types in Lagos metropolis.

Keywords: Disaster Management, Climate Change, Coastal Flood, Urbanisation Impact, Environmental Hazard and Risk

1. Introduction

Flood is one of the challenges of climate change and has been the subject of investigation in different climes. In the literature (Lankao & Tribbia, 2009; Cardona et al., 2012; Tauzer et al., 2019; Zischg & Bermúdez, 2020), consideration has been given to exposure and sensitivity metrics in the assessment of flood impact. Generally, exposure is defined as "the nature and degree to which a system is exposed to significant climatic variations" while sensitivity is "the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli (IPCC, 2001, p. 995). Adapting these definitions, exposure defines the contact between flood hazard and social-ecological systems. It is assessed through the inventory of available human population and economic assets in locations where the flood events are possible. On the other hand, sensitivity describes the level of harms posed by flood events as experienced by the exposed human population and assets. Thus, while people living in flood risks zones are exposed, their sensitivity differs by the degree of flood impact experienced. Whereas, it is this sensitivity that determines the level and severe of flood impact.

Worldwide, flood impact has complex and far-reaching consequences on humans, the natural and built environment (WHO, 2002; Hajat *et al.*, 2005; Olajuyigbe *et al*., 2012; Dutta & Herath, 2014; Liu & Xia, 2016; Leis & Kienberger, 2020; Dube et al., 2021; Ishiwatari & Sasaki, 2021; Lucas, 2021; Ritter et al., 2021). The immediate consequences include drowning, physical injuries, death, loss of economic goods and property as well as damages to infrastructure. Beyond the immediate are emotional and psychological problems such as anxiety, depression and mental disorders; and communicable diseases such as malaria, typhoid and cholera in which some eventually lead to death. The extent of flood impact has been studied considering among different socioeconomic groups comprising gender, age, income and ethnicity. The impact of flood was highly observed among women, children and elderly, ethnic minorities, low income earners and physically-challenged.

Whilst flood events are evident in Nigeria, Lagos State has been the focal point of most studies (Olajuyigbe *et al*., 2012; Oyekale, 2013; Wahab et al., 2014; Nkwunonwo *et al.*, 2016; Oladele, 2018; Wahab & Ojolowo, 2018; Olanrewaju et al., 2019). The reason being that Lagos State which is a political, administrative and spatial entity in Southwestern Nigeria has been experiencing flood over the years due to natural and man-made causes (Nkwunonwo *et al.*, 2016). The natural cause is due to the geographical nature of the State as it is located on a low-lying land occupied by ocean, seas, lagoons, creeks and rivers. These water bodies and wetlands both account for 78 per cent of the entire land mass of the State (Lagos State Government, 2014). The man-made cause pertains to increasing urbanisation in the State. High population and resulting human activities have brought about significant impact as land use/land cover change, pollution and climate change with dysfunctional effects on the ecosystem (Wahab & Ojolowo, 2018; Olanrewaju et al., 2019). Evident are wetland losses in the State due to large built up areas and activities like sea dredging; land reclamation through filling up of swamps and floodplains; and destruction of mangroves and wetlands.

The joint effects of natural forces due to the presence of water bodies and urbanisation process make the State susceptible to surface, river and surge floods (Adelekan & Asiyanbi, 2016; Nkwunonwo *et al.*, 2016). These are otherwise known as pluvial, fluvial and coastal floods respectively (Maddox, 2014). The pluvial flood is caused when heavy rainfall submerges the dry land independent of an overflowing water body. Fluvial flood is associated with intense and excessive rainfall with long duration which causes the water body to exceed its capacity. Coastal flood is attributed to areas that lie on the coast of seas or oceans and it is caused by extreme tidal conditions resulting from sensitive weather. Pluvial flood occurs in upland areas of Lagos State due to heavy rainfall over a short time independent of overflows from any surrounding water bodies. As for river flood, it occurs in river plains due to the river overflowing its bank due increased in water volume because of intense rainfall or other water bodies flowing into it, among other factors. Coastal flood happens in coastal areas of the State as storm surges displaced ocean and sea water into surrounding areas.

Studies have similarly shown that different types of flood are peculiar to some LGAs in Lagos State to their geography. Each flood occurrence in different forms of impact in terms of death tolls, affected persons and property losses have been documented (Etuenovbe, 2011; Gelleh *et al.*, 2016; Nkwunonwo *et al.*, 2016; Adewara *et al.*, 2018). Nkwunonwo *et al.* (2016) presented a tabulated summary of flood events and impact from 1968 to 2012. Information from other sources also showed evidence. According to Akanni and Bilesanmi (2011), areas such as Ikoyi, Lekki and Victoria Island experienced coastal flood which was exacerbated by torrential rainfall in July 2011. Oyinloye *et al.* (2013) stated that in 2012, both coastal and fluvial flood occurred in Lagos State due to torrential rainfall which caused sea level rise in Atlantic Ocean, thereby causing the lagoons to rise and spread into flood risk areas of River Ogun. LGAs like Kosofe was affected due the release of water from Oyan dam as well as heavy rainfall, blockage of drainages and climatic factors. In 2017, areas in Lagos State that witnessed pluvial flood included mushin, Ogba, Agege and Ojoduwere while areas such as Lekki and Ajah witnessed coastal flood (Ayedun *et al*., 2018). While these different flood types are evident, little is known about their individual impact on households which depend on their exposure and sensitivity. Based on this gap, with evidence of similar exposure of households to flooding, this study seeks to understand the variation in the sensitivity to pluvial, fluvial and coastal floods in Lagos Metropolis, Nigeria.

