RESIDENTIAL BUILDING VULNERABILITY TO WINDSTORM DISASTERS IN IBADAN, NIGERIA, 2005 to 2015

By

ALEX AKINTADEADETOYE **SEWO**
Matric No: 93798
B.Sc (Hons) Geography, (Ibadan); M.Sc URP (Ibadan)

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CERTIFICATION

I certify that this thesis was carried out by Sewo, Alex Akintade of the Department of Urban and Regional Planning, Faculty of Environmental Design and Management, University of Ibadan.

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Supervisor   **Date**

Prof. Charles Olufisayo Olatubara
Professor of Urban and Regional planning,
Department of Urban and Regional Planning
University of Ibadan
Nigeria.

DEDICATION

This thesis is dedicated to Almighty God for making it a reality despite all odds; and to the memory of my late Father –Chief Mathew Olibamoyo SEWO, for laying the foundation for my education.

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A.A. Sewo

ABBREVIATIONS AND ACRONYMS

FEPA-	Federal Environmental Protection Agency
IFRC-	International Federation of Red Cross
ISDR-	International Strategy for Disaster Reduction
IPCC-	Intergovernmental Panel on Climate
NEMA-	National Emergency Management Agency
NPC -	National Population Commission
UNCHS -	United Nations Centre for Human Settlements
UNDP -	United Nations Development Programme
UNEP-	United Nations Environment Programme
UN-	Habitat United Nation Human Settlements Programme
UN/ISDR-	United Nations International Strategy for Disaster Reduction
USAID -	United State Aid for International Development
USIP-	United States Institute of Peace

ABSTRACT

Climate-induced disasters which negatively affect lives and properties are on the increase in the cities. Ibadan metropolis has experienced several devastating windstorms between 2005 and 2015. During windstorms, residential properties are the most often affected, resulting in injuries and fatalities. Studies on climate related disasters had focused largely on flooding and drought with little attention paid to windstorm. This study, therefore, was designed to analyse the vulnerability of residential buildings to windstorm disaster in Ibadan, Nigeria.

Concept of Vulnerability guided the study while the survey research design was adopted. Using a purposive sampling technique, five most severe windstorm disasters out of 21 that occurred between 2005 and 2015 were selected from the list provided by the Oyo State Emergency Management Agency. The disaster status of the selected windstorm were determined using United Nations Development Programme Framework. Out of 1,853 residential buildings damaged by windstorms 1,115 (60%) that had been repaired and re-inhabited were geo-referenced for subsequent analysis. A questionnaire containing socio-economic characteristics (age, sex and income); housing and neighbourhood characteristics (age, height, wall material, roof types, topographical elements and wind direction) was administered on the household heads in the geo-referenced buildings. The geo-referenced building locations were overlaid on the administrative map of Ibadan to determine windstorm track. Ten In-depth Interviews (IDI`s) were conducted on victims of the windstorm disasters. Quantitative data were analysed using descriptive and inferential statistics (logistic regression, analysis of variance and nearest neighbour analysis) at $p \leq 0.05$. Qualitative data were content analysed.

Respondents' age was 55.7±13.8 years, 46.3% were males and 24% earned less than ₦10, 000.00 monthly. About 46% of the buildings affected were more than 80 years old. Buildings generally devastated were one floor (44.9%). Mud buildings (54.9%) were mostly vulnerable and hip-roof building devastation (84.3%) was considerably high. Most residential buildings (65.8%) in neighbourhoods with relatively low elevation (171 to 190 meters) were considerably devastated by windstorm disasters between 2005 and 2015. However, 12.5% of buildings devastated were on hill crests (211 to 230 meters), 11.4% on the troughs (151 to 170 meters) and 10.2% up-hill (191 to 210 meters). Up-hill buildings were mildly devastated. Neighbourhoods located relatively on low lands were more vulnerable to windstorm disasters. Windstorm track (South West Trade Wind (78%) and North East Trade Wind (22%)) traversed the old quarters (traditional neighbourhood). Factors such as roofing style, (ß=-.2.74), materials used for construction (mud buildings) (ß=-1.19), vegetal cover (ß=17.16) and elevation, (ß=-.66) significantly influenced residential buildings vulnerability to windstorm disaster in Ibadan. Numbers of residential buildings devastated by windstorms varied significantly across residential neighbourhoods $F_{(2,1004)}=3.275$. Devastated residential buildings were clustered (*I*: 0.482538), indicating hotspots of windstorms vulnerability in Ibadan. Age of buildings and materials used for construction were the perceived causes of windstorms disasters.

The vulnerability of residential buildings to windstorm disaster in Ibadan Nigeria was influenced by wind direction, vegetal cover and elevation. Therefore, the adoption of tree planting should be of priority to residents and policy makers.

Keywords: Building vulnerability, Climate induced disaster, Windstorm in Ibadan
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CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Windstorm disaster vulnerability, is an issue of great concern in most cities of the world (Smith, 1992; Potsiou *et al.,* 2010, Ritchie and Roser 2019). The frequency and intensity of this disaster has been on the increase since the second half of the 20th century (ISDR, 2002;Blackmore and Tsokri, 2004; Olatunde 2012; Wahab, 2013). The most vulnerable regions to windstorm disaster are the coastal parts of North America and Asia (Maynard-Ford, 2008). The occurrence of windstorm disaster in these regions and in other parts of the world from 1970 to 2014 has led to the death of over 3.7 million people and an estimated $1.7billion urban infrastructural damage (Pyle, 2006; Olorunfemi and Raheem, 2013). In 2015 alone, windstorm disaster caused the highest insured losses to natural disaster in most parts of the world while 2017 and 2018 saw highest insurance pay out of USD 219 Billion (Sigma, 2016 and 2019).

In developed countries, windstorm disaster, especially hurricane and tropical cyclone leads to physical damage and few casualties. Less than 10% of lives lost to natural disaster occur in developed countries. In North American and Asian countries, physical conditions such as location/locational factors triggers vulnerability ofcities found in the coast, low lying areas and near the mouth of major rivers to windstorm disaster (Shebinin et al., 2007). In Africa and other developing countries, windstorm disaster vulnerability is caused by theanthropogenic circumstances such asrapidly expanding human settlements, poor environmental management and worsening socio-economic conditions (Adelekan, 2010; Odjugo, 2010;Adebimpe, 2011;Olorunfemi and Raheem, 2013).Social environmental interaction between man and nature, such as high buildings concentration, urban heat island and urban pollution are factors capable of birthing and increasing the rate of windstorm frequency in the cities (Bentley, *et al* 2010, Haberlie, *et al* 2015).

In West Africa, vulnerability to windstorm disaster is influenced by both tropical maritime air mass (warm moist south-westerly air mass, South West trade wind) and the tropical continental air mass, a cool dry wind, north east trade wind. (Ayoade, 1988). Both air masses meet at Intertropical discontinuity (ITD)boundary, creating alow pressure zone (vacuum),rapid inflow ofTropical Maritime Air mass from the South Atlantic Ocean sets up convectional currents resulting in thunderstorm(Bimbo and Magaji, n.d.). Adelekan (1998). Thunderstorm`s micro or macro burst generates powerful vertical wind shears,and when hit urban areas, properties are eroded and fatalitiesrecorded (Halmiton and Arcbold 1945).In Nigeria, thunderstorm,a short-lived local event, characterised byhigh-wind, lightning, and rainfall Mohammed and Kawu, (2014), whose influence though downburst wind and flooding covers long distance up to tens of kilometres Ginger. (2011), is the main cause of windstorm disaster (Halmiton and Arcbold 1945; Eldridge 1957; Meteorological Organization, 1999; Munich Re, 2006; Raetzo, 2006;Adelekan, 2010; World Olatunde, 2012; Raes, 2012; Mohammed and Kawu, 2014). Windstorm disaster occur predominantly in Nigeria at the beginning (March - May) and end (late September/ October), of the rainy season, causing damages to buildings and inflicting socio-economic losses on the community and the victims (FEPA, 1994, Ginger, 2011). Houses vulnerable to windstorm in Nigeria are commonly found around neighbourhoods in the precolonial quarters where buildings were built with limited engineering input and non-existence regulatory frameworkAdelekan, (2012), exposing such areasto social biological and physical (biophysical) vulnerabilities, a social groups and landscapes that are susceptible to loss from environmental hazards and events (Cutter *et al*, 2000). .

To mitigate the risk and vulnerabilities of lives and urban infrastructures to windstorm disasters in Nigeria, preference must be given to sustainable urban planning practices as already in force in countries like Australia (NISER, 2010;Bajracharya *et al*., 2011). It is expected of a city planners to evolve strategies to mitigate vulnerability to windstorm disaster and enhance city resilience through approaches such as land use plan and building code practices (Gunne-Jones, 2003; Caragliano et al., 2007; Alan et al., 2013). In Nigeria and as in other developing nations, government agencies, town planners, and other regulatory bodies who are to provide necessary recipe for city management lack the technical knowledge, therefore leaving cities susceptible to disasters (Escaleras et al., 2007;NISER, 2010).

Several studies have been conducted by researchers on windstorm disaster and susceptibility indicators in Nigeria. These studies include that of Adebimpe (2011) who found Nigerialandscape and citizenry vulnerable to windstorms disaster.Udogwu, *et al* (2009) identified Nigeria states mostly vulnerable to windstorm disaster asAbia, Akwa Ibom, Anambra, Bauchi, Delta, Edo, Enugu, Ekiti, Imo, Kaduna, Jigawa, Kano, Katsina, Kebbi, Kogi, Kwara, Niger, Ondo, Osun, Oyo, Sokoto and FCT are windstorm disaster vulnerable states in Nigeria rated Nigeria.Adelekan, (2010), investigated vulnerability factors and identified weak and aged buildings in Ibadan, Nigeria. Henderson, (2004),identified socio-economic stress, aging and substandard physical infrastructure, weak education, poor and or absolute lack of preparedness, insufficient funding for preparedness, response, and mitigation, by emergency management institutions, weak enforcement of building code, faulty plan, and substandard construction as windstorm disaster vulnerable indicators in Nigeria. Mijinyawa and Awogbuyi, (2011) evaluatedphysical windstorm disaster indicators in Ibadan and identifiedwind speed and direction.

The need to study a locale to know how vulnerable it is to windstorm disaster and how the locale fares during windstorm hazard has become imperative. Researchers from the social sciences and humanities argued in 1980`s and 1990`s, that the impact of a natural hazard depends not only on the physical characteristics of a neighbourhood, but on the capacity of people to absorb the impact and recover from losses. The focus of attention has consequently moved from physical vulnerability to social and economic vulnerability (Adebimpe, 2011), with mounting evidence that windstorm disaster has widely varying impacts on different social groups and countries. The causal factors of disaster are now studied both from the perspective nature i.e the disaster itself and the underlying factors that made the locale vulnerable to the disaster (Adelekan, 2010). Although Mijinyawa and Awogbuyi (2011) considered physical factors while Henderson, (2004) and Adelekan, (2010), investigated social factors exposing community to windstorm disaster separately and non-included biological vulnerability factors, this research focuses both on biological, physical and social factors (biophysical and social vulnerabilities) factor. So far, there is no empirical evidence in literature of any study in Nigeria that had separately studied social vulnerability and biophysical risk of a place and then combine their findings to explain vulnerability to windstorm disaster. This study is premised on the need to fill the gap so that a coordinated mitigation and adaptation approach to windstorm disaster that affect multiple neighbourhoods in Ibadan can be developed. This research examined the vulnerability of people and places to windstorm disaster in Ibadan. to achieve this, an empirical examination of windstorm disaster vulnerable neighbourhoods, was carried out with focus on biophysical and social vulnerabilities indicators. Geographical information system (GIS) analysis was also employed for a comprehensive hazard assessment of windstorm disaster vulnerability in the city. Geographic Information Systems (GIS) adoption in disaster planning and management is growing both in developing and developed countries (Cutter, 2000). It is used to monitor responses and estimate losses (FEMA 1997). The technology has also been used in hazard identification and in response to social issues (Hodgson and Palm 1992; Brainard *et al*., 1996 and Carrara and Guzzetti 1996). In Nigeria, researchers have adopted GIS to study flood disaster anddrought (Olorungunlorisa 2004; Eguaroje 2015; Ugoyibo 2017), however, GIS have not been adopted in the academics to study the duo of biophysical and social vulnerability to windstorm disaster in Nigeria. Undoubtedly, a gap exist in the literature on the appropriate systematic method to analyse neighbourhood vulnerability of windstorm disaster, a void to be fill also by this study.

1.2 **Statement of Research Problem**

The vulnerability of Ibadan residents to climate induced emergencies is determine by vulnerability inherent to the element at risk (building condition) and ability to withstand external forces imposed by the powers of windstorm disaster. The vulnerability of buildings in Ibadan neighbourhood to windstorm disaster is always ignited by human activities especially in places where low-income indigenes live (Adelekan, 2012). Also, migrants to the city move to the overstressed urban local government areas (Ibadan South West, Ibadan South East, Ibadan North, Ibadan North West and Ibadan North East) which presently have the largest population concentration in the state. The high population and human activity in these areas coupled with other externalities such as urban expansion, very high building concentration, heat island and pollution have led to an increase in the rate of windstorm disaster occurrence in Ibadan. Bentley, *et al* (2010) and Haberlie, *et al* (2015) had proven in their researches that urban heat island, pollution and building concentration have the capacity to ignite the birth of thunderstorm and increase by 5% the rate of occurrence of windstorm disaster in a city.

