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Journal of Environmental Planning and Management

ISSN: 0964-0568 (Print) 1360-0559 (Online) Journal homepage: https://www.tandfonline.com/loi/cjep20

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To cite this article: Idowu Ajibade, Frederick Ato Armah, Vincent Zubedaar Kuuire, Isaac Luginaah, Gordon McBean & Eric Y. Tenkorang (2015) Assessing the bio-psychosocial correlates of flood impacts in coastal areas of Lagos, Nigeria, Journal of Environmental Planning and Management, 58:3, 445-463, DOI: 10.1080/09640568.2013.861811

To link to this article: https://doi.org/10.1080/09640568.2013.861811

Journal of Environmental Planning and Management, 2015
Vol. 58, No. 3, 445–463, http://dx.doi.org/10.1080/09640568.2013.861811

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Assessing the bio-psychosocial correlates of flood impacts in coastal areas of Lagos, Nigeria

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(*Received 6 April 2013; final version received 29 October 2013*)

This paper explores the complex heterogeneous experiences of flood impacts based on a bio-psychosocial model of socio-economic, demographic, behavioural and environmental factors. Using ordinary least squares regression on a cross-sectional survey of 1003 individuals, flood impacts in three contiguous coastal neighbourhoods in Lagos, Nigeria, were modelled. The results show that approximately 52% of the variability in flood impact was accounted for by education, age, family structure, ethnicity, personal health concern and income. While involvement in coping was not a significant predictor of flood impacts, relocation emerged as a strong predictor. The inclusion of behavioural factors did not change the magnitude and significance of the relationship between demographic factors and flood impacts. However, the effects of age, education and personal health concern disappeared when environmental factors were controlled. The overall importance of the predictors for determining flood impact in decreasing order is as follows: income > coping strategies > ethnicity = participation in community development > family structure > personal health concerns > housing quality > reasons for living in residential locality > neighbourhood vulnerability to flood > housing vulnerability to flood.

Keywords: bio-psychosocial; flood impacts; behaviour; environment; Lagos

1. Introduction

Climate change threatens to increase the unpredictability and incidence of extreme weather events across the world (Milly *et al.* 2002; IPCC 2007). Studies indicate such events could have various devastating impacts on exposed and vulnerable populations (Dolan and Walker 2006; Warner *et al.* 2009; IPCC 2012). In particular, coastal areas have been recognised as locations that are acutely prone to extreme weather events, including flooding (Clark *et al.* 1998; Dolan and Walker 2006). Among natural catastrophes, flooding has claimed more lives than any other single natural hazard (Few, Pham, and Bui 2004). In the decade 1986 to 1995, flooding accounted for 31% of the global economic loss from natural catastrophes and 55% of the casualties (Borrows and De Bruin 2006). This is mainly so when these locations experience high population growth and rapid urbanisation. Flooding can result both from strong winds and cyclones originating from offshore at places of high pressure that drive water inland, and the

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combined effect of excessive rainfall and densely built urban environments with no effective drainage system (Clark *et al.* 1998). Furthermore, urbanisation can increase surface water runoff between two and six times the natural rate (Douglas *et al.* 2008), thus causing severe flooding with consequence for injuries, deaths and damage to homes and properties. The damaging effects of flooding are likely to become more prevalent and more serious in the future.

Urbanisation rates within West Africa are among the highest in the world (Barredo and Demicheli 2003). The population of this sub-region is expected to increase to over 500 million by 2020 (Chen and Heligman 1994; Barredo and Demicheli 2003). Lagos forms part of the high population density corridor within West Africa. Like many other developing world cities, it is generally saddled with problems of inadequate urban planning, poor management and an acute deficit of infrastructure, particularly in the face of an increasing population. As old urban centres such as Lagos continue to expand their borders, population density within old neighbourhoods lacking basic infrastructure and good drainage channels will also increase. This will heighten exposure to flooding and other climatic hazards and will pose a big challenge to the urban poor who reside in such areas (Douglas *et al.* 2008).

The factors mediating the impact of flood events vary considerably within the fast urbanising population of Lagos. Remarkably wide socio-economic disparities exist within populations in this megacity, as does the capacity to cope and respond to flooding. While the impacts of flooding on physical infrastructure, such as buildings, have been well researched, there is comparatively little research regarding the impacts of flooding on populations. For example, we are only beginning to understand the impact of floods in time and space on people of varying levels of socio-cultural and economic status, even within the same coastal community (Clark *et al.* 1998). Previous studies from Europe, Latin America and Asia (Azar and Rain 2007; Raaijmakers, Krywkow, and van der Veen 2008; Sundram *et al.* 2008; Zahran *et al.* 2008) have reported differential experiences of flood impacts by vulnerable communities during flood events, although none explicitly used a bio-psychosocial approach to examine flood impacts. Yet, a bio-psychosocial approach is interesting as it embraces some aspects of the three dimensions of vulnerability (exposure, sensitivity and adaptive capacity).