2. Methods

This study was conducted in Lagos Metropolis that comprises sixteen local government areas (LGAs) out of the twenty LGAs in Lagos State (Fig. 1). Lagos Metropolis therefore forms the largest urban agglomeration in the State. This research is a cross-sectional study that commenced in April 2019 and ended in September of the same year. A stratified random sampling technique was employed in the selection of the LGAs where data were collected from households. The background knowledge is that all the 16 LGAs are affected by different types of flood during the raining season yearly and households are exposed to this hazard. Owing to the peculiarity of the objective of this study, the LGAs were at first stratified into homogenous zones based the dominant flood types. Two LGAs were selected from zones apiece using simple random sampling technique. These are Alimosho and Agege LGAs in the pluvial zone, Ikeja and Kosofe LGAs in the fluvial zone, and Apapa and Lagos Island in the coastal zone. Information from available studies (Wahab *et al.*, 2014; Wahab & Ojolowo, 2018) provided the number of existing streets, flood-risk streets and buildings in the Metropolis. Using the information, a total of 512 buildings were selected based on systematic sampling for household questionnaire survey (Table 1). One household from each building were administered the questionnaire, making up 512 respondents from whom the questionnaires were retrieved.

The questionnaire contained socioeconomic characteristics (gender, age, occupation and income) of respondents and three sensitivity scales that were developed using 5-point Likert scale (1 – Not Sensitive at All; 2 – Not Sensitive; 3 – Moderate; 4 – Sensitive; 5 – Very Sensitive). These are the *Human Health Scale (HUHS)*, *Personal Property Scale (PEPS)*, and *Public Property Scale (PUPS)*. The data collected were analysed using descriptive and inferential statistics using SPSS 26 (Statistical Product and Service Solutions). The cross tabulation makes up the descriptive statistics and Analysis of Variance (ANOVA) the inferential statistics. The Levene Statistic served as a pre-test of homogeneity of variance and the Tukey HSD of multiple comparison served as the post hoc test. ANOVA test is likewise referred to as the Fisher analysis of variance (F). It is the main inferential statistic in this study that is used for hypothesis testing and is based on the F-distribution. ANOVA in its true sense is used in comparing whether there is significant variation in treatment or group means. In using ANOVA test, parametric test assumption in which the data contained by the dependent variables must exist on either interval or ratio level of measurement and the independent variables contained data on nominal level of measurement must be met. The test therefore applies to two quantitative datasets whereby one is categorical or grouped and the other is continuous. The types comprise one-way or factor ANOVA, two-way or factor ANOVA or multiple ANOVA depending upon the type and arrangement of the data. As mathematically expressed in the following equations, the one-way ANOVA was employed in this study.

$$F = \frac{MST}{MSE} \quad \text{……………………. (i)}$$

Where,

F	=	ANOVA Coefficient
MST	=	Mean sum of squares due to treatment
MSE	=	Mean sum of squares due to error

MST is expressed as:

$$MST = \frac{SST}{K-1} \quad \text{……………………… (ii)}$$

$$SST = \sum n (x - \bar{x})^2 \quad \text{……………………… (iii)}$$

Where,

SST	=	Sum of squares due to treatment
K	=	Total number of groups
n	=	Total number of samples in a population.

MSE is expressed as:

$$MSE = \frac{SSE}{N-K} \quad \text{……………… (iv)}$$

$$SSE = \sum (n-1) S^2 \quad \text{………………. (v)}$$

Where,

SSE	=	Sum of squares due to error
S	=	Standard deviation of the samples
N	=	Total number of observations or populations

For the cross-tabulation analysis, flood sensitivity was an aggregate measure of all the variables in the three sensitivity scales and was also determined on the level of high and low sensitivity. The primary null hypothesis is that no statistically significant difference exists in flood sensitivity across the pluvial, fluvial and coastal zones in Lagos Metropolis. However, this was tested on the basis of the indices computed from the composite scoring of variables disaggregated based on each sensitivity scale. The computed indices are the *Human Health Index (HUHI)*, *Personal Property index (PEPI)*, and *Public Property index (PUPI)*. Three null hypotheses were then formulated as follows:

Ho1: There is no statistically significant difference in households' flood sensitivity to human health across the pluvial, fluvial and coastal zones in Lagos Metropolis.
Ho2: There is no statistically significant difference in households' flood sensitivity to personal property across the pluvial, fluvial and coastal zones in Lagos Metropolis.
Ho3: There is no statistically significant difference in households' flood sensitivity to public property across the pluvial, fluvial and coastal zones in Lagos Metropolis.

3. Results

The results in Table 2 provide very useful descriptive statistics about the mean scores, standard deviations, 95% confidence intervals and the ranges of the datasets (maximum-minimum) for flood sensitivity to human health, personal property and public property across the pluvial, fluvial and coastal zones. The mean scores are descriptively considered similar. However, what is required is the measure of statistical significance of these mean scores. Down the lane is test of homogeneity of variances determined using the Levene Statistics which further compares the median scores. The results (Table 3) show all the p-values to be greater than the level of significance (alpha = 0.05). These show equality of variances for households' flood sensitivity to human health, personal property and public property across the pluvial, fluvial and coastal zones (that is, no significant difference in their variances). The Table 4 is the output of the ANOVA analysis. It is required to understand whether any statistically significant difference exist between the group means as indicated by the three hypotheses of study. All the hypotheses were test at a level of significance of 0.05 (alpha = 0.05). The first hypothesis (Ho1) being tested shows that there is no statistically significant difference in households' flood sensitivity to human health across the pluvial, fluvial and coastal zones as determined by one-way ANOVA ($F(2,509) = 1.240$, $p = .290$). The second hypothesis (Ho2 also shows there is no statistically significant difference in households' flood sensitivity to personal property and public property across the pluvial, fluvial and coastal zones as determined by one-way ANOVA ($F(2,509) = .151$, $p = .860$). The third hypothesis (Ho3) also shows there is no statistically significant difference in households' flood sensitivity to public property across the pluvial, fluvial and coastal zones as determined by one-way ANOVA ($F(2,509) = .947$, $p = .389$).