This increase had also translated to massive property loss and increased in the economic costs of windstorm disaster recovery. Thus, the Oyo State Emergency Management Agency (OYSEMA), the primary state agency responsible for distributing relief material to disaster victims, has been experiencing tremendous increase in disaster-assistance pay-outs since 2008. The March 6th, 2008 windstorm disaster assistance pay out, cost the state government ₦ 38, 278,200.00k in social support (Adelekan, 2010; OYSEMA, 2015). In 2004, 46 housing units valued for 10million Naira in social support at Oluyole LGA were devastated and in 2012, 243 buildings valued for social support at ₦ 1,276,344.20 were also devastated in Ibadan South East LGA. In Ibadan North LGA at Okeitunu area of Agbowo, on the 5th of April 2012, 40 damaged buildings were valued for social support at ₦2, 788,644.20. At Felele, a community where building code is strictly observed, 24 buildings valued for social support at ₦842, 504.00k were blown off (OYSEMA, 2015). Oyo state government had spent over fifty million to rehabilitate victims of four extreme windstorm events within a period of 7 years. These events reveal/portray the emerging risk of neighbourhood vulnerability to windstorm disaster and the windstorm rating as a climatic hazard in Ibadan and other urban centres in Nigeria (Akpodiogaga and Odjugo, 2009; Adelekan, 2010).

The combination of the increasing rate of windstorm occurrence, uncontrolled city expansion, non-windstorm resilient buildings and continuously rising temperature (NOAA 2019), have exposed Ibadan to a wide range of windstorm hazardsAbatan, *et al* (2018). When these hazardous events interact with vulnerabilities, the results become costly, economically and socially. The need thus arise for an inclusive planning where both individual, institutions and households resiliency are strengthened. This is important because the tenacity of people affected by windstorm disaster to recover quickly and efficiently after a windstorm becomes imperative.

As the economic losses, human losses and recovery cost of windstorm disasters in Ibadan increases, the tendencies are exacerbated by anthropogenic forces (Adelekan 2010). Watson (2000) notes that the predicted increase in extreme climate activities will result in "tremendous economic losses and lack of lifestyles". These extreme weather events would require lot of funds for facility restoration. Of course and in most cases, these funds are diverted from different social investments (McBean, 2005 in Joakin 2008). So long hazardous events occur and perhaps increase, the physical, economics and anthropogenic losses attributed to these events can be significantly reduced through a variety of mitigation and preparedness programmes. These will also be reduced through a more understanding of the social, economic and political processes that work to create vulnerability.

Few studies such as that of Akpodiogaga and Odjugo, (2009); Ede (2011), Adebimpe (2011), McBean and Ajibade, (2009), Olatunde (2012), Wahab, (2013), Olorunfemi and Raheem, (2013), Olatunde, (2012), Schmidlin and Ono, (1996) have attempted to synthesise the various sub factors concerned with natural disaster vulnerability in Nigeria. Most of these researchers base their study on drought, flooding and or wild fire incidences. Few studies on windstorm, also, had focused on single windstorm incident. For example, Adelekan (2010) focused on 2008 windstorm disaster in Ibadan while Mijinyawa and Awogbuyi (2011) focused on farm settlements around the city. Little attention has been paid to the study of multiple windstorm disasters vulnerability, creating a vacuum of neglect in windstorm disaster vulnerability research in Nigeria.

Therefore, the research among other thingsexamineda compendium of different windstorm disasters, their social and biophysical vulnerability indicators, the context in which they occurred, spatial dimension of the events, the neighbourhood characteristics of the affected areas, the housing, socio-economic, political, temporal, the environmental characteristics, and their lifelines. The study also evaluated rate of windstorm disaster occurrence, hot spots areas,range of adjustment available to mitigate windstorm disaster vulnerability,people's perception and choices during windstorm disaster incident. It also studiedextent and profiled rising attention level among the public and the decision makers using the hazard of place model, designed by (Mitchel et al 1989 and Palm 1990).

In an attempt to address the issues that made people and places vulnerable to windstorm, this study, tackles the following key questions:

1. What are the socio-economic profile of windstorm disaster vulnerable persons in Ibadan?
2. What factors (physical and anthropogenic) determine the vulnerability of neighbourhoods' buildings in Ibadan?
3. What are the local factors capable of triggering windstorm disaster in Ibadan?
4. Where and what are the resilient planning strategies required to haltwindstorm disaster vulnerability in Ibadan?

1.2 Aim and Objectives

The aim of the study is to examine vulnerability indicators of the 2008, 2009, 2013 and 2014 windstorm disaster affected neighbourhoods in Ibadan with a view to identify windstorm paths and hazard.

The objectives to actualise this aim are to:

1. identify and map social, housing and neighbourhood characteristics of the affected persons and neighbourhoods in Ibadan.
2. investigate the relationship between number of buildings affected by windstorm and the affected neighbourhoods' elevation, building heights and vegetal cover.
3. examine perception, adaptation and mitigation strategies of the affected population in Ibadan.
4. Develop resilience strategies and integrated windstorm disaster risk and vulnerability map of Ibadan.

1.3 Test of Hypothesis

H_0 the number of buildings affected by windstorm disaster in the study area is not a function of average neighbourhood elevation, building height and vegetal cover.

H_0 the pattern of windstorm occurrence in Ibadan is not random.

H_0 the contribution of vegetation (trees) to windstorm disaster vulnerability in Ibadan is not significant.

1.5 Justification of the Study

In developing countries, the vulnerability of people and places to windstorm is caused and or aggravated by household, communal and institutional factors. At the household level, the income generating activities are not diversified and are often characterised by heavy reliance on the biophysical environment. Any alteration in the equilibrium of the biophysical parameters reverberate in the livelihood system of many households

(Adebimpe, 2011). In Nigeria, a significant proportion engages in commercial activities in their homes to sustain their families. When storms occur, houses suffer the most devastative effect. According to Adelekan (2012), Akpodiagaga (2009) and Adebimpe (2011), once a roof is blown off, the livelihood of urban residents whose houses serves both residential and commercial purpose are completely altered. The effects is felt more among the urban poor who lack the immediate ability to respond to their losses Adebimpe (2011).

Oyo state is selected for this study because of its long history of windstorm disaster and availability of windstorm data. Since 2005, Oyo state separated windstorm data from flooding and 57 windstorm events were on record up till 2015. The study was narrowed down to Ibadan for 4 basic reasons. (i.) Of the 57 windstorm events, 25 incidents occurred within Ibadan metropolis (Table 1.0). (ii.) The occurrence of windstorm events spread across the three categories of residential densities. The traditional core area around Idi-Arere, Bode, Kudeti Axis. The high density area around Academy, Owode, Ifelajulo, Sanyo Boluwaji and Molete Axis. The medium and low density area around Felele Axis. The new urban sprawl in Ibadan fringe around Apete and Moniya were also affected. (iii.) The terrain of the city provides an opportunity to experiment some concepts associated with wind. For example the higher altitude areas are consider vulnerable to wind events. (iv.) The researcher has a knowledge of the culture, tradition and language of the people of Ibadan.

The most devastated neighbourhood in Ibadan are in Odinjo/Academy, Elekuro/IdiAro, Odo-Oba, Agugu and Koloko/Omowunmi where the average occupancy ration is 17.5 persons per building (Table 1.0). In 2008, 1280 buildings were devastated during the 6th of March windstorm incident. By implication, 22400 people were rendered homeless. It is noteworthy that most of these homeless people are forced to temporarily relocate or move in to already overcrowded housing units described by the United Nations as a menace to health and to human dignity (Agbola, 1997) Overcrowded housing is known for high rate of juvenile delinquency; high rates of family dependence on members of the public for assistance; high levels of illiteracy; high proportions of unemployed women; greater levels of unemployment, poverty and divorce. Also identified are, alcoholism, drug abuse, higher rate of psychological disorders and mental deficiency, low marriage rates, low average educational level, low residential mobility (due to acute shortage of residential building and land), and a generally higher degree of social abnormality, lawlessness, crime and fear (Agbola,1997).

The institutional arrangements to provide cushion for households and individual when disaster strikes in oyo state (OYSEMA) paid these victims ₦38, 278,200.00k. This translates to an average of ₦ 29,904.40k per building. This amount is obviously not enough to procure planks talk less buying roofing sheet. Therefore, victims resort to salvaging the devastated materials and reusing them. This further contributes to the problem of place hazard.

Table 1.0 History of Windstorm Events in Oyo State, Ibadan

S/N	Year of Occurrence	Local Government Areas	Total Devastation
1	2005	Ona Ara	40
2	2005	Irepo	86
3	2006	Saki East	55
4	2006	Itesiwaju	69
5	2007	Orelope	40
6	2007	Atisbo	92
7	2008	Ibadan South East	1023
8	2008	Ibadan South West	146
9	2008	Oluyole	85
10	2008	Ogooluwa	12
11	2008	Ogooluwa	28
12	2008	Atisbo	62
13	2009	Ibadan North East	108
14	2009	Ibadan North	2
15	2009	Afijio	140
16	2009	Afijio	81
17	2009	Atisbo	69
18	2010	Irepo	20
19	2010	Akinyele	37
20	2011	Iddo	23
21	2011	Ibadan North	40
22	2012	Iddo	1
23	2012	Ibadan North East	1
24	2012	Ibadan North East	1
25	2012	Atiba	78
26	2012	Egbeda	2
27	2012	Ogooluwa	66
28	2012	Afijio	91
29	2012	Atisbo	271
30	2013	Ibarapa East	48
31	2013	Orelope	210
32	2013	Akinyele	17
33	2013	Oluyole	1
34	2013	Ibadan South East	1
35	2013	Egbeda	1
36	2013	Ibadan City (Various)	22
37	2013	Egbeda	23
38	2013	Akinyele	114
39	2014	Iddo	2
40	2014	Iddo	113
41	2014	Ibadan South East	243
42	2014	Ibadan South East	25
43	2014	Ogooluwa	46
44	2014	Irepo	102
45	2014	Irepo	142
46	2014	Itesiwaju	80
47	2014	Orire	110
48	2014	Atisbo	141
49	2014	Irepo	143
50	2015	Saki East	123
51	2015	Saki East	50
52	2015	Atiba	511
53	2015	Afijio	161
54	2015	Oyo West	429
55	2015	Oyo East	251
56	2015	Ibadan North East	8
57	2015	Surulere	197

Source: OYSEMA (2015); Authors Construct (2016)

Even as researcher and disaster professionals commonly agree on the contribution of social factors, economic courses and political processes involved within the advent of catastrophe occasions globally, few research had been undertaken in Nigeria to evaluate the role of vulnerability in the occasion of windstorm disaster. Although quite a few vulnerability literature exists on advanced countries, yet, there are no consensus on the meaning of vulnerability and the variables that have an effect on vulnerability is also lacking in developing countries (Henstra & McBean, 2005). This research attempts to strengthen the body of literature related to vulnerability through an analysis specific to Nigeria, as a developing country.

Nigeria lacks a fully developed emergency management program. Akpodiagaga and Ojudgo (2009) argued that the large amount of money and lives lost to windstorm in Nigeria, is an indication that wind related hazards are getting out of hands. He beckon on governments at all levels (federal state and local government) to evolve developmental policies and plans with a view to raise awareness for the risk of wind hazards and the necessary preparedness to curtail same. He argued that Nigeria has yet to fully put into effect different mitigation strategies against its windstorm disaster management, rather, attention has been geared towards response and recovery. More recently, Nigeria Emergency Management agency (NEMA) and National Orientation Agency (NOA) in collaboration with Nigeria metrological agency (NiMET) has been using all available platforms and mass media organization to fore warm the populace of bad weather. This mitigation approach recognizes the need to enhance communal and individual resilience to emergencies yet, appropriate mitigation and resilience methodology in combatting disaster is lacking (Akpodiagaga and Ojudgo, 2009). This research, by examining windstorm prevalent communities, therefore, provide insights on building vulnerability to windstorm disaster in Nigerian cities. According to Ferrier (2008) management of disaster has shifted from an all-hazard paradigm, wherein the method to reaction and recuperation changed into almost the same for all disaster kinds, to a disaster risk technique wherein reaction and recovery are based upon the individual community's recognized risks by incorporating mitigation and resilience. He further stated that that the modern knowledge does now not effectively dissect the vulnerability that exists in the community. The information of vulnerability and the way these vulnerabilities are created is an offshoot of place based concept published by Cutter (1996). The principle combines both the concept of bio-physical and social vulnerability. The idea of Bio-physical vulnerability focuses on factors in the environmental that causes dangerous situations thus considers vulnerability to be a preexisting circumstance while social vulnerability considered the anthropogenic factors of the city and or region demography (Cutter, 1996). The merging of those two theories creates an understanding of vulnerability that is both based upon the physical features which can be particular to the location, in addition to the social, political and monetary processes going on at the local scale. Cutter et al., (2000) observe that this explicit consciousness on place draws the consciousness of the researcher to "look at some of the underlying social and biophysical elements that make contributions to vulnerability as well as to to evaluate their interaction and intersection".