The goal of this paper is to examine risk factors considered important in understanding differential impacts and exposure to flood events within heterogeneous communities in Lagos, Nigeria. These include bio-psychosocial risks factors (socio-economic, demographic and behavioural factors) and how these risk factors influence exposure and vulnerability to flood impacts. Understanding the nexus between bio-psychosocial risk and flood impacts is critical for two main reasons: it is important for designing strategies aimed at minimising the impact of floods before they occur and it may also help identify the people most at risk during and after a flood disaster. Lagos was selected as the study area because it is one of the world's coastal cities most at risk from the impacts of climate change. In an assessment of 136 port cities, Lagos ranked fifteenth for populations exposed to flooding and sea level rise within in a future climate scenario for the 2070s (Nicholls *et al.* 2007). Many parts of the city are susceptible to flooding, influenced by changes in precipitation patterns and storm surges. This study was conducted as a part of the Coastal Cities at Risk (CCaR) Project – Building Adaptive Capacity for Managing Climate Change in Coastal Megacities.

2. Theoretical framework

2.1. Disaster and the bio-psychosocial model

Studies of disaster impacts began in the 1940s with the exploration of the varied causes, as well as social responses to natural disasters (Lemons 1957; Fritz 1961; White and Haas 1975). The understanding then was that natural disasters were largely a function of natural events independent of human activities. However, more recent studies have shown that disaster is a product of complex interactions between society and the physical environment (Peet and Watts 2004; Cutter 2005; Birkmann 2006). A natural event, such as a flood, might be a rapid physical on-set caused by heavy precipitation, but the ensuing disaster is often linked to a long-term process in human activities, decisions, values and behaviour, including socio-economic, political and environmental conditions in society (O'Keefe, Westgate and Wisner 1976; Lewis 1988; Wisner *et al.* 2004). Different types of disasters have been examined using diverse theoretical approaches. A number of robust approaches have been used to study vulnerability of social systems to hydrological and climate hazards (see Clark *et al.* 1998; Eakin and Luers 2006; Azar and Rain 2007; Zahran *et al.* 2008). In this study, we adopt a bio-psychosocial model consisting of four main factors: socio-economic, socio-demographic, behavioural as well as environmental factors (see Figure 1) to study the exposure and impacts of floods on residents in coastal communities in Lagos, Nigeria.

The bio-psychosocial model is commonly applied in clinical psychology and medicine to explore the biophysical, psychological (which entails thoughts and behaviours), as well as social factors influencing the experience, impacts and care of illnesses and health trauma (Smith 2002; Marelich and Erger 2004; Borrell-Carrió, Suchman, and Epstein 2004; Waddell 2004). It is a universal component of the way people react to and cope with illnesses or health problems (Frankel and Quill 2005). This integrative model is also applicable in disaster management given that biological,

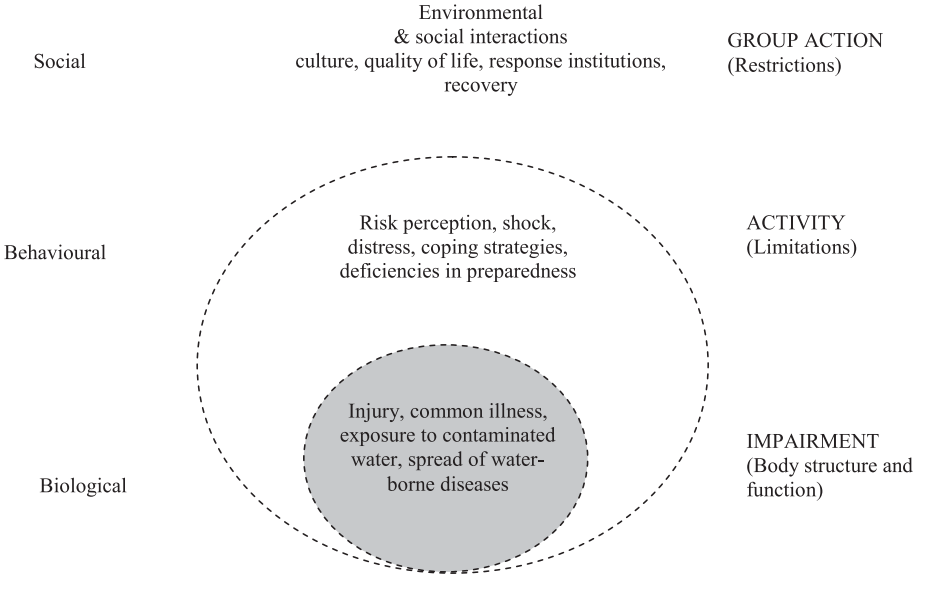

Figure 1. Bio-psychosocial framework as applied to disasters. Source: adapted from Waddell (2004).