If this is the case, could there be significance between paired flood zones? This is later determined using the post-hoc which is the Tukey test as equality of variance has earlier on been confirmed. Although, some studies have restricted proceeding to the post-hoc test, if the ANOVA result is not significant, others suggested that continuing with the post-hoc test, for two reasons: (i) the ANOVA and post-hoc tests are not the same statistics, so they are achieving different objective; and (ii) there might be variation within pair of sample groups, which might not have been detected when other sample groups are involved. Furthering the analysis to post-hoc test, the results are presented in Table 5. For the first hypothesis, the Tukey post hoc test reveals no statistically significant difference in households' flood sensitivity to human health between the pluvial and fluvial ($p = .698$), pluvial and coastal zones ($p = .640$), as well as fluvial and coastal zones ($p = .260$). For the second hypothesis, the Tukey post hoc test reveals no statistically significant difference in households' flood sensitivity to personal property between the pluvial and fluvial ($p = .859$), pluvial and coastal zones ($p = .930$), as well as fluvial and coastal zones ($p = .982$). For the third hypothesis, the Tukey post hoc test reveals no statistically significant difference in households' flood sensitivity to public property between the pluvial and fluvial ($p = .608$), pluvial and coastal zones ($p = .397$), as well as fluvial and coastal zones ($p = .967$). In general, the results for all the flood zones therefore indicate no statistically significant difference in households' flood sensitivity across the zones as the p-values are greater than the significant level of 0.05. While the claim is assertive as no statistically significant differences exist between pairs as indicated by the post hoc test. These results as the same when the observed variables under the descriptive composite scores were subject to test (Tables 6-11).

4. Discussion

Lagos State has a long history of flood occurrences while many were basically disasters because by international standard, the events answered to any of the four criteria provided by CRED (2011) which are: ten or more human deaths; 100 affected persons; declaration of a state of emergency; or a call for international assistance. As such, there were occurrences of deaths and damages to property such as land, buildings, vehicles, farmlands and investments as well as critical infrastructure including electricity, water supply and bridges. Nkwunonwo *et al.* (2016) provided some documentations on many of the flood events and their impacts in Lagos State. Based on these documentations and several others, the types of flood across various area in Lagos metropolitan areas were determined and those areas delineated into pluvial, fluvial and coastal flood-risk and -disaster zones.

Having similarly exposure to flooding as an extreme climate event, the perception of households of each zone on flood sensitivity to their personal and community lives provides great insights. In all the flood zones, it is generally established that flood negatively affects the respondents in terms of their health, personal property and public property at varying degree of sensitivity. The health issues were related to loss of lives, illnesses and diseases such as malaria and typhoid. Personal property comprised buildings, livestock and vehicles while public infrastructure included roads, drainages and electricity. Considering respondents' socioeconomic vulnerability, their socioeconomic attributes were related to the perceived sensitivity of flood. The sensitivity of flood was higher in males than females. The sensitivity of flood was also higher among the poor who are basically the low income earners. Although these were the cases in all the zones, they were more evident in the pluvial and fluvial zones compared to the coastal zone. This implies that high poverty increases people's sensitivity to disaster which in this case is flood as it is the highest driver of vulnerability in this location. These results agree with some studies (Odunuga *et al.*, 2012; Zou & Thomalla, 2008; Nkwunonwo et al., 2015; de Almeida & Mostafavi, 2016; Nkwunonwo & Ugonna, 2016) in Nigeria and other climes but which have individually studied each flood type.

In the result section, it is established that the sensitivity of households to flood in the pluvial zone is not significantly different from that in the fluvial and coastal zones. It is good to remember that the sensitivity assessment or evaluation is perceptual (subjective) and not actual (objective) measurement. Only the experiences and feelings of losses of the households are reflected and contextualised. If an objective assessment were made, the results might likely be different. Nevertheless, the results of this study have been able to prove that the measure of loss is likely to be the same among households that live with flood and is independent of the areas they live or flood types they are exposed to. To put things in perspective, is to consider individuals or households that lost their only means of livelihood to flood. Although these could be petty trades such as small farmlands or farm produce businesses, the victims are likely to be more grieved than those who lost one of their many vehicles to flood even if the cost implication is much more than those of the pretty trades. This kind of scenario might have played out confounding the results across the pluvial, fluvial and coastal zones, therefore resulting into the significant difference in flood sensitivity established by the results of this study. Further studies might therefore seek to understand the influence of experience and emotions in the evaluation of sensitivity of different flood types.

5. Conclusion

This study has considered the sensitivity of households to different flood types in Lagos Metropolis. The sensitivity to flood in the metropolitan area were attributed to human health, personal property and public problem. The flood sensitivity attributes were descriptively related to the socioeconomic characteristics of respondents. The households' sensitivity to flood was higher in males than females and the low income earners in all the flood zones. Further, the literature establishes households' exposure and sensitivity to flood as measures of flood impact. As households' exposure to flood in the delineated zones is similar and no variability exit in their sensitivity to flood in these zones, the impact as perceived by households is therefore not significantly different across the pluvial, fluvial and coastal flood zones. It is therefore concluded that households that have experienced surface, river and surge flood expressed the similar perception of impact of losses to these flood types in the metropolis. Emphasis is then laid on the descriptive results of this study, particular regarding the situation of the low socioeconomic group. This study therefore recommends flood mitigation strategies and responses in all the zones and priority should be given to the households belonging the low socioeconomic class in the different flood zones in the disbursement of limited government resources.