This model was employed for four predominant motives. (i), it is a compromise among different models and theories because the model consists both physical and social elements. This gives a more holistic method to study vulnerability which examines not only the risk produced as a result of social process, also, the risk produced via physical process. (ii) The method easily incorporates physical attribute of urban areas and the degree of vulnerability in a selected geographical area (Cutter, 1996). This gives room for distinctiveness of each neighborhoods or political boundary to be tested under the context of an all-encompassing model. (iii) As this concept recognizes the associations between all components of hazard and factors responsible for risk and mitigation efforts, the concept is fundamentally dynamic. The fact that small changes within the social fabric or mitigation attempts can produce greater modifications in the vulnerability of the general area is noteworthy. Adebimpe, (2011) corroborates these claims as she narrate the position of people (individual or group) as active participants in the vulnerability process. Finally, hazard of a place model considers a wide range of social issues and elements in explaining the overall social vulnerability. The model encapsulates not only quantifiable variables which include ethnicity, age, education level and gender, but also, seemingly immeasurable statistical factors (i.e. perceptions and experiences of the community toward risk and hazard, coping potential and so on.).

This helps the use of qualitative and quantitative research techniques that attempt to apprehend the perceptions and reviews of a spread of actors in the emergency management field.

This studies also pursuits to add to the existing vulnerability and resiliency literature through its emphasis on the association between vulnerability and resilience. While current literature has typically reached apex at the intrinsic connection in vulnerability and resilience studies, the nature of this connection has not been appropriately established (Joakin, 2008) through an investigation of the process of windstorm disaster vulnerability and resilience in Ibadan, this studies will similarly add to the debate and clarify the specific nature of this association.

1.6 Definition of Terms

This sub-section defines the meaning of some relevant operational words used in this research. This is important to facilitate clearer and better understanding of the study.

1.6.1 Vulnerability

This is explained as a set of conditions determined by the physical, socio-economic and environmental factors or processes, which increase susceptibility to the impact of hazards (UNDP, 2004, Adelekan, 2010). It is a situation where an incident produces devastating effect on livelihood of people (Adebimpe, 2011).

1.6.2 Disaster

This is a serious disruption of the functioning of a community or a society involving wide spread human, material, economic or environmental loss as a result of a badly managed risk (www.ifrc.org retrieved 21 July, 2017).

1.6.3 Windstorm

It is refers to an intense atmospheric disturbance characterized by dangerous gusts of wind without rain (FEPA, 1994).

1.6.4 Affected Person

In this research, an affected person denotes somebody or group of peoples that has suffered catastrophic event.

1.7 Scope of Study

For the purpose of this study, the scope will be limited to Ibadan. Neighbourhoods that have not been affected by windstorm disaster will be excluded. Only victims and vicinity in which windstorm disaster occurred between 2005 and 2015 will be examined.

1.8 The Study Area

1.8.1 Brief history of Ibadan

The present day Ibadan was founded in 1829 (Ayorinde, 1994). At the time, it was only a war camp known as Eba Odan (near grass land). Gradually, the city grew and was renamed Ibadan. it became a refuge for people who were thirsty for peace, unity equity and security. Unlike other Yoruba towns, Ibadan growth pattern was centripetal. Each group of people occupied different parts of the city. For instance, a few Egbas took up residence to the west in such quarters like Opoyiosa, people from Ile-Ife and Oyo settled down at Ayeye, Orita merin, Bere and Opo-Labiran. The Ijebus settled at Isale Ijebu. By the 19^{th} century, the city had outgrown its original site as a meagre war camp. It became a centre of economic, political, social, cultural and administrative functions; people continued to migrate to Ibadan. It started to develop into some traditional residential quarters; each of which was controlled by a war leader. For example, Ayeye area was controlled by a renowned warrior of Ibadan named Ibikunle (Ayorinde, 1994).

1.8.2 Geographical Location and Size of Ibadan

Ibadan, the largest indigenous city in Africa, is the capital of Oyo state. It is made up of eleven local government area; five of which are within the inner city. They are Ibadan North West, Ibadan North East, Ibadan South East, and Ibadan South West. The remaining six local government areas are Akinyele, Lagelu, Egbeda, Ona-Ara, Oluyole and Iddo. The city is located within longitude 7^{o} 15` 10`` to $7^{o}$ 33` 30`` North and longitude 3^{0} 43` 47`` to $4^{0}$ 06` 47`` East of the Greenwich. The estimated area of the metropolis as calculated according to the updated google earth image of December 2015 is 667sqkm. The city is located at an approximate distance of 145km north east of Lagos and 659km south west of Abuja. The city is directly connected to many towns in Nigeria and its rural hinterland by system of roads, railway and air routes.

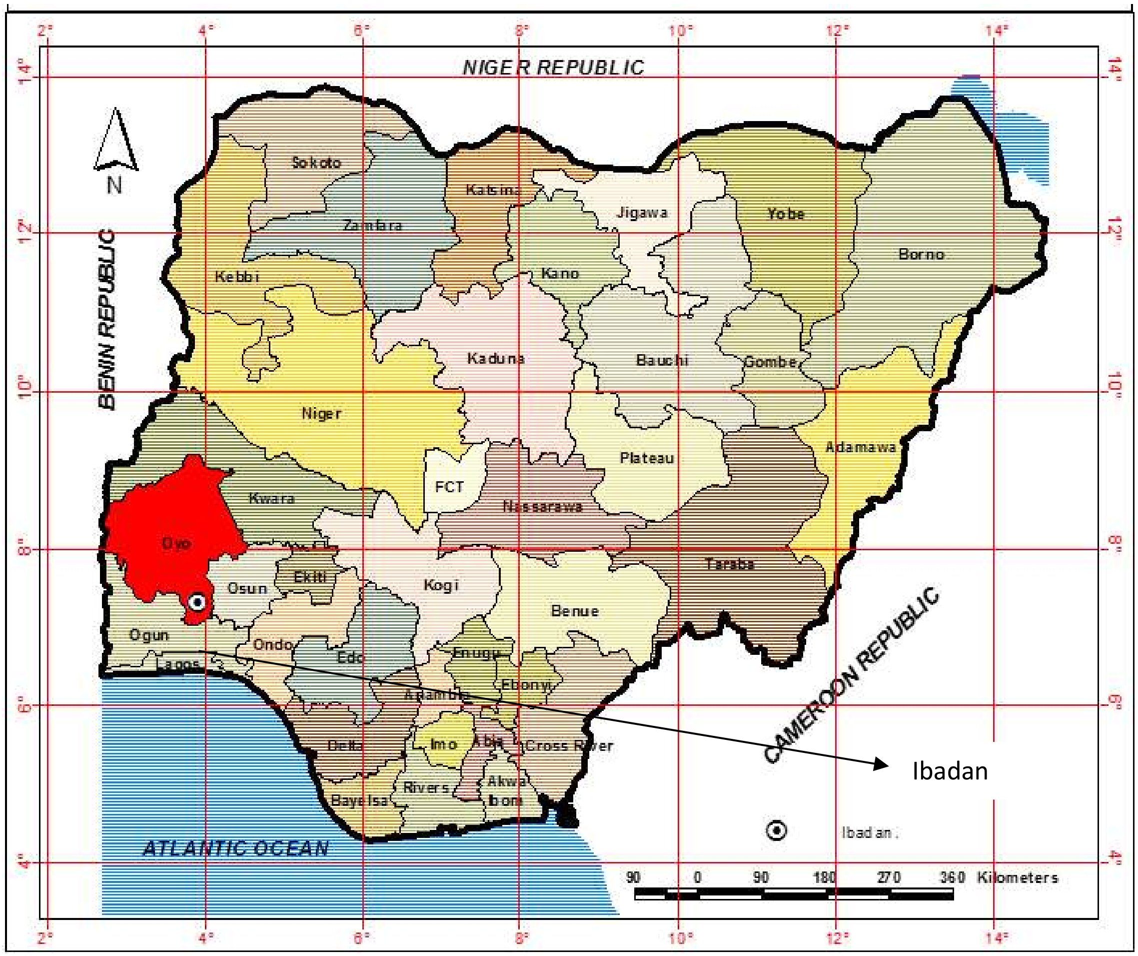

Fig. 1.1: National Location of Oyo State

Source: Federal Survey, Federal Ministry of Environment, Abuja (2015)

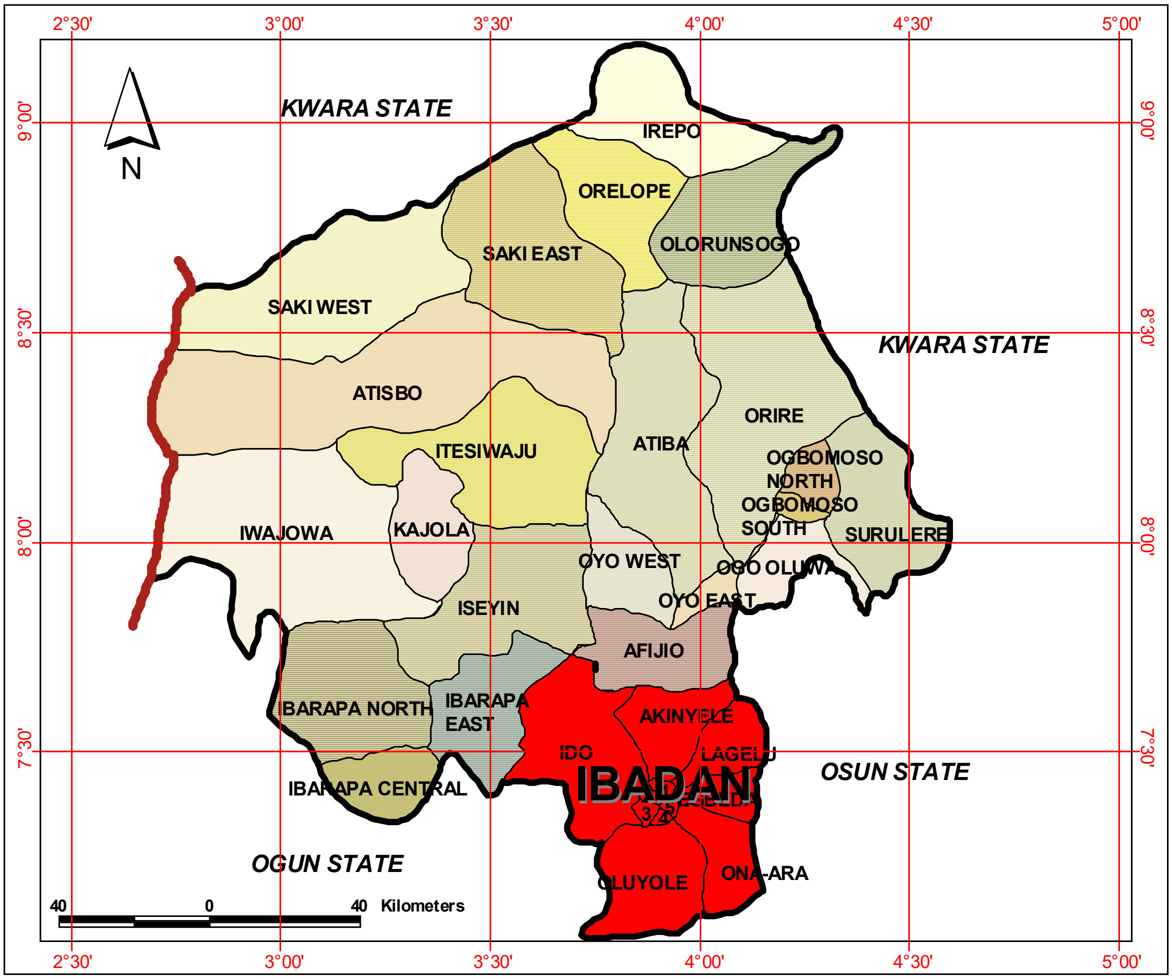

Fig. 1.2: Ibadan Region within the Context of Oyo State, Nigeria

Source: Oyo State Ministry of Lands, Ibadan (2016)

1.8.3 Physical Characteristics of Ibadan

The physical setting of the city consists of ridges of hills that run approximately in northwest – southeast direction. The largest of these ridges lie in the central part of the city and contains such peaks as Mapo, Mokola and Aremo (Ayeni 1994). Others are located at Oremeji, Mapo, Oke-Padi, Oke-Offa, and the inselberge found mainly around eastern corner along Ibadan Oyo road and the ridges between University of Ibadan and the Polytechnic, Ibadan. These hills range in elevation from 160 to 275 metres above sea level and are formed from sedimentary rocks of cretaceous ages obtained in the south–western part of the country (Ayorinde, 1994).

1.8.5 The Climatic Characteristics of Ibadan

Ibadan exhibits the typical West African monsoon climate marked by distinct seasonal shifts in wind patterns. During the rainy season between March and October, the city is under the influence of moist maritime South-West monsoon wind which blow inland from the Atlantic Ocean. The dry season occurs from November to March when the dry dust laden wind blows from the Sahara desert. The area experiences high relative humidity and generally two rainfall maxima regimes during the rainfall period of March to October. The mean temperatures are highest at the end of the Harmattan (averaging 28°C), that is from the middle of January to the onset of the rainy season in the middle of March. Even during the rainfall months, average temperatures are relatively high, between 24°C and 25°C, while annual fluctuation of temperature is about 6°C (Ayorinde, 1994).

1.8.6 Land-Use Pattern of Ibadan

Ibadan, an indigenous city, grew organically without a proper physical plan. Some sectors are plan others arent. The unplanned sector of the city is found majorly in the core area, dovetailing towards the south eastern part predominantly inhabited by the indigenes. This area constitutes about 40% of the spatial coverage. The non-indigenous sector comprises a mixture of planned and unplanned area (Muili, 2005).