psychological and social factors influence people's experience of disaster. The bio-psychosocial model broadly shows that a disaster can impair people's physical bodies and minds; that people exposed to the disaster often display different reactions and symptom levels during or after the disaster; and that some people will be more affected than others, depending on the nature of the event and the characteristics of the persons who have experienced or witnessed it (Koopman *et al.* 1995). These characteristics may be physical-biological, environmental, social, cultural and behavioural (Figure 1). Whereas some people experience significant subjective discomfort, others display conspicuous impairment in their day-to-day functioning, such as sleeplessness, and still others indicate clear impairment in one or more functional aspects, such as work productivity or the ability to engage in and enjoy leisure activities. Disaster-induced reactions may be classified into four categories on the basis of human mental functions: emotional (e.g. feelings of shock and helplessness, loss of pleasure, sadness); cognitive (e.g. impaired concentration and decision-making ability, disbelief, decreased self-efficacy); physical (e.g. fatigue, exhaustion, startled response, reduced immune response, insomnia, vulnerability to illness); and interpersonal (e.g. social withdrawal, impaired work or school performance, distrust, externalisation of vulnerability) effects (Waddell 2004). If they occur, these effects weaken people's response capabilities during the course of a disaster. In disaster literature, the bio-psychosocial model has previously been applied to tsunami-affected elderly people (Prueksaritanond and Kongsakol 2007); and to the experience of bushfires in Australia (Raphael 1984). That is, after a disaster, researchers surveyed the affected population to examine their post-impact reactions, and then tracked them for several years after the disaster in an attempt to understand the factors related to increased or decreased risk for impairment (Norris, Friedmann and Watson 2002; Clark 2003; Nickell *et al.* 2004; Stein *et al.* 2004).

Despite its contribution to the advancement of knowledge in clinical and disaster research, the bio-psychosocial framework has been criticised as overly broad and difficult to apply (Alonso 2003). Its usefulness has been framed as essentially heuristic, rather than a true scientific model capable of generating testable hypotheses (McLaren 1998). However, Borrell-Carrió, Suchman, and Epstein (2004) maintained that the bio-psychosocial model makes a necessary contribution to the scientific method and research, and proposed that the model should include a careful evaluation of causality with the need to make linear approximations while recognising that in open systems (e.g. human society) it is often impossible to know all of the factors contributing to and influencing a particular outcome. This refined modification of bio-psychosocial model is useful in disaster research because it helps to make more visible certain risks factors in everyday life, yet recognising that other factors influencing the outcome of disaster may not be fully known or accounted for.

2.2. Application of bio-psychosocial model in flooding contexts

In flooding contexts, psychosocial and behavioural factors are central to the experience of disaster as they shape people's interaction with the event and also influence observed outcomes (impacts). Such cognitive characteristics are particularly important in coping and demonstrating resilience to disasters. For example, awareness and knowledge of flood are important factors which influence behaviours adopted to minimise damage and they may also be responsible for influencing behaviours such as relocation from flood areas (Warren, Tindle, and Whalley 2011). Paton, McClaure, and Burgelt (2006) argued that risk perception influences people's behaviour during flood events. Behaviours

adopted as a result of individuals' perception of risk have consequences for people's safety, coping strategy, reduction or exacerbation of economic damage to property. In this study, behavioural factors that shape experiences of flood impacts were conceptualised to include reasons for living in the area of residence, engagement in coping, adoption of coping strategies and participation in community development. Furthermore, influences of socio-economic factors (i.e. respondent's education, occupation and income) on flood impacts were also examined. While these factors alone may not be responsible for flood impacts, it is posited that socio-cultural/demographic factors such as gender, ethnicity, religion and family structure are important interveners of the intensity of flood impacts. All the above factors influencing the extent of flood impacts operate within the larger environment. There is no doubt that neighbourhood or environmental characteristics have a direct and yet complex interaction with natural phenomena on the one hand, and psychosocial factors on the other, and together they shape the vulnerability of individuals to the incidence of flooding. Therefore, factors such as residential locality, perception of neighbourhood to flooding and access to basic amenities specifically, sanitation and health facilities were accounted for in this study.

3. Materials and method

3.1. Survey and data collection

The survey for this study was conducted in three heterogeneous communities in Lagos: Ijora Badia, Ajah and Victoria Island. These communities were purposively selected for the study because of their swampy terrain, annual experience of flooding and their diverse socio-economic status. Badia is a slum settlement in mainland Lagos with a predominantly low-income population. Ajah is situated in the northern half of Lagos Island and is home to a high proportion of people with middle and upper-incomes. Victoria Island is situated in the south of Lagos Island; the area has both a high proportion of high-income households and a smaller group of people with low-incomes living in squatter settlements. A sample of 1003 respondents was selected using a combination of probability sampling proportional to size and equal size sampling in appreciation of the spread and peculiarities of Lagos state inhabitants and landscapes. In total, 453 female and 550 male participants were interviewed. The survey data which formed the basis of our analysis were collected after the 2011 July rainstorm which devastated the city of Lagos, causing mass injuries, displacements, death and destruction of homes and infrastructure. All men and women aged 18 and over who were permanent residents of the households were eligible to be interviewed. Socio-demographic information about respondents was collected, including age, gender, education and occupation. Information on characteristics of the household's dwelling unit, such as the source of water, type of toilet facilities, materials used for housing construction and dwelling ownership status was collected. In addition, information about personal health status, disease prevalence, shocks; income profile; access to social services, culture; expenditures on food and income; and climate change perception and adaptation options were elicited.