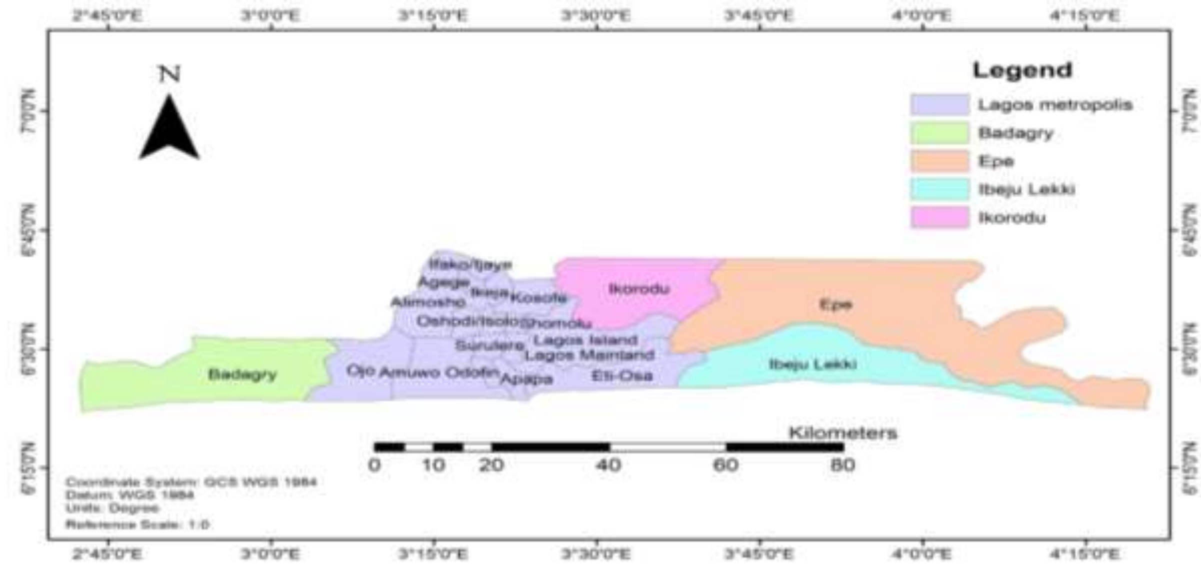

Fig. 1: Local Government Areas in Lagos State

Table 1: Sample Frame and Sample Size in Flood Zones in Lagos Metropolis

Flood Zone	Streets	Flood-risk streets	Selected flood-risk streets	Buildings on selected flood-risk streets	Buildings sampled
Pluvial	1985	355	27	1708	213
Fluvial	600	107	23	1053	132
Coastal	470	83	24	1332	167
Total	3055	546	74	4093	512

Table 2: Descriptive Summary of Households' Flood Sensitivity across Zones in Lagos Metropolis

Variables		N	Mean	Std. Deviation	Std. Error	95% CI for Mean Lower Bound	Upper Bound	Min	Max
Human Health Index	Pluvial	213	3.4110	.42955	.02943	3.3530	3.4690	2.82	4.27
	Fluvial	132	3.3712	.44124	.03841	3.2952	3.4472	2.82	4.27
	Coastal	167	3.4524	.46429	.03593	3.3814	3.5233	2.82	4.27
	Total	512	3.4142	.44435	.01964	3.3757	3.4528	2.82	4.27
Personal Property Index	Pluvial	213	3.1062	.57853	.03964	3.0281	3.1844	2.25	3.88
	Fluvial	132	3.1402	.60690	.05282	3.0357	3.2446	2.25	3.88
	Coastal	167	3.1280	.56687	.04387	3.0414	3.2146	2.25	3.88
	Total	512	3.1221	.58127	.02569	3.0716	3.1725	2.25	3.88
Public Property Index	Pluvial	213	3.2638	.28394	.01946	3.2255	3.3022	2.70	3.80
	Fluvial	132	3.2348	.25740	.02240	3.1905	3.2792	2.70	3.80
	Coastal	167	3.2269	.27756	.02148	3.1845	3.2694	2.70	3.80
	Total	512	3.2443	.27521	.01216	3.2204	3.2682	2.70	3.80

Table 3: Levene Statistic Summary of Households' Flood Sensitivity across Zones in Lagos Metropolis

Variables	Levene Statistic	df1	df2	Sig.
Human Health Index	1.668	2	509	.190
Personal Property Index	1.823	2	509	.163
Public Property Index	1.476	2	509	.229

Table 4: ANOVA Summary of Households' Flood Sensitivity across Zones in Lagos Metropolis

Variables		Sum of Squares	df	Mean Square	F	Sig.
Human Health Index	Between Groups	.489	2	.245	1.240	.290
	Within Groups	100.406	509	.197		
	Total	100.896	511			
Personal Property Index	Between Groups	.103	2	.051	.151	.860
	Within Groups	172.549	509	.339		
	Total	172.652	511			
Public Property Index	Between Groups	.143	2	.072	.947	.389
	Within Groups	38.560	509	.076		
	Total	38.704	511			

Table 5: Tukey HSD Summary of Multiple Comparisons in Lagos Metropolis

Dependent Variable	(I) Flood Zone	(J) Flood Zone	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Human Health Index	Pluvial	Fluvial	.03980	.04920	.698	-.0758	.1554
		Coastal	-.04136	.04591	.640	-.1493	.0665
	Fluvial	Pluvial	-.03980	.04920	.698	-.1554	.0758
		Coastal	-.08116	.05173	.260	-.2027	.0404
	Coastal	Pluvial	.04136	.04591	.640	-.0665	.1493
		Fluvial	.08116	.05173	.260	-.0404	.2027
Personal Property Index	Pluvial	Fluvial	-.03393	.06450	.859	-.1855	.1177
		Coastal	-.02177	.06018	.930	-.1632	.1197
	Fluvial	Pluvial	.03393	.06450	.859	-.1177	.1855
		Coastal	.01216	.06781	.982	-.1472	.1715
	Coastal	Pluvial	.02177	.06018	.930	-.1197	.1632
		Fluvial	-.01216	.06781	.982	-.1715	.1472
Public Property Index	Pluvial	Fluvial	.02900	.03049	.608	-.0427	.1007
		Coastal	.03690	.02845	.397	-.0300	.1038
	Fluvial	Pluvial	-.02900	.03049	.608	-.1007	.0427
		Coastal	.00790	.03206	.967	-.0674	.0833
	Coastal	Pluvial	-.03690	.02845	.397	-.1038	.0300
		Fluvial	-.00790	.03206	.967	-.0833	.0674