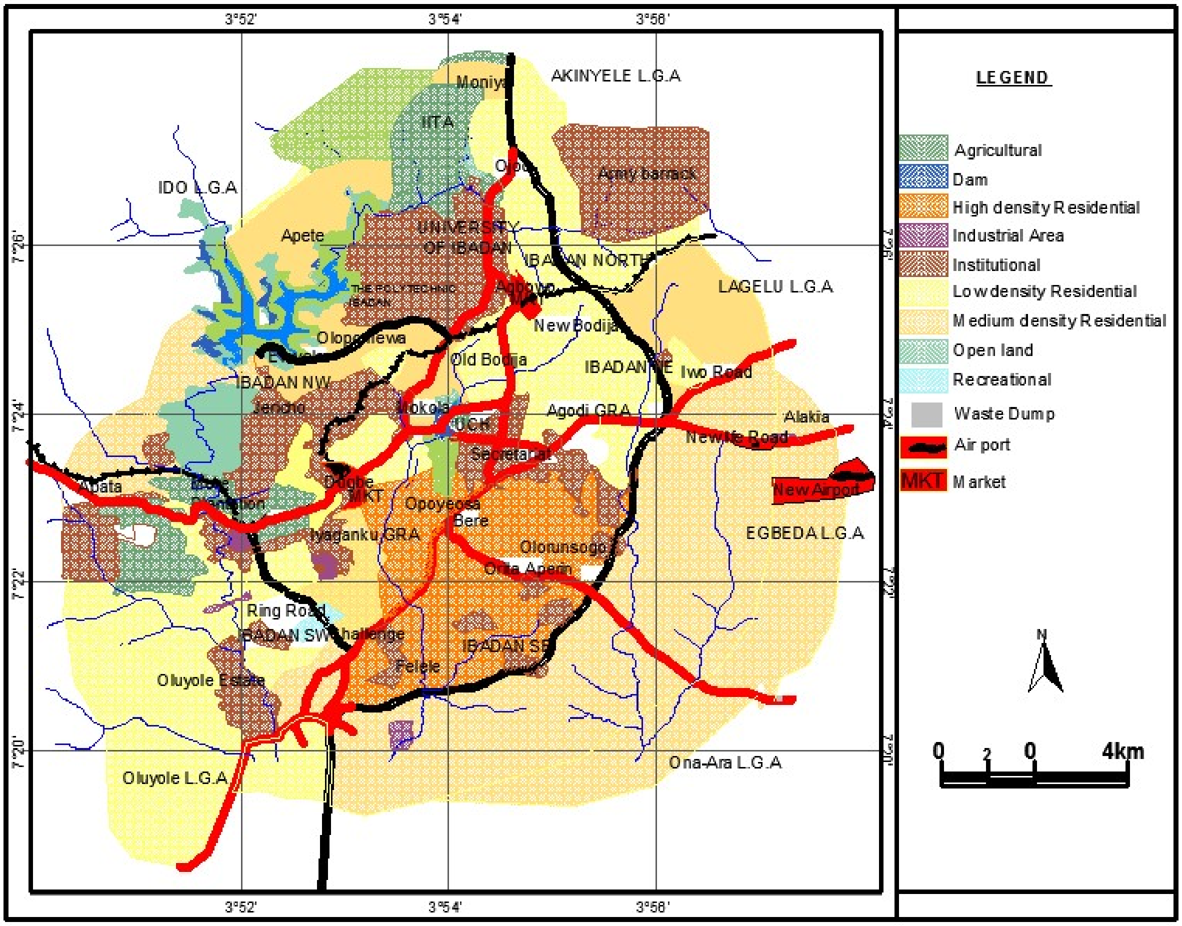

Fig.: 1.3: Land-Use Map of Ibadan
Source: Ministry of Lands, Ibadan (2015)

The core areas have mainly residential houses and are inhabited largely by the indigenous Ibadan people and early non-Yoruba migrants. The core area is of high density area –Beere Labiran, Oje etc., where the process of compound disintegration called growth by fusion may still be observed today (Mabogunje, 1968).

Commercial activities in Ibadan span Gbagi-Dugbe axis, Gate –Iwo road axis, etc. Dugbe is the modern central business district of Ibadan. Ibadan is an important education centre hosting institutions such as universities, polytechnics and over 100 secondary schools. It also harbours the largest teaching hospital in the country and other research institutes such as International Institute of Tropical Research (IITA), Nigeria Social Economic Research (NISER) and a host of others (Fig. 1.3)

1.8.9 Population Distribution of Ibadan

Ibadan metropolis had a population of 2,550,593 in 2006 projected to 3,294,260 in 2016 at 3.5 growth rate (NPC 2015). The breakdown of the population to the eleven local governments is as shown in table 1.1.

1.8.10 Windstorm and Pattern of damage in Ibadan

The maximum wind gusts speed reported for Nigeria western region between 1953 and1969 is 50 knots (Soboyejo, 1971) this is an indication that there has been a long history of occurrence of windstorm in south western states in Nigeria. The highest annual gale in Ibadan from 1984-1986 was 41 knots (Fagbenle and Karayiannis, 1994). However, since year 2000 the intensity of urban gale in Ibadan has been on the increase. The very first windstorm documented by OYSEMA for Ibadan happened on the 17th, 24th, and 29th of March, 2004 and 46 buildings were reported to have been destroyed in Oluyole LGA. This was followed by the windstorm event on the 26th of May, 2005 in Ona Ara LGA where 40 buildings were devastated. On the 6th of March, 2008 a major incident that ravaged 3 LGAs (Ibadan South West, Ibadan South East and Oluyole LGAs) took place. It affected over 1000 households and devastated over 1193 buildings. Thus, from 1989 to 2008, three windstorm incidents were reported. In year 2000, 52knots were recorded for an incident and since 2004 windstorm with peak gusts of 48 knots and above have become frequent in the city with each year recording at least one windstorm event (Adelekan 2010, Adelekan 2012).

Table 1.1: The Eleven Ibadan Local Government Areas, Wards and Communities

Local Governments Areas	2006 Population	Projected 2016 Population	No of Wards
Ibadan North-West	152834	197155	11
Ibadan South-West	282585	364534	12
Ibadan North	306795	397765	12
Ibadan South-East	266046	343199	12
Ibadan North-East	330399	426214	12
Oluyole	265059	341926	10
Egbeda	281573	363229	11
Iddo	103261	133206	10
Lagelu	147957	190864	12
Ona-Ara	202725	261515	11
Akinyele	211359	276653	12
Total	2550593	3294260	125

Source: Adapted from NPC 2015.

The neighborhoods ravaged by the windstorm that happened on March 2008, August 2011, February 2012 and February 2013 suffered physical damages to private and public buildings. Infrastructure spanning from the precolonial communities generally referred to as the inner core area of the city to most parts of the urban fringe as found in Oluyole LGA, Ibadan South East LGA, Ibadan South West LGA and Ido LGA and Akinyele LGA were affected (Adelekan 2010, Vanguard 2014, OYSEMA 2015). In February 2012, it was reported in the news that windstorm damaged six petrol filling stations at Olorunsogo and Akanran, Ire-Akari area, along Olomi/Academy. In 2013, around Soka area along Ibadan/Lagos Expressway, the roof of an industrial building designed for and being used for a feed mill on Anuoluwapo Street was blown off. The roof of the Divisional Police headquarters, Felele straight, Lagos - Ibadan expressway area suffered serious devastation in 2012. The roof of the new auditorium of the All Nations Evangelical Church, Idi-Oro area of Soka, was blown off in 2013. A storey building housing Jimbayad and Company at the Anfani junction in 2013 suffered devastation. Houses along the street at Idi-Arere Junction and Ayeye were devastated in 2012 and 2008. A school situated at Oke-Ode, Sanyo, Ibadan was also seriously affected. Fola Model School was not an exception in 2013. A private school, Montessori Careline, at Soka area, was attacked by windstorm in 2012 and most regrettably, the lives of five persons and four pupils were lost as a result of windstorm disaster occurrence (Adelekan 2010, Agbola 2012, Daily Times, Vanguard, Punch and Tribune). Statistics shows windstorm devastation as an annual occurrence in Ibadan from 1999 upwards as experiences in 2004, 2005, 2008, 2011, 2012 and 2013 and 2014 were particularly explosive, with an unprecedented rate of maximum gale up to three cases per annum (Adelekan 2010, IITA 2011 Agbola 2012, Vanguard 2013). In March 6, 2008 windstorm destroyed, 22 secondary schools and 4 primary schools in addition to over 1000 buildings that were devastated.

Beaufort scale categorised wind speed from 41to 47 knots as strong gale which has capacity to cause slight damage to structural facilities, dislodge roofing and break off large tree branches. The gust speed wind of 48 to 55 knots was branded storm wind and it has the capacity to uproot large trees and cause considerable structural damage. 1984-1989 gust speed highest value for Ibadan was 41 knots (Fagbenle and Karayiannis, 1994). From 1989-1998, the highest value for Ibadan was 52knots. From 1999 to 2008, the highest value for Ibadan was 46 knots. The highest wind speed value for 2008 and

2012 was 46knots. From 1953 to an over forty year period, the gust speeds in Ibadan have been oscillating between storm and strong gale. From 1999 upwards, the maximum gust speed in the city remained on strong gale and according to Beaufort`s wind speed scale of measurement, strong gale is the category of wind preceding storm. The gale occurred over 12 times between 2008 and 2012 and by 2020, the strong gales have remained steadily at 46 knots may have become storm wind as Ibadan continues to expand (Sewo and Olatunbara, 2015). Gust is a sudden onset of wind increase of at least 16 knots (30 km/h) or greater sustained for a period of one minute minimum. According to National Weather Service observing practice, gusts are reported when the peak wind speed reaches at least 18 mph and the variation in wind speed between the peaks and lulls is at least about 10 mph. The strongest wind gust ever recorded occurred at Australia's Barrow Island, with a gust of 253 mph during the incident of tropical cyclone Olivia on April 10, 1996. Gusts at the ground are caused by either turbulence due to friction, wind shear or by solar heating of the ground. These three mechanisms can force the wind to quickly change speed as well as direction(Popular Science, 1995). Gust wind was identified as a weakening influence over urban infrastructure with its ability to prepare buildings and infrastructure for structural failure during strong gale or storm wind occurrence (Bunting *et al* 1993).

Table 1.2: Windstorm disaster and pattern of damage in Ibadan

S/N	Date of Occurrence	Local Government Areas	Damages
			Buildings
1.	March 2004	Oluyole	46
2.	22/05/2005	Ona Ara	40
3.	06/03/2008	Ibadan South East	1049
		Ibadan South West	146
		Oluyole	85
4.	14/02/2009	Ibadan North	2
5.	26/02/2009	Ibadan North East	108
6.	27/9/2010	Akinyele	37
7.	26/08/2011	Iddo	23
		Ibadan North	40
8.	23/02/2012	Ibadan North East	1
9.	01/04/2012	Egbeda	2
10	30/06/2012	Ibadan North East	1
11	26/10/2012	Iddo	1
12	17/02/2013	Oluyole	1
		Egbeda	23
13	4/03/2013	Akinyele	114
14	22/04/2013	Ibadan City (Various)	22
15	02/05/2013	Ibadan South East	1
16	15/06/2013	Egbeda	1
17	20/06/2013	Akinyele	17
18	12 /03/2014	Iddo	113
19	16/03/2014	Ibadan South East	25
20	01/04/2014	Ibadan South East	243
21	01/07/2014	Iddo	2
22	09/01/2015	Ibadan North East	8
Total		**Seven Local Government Areas**	**2151**

Source: Vanguard 2013, OYSEMA (2015) and Authors Construct (2015)

CHAPTER TWO

Literature Review, Conceptual Issues and Theoretical Framework

2.1 Literature Review

The concern of researchers on windstorm disaster isn't always to find and categorise the characteristics of vulnerability to windstorm disaster, but also to systematically appraise windstorm disaster vulnerability and resilience factors, to make them applicable to the various windstorm disaster issues. This section reviews the relevant vulnerability literatures, their approaches, research designs, and indicators, instruments for data collection, analytical approaches, findings, research gaps and methodological issues. Also, the relevant concept, model and theories are also reviewed.

2.1.1 Household,Neighbourhood Characteristics, Vulnerability Indicators, and Windstorm Disaster Scale

Efforts of researcher in this field have been of great significance. Researchers such as Lorretti, (1996); Klimanek *et al*., (2008); Adelekan, (2012); Adebimpe, (2011) and Becarri *et al*., (2016), have strived to employ appropriate analytical method to explain the relevance of the factors, a typical example is that of Adelekan (2012). The research adopted cross-sectional approach and sought to identify the vulnerability factors subjecting Ibadan to wind hazard in view of the changing patterns of urbanisation, land use, land cover and wind climate in Ibadan, the largest (traditional urban) centre in Sub-Saharan Africa.

The questionnaires comprised semi structured questions on household and socio-demographic characteristics of respondents, their past windstorm experience, and their perception of the windstorm event. Also included were the social and economic impacts of the windstorm events on the respondents' households. Household and individual coping and recovery strategies were examined, and for each building, adult residents who had good knowledge about the windstorm event were interviewed. The derived data which were fixed into few dire scopes, (factors) or cluster of interrelated variables. The variables were then resolved into 6 dimensions and labelled: (i) Socio-economic and housing characteristics; (ii). Windstorm related damage and impact; (iii) Response and recovery measures; (IV) Risk Perception; (v) Adaptation strategies; (VI) Mitigating losses through insurance.