3.2. Measures

3.2.1. Dependent variable

The outcome variable for this study is flood impact as reported by respondents. Flood impact is a 13-item additive scale, which was computed from a set of questions that

elicited information on specific types of flood impacts encountered by respondents in the past 5 years. The questions asked in the survey were: whether or not respondents had experienced damage to personal properties, individual health problems, restricted movement, collapse of buildings, and loss of lives as a result of floods. Other questions elicited information on whether or not respondents had experienced homelessness, damaged roads and homes filled with water as a result of floods. The responses were dichotomised with '0' indicating respondents had not experienced flood impact and '1' indicating respondents had experienced flood impacts. Based on these responses, a composite measure (summative index) was computed using a summated score for the flood impact scale ranging from 0 to 9, with 0 indicating the least flood impact and 9 indicating the highest level of flood impact. The reliability estimate (Cronbach's Alpha) was 0.73, which is higher than the generally accepted internal consistency threshold of 0.70.

3.2.2. Independent variables

Multiple independent variables were used to account for individual, socio-economic, residential and environmental characteristics. Theoretically relevant factors that could potentially influence flood impacts included within this analysis may be divided into four categories: socio-economic, demographic, behavioural and environmental variables (Table 1). The socio-economic variables included education, income and occupation. Demographic variables included age, gender, family structure, ethnicity and religion. Behavioural variables included health concerns, engagement in coping, coping strategies during floods, reasons for living in the community, rate of water use and participation in community development. Environmental factors included housing quality, residential locality and vulnerability of dwelling to flooding, vulnerability of neighbourhood to flooding, access to water services, and distance to nearest healthcare facility.

3.3. Statistical analyses

Descriptive and multivariate techniques were applied to examine associations between flood impacts and a number of personal, behavioural, environmental and socio-demographic determinants in Lagos, Nigeria, using STATA 12SE software. The ordinary least squares technique was employed for the analysis. Analyses were preceded by diagnostic tests to establish whether variables met the assumptions of the regression model. Bivariate analysis was initially performed to examine zero-order correlations between the dependent variable and theoretically relevant independent variables. Further, multivariate models were estimated to explore the net effects of the predictor variables using the stepwise selection approach. For analytical and comparative purposes, the standardised regression coefficients were estimated. Positive beta coefficients for any of the predictors indicate high flood impact, while negative coefficients show low flood impact.

4. Results

4.1. Descriptive results

Table 1 shows descriptive analyses, including univariate distribution of selected variables used for analysis and bivariate associations between selected dependent and independent variables.

Table 1. Descriptive statistics and bivariate relationships between flood impacts and explanatory variables.

Variables	Frequency	%	Beta coef.	Std. err.
Socio-economic factors				
Income (ref: N5,000 – N15,000)	186	18.5		
N15,500–N25,000	232	23.1	0.27***	0.23
N25,500– N50,000	207	20.6	0.20***	0.24
N50,500 or more	97	9.7	−0.08*	0.29
Will rather not say	281	28.0	0.06	0.22
Respondent Education (ref: up to primary)	348	34.7		
Secondary	388	38.7	−0.06	0.17
Tertiary	267	26.6	−0.31***	0.19
Respondent occupation (ref: unemployed)	105	10.5		
Civil servant	163	16.3	−0.10*	0.30
Artisan	189	18.8	0.02	0.30
Self-employed	546	54.4	0.05	0.26
Socio-cultural/demographic factors				
Age (ref: 18–30)	209	20.8		
31–40	622	62.0	−0.02	0.19
41–65	172	17.1	−0.16***	0.25
Gender (ref: female)	453	45.1		
Male	550	54.8	0.06	0.16
Family structure (ref: 1–3)	252	25.1		
4 to 5	506	50.5	−0.23***	0.18
6 or more	245	24.4	−0.27***	0.21
Ethnicity (ref: Yoruba)	628	62.6		
Ibo	325	32.4	0.17***	0.16
Hausa	23	2.3	−0.08**	0.51
Other	27	2.7	−0.09**	0.47
Religion (ref: Christian)	650	64.8		
Moslem	338	33.7	−0.02	0.16
Other	15	1.5	−0.04	0.64
Psychosocial/Behavioural factors				
Personal health concerns (ref: nothing)	497	49.6		
Malaria and fever	436	43.5	−0.32***	0.15
Cholera	70	7.0	−0.16***	0.30
Reasons for living in area (ref: family ties)	213	21.2		
Business	373	37.2	−0.07	0.21
Cheap housing	369	36.8	0.17***	0.21
Recreational	48	4.8	0.02	0.38
Rate of water use (ref: never)	817	81.5		
Everyday	186	18.5	−0.13***	0.20
Participation in comm devt (ref: never)	327	32.6		
Almost every day	80	8.0	0.11**	0.29
At least once a week	102	10.2	−0.09**	0.27
At least once a month	391	39.0	0.26***	0.18
Rarely	103	10.3	0.01	0.27
Engagement in coping (ref: No)	263	26.2		
Yes	740	73.8	0.25***	0.17
Coping strategies during floods (ref: nothing)	171	17.1		
Relocate	387	38.6	0.46***	0.21
Drain water with bucket	333	33.2	0.22***	0.21
Other mechanisms	112	11.2	0.00	0.28