Table 6: Descriptive Summary of Households' Flood Sensitivity to Human Health across Zones in Lagos Metropolis

Variables		N	Mean	Std. Deviation	Std. Error	95% CI for Mean Lower Bound	Upper Bound	Min	Max
Incidence of human death	Pluvial	213	3.00	1.135	.078	2.84	3.15	1	5
	Fluvial	132	2.93	1.043	.091	2.75	3.11	1	5
	Coastal	167	3.09	1.113	.086	2.92	3.26	1	5
	Total	512	3.01	1.104	.049	2.91	3.11	1	5
Incidence of food poison/ contaminated food sources	Pluvial	213	3.23	1.516	.104	3.02	3.43	1	5
	Fluvial	132	3.22	1.608	.140	2.94	3.50	1	5
	Coastal	167	2.95	1.582	.122	2.71	3.19	1	5
	Total	512	3.13	1.564	.069	3.00	3.27	1	5
Incidence of polluted water sources	Pluvial	213	3.71	1.431	.098	3.52	3.90	1	5
	Fluvial	132	3.61	1.507	.131	3.35	3.87	1	5
	Coastal	167	3.68	1.415	.109	3.47	3.90	1	5
	Total	512	3.67	1.443	.064	3.55	3.80	1	5
Incidence of malaria	Pluvial	213	3.41	1.758	.120	3.17	3.65	1	5
	Fluvial	132	3.38	1.745	.152	3.08	3.68	1	5
	Coastal	167	3.54	1.664	.129	3.28	3.79	1	5
	Total	512	3.44	1.723	.076	3.29	3.59	1	5
Incidence of cholera	Pluvial	213	3.31	1.476	.101	3.11	3.51	1	5
	Fluvial	132	3.19	1.457	.127	2.94	3.44	1	5
	Coastal	167	3.49	1.405	.109	3.27	3.70	1	5
	Total	512	3.34	1.450	.064	3.21	3.46	1	5
Incidence of typhoid	Pluvial	213	3.62	1.108	.076	3.47	3.76	1	5
	Fluvial	132	3.59	1.070	.093	3.41	3.78	1	5
	Coastal	167	3.50	1.052	.081	3.34	3.66	1	5
	Total	512	3.57	1.079	.048	3.48	3.67	1	5
Incidence of pink eyes	Pluvial	213	3.64	.877	.060	3.52	3.76	1	5
	Fluvial	132	3.61	.853	.074	3.47	3.76	1	5
	Coastal	167	3.57	.991	.077	3.42	3.72	1	5
	Total	512	3.61	.908	.040	3.53	3.69	1	5
Incidence of dermatitis or skin diseases	Pluvial	213	3.75	.927	.064	3.62	3.87	2	5
	Fluvial	132	3.77	.915	.080	3.61	3.92	2	5
	Coastal	167	3.90	.811	.063	3.77	4.02	2	5
	Total	512	3.80	.889	.039	3.72	3.88	2	5
Incidence of hypertension	Pluvial	213	3.43	1.099	.075	3.28	3.58	1	5
	Fluvial	132	3.37	1.135	.099	3.18	3.57	1	5
	Coastal	167	3.53	1.091	.084	3.37	3.70	1	5
	Total	512	3.45	1.106	.049	3.35	3.54	1	5
Psychological problems	Pluvial	213	3.10	1.354	.093	2.92	3.28	1	5
	Fluvial	132	3.07	1.388	.121	2.83	3.31	1	5
	Coastal	167	3.27	1.301	.101	3.07	3.47	1	5
	Total	512	3.15	1.346	.059	3.03	3.26	1	5
Incidence of injuries	Pluvial	213	3.34	1.086	.074	3.20	3.49	1	5
	Fluvial	132	3.35	1.026	.089	3.17	3.53	1	5
	Coastal	167	3.46	1.057	.082	3.29	3.62	1	5
	Total	512	3.38	1.061	.047	3.29	3.47	1	5

Table 7: Descriptive Summary of Households' Flood Sensitivity to Personal Property across Zones

Variables		N	Mean	Std. Deviation	Std. Error	95% CI for Mean Lower Bound	Upper Bound	Min	Max
Damage to building structure	Pluvial	213	3.25	1.189	.081	3.09	3.41	1	5
	Fluvial	132	3.21	1.192	.104	3.01	3.42	1	5
	Coastal	167	3.32	1.125	.087	3.15	3.49	1	5
	Total	512	3.26	1.168	.052	3.16	3.36	1	5
Damage to water supply utilities in the building	Pluvial	213	2.81	1.029	.071	2.67	2.95	1	5
	Fluvial	132	2.80	1.032	.090	2.62	2.97	1	5
	Coastal	167	2.83	1.045	.081	2.67	2.99	1	5
	Total	512	2.81	1.033	.046	2.72	2.90	1	5
Damage to electricity utilities in buildings	Pluvial	213	3.19	1.088	.075	3.05	3.34	1	5
	Fluvial	132	3.26	1.067	.093	3.07	3.44	1	5
	Coastal	167	2.95	1.029	.080	2.79	3.11	1	5
	Total	512	3.13	1.069	.047	3.04	3.22	1	5
Damage to drainage utilities in the building	Pluvial	213	2.74	1.007	.069	2.61	2.88	1	5
	Fluvial	132	2.80	1.022	.089	2.63	2.98	1	5
	Coastal	167	2.85	1.128	.087	2.68	3.02	1	5
	Total	512	2.79	1.051	.046	2.70	2.88	1	5
Damage to sewerage in the building	Pluvial	213	3.22	1.293	.089	3.05	3.40	1	5
	Fluvial	132	3.30	1.301	.113	3.08	3.53	1	5
	Coastal	167	3.33	1.355	.105	3.12	3.54	1	5
	Total	512	3.28	1.314	.058	3.16	3.39	1	5
Damage of vehicle	Pluvial	213	2.98	1.032	.071	2.84	3.12	1	5
	Fluvial	132	3.05	.987	.086	2.88	3.22	1	5
	Coastal	167	3.03	1.100	.085	2.86	3.20	1	5
	Total	512	3.01	1.042	.046	2.92	3.10	1	5
Disruption of business	Pluvial	213	3.38	1.154	.079	3.23	3.54	1	5
	Fluvial	132	3.47	1.094	.095	3.28	3.66	1	5
	Coastal	167	3.34	1.107	.086	3.17	3.51	1	5
	Total	512	3.39	1.123	.050	3.30	3.49	1	5
Death of Livestock	Pluvial	213	3.27	1.511	.104	3.06	3.47	1	5
	Fluvial	132	3.23	1.543	.134	2.97	3.50	1	5
	Coastal	167	3.37	1.391	.108	3.16	3.58	1	5
	Total	512	3.29	1.479	.065	3.16	3.42	1	5