The studies reveal that vulnerability to windstorm hazards is high in the core areas of Ibadan. These areas are set in the traditional style and are characterised by poor quality and poorly maintained housing. Occupants are mostly indigenous populations of low socio-economic status. The study also reveals that the age and deteriorating nature of the buildings and infrastructure in the affected section of the city also exacerbate the resident's vulnerability. The risk perception of residents of the city`s core areas in relation to severe winds, along with changes in socio economic and environmental characteristics of study population over time, also contribute to the low adaptive capacity of residents to the windstorm hazard events in Ibadan.

The study notes that with the probability of increased frequency of stronger local wind events in the future as a result of climate change, urban vulnerability to windstorm hazard, especially in traditional cities, will increase unless a decisive action is taken to mainstream a consideration of climate and vulnerability profile of urban centres within urban development and planning.

Lorreti and Tegen (1996) examined disaster in Africa: old and new hazards and growing vulnerability. The study points out that disaster occurs when hazard and vulnerability meet. The research adopted theoretical approach to profile the 1995-1996 disaster incidents. The study established that Africans suffer over 60% of all global disaster related deaths. The study identified vulnerability factors in the region as environmental degradation, political and cultural instability, unplanned human concentration, and exponential city growth up to 7% per annum. Poverty, poor state of infrastructures and poor literacy levels were also identified.

The research notes that the impact of disaster is linked through complex causal chain. It stated that disaster still affect people directly by precluding production, destroying assets and stock, denying access to services, disrupting the environment and social fabric and wasting development opportunity. The study found that Africa is highly vulnerable to disaster and that it is easy for windstorm disaster for example to escalate and multiply its impact in Africa, just like Epidemic, Drought, Flooding, Agricultural pest and Bush fire.

2.1.2 Geographic Trends, Pattern of Spatial Differentiation and Risk Map

Maynard-Ford (2008) revealed Methodological approaches to record disasters at macro or household level in his research on mapping vulnerability to disaster in Latin America and the Caribbean, 1990-2007. The researcher claims the vulnerability of a population and its infrastructure to disastrous events is a factor of both the probability of occurrence of hazardous event and the community`s ability to cope with the resulting impacts. The objective of the research was to identify geographic trends in regional occurrence of disaster and vulnerability population. The study employed empirical approach and gathered data over a period of 100 years at administrative level to carry out the study. The fact that disaster mapping at the country level produces only a basic view of which countries experience various types of natural disasters while disaster mapping at the administrative level shows which geographic areas of the country including populated areas are historically most susceptible to different hazard types, justifies the scope (administrative level against national and regional levels).

The research adopted UNDP`s, (2004) definition of vulnerability as the condition that determined physical, social, economic and environmental factors or processes which increase susceptibility to impact of hazards. They identified disaster as spatially referenced circumstances which could be captured through information such as the name of incident country, name of disaster, date of occurrence, incident location, geographical coordinate and comment (river basin etc). They asserted that the ability to spatially tie events to administrative boundary level enables the creation of maps with more regional details using hotspot methodology which is the combination of probability of exposure and historical vulnerability and EM-DAT data. EM-DAT identifies areas historically prone to disasters, while the hotspot identifies grid level areas at risk of hazard. The research also identified standards for recognising events as a disaster based on EM-DAT requirement: 10 or more people killed, 100 or more people affected; a call for international assistance; and national declaration of a state of emergency.

The research adopted GIS overlay analytical method to analyse spatial data collected based on information on location, disaster type at the disaggregate administrative district level to produce individual district map and the Topographical map that were then processed using ESRI ArcMap 9.2 overlay at the dataset in GIS. The output were the Disaster Map underplayed by digital elevation model (DEM) which adequately articulates the connection between disaster location, concentration and landscape. The research found that the disaster map was able to display the storm track of the nine greatest windstorm disasters in terms of number of people affected. The windstorm track that was displayed in the disaster map emphasized the vulnerability of the incident areas.

The research noted that the mapping of vulnerability to disaster at the administrative level enables the viewer to see a more localised resolution of past vulnerable population. Trends in the data suggests disaster occurs most often in places that are highly populated. According to EM-DAT, a disaster occurs when a certain number of people are affected. The paper notes that without the presence of people, major events are not devastating and not considered to be disaster. Also, high concentration of population was identified to create a more vulnerable environment. It was concluded that human activities increases vulnerability to disaster.

Klimanek *et al*., (2008) in their study on geo-information analysis of factors affecting wind damage in the Sumava national park adopted the GIS method to determine vulnerable areas and to produce disaster risk map. The study was singled out as a test area for the remotely accessed decision support system for environmental risk management. The study focused on cross border analysis, classification, quantification and resolution of environmental problems. The study aimed at analysing pattern of spatial differentiation in wind throw events in the Sunava National Park caused by windstorm kyrill and to produce proposal for concrete measures that will alleviate the effects of windstorm in the future. The main objective of the study was to establish a remotely and commonly accessed system for risk management at transnational level. The study used GIS tools and a geodata base for analysing forest vulnerability to wind in a purposely selected Czec and Bavarian border in the Sumava region. The study employed both empirical experience (measured features value) and mechanical computing using physical features of individual trees, forest stands and damaging winds. The data for the analysis was retrieved from Sumava National Park`s administration.

The decisive factors considered for integration into the analysis based on analysis of preliminary data and field research are (i) Natural factors (direction and strength of wind; the configuration of the terrain; slope gradients; exposure and curvature and the forest site condition; soil depth and moisture regime (ii) Anthropogenic factors (Species; Age and spatial composition of the forest stand). The procedure included mapping of affected area after wind throw with GPS, construction of digital model of the terrain using topographical map at scale 1:25000, maps of exposed production of slope gradients, and relief curvature. Soil and moisture condition of the site was also produced using secondary data. Wind direction and speed data were retrieved. The relationship between wind throw occurrence and the relevant natural and forestry factors were evaluated based on digital terrain model and data attached to the digital forestry topographical map. The methodology thus produced an integrated risk assessment map. A map that was further subjected to map algebra. The resulting values were then divided into five categories where five represents the greatest risk based on their estimated susceptibility to wind damage. The relationship between risk rate of a spot area and occurrence of wind throw during windstorm kyrill was then compared on the resulting map.

The study identified three components of risk areas as regards vulnerability factors that initiated outbreak of disaster; geological (morphological); meteorological (climatic, hydrological) and biotic (caused by man). The study found that every wind throw incident is unique because there are wide variations between the results of each analysis. The incident reoccurs regularly though at unregular intervals and some areas were more susceptible to wind throw than others. The study noted that the relationship between the damage caused by the winds and other natural factors vary that terrain features have partial impact on the area of windrow distribution; that the more damaged stands were generally found in the area around gentle slope sites of 8-15 degrees; that the leeward side of elevation with respect to general wind direction (not local), were heavily damaged; that windward areas were mildly damaged. The study also noted that the landscape, its configuration, and the character of the surface played a vital role in modifying both the wind direction and speed and the winds devastating power. The study suggested further study on the effect of aerodynamic factors and recommended use of the wind throw risk map for regional planning, disaster management and in formulation of future forest management measures.

2.1.2.1 Physical Indicators and Windstorm DisasterVulnerability; the Global Perspective

In the spectrum of natural hazards, several researchers have explained some discrete categories of climatic/meteorological menace. Amongst these are; Burton and Kates (1964), Bryant (1991) and Jones (1991). Others, like Smith (1992), used the terminology, "atmospheric" hazards such as, fog, snow, frost, hail, lightning, tornadoes, windstorms, temperature extremes, etc., for their classification. These climate hazards are not single element hazards, but compound element events, such as thunderstorms, windstorms and torrential rainfall where multiple elements combine to increase their vulnerability. Windstorm occurrence appears frequently in a region where hazardous situation enhances storm risk. Such regions as coastal communities, the Caribbean, Western Pacific Northern Atlantic, Bangladesh and Northern America are particularly vulnerable to globally-recognized damaging wind (Eves, 2003; Kahn, 2005; Dilley *et al*., 2005; Living with Risk, 2006; Zenklusen, 2007; Schumacher and Strobl, 2008; Erlambang, 2008). Disastrous meteorological events are therefore peculiar to the coastal part of North America, and Asian countries. In these areas, vulnerability to hurricane, tornado, cyclone, typhoon etc., is high (Marnard-Ford, 2008). According to Sherbinin *et al*., (2007) windstorm disaster prone cities, such as Mumbai, Rio de Janeiro and Shanghai are vulnerable because of their locations. i.e, most of them are located on or near the coast, in low lying areas near the mouths of major rivers. These locations place global cities at great risk of climate hazards. Amongst the vulnerable population are women, children and older adults. Factors such as inability to access health facility, sexual assault and substantive rape during disaster also tend to aggravate their vulnerability (Walter, 1998; Bokszczanin, 2007; Rosenkoetter et al., 2007; Thornton and Voigt, 2007).

Literature revealed that 100 cities with largest population around the globe were mostly (78%) vulnerable to windstorm disaster. In developing countries however, 86 per cent of city dwellers are vulnerable. Much more vulnerable also, are the urban poor, because they live in hazardous areas and by extension build hazardous dwellings. They have fewer resources, which makes them more susceptible to disasters. They are less likely to receive timely warnings. Even if warnings were issued, they have fewer options for reducing losses in a timely manner. The poverty level affects the resilience and process of recovery from disasters. Thus, researchers recommended that disaster mitigation, preparedness and prevention programmes must be designed to address socio-economic issues, not only geological and meteorological aspects (Degg, 1992; Grunfest, 1995; EM-DAT, 2002; IFRC, 2002; Masozera et al., 2006, Kellenberg and Mobarak, 2007; Ginger et al,, 2011).

The most vulnerable regions to climatic disaster are the developing countries in Asia and Africa (Guha-Sapir et al., 2004). Asia and Africa bear disproportionate burden of losses to disasters. Over the last 30 years, approximately 88% of the total people reported killed and 96% of the people reported affected live in these two regions. Over the last decade, more than 75% of the total number of people killed by disasters worldwide were in Asians. Of these are 98% for droughts and famine, 72% for earthquakes, 71% for avalanches and landslides and 56% for wind-related disaster. Of the total of those reported killed by volcanic eruptions, Africa takes the lead with 62% thereabout. Only forest/scrub fire fatalities are more or less evenly spread out across the world, with 27% in Africa, 24% in the Americas, 25% in Asia and 22% in Europe. Africa has not been captured as a hot spot for extremely damaging wind, since frequency of global natural disasters taken over a 30years period (1973-2003) showed low windstorm disaster profile for Africa (Guha-Sapir, 2004). The vulnerability of a community to wind disaster is dependent on the exposure of houses, infrastructure and services (Sanderson, 2000; OCHA, 2000; Walter, 1998; Levine et al., 2007; Ginger et al., 2011). The 56% windstorm disaster vulnerability factors identified are socio-economic stress, aging and inadequate physical infrastructure, weak education and poor and or absolute lack of preparedness. Insufficient funding for preparedness, response and mitigation by emergency management institutions. Poor building code enforcement, faulty plan and design, and poor construction, were also identified. Thus, researchers concluded that the effect of disaster in developing countries has out-weighed that of developed countries. Hence, several factors associated with low level development exacerbate such effects and that the impact of natural phenomena on the prospects for long term development is considerably greater in less developed countries (Cheney, 1995; Bell, 1999 cited in Eves, 2003; Department of Community Services, 2002; Henderson, 2004; Johnson, 2007; Ede, 2011).

2.1.3 Windstorm Disaster adaptationsand Mitigating Strategies

As part of the action required to mainstream vulnerability to windstorm disaster in the city, Mijinyawa and Awogbuyi, (2011) carried out a study on development of a wind rosette for farm stead planning in Ibadan environ, Nigeria. They examined the (vulnerability) factors that determine the severity of wind load imposed on structures in Ibadan. The objective of the study was to determine the prevailing wind direction in Ibadan in order to appropriately orientate wind pressure withstanding structures on the farm buildings and residential buildings in Ibadan. The study employed longitudinal approach which identified the distribution of wind direction and speed experienced at four cardinal points in Ibadan for a period of 20 years, 1990 to 2009. Data were analysed using percentage of frequency of occurrence. The study found the South West wind (easterly wind) as the prevailing wind in Ibadan. This finding was established on Atlantic Ocean South Westerly wind direction.

The result revealed that different buildings require different orientations to the prevailing wind direction and inappropriate orientation will expose the building to structural damage or reduce its efficiency. In order to reduce vulnerability of farm buildings to windstorm devastation and to minimise the devastating effect of winds on structures. The study recommended that buildings in Ibadan should be orientated in South East direction and located on the windward side of a farm.

Mijinyawa and Awogbuyis`s (2011) recommendation that buildings should be oriented on their windward sides so as to mitigate vulnerability to windstorm disaster in Ibadan has become necessary to foster housing sustainability in the country. It is obvious that the policy making bodies in the country do not adequately cater for the needs of disaster victims. Adebimpe (2011) in her study on climate change related disaster and vulnerability; an appraisal of the Nigeria policy environment opines that emergency situations arising from natural disaster such as windstorm and human made disasters are common and vary in space, time and magnitude. She identifies events such as rainstorm as being capable of producing devastating effects on livelihood in Nigeria. The study employed crossectional approach which harnessed the experience of female farmers in

Ilorin along three streams (River Asa, River Amukle and River Aluko) both during the dry season and at the onset of rain. A survey of 120 women was done a structured questionnaire to elicit information on their experiences during incident of disaster.