(*continued*)

Table 1. (*Continued*)

Variables	Frequency	%	Beta coef.	Std. err.
Environmental factors				
Residential locality (ref: Ijora Badia)	607	60.5		
Ajah	120	12.0	−0.26***	0.23
Victoria Island	276	27.5	−0.27***	0.17
Housing quality (ref: wooden shack)	181	18.1		
Wooden on stilts	191	19.0	−0.08*	0.24
Concrete	631	62.9	−0.35***	0.20
Household vulnerability to flood (ref: no)	228	22.7		
Yes	603	60.1	−0.03	0.23
Refused to answer	172	17.1	−0.17***	0.37
Neighbourhood vulnerability to flood (ref: no)	131	13.1		
Yes	810	80.8	−0.01	0.18
Don't know	62	6.2	0.37***	0.23
Access to water and sanitation (ref: poor water access)	569	56.7		
Good water access	434	43.3	0.08*	0.16
Distance to nearest healthcare facility (ref: 5km or more)	730	72.8		
Less than 5 km	273	27.2	−0.17***	0.17

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

The bivariate level analysis shows socio-economic differences regarding flood impact among respondents. For example, individuals with higher levels of education were less affected by floods compared to those without formal education. It also emerged that socio-cultural/demographic factors, such as age, ethnicity and family structure, were associated with flood impacts. Psychosocial/behavioural factors were also important predictors of experiences of the impact of flooding. Individuals who indicated they lived in the locality because of cheap housing were more affected by floods compared to those who lived in the locality because of family ties. Residents who engaged in coping strategies were more affected by floods compared to those who were not engaged in coping strategies. Individuals who had personal health concerns were less affected by floods compared to their counterparts who had none. Environmental factors similarly played a key role in how flooding affected respondents. Housing quality, access to water and sanitation services, vulnerability of households and neighbourhoods to flooding and distance to nearest healthcare facility were significant predictors of flood impacts. However, the relationship between gender and flood impact was not significant.

4.2. Multivariate analyses

Table 2 shows multivariate results for selected dependent and independent variables. The highest Adjusted R^2 obtained was 0.50, indicating that 50% of the variation of the flood impact values is explained by the variation of the independent variables. For personal factors alone, the Adjusted R^2 obtained was 0.17, indicating that 17% of the variation in flood impact is explained by the personal factors. When socio-demographic factors are included, the Adjusted R^2 obtained was 0.27, indicating that 10% of the flood impact variation is explained by the variation of the socio-demographic variables. On inclusion of psychosocial/behavioural variables, the Adjusted R^2 obtained was 0.38, indicating that 11% of the flood impact variation is explained by the variation of the behavioural factors. After environmental factors were accounted for, the highest Adjusted R^2 obtained was

Table 2. Multivariate relationships between flood impact and explanatory variables.

	Model 1: Socio-economic factors		Model 2: Socio-cultural/demographic factors		Model 3: Psychosocial/Behavioural factors		Model 4: Environmental factors	
	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.
Intercept	3.26	(0.28)***	3.95	(0.31)***	2.23	(0.44)***	5.22	(0.49)***
Income (ref: N5,000–N15,000)								
N15,500–N25,000	0.26	(0.24)***	0.28	(0.24)***	0.21	(0.23)***	0.06	(0.22)
N25,500–N50,000	0.37	(0.25) ***	0.38	(0.24)***	0.28	(0.24)***	0.27	(0.23)***
N50,500 or more	0.07	(0.31)	0.07	(0.30)	0.06	(0.29)	0.01	(0.27)
Will rather not say	0.09	(0.22)*	0.10	(0.21)**	0.11	(0.21)**	0.05	(0.19)
Respondent education (ref: up to primary)								
Secondary	–0.04	(0.18)	–0.08	(0.17)*	–0.07	(0.17)*	–0.05	(0.16)
Tertiary	–0.32	(0.23)***	–0.36	(0.23)***	–0.27	(0.23)***	–0.23	(0.23)***
Respondent occupation (ref: unemployed)								
Civil servant	–0.18	(0.32)***	–0.11	(0.31)*	0.00	(0.29)	–0.03	(0.28)
Artisan	–0.02	(0.29)	–0.02	(0.30)	0.00	(0.29)	–0.01	(0.27)
Self-employed	–0.14	(0.26)**	–0.22	(0.26)***	–0.16	(0.25)**	–0.21	(0.24)***
Age (ref: 18–30)								
31–40			–0.08	(0.19)*	–0.05	(0.19)	0.04	(0.18)
41–65			–0.19	(0.25)***	–0.10	(0.25)*	0.04	(0.24)
Gender (ref: female)								
Male			0.06	(0.15)	0.04	(0.15)	0.03	(0.14)
Family structure (ref: 1–3)								
four to five			–0.12	(0.18)**	–0.03	(0.18)	–0.09	(0.17)**
six or more			–0.14	(0.21)***	–0.07	(0.21)	–0.06	(0.19)
Ethnicity (ref: Yoruba)								
Ibo			0.20	(0.17)***	0.26	(0.17)***	0.19	(0.17)***
Hausa			–0.07	(0.46) **	–0.06	(0.44) *	–0.06	(0.40)**
Other			–0.10	(0.44) **	–0.04	(0.42)	–0.03	(0.38)