Table 8: Descriptive Summary of Households' Flood Sensitivity to Public Property across Zones in Lagos Metropolis

Variables		N	Mean	Std. Deviation	Std. Error	95% CI for Mean Lower Bound	Upper Bound	Min	Max
Community water supply disrupted	Pluvial	213	3.38	.912	.063	3.26	3.51	1	5
	Fluvial	132	3.38	.904	.079	3.22	3.53	1	5
	Coastal	167	3.29	1.024	.079	3.13	3.44	1	5
	Total	512	3.35	.947	.042	3.27	3.43	1	5
Community electricity disrupted	Pluvial	213	3.35	1.079	.074	3.21	3.50	1	5
	Fluvial	132	3.48	1.088	.095	3.30	3.67	1	5
	Coastal	167	3.50	1.113	.086	3.33	3.67	1	5
	Total	512	3.43	1.092	.048	3.34	3.53	1	5
Community roads damage/could not be plied	Pluvial	213	3.08	1.193	.082	2.92	3.24	1	5
	Fluvial	132	3.01	1.287	.112	2.79	3.23	1	5
	Coastal	167	2.89	1.177	.091	2.71	3.07	1	5
	Total	512	3.00	1.213	.054	2.89	3.11	1	5
Community health care centres could not be accessed	Pluvial	213	3.11	.894	.061	2.99	3.23	1	5
	Fluvial	132	3.11	.840	.073	2.96	3.25	1	5
	Coastal	167	2.99	.931	.072	2.85	3.13	1	5
	Total	512	3.07	.893	.039	2.99	3.15	1	5
Community drainage systems damaged	Pluvial	213	3.79	1.246	.085	3.63	3.96	1	5
	Fluvial	132	3.71	1.201	.105	3.51	3.92	1	5
	Coastal	167	3.82	1.253	.097	3.63	4.01	1	5
	Total	512	3.78	1.235	.055	3.67	3.89	1	5
Community markets could not be accessed	Pluvial	213	3.13	1.004	.069	2.99	3.26	1	5
	Fluvial	132	3.15	.977	.085	2.98	3.32	1	5
	Coastal	167	2.94	.929	.072	2.80	3.08	1	5
	Total	512	3.07	.976	.043	2.99	3.16	1	5
Community telecommunication networks disrupted	Pluvial	213	3.11	1.104	.076	2.96	3.26	1	5
	Fluvial	132	3.02	1.070	.093	2.83	3.20	1	5
	Coastal	167	3.24	.995	.077	3.09	3.39	1	5
	Total	512	3.13	1.062	.047	3.03	3.22	1	5

Transport facilities damaged	Pluvial	213	3.20	1.157	.079	3.04	3.35	1	5
	Fluvial	132	3.03	1.217	.106	2.82	3.24	1	5
	Coastal	167	3.03	1.229	.095	2.84	3.22	1	5
	Total	512	3.10	1.197	.053	3.00	3.20	1	5
Disruption of water bodies and catchments	Pluvial	213	3.00	1.057	.072	2.85	3.14	1	5
	Fluvial	132	3.02	1.126	.098	2.82	3.21	1	5
	Coastal	167	3.04	1.008	.078	2.89	3.20	1	5
	Total	512	3.02	1.058	.047	2.92	3.11	1	5
Destruction of green infrastructure	Pluvial	213	3.49	.775	.053	3.38	3.59	1	5
	Fluvial	132	3.45	.755	.066	3.32	3.58	1	5
	Coastal	167	3.53	.751	.058	3.42	3.65	1	5
	Total	512	3.49	.761	.034	3.43	3.56	1	5

Table 9: ANOVA Summary of Households' Flood Sensitivity to Human Health across Zones in Lagos Metropolis

Variables		Sum of Squares	df	Mean Square	F	Sig.
Incidence of human death	Between Groups	1.917	2	.958	.786	.456
	Within Groups	621.034	509	1.220		
	Total	622.951	511			
Incidence of food poison/contaminated food sources	Between Groups	8.273	2	4.136	1.696	.184
	Within Groups	1241.429	509	2.439		
	Total	1249.701	511			
Incidence of polluted water sources	Between Groups	.881	2	.441	.211	.810
	Within Groups	1063.648	509	2.090		
	Total	1064.529	511			
Incidence of malaria	Between Groups	2.335	2	1.168	.393	.676
	Within Groups	1514.022	509	2.975		
	Total	1516.357	511			
Incidence of cholera	Between Groups	6.692	2	3.346	1.595	.204
	Within Groups	1067.527	509	2.097		
	Total	1074.219	511			
Incidence of typhoid	Between Groups	1.237	2	.618	.530	.589
	Within Groups	594.090	509	1.167		
	Total	595.326	511			
Incidence of pink eyes	Between Groups	.518	2	.259	.313	.731
	Within Groups	421.136	509	.827		
	Total	421.654	511			
Incidence of dermatitis or skin diseases	Between Groups	2.381	2	1.190	1.510	.222
	Within Groups	401.299	509	.788		
	Total	403.680	511			
Incidence of hypertension	Between Groups	2.075	2	1.037	.848	.429
	Within Groups	622.502	509	1.223		
	Total	624.576	511			
Psychological problems	Between Groups	3.823	2	1.912	1.055	.349
	Within Groups	922.190	509	1.812		
	Total	926.014	511			
Incidence of injuries	Between Groups	1.368	2	.684	.607	.545
	Within Groups	573.364	509	1.126		
	Total	574.732	511			