The study found that most of the women interviewed are either divorcees or widows and therefore has a need for social support. During the early rains of the 2006, most of these women lost their farmland to the flooding and their homes were devastated by the windstorm that accompanied the rain. The relief materials distributed as intervention by the government agency building materials and household items. The study also found that the funding of relief items given during incidents of disaster is rested on the federal government. This is done via the disbursement of an Ecological Fund to NEMA, the National Emergency Management Agency which is responsive for creating policies and institutional framework to fund disaster. The production of Eco-Climate Atlas Map is also identified as one of the important ways to tackle natural disaster in Nigeria.

According to the study, the prospect for poverty eradication in Nigeria may be worsen if actions are not taken urgently. Suggested action includes the implementation of policies that will reduce vulnerability, achieve equitable growth and improve the governance and institutional context in which poor people live to reduce vulnerability should be rooted in vulnerability analysis and the understanding of both household level and macro response options that are available to decrease the poor`s exposure to climate risk.

Natural disasters may intensify reductions in livelihood, disruptions in socio-economic activities, and reduction in levels of life satisfaction. Yet, the degree to which a country is affected depends on a number of proxies for institutional quality, including measures of democracy, educational attainment of the population, level of corruption, macroeconomic conditions, income inequality, and ethnic fragmentation. In addition, researchers have discovered that greater educational attainment, greater openness, and a strong financial sector may help to boost the tensile strength of community to disaster (Kellenberg and Mobarak, 2011; Toya and Skidmore, 2007). Africa is a home to disaster occurrence as a result very high urbanization rate (Diagne, 2007). In developed nations however, this is not applicable they have the capacity to protect their properties from the devastating effects of windstorm disasters. They design and enforce building code, develop early warning systems and provide effective and timely care and assistance during and after emergencies (Kahn, 2005; Escaleras and Register, 2008).

Coping mechanism and other measures to combat and lessen the effect of damaging wind can be differentiated into several factors. In advanced countries, literatures indicates that weather forecasting, building codes, public awareness, disaster alarm and building retrofitting for more resilient communities and people are recommended. These measures are used to predict, tolerate and or moderate the effects of windstorm. Though these technologies may not have efficiently controlled the incidences of disaster; they have offered opportunities to researchers to examine the past and learn new ways to cope with disasters. Also, dependence upon external technologies and supplies when disaster occur has impeded maximal utilisation of indigenous knowledge and local mitigation practices in teaching disaster preparedness and mitigation (Bhandari et al., 2004; Henderson and Ginger, 2008; Dotto et al., 2010).

Considering the risk of disaster adaptation and its respective expenditure, Schumacher and Strobl (2008) found that an increase in wind damage vulnerability increases adaptation expenditure. While developed nation's benefit from their technologically driven facilities, less developed nations expend their wealth procuring these facilities and therefore suffer great economic loss when disaster occurs. Also, is another evil that must be nipped on the bud as a natural disaster mitigation measure. Studies shows that most poorly constructed urban facilities are built by corrupt contractors who bribe government regulators to secure their contract. They therefore lower construction cost and increase safety risks. Regulators who have been earlier bribed have no other choice than to approve structures that do not meet required standards. When disaster therefore occurs, the impact of corrupt practices in the regulatory bodies are felt. The model predicts that, the level of public sector corruption in a country will have a significant positive effect on the number of fatalities from natural disaster such as damaging wind (Escaleras et al., 2007).

Implication of external factors to disaster mitigation has also been considered. A typical example of this factor is international financial flows into a country following a natural disaster. Researchers examined the response of various types of financial flows, including official development assistance, loans from multinational institutions, bank and trade-related loans, foreign direct investment, portfolio investment, and migrants' remittances following damaging wind and found that official development assistance is the only type of international financial flow that responds in a significant manner to damaging wind and that the response of official development assistance to devastating windstorm tends to be greater for poorer countries than richer countries. Whereas richer countries are better able to engage in self-insurance prior to the occurrence of hurricanes, poorer countries are more reliant on external funding sources. In many cases, such development assistance is substantial, replacing nearly 80% of the economic damage following a devastating wind occurrence. However, they also found that most response to storm occurrence is aided by the level of news coverage of such storm (Roy et al., 2002; Eiseensee and Stromberg, 2007; Yang, 2008).

Using technology as mitigation measure against disaster was discussed by Annunziato (2007), who examined the Tsunami Modelling System developed by the Joint Research Centre. The Tsunami Assessment Modelling System was developed by the European Commission, Joint Research Centre, to serve Tsunami early warning systems such as the Global Disaster Alerts and Coordination System (GDACS) in the evaluation of possible consequences of a Tsunami of seismic nature. The Tsunami Assessment Modelling System is considered operational and has started calculating in real time all the events occurring in the world, calculating the expected tsunami wave height and identifying the locations where the wave height should be too high. Information gotten from this site is essential for evacuative plan and other measures to avoid extreme vulnerability to disaster.

Although, earlier paragraphs have succinctly outlined windstorm disaster mitigation strategies in Nigeria, yet, in the past few decades, mitigating windstorm disaster has remained one of the most unattainable expectations of majority of the victims of windstorm disaster in Nigeria (Adelekan, 2010). Since mitigation of windstorm disaster vulnerability is no doubt an important research focus, the ultimate aim of any research in this area have been to prepare and to mitigate the vulnerable communities' against further devastation. So far, the criteria guiding preparedness and mitigation have been based on foreign standard rather than the combination of both foreign and local knowledge (Mercer et al., 2007; Kahn, 2005; Escaleras et al., 2008) themselves posited that developed nations are more capable to protect against the devastating effects of windstorm disasters by designing and enforcing building codes, developing early warning systems, and providing effective and timely post disaster emergency care and assistance. This is not the case in Nigeria where the mitigation approaches of the developed nations is being used in a developing nations without any attempt at adaptation (Diagne, 2007). Therefore, the tasks confronting environmentalist, planners and policy makers and other disaster management profession, are to be able to identify the local factors which determine preparedness and windstorm disaster vulnerability mitigation, and use them as inputs to windstorm disaster vulnerability management.

2.1.3.1 Storm Predictions

Storm prediction is a modern and an acceptable way to mitigate the effect of storm on man. Amongst the technology developed in line with this assertion is the Wind profiling radar (WPR), an upper-air remote sensing system. The system can monitor and detect various weather events in a convenient and real-time manner, and can depict the detailed structures of atmospheric motion. Moreover, it can retrieve the distribution of temperature advection with time and height by adopting high-resolution wind profiler data. It can also address a wide range of scientific issues including wind field detection, numerical weather predictions, precipitation processes, and rain droplet spectrum retrieval analysed the vertical structure and evolution features of rain clouds by utilizing the return signal power of WPR (Udogwu et al., 2009; Wang et al., 2012).

2.1.3.2 Social Support

Social support and humanitarian aids were described by Soneye (n.d.) as outcomes of the concerns by stakeholders over losses associated to disaster. Soneye (n.d.) identified four priorities of the social/humanitarian support as authenticated by Darcy and Hofman (2003); as; Protection of life, health, subsistence and physical security. He also identified the flows of the support via government, charitable non-governmental organizations and private donors for general support and rehabilitations/reconstruction as the case may be (Smith and Petley, 2008). Soneye found that private individuals ranked first in humanitarian support for Lagos victims of disaster for a period of 2010-2012; while government agencies tailed behind. Corporate organizations however ranked the least amongst the 6 donors (Private individual 1st, Government Agencies 2nd, Community based Organisations 3rd, Religious group 4th, Non- Governmental

Organisation 5th and Corporate Organisations 6th) investigated. The research concluded that though disaster forecasting and preparedness is deficient in Nigeria, yet, coordination of field rescue operations and support for victims is unfortunately uncoordinated.

Public response to disasters commenced in 1976 with the creation of the National Emergency Relief Agency (NERA). It was renamed National Emergency Management Agency (NEMA) in 1999 (NEMA, 2011; Adebimpe, 2011) Its objectives are to: (i) formulate policy on all activities relating to disaster management in Nigeria and coordinate plans and programmes for efficient and effective response to disaster at the national level; (ii) coordinate and promote research activities relating to disaster management at National level; (iii) monitor the state of preparedness of all organizations or agencies, which may contribute to disaster management in Nigeria; (iv) collate data from relevant agencies so as to enhance the forecasting, planning and field operation of disaster management; (v) educate and inform the public on disaster prevention and control measures; and, (vi) to coordinate and facilitate the provision of necessary resources for search and rescue and other types of disaster curtailment activities and distress call. NEMA was designed to be supported by its state counterpart to manage ensuing disaster operations at respective local levels. Nevertheless, the primary source of financing NEMA and its activities is a proportion of the Nigerian`s ecological fund -a certain proportion of oil revenue set aside to tackle environmental problems and emergencies (Adebimpe, 2011).

2.1.3.3 Insurance

The greatest challenge of any insurance company may be the imbuement of clients who suffer from massive occurrence of large scale disaster. Though, natural disaster insurance has been considered as one of the most efficient ex-ante mitigation strategies in handling material loss; yet, research has shown that natural hazard insurance is very limited in the relief it can proffer. Also, individuals underestimate the probability of the occurrence of a natural disaster, thus their refusal to fully insure their properties against natural disaster. Private insurer, on the other hand are often reluctant to offer insurance against natural disaster such as hurricanes, floods, earthquakes due to the uncertain nature of low-probability, high-loss risks and the potential for large-scale disasters to result in financial insolvency. Thus, a mandatory comprehensive disaster insurance for the disaster-prone areas, was suggested as a mitigation factor. In the absence of appropriate disaster insurance, property owners with bank loans have the incentive to shift the risk of disaster to banks. In response, banks offer fewer loans in risk-prone areas when there is an under-provision of insurance in markets. The mandatory insurance, suggested by Kunreuther and Pauly (2006), could help to alleviate this distortion in bank credit markets (Kunreuther, 1996; Kunreuther and Pauly, 2004; Kunreuther and Pauly, 2006; Kunreuthe et al., 2007; Raschky,2007; Garmaise and Moskowitz; 2009; Chen et al., 2009). Although, insurance with high premium may be suggested, and individuals might be sceptical about disaster insurance, yet, research, reveals that insurance may not be an all-dependable mitigation. This is because when natural occurrences are adequately covered by insurance, and or enjoy financial aids across quarters, these only replace the physical losses and not personal losses, such as keepsakes and memorabilia, not to mention the emotional stress on the house residents (Department of Community Services (DOCS), 2002).

2.1.3.4 Policy Formulations

It is the duty of any responsible government to protect her citizen from internal and external aggression, natural and man-made disaster and self-inflicted chaos. Amongst the strategies adopted to safeguard the public from natural disaster are policies designed to ameliorate, caution and or out-rightly prevent community vulnerabilities to both natural and man-made disaster. According to Hallegatte and Dumas (2009), institutional policy on technological improvement is part of the ways in which government can meaningfully contribute to disaster mitigation. Government investment in upgrading technology would create additional short-term costs but would lead to long-term productivity gains in terms of safety to lives and properties and other associated effects of disaster such as keepsakes and memorabilia DOCS (2002). It has been strongly recommended in developing countries, to evolve policies that can safeguard agricultural produce. This will serve as a strategy against short-term income losses to agricultural communities. Reforestation, available insurance policies, and encouragement of relocation from disaster prone areas are issues the government can work on in their policy formulation (Smith et al., 2006; Kellenberg and Mobarak, 2007; Banerjee, 2007).

Smith et al. (2006) opines that movement away from the disaster risk areas is an area government could invest in. Researches, however, found that higher-income households are relatively unaffected and are therefore less likely to move following a micro scale wind disaster incident. This observation is consistent with the theory that higher-income households have the resources to self-protect. They “build damaging” wind-resistant structures that are insured. Middle-income households avoid construction of structures in area that are at risk low income households, income, tend to move into damaged areas to take advantage of low property prices and the increase in perceived risk i.e. reliefs given when disaster occurs. Thus, the need to tactically develop a government policy to encourage populace to move.

2.1.4 Resilience, Indicators and Windstorm Disaster Vulnerabilities

Recent attempt directed at evaluating variables required to capture, process, analyse, and present disaster information were examined by Becarri *et al.,* (2016). The research examined a comparative analysis of disaster risk, vulnerability and resilience composite indicators. The study adopted empirical approach to analyse 126 grey and academic literatures and 106 methodologies used by researchers to determine the composite indicators for comparing nation’s performance in disaster risk, vulnerability and resilience from 1st of January, 1990 to 31st of March, 2015. The literature selected for study were contemporary researches that addressed multiple and or all hazards using methodologies, variables and data collection procedures that have been tested, verified and implemented. Data of index construction, geographic areas of application, variable used and other relevant data were analysed. The criteria qualifying literature for inclusion were composite indicators either spatial or through the use of scorecard; disaster vulnerability or resilience of total risk; focus on multiple/ all hazards; communities or government target not household; full methodology published or publicly available; focus on meteoroidal or climate vulnerability and those that adopted tested implemented framework. The data (literature) were sourced through Vuwiki, Scopus, Web of Knowledge, and google scholars using snowballing approach.

The study found that methodological approach used by most of the researchers focused mainly on hierarchical and similar deductive method, principal component analysis, stakeholder focus group discussion, relational analysis and novel statistical methodologies. Also, research found that vulnerability variables selection methodologies adopted by most researchers indicated that variables for collecting data for vulnerability disaster are chosen by expert judgement; through literature theory and from model and stakeholder`s knowledge. The research also found that vulnerability data collection methodologies were sourced from existing data collected by the government or national statistics agencies and non-governmental organisations; household survey; workshop or survey of relevant stakeholders. The research found principal component analysis as the most used statistical weighting method. As regard index construction and aggregating, both induced and deductive approach were used to construct models. The research also found that most researchers presented their results using maps and tables, interactive display, risk management index, economic vulnerability index, rural resilience index, and resilience capacity index. The research indicated that those researches relying on national statistics use fewer variables while those depending on household data through questionnaire uses more variables to garner data.