(*continued*)

Table 2. (*Continued*)

	Model 1: Socio-economic factors		Model 2: Socio-cultural/demographic factors		Model 3: Psychosocial/Behavioural factors		Model 4: Environmental factors	
	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.
Religion (ref: Christian)								
Muslim			0.04	(0.17)	0.08	(0.16)*	0.05	(0.14)
Other			–0.02	(0.57)	–0.02	(0.53)	–0.02	(0.48)
Personal health concerns (ref: nothing)								
Malaria and fever					–0.11	(0.16)***	–0.15	(0.15)***
Cholera					–0.07	(0.28)*	–0.03	(0.26)
Reasons for living in area (ref: family ties)								
Business					–0.12	(0.19)**	–0.20	(0.18)***
Cheap housing					0.01	(0.19)	0.00	(0.18)
Recreational					0.05	(0.35)	0.03	(0.34)
Rate of water use (ref: never)								
Everyday					–0.03	(0.18)	–0.01	(0.19)
Participation in comm devt (ref: never)								
Almost every day					0.16	(0.28)***	0.19	(0.27)***
At least once a week					0.01	(0.24)	0.00	(0.26)
At least once a month					0.25	(0.17)***	0.17	(0.18)***
Rarely					0.07	(0.25)*	0.06	(0.23)*
Engagement in coping (ref: No)								
Yes					0.01	(0.20)	0.09	(0.20)*
Coping strategies during floods (ref: nothing)								
Relocate					0.25	(0.21)***	0.23	(0.21)***
Drain water with bucket					0.07	(0.21)	0.14	(0.20)***
Other mechanisms					0.01	(0.27)	0.00	(0.26)
Residential Locality (ref: Ijora Badia)								
Ajah							–0.07	(0.33)

(*continued*)

Table 2. (*Continued*)

	Model 1: Socio-economic factors		Model 2: Socio-cultural/demographic factors		Model 3: Psychosocial/Behavioural factors		Model 4: Environmental factors	
	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.	Beta Coef.	Std. Err.
Victoria Island							–0.01	(0.26)
Housing quality (ref: wooden shack)								
Wooden on stilts							–0.17	(0.23)***
Concrete							–0.19	(0.21)***
Household vulnerability to flood (ref: no)								
Yes							–0.27	(0.23)***
Refused to answer							0.10	(0.34)
Neighbourhood vulnerability to flood (ref: no)								
Yes							–0.19	(0.22)***
Don't know							–0.17	(0.32)***
Access to water and sanitation (ref: poor water access)								
Good water access							–0.02	(0.15)
Distance to nearest healthcare facility (ref: 5km or more)								
Less than 5 km							–0.01	(0.18)
R^2 (Adjusted R^2)	0.18	(0.17)	0.28	(0.27)	0.40	(0.38)	0.52	(0.50)

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

0.50, indicating that 12% of the flood impact variation is explained by the variation of the environmental factors.

In Model 1 it is evident that income is associated with flood impacts. Specifically, respondents with tertiary education experienced lower flood impacts, compared to those with primary education. Beta coefficients were used to determine predictors with the most important effect on flood impact. While income produced the most effect on flood impact, education had the least effect. Thus, the order of importance of the predictors for determining flood impact is as follows: income > occupation > education.

In Model 2, when age, gender, family structure, ethnicity and religion were taken into account, the relationship between education (particularly, those with secondary education) and flood impact became stronger. Even after controlling for other variables, it was observed that respondents with tertiary education had decreased exposure to flood impacts compared to respondents with primary education. Meanwhile, associations between income and flood impact strengthened. A statistically significant relationship is observed between occupation and flood impact, and the association is strengthened with the inclusion of socio-cultural/demographic variables. In Model 2, age and family structure also had an inverse relationship with flood impact.

Model 3 shows a significant relationship between flooding impact and personal health concerns, reasons for living in the area, level of participation in community development and the types of coping strategies employed during flooding. However, relocation was strongly and positively associated with flood impacts for the various types of coping strategies adopted by respondents. The importance of the predictors in determining flood impacts in decreasing order is as follows in the psychosocial/behavioural model: relocation, participation in community development at least once a month, participation in community development at least once a day, livelihood reasons for living in the community, and personal health concerns.

In Model 4, environmental factors attenuated the effects of income on flood impact. Housing quality was inversely associated with flood impact, suggesting that higher quality houses were less affected by floods. It was surprising that vulnerabilities of households and neighbourhoods to flood were inversely associated with flood impact. Distance to nearest healthcare facility, access to water services and residential localities were unrelated to flood impact. The order of importance of the predictors for determining flood impact in decreasing order in the environmental model is as follows: household vulnerability to floods, neighbourhood vulnerability to flood events and housing quality.