Table 10: ANOVA Summary of Households' Flood Sensitivity to Personal Property across Zones in Lagos Metropolis

Variables		Sum of Squares	df	Mean Square	F	Sig.
Damage to building structure	Between Groups	.877	2	.439	.321	.726
	Within Groups	696.052	509	1.367		
	Total	696.930	511			
Damage to water supply utilities in the building	Between Groups	.102	2	.051	.048	.953
	Within Groups	545.271	509	1.071		
	Total	545.373	511			
Damage to electricity utilities in buildings	Between Groups	8.265	2	4.133	3.652	.027*
	Within Groups	575.967	509	1.132		
	Total	584.232	511			
Damage to drainage utilities in the building	Between Groups	1.120	2	.560	.506	.603
	Within Groups	562.934	509	1.106		
	Total	564.055	511			
Damage to sewerage in the building	Between Groups	1.223	2	.612	.353	.703
	Within Groups	881.394	509	1.732		
	Total	882.617	511			
Damage of vehicle	Between Groups	.402	2	.201	.184	.832
	Within Groups	554.502	509	1.089		
	Total	554.904	511			

Disruption of business	Between Groups	1.236	2	.618	.489	.613
	Within Groups	642.856	509	1.263		
	Total	644.092	511			
Death of Livestock	Between Groups	1.606	2	.803	.366	.694
	Within Groups	1116.448	509	2.193		
	Total	1118.055	511			

Table 11: ANOVA Summary of Households' Flood Sensitivity to Public Property across Zones in Lagos Metropolis

Variables		Sum of Squares	df	Mean Square	F	Sig.
Community water supply disrupted	Between Groups	1.023	2	.511	.569	.567
	Within Groups	457.696	509	.899		
	Total	458.719	511			
Community electricity disrupted	Between Groups	2.432	2	1.216	1.019	.362
	Within Groups	607.310	509	1.193		
	Total	609.742	511			
Community roads damage/could not be plied	Between Groups	3.305	2	1.652	1.123	.326
	Within Groups	748.695	509	1.471		
	Total	752.000	511			
Community health care centres could not be accessed	Between Groups	1.682	2	.841	1.055	.349
	Within Groups	405.787	509	.797		
	Total	407.469	511			
Community drainage systems damaged	Between Groups	.918	2	.459	.300	.741
	Within Groups	778.582	509	1.530		
	Total	779.500	511			
Community markets could not be accessed	Between Groups	4.378	2	2.189	2.312	.100
	Within Groups	481.948	509	.947		
	Total	486.326	511			
Community telecommunication networks disrupted	Between Groups	3.843	2	1.921	1.707	.182
	Within Groups	572.905	509	1.126		
	Total	576.748	511			
Transport facilities damaged	Between Groups	3.473	2	1.736	1.213	.298
	Within Groups	728.447	509	1.431		
	Total	731.920	511			
Disruption of water bodies and catchments	Between Groups	.203	2	.102	.091	.913
	Within Groups	571.672	509	1.123		
	Total	571.875	511			
Destruction of green infrastructure	Between Groups	.550	2	.275	.474	.623
	Within Groups	295.418	509	.580		
	Total	295.969	511			

References

Adewara, B. M., Irivbogbe, H. E., Yusuf, W., & Akitoye, M. (2018). Analysing flood risk in Lagos Island Local Government Area of Lagos State. Presentation at FIG Congress 2018 on Embracing Smart World Where the Continents Connect: Enhancing the Geospatial Maturity of Society, May 6-11, Turkey.

Akanni, O., & Bilesanmi, L. (2011, July 10). Flood: Lagos residents forced to relocate ... Drowning teenager rescured. Vanguard: Towards a Better Life for the People. Lagos: Vanguard Media Limited.

Ayedun, C. A, Durodola, D. O., Oni, S. A., Oluwatobi, A.O., & Ikotun, O. T. (2018). The flooding effect on building property values. A casestudy of Shogunro Residential Estate, Agege, Nigeria. *International Journal of Civil Environmental Engineering and Technology,* 9(6), 489-496.

Cardona, O. D., van Aalst, M. K., Birkmann, J., Fordham, M., McGregor, G., Perez, R., Pulwarty, R. S. Schipper, E. L. F., & Sinh, B. T. (2012). Determinants of risk: exposure and vulnerability. In: C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G. K. Plattner, S.K. Allen, M. Tignor, & P.M. Midgley (eds.). Managing the risks of extreme events and disasters to advance climate change adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). pp. 65-108. Cambridge, UK, and New York, NY: Cambridge University Press.

CRED: Center for Research on the Epidemiology of Disasters. (2011, October). Disaster loss characterization: Review of human and economic impact indicator definitions. Working Paper (Draft). Brussels: CRED

de Almeida, B., & Mostafavi, A. (2016). Resilience of infrastructure systems to sea-level rise in coastal areas: Impacts, adaptation measures, and implementation challenges. Sustainability, 8, 1115; 1-28, doi:10.3390/su8111115

Dube, K., Nhamo, G., & Chikodzi, D. (2021). Flooding trends and their impact on coastal communities of Western Cape Province, South Africa. *GeoJournal.* https://doi.org/10.1007/s10708-021-10460-z

Dutta, D., & Herath, S. (2014). Trend of floods in Asia and flood risk management with integrated river basin approach. Retrieved from https://www.researchgate.net/publication/239833068. Accessed 4 June, 2019.