The indicators used by most of the researchers to measure disaster vulnerability include population density, unemployment rate, population of 65 years and above, GDP per capital, percentage of female population, doctors per population, literacy level, total population, bed in hospital per population, percentage of individual below poverty line, Gini index, unemployment, old age, population in poverty, household water access, young age, income, housing tenure, warning system, hazard and exposure, transport, disaster impact, demography, education, health, service and infrastructure, economy, labour market, livelihood, housing and household asset, disaster resilience, civil society, geography, environment and government policy.

The study noted that a broad range of practice in the development of composite indicator for the measurement of disaster risk vulnerability and resilience shows that there is a substantial diversion in the literature. There are ranges of variables selection approaches, data collection methods, normalisation methods, weighting methods, aggregation approaches and variables being used. The research concluded that hierarchical approaches are easy to construct and are relatively simple to understand. Principal component analysis was also commonly employed with many cases influenced by the 2003 publication of Cutters social vulnerability index, while results were communicated using maps.

2.1.4.1 Indigenous Knowledge

The natural environment has become more vulnerable to hazardous events in a number of very complex ways in type, frequency and magnitude (Burton, Kates and White, 1993) and as opined by Vitek and Berta (1982), the inhabitants of hazardous environments have acquired accurate perceptions and knowledge of the natural hazards peculiar to their areas, thus the need to kick start hazard study that seek to garner knowledge from the indigenous population.

Indigenous knowledge, (UNEP, 2008), is broadly defined as the knowledge used by local people to make a living in a particular environment. Indigenous knowledge reflects many generations of experience and problem-solving techniques by ethnic groups at the local level. No country has same experience with another. Indigenous knowledge became an internationally acknowledged school of thought in the field of environmental studies during the United Nations Conference on Environment and Development (UNCED) held in June 1992 in Rio de Janeiro.

Indigenous knowledge has been applied to mitigate storm in some quarters (ISET, 2012). Reinforcing houses, placing heavy material such as sandbags on roofs, fastening the roof to walls, and reinforcing doors and windows, are among indigenous disaster coping strategies identified in the literature (ADPC, 2007). Other methods are holding doors in place, anchoring the roof to a structure, or hiding under beds. In cases of extremely strong wind such as typhoon, research encouraged likely victims to move to safer places such as neighbour's houses or public buildings nearby.

Research also revealed that vulnerability of indigenous population to wind hazard in developing countries can be addressed through the utilization of both indigenous and western knowledge in a culturally compatible and sustainable manner, though, great importance was attached to the adoption of local knowledge. Yet, combination of both local knowledge and western strategies were recommended to mitigate devastating wind (Mercer et al., 2007). Based on research, local perception, experience and knowledge of natural hazards, are more often deficient and unreliable unlike documented and research based studies (Agusomu et al., 2011).

Ibidun and Gbadegesin (2005) analysed the public perception of climate change issues in Ibadan. Their research was based on the experience of the citizens on climate perception in their local and global environment. The research found that very high percentages of the indigene are aware of the dynamics and the phenomena of the local climate. Also, Agusomu et al. (2011) studied the Perception of Natural Hazards in Riverine Communities of Bayelsa state. The paper found that Awareness and Perception of Natural Hazards phenomenon by the riverine communities is very high; i.e. the indigenes were fully aware of the incident of windstorm, floods, landslides, river-bank erosion, etc. A greater awareness of windstorms and tidal events was particularly noticed among the coastal dwellers. It was then concluded that the residents have developed a keener perception of hazard in the study area. The paper states that public education via mass media played an important role in the overall awareness of the populace and therefore concluded that hazard perceptions are better acquired through education.

2.2 The Concept of Vulnerability / Vulnerability of a Place

The degree to which a place is likely to experience harm due to exposure to biophysical and social vulnerability hazard or stress is referred to as Place Vulnerability (Cutter 2000; Pelling, 2003). Vulnerability concept was originally designed to study environmental risk, hazard, impact of climate induced disaster and resilience. The main tenet of the concept of vulnerability was to dissuade absolute attention on environmental, socio economics and technological hazard. As conceived, such focus may not be adequately sufficient to understanding the right response social group, ecosystem and place hazard (Mitchel, 1999; Pine 2003). Vulnerability concept shows that system's capacity to lessen stress by adopting multiple strategies majorly defines the system response and impact ability. Thus, understanding coping mechanism further elucidate where and what risk is involved and the possibility of hazardous circumstances turns into risk and impact places at risk of windstorm disaster (Turner et al, 2003).

Vulnerability as viewed by social scientist have basic elements namely (i) system exposure to situation; (ii) stress and shock; (iii) system ability to cope; (iv) consequences and (v) risk resulting from system with sluggish and or week recovery process. It is suggested that the category of people, region, city or places considered to be highly vulnerable those with susceptible environment. Often, the ability for this group of people to respond adequately and recover from disaster is usually weak. The nature of social vulnerability generally depends on the nature of hazard to which the human in question is exposed: although, social vulnerability is not a question of hazards severity or probability of occurrence. Certain property of system will make it more vulnerable to certain types of hazards than to others. For example, quality of housing is an important determinant of a community`s social vulnerability to windstorm. Vegetal cover also defines the biophysical vulnerability to windstorm disaster. The combination of both defines vulnerability of a place in windstorm disaster vulnerability study. Ibadan vulnerability to windstorm disaster will be evaluated through this concept. Social vulnerability indicators which includes population of women, children below 14, housing unit, housing quality and mean house rent will be merged with biophysical indicators such as Windfield zone, rate of windstorm occurrence, average elevation ratio and vegetation cover to develop the neighbourhood vulnerability map of Ibadan.

Hazard of place model of vulnerability, evolved by Cutter (1996) viewed vulnerability using both physical and social susceptibility approach (Figure 2.1). Cutter et al (2000) considered and combined physical and social factors to examined vulnerability of a specific place or neighbourhood thus the need to examine Ibadan based on the algorithm of this model; risk, mitigation and factors that brings about hazard. This is necessary because risk and mitigation combine to produce hazard. Risk, is the probability of and event occurring through a process which includes; the potential source of the risk (e.g., coastline windstorm devastation), the effect of the risk either high or low and the rate of occurrence. According to social amplification model in Cutters (2000), risks may be lessen by been proactive and by adoption of mitigation policies and measures.

Vulnerability of a place is therefore the sum of negative environmental factors, combining with external forces to disrupt the system of a place. A place experiencing different kinds of external forces thus increasing the stress release by these negative external factors is a replica of the stress experienced by the neighbourhood found in the study area. it is important to note that when negative environmental forces merged with a perturbed society, the result is often hazardous. When economic recession reduces one ability to cope with hazardous circumstances, created by the merger of both perturbed environment and society as the case of Ibadan, the vulnerability of such system becomes enlarged. Associated risk resulting from this enlargement are from multiple sources, with different scale. Thus, environmental risk (biophysical) and societal risk (social) often merge to produce adverse consequences (Wisner, 2001; and Pine, 2003).

As an extension to the hazard of a place model of vulnerability, emphasis is placed on the political “root causes” of disasters because societal structures result in differences in the level of impact of disasters on communities. Disaster risk can be defined as the interaction of natural hazard on one side and vulnerability on the other. The structuralism’s view of disaster is that economic and

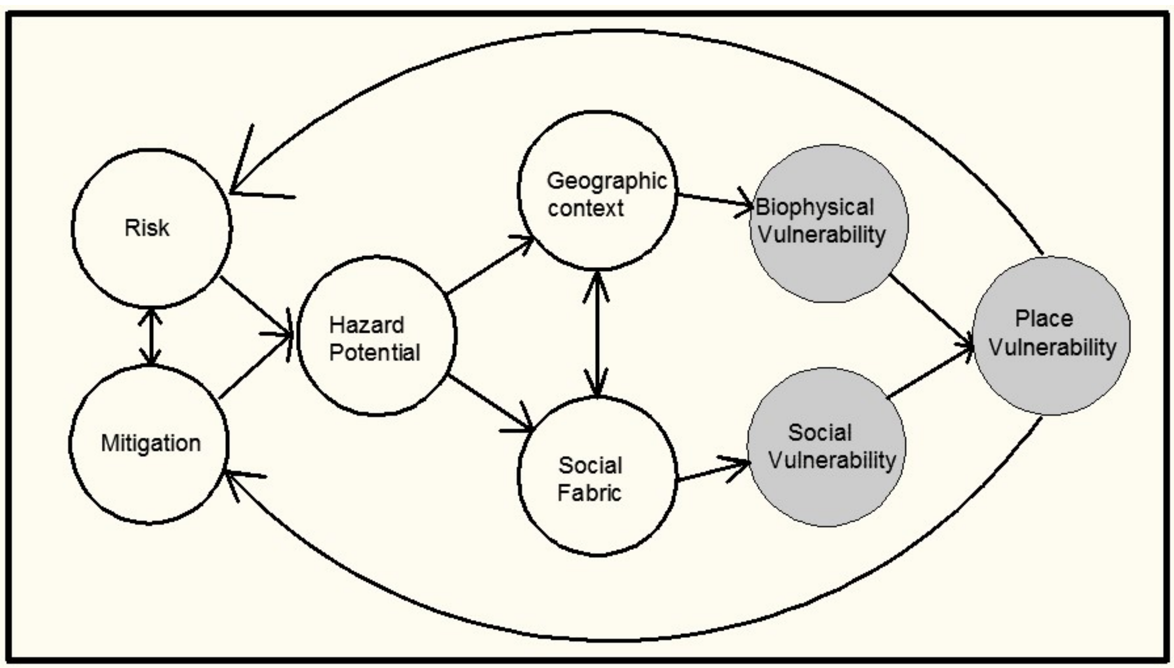

Figure 2.1:The Hazard of a Place Model of Vulnerability adapted from (Cutter, 2000)

Risk and mitigation interact to produce the hazard potential, which id filtered through social fabric to creat social vulnerability and the geographic context to produce biophysical vulnerability. The interaction between biophysical and social vulnerability create the place vulnerability.

political power discrepancies leads to uneven distribution of vulnerability, risk and disaster effects. As a result of this, great emphasis is placed on social, political and economic exclusion of the poor and powerless (Hewitt, 1983; Anderson and Woodrow, 1989; Blaikie et al., 1994). The solution to social exclusion from policy arena would then be the transformation of social and political structures that breed paucity and the social dynamics that serve to perpetuate it (Heijmans and Victoria, 2001). International relations affect the degree of local vulnerability. For example, Structural Adjustment Programme in Africa, a World Bank policy, encouraged situations of mass urbanisation, which negatively affected the environment and caused migrants to settle in unstable and unsafe locations, making them create disaster prone situations through environmental degradation in their justifiable quest for sustenance (Hamza and Zetter, 1998) which is a it a highly political concept. Disaster management in this field would need to focus on political and social changes at the local, national and international levels (Christoplos et al., 2001).

Technical experts, such as engineers and architects, have also explained the fact that natural hazard has varying impact on different kinds of structures, such as buildings. As a result, the characteristics of a disaster became more associated with its physical impact than with the natural hazard. Interest grew in the design and implementation of ways to mitigate losses through physical and structural measures to increase the resistance of structures to reduce hazard. Unfortunately, the cost of physical mitigation does not meet most countries` efforts to reduce risks by these means (UNDP, 2004). This this further affirms why a separate focus on both the traditional approach (physical characteristics) and the modern approach (social characteristics) in the study of vulnerability is most appropriate.

Since the 1080`s and 1990`s, arguments from researchers in the social sciences and humanities have moved from the study of the natural event to determine the causal factors of the disaster to the study of the unnatural development that generated different levels of vulnerability (Adelekan, 2010; Adebimpe, 2011). In the 1990`s, vulnerability reduction began to be advanced as a key strategy for reducing disaster impact. Though this this was initially vague to implement, by the end of the 1990`s however, it was clear that development processes were not only generating different patterns of vulnerability, but were also altering and magnifying patterns of hazard. A strong argument put forward as evidence has to do with the impact of global climate change. Vulnerability assessment through risk management and reduction has been advanced as an integral paradigm that builds on and incorporates all the previous strategies from the perspective that all development activities have the potential to increase or reduce risks (UNDP, 2004).

The vulnerability view that is of relevance to this study is that expressed by Adebimpe (2011). It states that African cities are more susceptible to anthropogenic vulnerability, with mounting evidence that natural hazards had widely varying impacts on different social groups and on different countries. Adelekan (2010) asserts that the causes of windstorm disaster is unnatural. Mijiyawa and Awogbuyi (2011) however attempted to merge physical causes with the social indicators. He linked wind speed, wind direction and building orientation to vulnerability to windstorm disaster in Ibadan. In this study, drivers of windstorm disaster interact with the social and biophysical vulnerability factors of the neighborhoods in Ibadan is examined based on vulnerability of a place. The social vulnerability fabric includes socio-demographic factors, belief of knowledge associated with risk, hazard and total ability to cuisine hazard. Physical indicators are terrain, topographical pattern and proximity to the hazardous sites such as high hill areas and old/weak vegetal cover. This hazardous circumstances produces the biophysical vulnerability of a place. The relationship of the components of social and biophysical vulnerability end up in the place susceptibility. Feedback loop of place vulnerability consist initial risk, mitigation inputs allowing for reducing risk, subsequently leading to decrease or increase vulnerability (Cutter et al 2000). The operationalisation of place vulnerability model therefore consider bio-physical vulnerability and place vulnerability leading to hazardous indicators employed to study vulnerability of a place of Ibadan. As such, biophysical vulnerability were measured by rate of occurrence (frequency) vegetal cover, average elevation and delineation of hazard zones), social vulnerability (measured by socio demographic characteristics), and a combination of physical and social which produces overall place vulnerability of the city.