5. Discussion

This paper assessed the bio-psychosocial determinants of flood impacts and its distribution across the population in flood-prone coastal communities in Lagos. Many models have been criticised for being over-simplified and not accommodating sufficient intervening relationships or feedback loops between explanatory factors and flood impacts (Malmgren 2005). Thus, the approach to hazards in this study takes a holistic view of flood, mostly as a function of the interplay between socio-economic (e.g. income), socio-cultural/demographic (e.g. ethnicity), psychosocial/behavioural (e.g. coping strategies), and environmental factors (e.g. residential locality). This implies that a plethora of factors shape the occurrence of flood and its impact on humans. Theoretically relevant bio-psychosocial factors that appear to predict vulnerability to the impact of floods may be considered as biological, cognitive-affective (emotional), immediate living environment (household, neighbourhood), behavioural and societal/macro categories (Lightman 2005).

Biological factors including age, gender, early life stressors, previous injuries and previous history of illness has been implicated (Lutgendorf and Constanzo 2003; Lightman 2005; Knocke and Kolivras 2007). Cognitive-affective comprises climate beliefs (regarding the causes and consequences of flooding), anxiety, depression and flood-related conditions. Behaviour encompasses risk taking, coping behaviours and risk aversion behaviours such as participation in community development after flooding can attenuate vulnerability (Conner-Smith and Compas 2004). Social factors which include socio-economic-status, social support and culturally-held beliefs about floods (Sperry 2005) may conspire with other factors to create vulnerability to flooding and worsen flood impacts (Marmot 2005; Deely 2006; Orth-Gomer 2007).

An advantage of applying the bio-psychosocial approach to disaster research is that it adequately captures the three dimensions of vulnerability: exposure, sensitivity and adaptive capacity. For example, in this study exposure indicators used include household and neighbourhood vulnerability to flooding. Sensitivity indicators include residential locality, personal health concerns, age, housing quality, and distance to nearest health facility. Adaptive capacity indicators include income, education, occupation, participation in community development, engagement in coping, coping strategies, and access to water and sanitation services. Increasingly, this multi-factorial notion of hazards is receiving much attention in the literature (see King 2002; Messner and Meyer 2006; Knocke and Kolivras 2007). Education was an important predictor of flood impact. According to Thieken *et al.* (2007), education stimulates precaution and preparation and helps to limit and manage the adverse effects of a catastrophe, and to build up coping capacities by flood-resilient communities. In addition, those with higher levels of education and incomes are capable of performing effective flood emergency measures, thereby reducing flood impacts, whereas households with fewer educated individuals have more difficulties (Thieken *et al.* 2007). Other scholars have made similar observations in varying contexts (see Knocke and Kolivras 2007; Lin, Shaw, and Ho 2008). Indeed, tertiary education was a more powerful predictor of flood impact than secondary education in all four models (see Table 2). This probably suggests heterogeneity in flood impact based on the type of education (formal or informal) and level of formal education (primary, secondary or tertiary).

Concern for personal health was also an important predictor of flood impact. Few (2007) argued that flood impacts and health concerns are intrinsically linked. This linkage has hitherto been predominantly explored in the flood impact-health concern direction rather than in the reverse direction. For example, it is suggested that flood impact can culminate in increased exposure to disease pathogens and/or their vectors, exposure to airborne allergens and chemical releases, nutritional deficiencies caused by food shortages, and psychosocial and mental health outcomes associated with loss, disruption and displacement (Manuel 2006; Few 2007). In developing countries such as Nigeria, disruption of water and sanitation systems, impairment of hygiene practices, changes to the local environment and population displacement during and after extreme events may lead to elevated risk from a range of endemic water-borne diseases. Amplified exposure to infectious disease is thus a critical concern in the context of flooding (Manuel 2006; Few 2007).

Age, family structure, ethnicity and income were important predictors of flood impact. This is consistent with the findings of several scholars. For example, Chan and Parker (1996) indicated that the vulnerability of people to hazards and flood impacts are usually affected by variables such as income, ethnicity, educational attainment, age and gender. Those who find it hardest to reconstruct their lives following disaster are the most

vulnerable, and these are generally the poor. In terms of age, older people are more vulnerable to flood impacts because of limited mobility and reduced hearing and visual capacities (Tapsell *et al.* 2002). In addition, many older people have lost their partners and are living on their own or in a rest home. Often, they have limited social networks and few resources, making recovery difficult (Thrush, Bruningham, and Fielding 2005). In terms of family structure, deprived people with large-sized families are more hampered in meeting basic needs, such as food, housing and emotional support to their children (Tapsell *et al.* 2002).

Reasons for living in the community, participation in community development and type of coping strategies during floods were important predictors of flood impact. Messner and Meyer (2006) argued that the ability of individuals or groups to cope with the impact of floods is often correlated to general socio-economic indicators such as age, coping strategies, social structure, poverty, gender, ethnicity, education, social relations, institutional development, and proportion of the population with special needs (children and the elderly). Consistent with Messner and Meyer (2006), this study found that age, education, income, ethnicity and coping strategies were important predictors of flood impact. However, unlike Messner and Meyer (2006) this study did not find any relationship between gender and flood impact. This was possibly due to the research method which was strictly quantitative, as studies have shown that more nuanced understanding of gender and gender issues in various contexts are better elicited through qualitative methods (Haraway 1988; Harding 2004). In relation to social impacts of floods, financially deprived people have difficulties coping with material damage, which may exacerbate their poverty. The impact of the loss of personal items seems to be higher for them than for other income groups. Their susceptibility to flood impacts is also higher than other socio-economic groups (Werrity *et al.* 2007). This is because, first, they live in low quality houses that are not resistant to floods and second, due to their marginal social and economic status, they are forced to remain living in impoverished neighbourhoods.