Etuenovbe, A., 2011. The devastating effect of flooding in Nigeria. *Journal of Environment and Earth Science,* Vol. 3 No. 5: 57-66.

Gelleh, I. D., Ibidun, O. A., & Okeke, U. H. (2016). Flood vulnerability assessment in Lagos City using multi-criteria analysis. *Greener Journal of Environmental Management and Public Safety,* 5(2), 24-32.

Hajat S., Ebi K.L., Kovats R.S., Menne B., Edwards S., Haines A. (2005) The Human Health Consequences of Flooding in Europe: A Review. In: Kirch W., Bertollini R., Menne B. (eds) Extreme Weather Events and Public Health Responses. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-28862-7_18

IPCC (2001). Climate change 2001: Impacts, Adaptation and Vulnerability, Summary for Policymakers, WMO.

Ishiwatari, M., & Sasaki, D. (2021). Investing in flood protection in Asia: an empirical study focusing on the relationship between investment and damage. Progress in Disaster Science, 12. https://doi.org/10.1016/j.pdisas.2021.100197

Lagos State Government. (2014). Lagos State Millennium Development Goals report. Ministry of Economic Planning & Budget. Lagos State Government, Lagos State, Nigeria.

Lankao, P. R., & Tribbia, J. L. (2009). Assessing patterns of vulnerability, adaptive capacity and resilience across urban centers. Paper presented at the Fifth Urban Research Symposium 2009.

Leis, J., & Kienberger, S. (2020). Climate risk and vulnerability assessment of floods in Austria: Mapping Homogenous Regions, Hotspots and Typologies. Sustainability, 12, 6458. doi:10.3390/su12166458

Liu, Z., & Xia, J. (2016). Impact of climate change on flood disaster risk in China. *Chinese Journal of Nature*, 38(3), 182-188. doi: 10.3969/j.issn.0253-9608.2016.03.003

Lucas, B. (2021). Urban flood management in Nigeria. K4D Helpdesk Report 948. Brighton, UK: Institute of Development Studies. doi: 10.19088/K4D.2021.018

Nkwunonwo, U. C., & Ugonna, C. (2016). A review of flooding and flood risk reduction in Nigeria. Global Journal of Human-Social Science: B Geography, Geo-Sciences, Environmental Science and Disaster Management. 16 (2), 22-37.

Nkwunonwo, U. C., Whitworth, M., & Baily, B. (2015). Flooding and flood risks reduction in Nigeria: Cardinal gaps. *Journal of Geography and Natural Disasters*. 5, 136. doi: 10.4172/2167-0587.1000136

Nkwunonwo, U. C., Whitworth, M., and Baily, B.: Review article: A review and critical analysis of the efforts towards urban flood risk management in the Lagos region of Nigeria, Nat. Hazards Earth Syst. Sci., 16, 349–369, https://doi.org/10.5194/nhess-16-349-2016, 2016.

Odunuga, S., Oyebande, L., & Omojola, A. (2012). Social-economic indicators and public perception on urban flooding in Lagos, Nigeria. Hydrology for Disaster Management Special Publication of the Nigerian Association of Hydrological Sciences, 82-96. Retrieved from http://www.unaab.edu.ng

Oladele, B. (2018). Residents' sense of place in coastal areas of Lekki, Lagos State, Nigeria (Bachelor Thesis). Department of Urban and Regional Planning, Obafemi Awolowo University, Ile-Ife, Nigeria.

Olajuyigbe, A. E., Rotowa, O. O., & Durojaye, E. (2012). An assessment of flood hazard in Nigeria: The case of Mile 12, Lagos. *Mediterranean Journal of Social Sciences*, 3(2), 367-377. doi:10.5901/mjss.2012.v3n2.367

Olanrewaju, C. C., Chitakaita, M., Olanrewaju, O. A., & Louw, E. (2019). Impact of flood disasters in Nigeria: a critical evaluation of health implications and management. *Journal of Disaster Risk Studies*, 11(1), 557. doi:10.4102/jamba.v11i1.557

Oyekale, A. S. (2013). Impact of flooding on the health of coastal fishing folks in Epe Division of Lagos State, Nigeria. *Journal of Human Ecology*, 44(2), 183-188.

Oyinloye, M., Olamiju, I., & Ogundiran, A. (2013). Environmental impact of flooding on Kosofe Local Government Area of Lagos State, Nigeria: A GIS perspective. *Journal of Environment and Earth Science*, 3(5), 57-66.

Ritter, J., Berenguer, M., Park, S., & Sempere-Torres, D. (2021). Real-time assessment of flash flood impact at pan-European scale: The ReAFFINE method, *Journal of Hydrology*, 603. https://doi.org/10.1016/j.jhydrol.2021.127022.

Tauzer, E., Borbor-Cordova, M. J. & Mendoza, J., de la Cuadra, T., Cunalata, J., & Ibarra, A. S. (2019). A participatory community case study of periurban coastal flood vulnerability in Southern Ecuador, SocArXiv ygh92, Center for Open Science. doi:10.31219/osf.io/ygh92

Wahab, B., & Ojolowo, S. (2018). Drivers and spatial extent of urban development in flood-prone areas in metropolitan Lagos. *Journal of Sustainable Development*, 11(2), 98-111.

Wahab, B., Ojolowo, S., Adelekan, I., & Fasona, M. (2014, September). Building contraventions and incidence of flood in the Lagos metropolis. Paper presented at the 6th International conference on flood management, Sao Paulo, Brazil.

WHO (2002). Floods: climate change and adaptation strategies for human health. Report on a WHO meeting London, United Kingdom.

Zischg, A. P., & Bermúdez, M. (2020). Mapping the sensitivity of population exposure to changes in flood magnitude: prospective application from local to global scale. Frontiers in Earth Science, 8, 390. doi:10.3389/feart.2020.534735

Zou, L., & Thomalla, F. (2008). The causes of social vulnerability to coastal hazards in Southeast Asia. An SEI Working Paper. Sweden: Stockholm Environment Institute.