Housing quality, vulnerability of household to flooding and neighbourhood vulnerability to floods were important predictors of flood impact. The findings on housing quality are consistent with the observations of Knocke and Kolivras (2007). According to Maantay and Maroko (2009), certain individuals may be disproportionately exposed to hazards (including floods) due to physical factors, such as having poor quality housing that inadequately withstands hazard events, or living on marginal lands prone to hazard events. Further, they are vulnerable to the impacts of hazards because of disadvantages linked to lack of strong social, financial or political support structures, and thus suffer greater relative losses and experience a longer recovery time after a disaster than the affluent or socially supported.

Negative psychosocial impacts which entail 'emotion-focused coping' responses generally disrupt the social functioning of only a very small portion of an affected population (Lindell and Prater 2003). Given the multiplicity of interacting factors contributing to flood impact and the heterogeneity of the affected population, many intervention strategies are available, which place demands upon policy makers to provide competent and evidence-based flood intervention to address the needs of the population. Such interventions need to take place at the institutional level. Usually at the individual level, the majority of people affected by floods engage in adaptive 'problem-focused coping' activities to save their own lives and those of their closest associates. Further, there is an increased incidence of pro-social behaviours such as helping with the reconstruction of houses (Siegel, Bourque and Shoaf, 1999). In some cases, people even engage in altruistic behaviours that risk their own lives to save the lives of others

(Tierney, Lindell, and Perry, 2001). There are also psychosocial impacts with long-term adaptive consequences, such as changes in risk perception and beliefs in the likelihood of the occurrence of a disaster and its personal consequences for the individual and increased hazard intrusiveness frequency of thought, discussion and receipt of information about a hazard. In turn, these beliefs can affect residents' adoption of household flood adjustments that reduce their vulnerability to future floods. By contrast, an institutional intervention allows for a more proactive and systematic approach to flood risk reduction through: control of development and runoff from floodplains; improving flood resistance of buildings, managing urban drainage systems; giving flood forecasting and warnings; providing micro-insurance for flood victims, and supporting post-flood recovery efforts (Hall *et al.* 2003). The combination of individual coping strategies with institutional interventions can aid a more effective and long-term flood risk reduction and management in coastal cities.

This study is not without limitations. Here, people are under-stood and represented statistically and in aggregates rather than in more qualitative or nuanced ways. Crucially, the analysis under-taken reveals potential exposure to flood, but does not tell us much about the variation in how the impacts of flood might actually be experienced. Differences in impact in this study were typically approached in terms of how demographic, socio-economic and cultural groups of various forms were more or less impacted by flooding. However, according to Walker and Burningham (2011), it must be recognised that conceptualising the uneven impacts of flooding in terms of distinct population groups is problematic, given that some of these groups overlap in complex ways (for example, disabled people are disproportionately likely to be poor, as are members of minority ethnic groups, women and the elderly); not all within them are equally vulnerable and vulnerability is a dynamic rather than a static quality (people can move in and out of vulnerability) (O'Brien, Sygna, and Haugen 2004).

6. Conclusion

The frequency and severity of floods have increased markedly worldwide. Impacts associated with flood events are increasing exponentially in developing countries, where local adaptation and flood mitigation capacities are generally weak. Using multi-factorial notions of flood, this study demonstrates that flood impacts are as a result of the complex interplay among socio-economic, socio-demographic, behavioural and environmental factors. Age, family structure, ethnicity, personal health concerns and income were important predictors of flood impact, likewise reasons for living in the community, participation in community development and type of coping strategies during floods. Furthermore, housing quality, vulnerability of households to flood, and neighbourhood vulnerability to flood were important predictors of flood impact. Heterogeneities in flood impacts were evident even within the same community, suggesting the need for a nuanced understanding of the flood impacts within populations. The overall importance of the predictors for determining flood impact in decreasing order is as follows: income $>$ coping strategies $>$ ethnicity $=$ participation in community development $>$ family structure $>$ personal health concerns $>$ housing quality $>$ reasons for living in residential locality $>$ neighbourhood vulnerability to flood $>$ housing vulnerability to flood. Neighbourhood and housing are defining characteristics of the physical environment. Therefore this study shows that although the physical environment is important for determining flood impact, the social determinants are more important. This information is

necessary to inform policy and decision making on adaptation and disaster risk strategies not only in West Africa but in the context of other developing countries.

Acknowledgement

The authors acknowledge research funding from the Coastal Cities at Risk: Building Capacity for Managing Climate Change in Coastal Megacities (CCaR) project, which is part of the International Research Initiative on Adaptation to Climate Change (IRIACC).

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