2.3 The Resilience Concept

Upward 1990s, disaster experts on environmental (earth and climate) systems analysts, had focused on non-linear processes, tipping points, adaptive (co-) management and resilience (Frerks et al., 2011). This adoption becomes necessary because of the tenet of the resilience concept which states that more resilient communities are less vulnerable to meteorological hazards (UNESDR, 2002). Resilience is generally defined as "the system capability to hold on to its structure and forms of behaviour while undergoing external and internal disturbances", while stability is the "tendency of a system to retain a balance condition of steady state and resist any departure from that condition and, if perturbed, return rapidly to it" (Hollins, 1986). Further, Cutter, (2008) defined resilience as the ability of human system to respond and to recover. This includes those inherent conditions that allow the system to absorb impacts and cope with the event, as well as post event adaptive processes that facilitate the ability of the system to recognise, change and learn from the event. If the human system as selected by Cutter (2008) means a human community, then, NHSS, (2009) defined community resilience as sustained ability of the community to withstand and recover both from the short term and long term effects of adversity. Noris (2008) affirmed that community resilience emerges from four primary set of adaptive capacity; economic development; social capital; information; and communication and community competence.

Resilire, a Latin wordis translated jump back to original state. The term is used to describe the ability of a material to retain strain energy by maintaining its elasticity without breaking (Gordon 1978). Resilient has been in use since 1978 to any system that experience stress yet able to maintain its integrity.

In the 1970s,Holing, an ecologist, defined the term resilience in the context of ecosystem as a measure of the ability of a system to absorb changes and still persist (Holing, 1973). In hazards research, resilience means the ability to survive and cope with a disaster with minimum impact and damage (Berke and Campanella, 2006). According to Handner and Dovers (1996), the fluctuations of stable system to stress is less and possess the ability to return to its original state when compared to a resilient system with a wide margin of instability leading to great fluntuation. . Frerks et al. (2011) reviewed several ecological literature on resilience and concluded that the capacity or ability of a system to anticipate risk or disturbance, absorb or limit impact, and bounce back after a crisis affecting human and natural systems proves that resilience should be seen as the shared, social capacity to anticipate, resist, absorb, and recover from an adverse or disturbing event or process through adaptive and innovative processes of change, entrepreneurship, learning and increased competence.

Holling`s (1973) seminal work incited intense conceptual debate among ecologist on issues relating to resilience. According to his research, even after several perspective and understanding of ecological resilience, yet, after 47 years, it does not seem as if there is a general consensus operational definition of resilience. While Pimm (1984) considered resilience in term of rate of return to original state, after a system experience disturbances, his postulations were faulted by a group of researcher who opined that a system remained in equilibrium state until an external forces disturb it. More so, they were of the view that such system (ecosystem) will quickly go back to its original state because of the dynamism in an ecosystem. Although it appears like there are many disagreement on the concept of ecological resilience, it has continued to gain ground in the social sciences where it is being used to describe the behavioural response of communities, institutions and economies to meteorological disasters. Timmerman (1981) is among the first to discuss the resilience of a society to climate related disaster. He links resilience to vulnerability. He defines resilience as the measureto whicha system or part of a system can to absorb and recover from disaster. the difference identified by Dovers and Handman (1992) between reactive and proactive resilience indicate that a society with reactive resilience prepares for the future by strengthening the status quo and making the present system resistant to meteorological change, whereas, one that develops proactive resilience accepts the inevitability of occurrence of disaster and tries to create a system that is capable of adapting to this new condition. This broadens the traditional interpretation of resilience, which defines resilience as ability to recover from primarydisturbance.

There was also a linkage between resilience, planning and adaptation to hazards, resulting to institutional resilience (Dovers et al., 1992). Institutional resilience provides the required frameworkwhere rigidity and inadequacy of institutions has direct linkage to global framework. Thus, contemporary local policy and institution are subset of global phenomenon except climate induced disasters has direct link with politics and the economy, the tenacity and effect of such disaster may not gain the deserved sympathy and publication.

Adger (2000)in Timmerman (1981) described social resilience as human community capability to cope and recover from perturbation affecting its infrastructure, its environment, social economy, and or political upheaval. Adger,had revealed earlier in 1977 that social resilience is a function of change in institution, the structure of the economy, the right to properties, individual access to resources, and changes in community demography (Adger 1977).Although Ecologist argument in regard to resilience is the desired solution to environmental changes, (Common, 1995, Chapin et al., 2000.) Adger (2000) conclusion was that resilience only have a semblance of stability, however, it yet to be proving as all-time desirable concept.

As observed, the concept of resilience shows that the straight forward concept used only in mechanics is now a complex multi concept with contested definitions and even relevance. Notwithstanding, the concept of resilience has been applied to a number of discipline meant to focus on the relationship that exist between man and his natural environment, however, over the years it becomes clearer that man and his environment are interlinked. Thus, their resilience depend on the hitherto established between man and his environment as against the resilience put up by individual component within the system.

In windstorm disaster prone communities, resilience is geared towards the individual and household`s capacity to deal with a disastrous event. Resilience is a long term adaptive approach based on social learning and change and it includes response and coping, but goes beyond it and is also geared to social and systemic aspects of dealing with disaster rather than individual and household capacities alone. Thus in windstorm disaster prone communities, it is advisable to invest in resilience. Investment in resilience is expected to promote structural vulnerability reduction if disaster agencies are carried along.

Although there is as yet fairly little insight on how to translate resilience into a workable concept, Its potential strengths are clean in comparison to the earlier danger, risk and vulnerability paradigm. There is thus far little substantial work at the operationalization of the idea and its use in policy practice. Its present recognition seems partly the product of a political and coverage making discourse that seeks to shift the duty for mediating the effect of disasters to the society at large. The issue of resilience has a crucial bearing at the perceptions, behaviors and responses in the given public coverage contexts. Its miles associated with a sort of paradigm shift or shift of focus over the last one or two many years concerning duties and roles in public policy making. In a resilience-method, there's a particularly sturdy emphasis on network and grassroots involvement compared to the conventional reliance on state-added services via employer which include country wide National Emergency Management Agency (NEMA) and Oyo State Emergency Management Agency (OYSEMA). Therefore, stakeholder engagement and public-private partnerships should be introduce and encouraged at both nation and local levels.

As found, it is apparent that the field of disaster management that favours collaboration between government and residents was already promoted in the 1994 and 2005 in Yokohama and Hyogo frameworks respectively (Frerks et al., 2011). It is however vital to elucidate the influences of such paradigmatic shifts for the anticipation of, prevention of, and healing from shocks. A grassroots or community-primarily based angle has often been taken into consideration merely on ideological or sentiment ground to enhance effectiveness in the subject of resilience promotion. Thus, the study gives credence to this fact by involving the residents of windstorm disaster vulnerable communities in this research. This will also strengthen their ability to prevent, cope and absorb shock when windstorm occurs. The following steps have been adopted by this research to strengthen the resilience of Ibadan to windstorm disaster; boundary delineation and conceptual elaboration of the notion of resilience; review of literature on vulnerability to windstorm, resilience and the identification of pertinent issues and emerging themes;

building of a conceptual framework on resilience; defining descriptive-analytical benchmarks or indicators such as physical, socio economic and anthropogenic for resilience; developing and recommending a policy-relevant approach to enhancing Ibadan resilience; applying Ibadan as a framework for this study and by proposing policy measures to enhance disaster resilience in the city. Obviously, these steps adopted from Frerks et al. (2011) can help to promote resilience of disaster-prone areas in Ibadan. This is needful since vulnerability and resilience have become mainstream notions as useful additions to hazard and risk in recent years. An attention on vulnerability assist a practitioner to observe a systemic approach to windstorm disaster vulnerability makes little sense as the sum total of protection may increase the risk of suffering and leads to loss which differs between certain social groups. The concept of resilience and reduction of people's vulnerability to disaster is highly dependent on one's socio-economic standing (Klein et al., 2002). Nonetheless, a consensus that mitigating vulnerability and promoting the concept of resiliency can be of help in windstorm disaster vulnerable communities while the government plays out the required politics to bring the vulnerable group along.

CHAPTER THREE

Research Methodology

A key component of the vulnerability research is the acquisition of systematic baseline data, particularly at the neighbourhood level. These data provide inventories of hazard areas and vulnerable populations' information that is essential for pre impact planning, damage assessments, and post disaster response. In this research, vulnerability is examined from social and biophysical perspective. Indexes are constructed and Geographical Information Science (GIS) was employed for cluster and hotspot analysis. Inferential and descriptive statistics were employed to validate the GIS output and results. The various processes, procedures, principles, methods and models by which data and information were sourced, specified, defined, collected, processed and analyzed are encapsulated in research methodology (Alabi, 2009).

3.1 Research Design and Instrument for data collection

Survey method research design was adopted for collecting primary data for this study. This method was chosen because the validity of its findings is guaranteed and versatile as it, provides access to variety of data. In addition, the method is relatively accurate and representative. Questionnaire and interview guide were major instruments used for data collection. These are essential as they support generalisation and are used for checking reliability of data generated by other methods. They give very good responses rate as interviewer and respondents can resolve confusing questions which reduces bias on the part of the interviewer.

Structured questionnaire was administered to households in the selected localities where the selected windstorm disaster took place. The questionnaire was designed to collect information on the social fabric and the geographic filter. Social fabric includes socio-demographic characteristics (age, poverty, poor quality housing, inability to respond quickly, gender, race and ethnicity, population distribution and density, Cutter (2000). The geographic filter are the physical condition of the place this includes the geographic location and the height above sea level where the sampled building is located. Availability of vegetal cover was also considered.

Interview guide was designed and conducted on the Secretary, Oyo State Emergency Management Agency. The interview enable researcher to elicit information on the management and mitigation plan for windstorm disaster in Ibadan in particular and Oyo state in general. The information collected includes the history of windstorm in the state, the management strategy, the plan to mitigate it and the total and individual amount of social support granted to the windstorm affected persons and the modality of awarding the grant. The interview also sourced information on the past and present challenges confronting the agency. Other information collected include the difficulties encountered by the agency on assessment and collation of affected people, appropriate management and disbursement of social supports.

The study also sourced information through (FGD) on the windstorm affected people management and mitigation strategies. The study collected information on length of stay in their area, the number of windstorm they have witnessed, their source of information on impeding windstorm, what they think makes people vulnerable to windstorm, how they have been affected by windstorm, their perception about building age and windstorm disaster vulnerability, their mitigating strategies, presence of forest reserve in their neighbourhood, their expectation from individual, community and government to control windstorm amongst others. These information were sourced through structured interviews conducted on group of group of persons, minimum of 10 persons in the neighbourhoods with highest devastation in some selected windstorm events.

3.2 Population of Study

The population of study consist 2105devastated buildings found in the 21 windstorms incidents between 2005 and 2015 in Ibadan (Table 3.1).

3.2.1 Sample Frame

The 21 windstorms events in nine local government areas and 2105 devastated buildings in Ibadan between year 2005 and 2015 (Table 3.2) represent 34.605% of the 6083 devastated buildings in Oyo state within a period of ten years (OYSEMA report 2015). The 5 (five) selected windstorm disaster where 1858 buildings were devastated, represents 88.27% percent of the total occurrence of 2105 devastation in Ibadan. These five cases spread across seven (7) LGAs in the city and were the windstorm events selected based on UNDP criteria for categorizing windstorm disaster (Table 3.2). Windstorm disaster categorization based on number of people affected was employed by Maynard-Ford (2008) to map vulnerability to disaster in Latin America and the Caribbean, 1900-2007. It is on these same paradigms that the 5 selected disasters used in this research is based. The sample frame for this study was the 1858 buildings devastated in 51 Neighbourhoods during 2008, 2009, 2013 2014a and 2014b in Ibadan.

Table 3.1: Windstorm Incidents in Oyo state 2005-2015

S/N	Date of Occurrence	Local Government Areas	Total Devastation
1.	22/05/2005	Ona Ara	40
2.	06/03/2008	Ibadan South East	1023
3.	06/03/2008	Ibadan South West	146
4.	17/02/2013	Ibarapa East	48
5	26/02/2009	Ibadan North East	108
6	05/04/2006	Saki East	55
7	08/03/2015	Saki East	123
8	15/03/2015	Saki East	50
9	10/05/2007	Orelope	40
10	16/03/2013	Orelope	210
11	06/08/2008	Oluyole	85
12	20/06/2013	Akinyele	17
13	26/10/2012	Iddo	1
14	17/02/2013	Oluyole	1
15	02/05/2013	Ibadan South East	1
16	23/02/2012	Ibadan North East	1
17	30/06/2012	Ibadan North East	1
18	15/06/2013	Egbeda	1
19	04/04/2012	Atiba	78
20	09/02/2015	Atiba	511
21	09/02/2015	Afijio	161
22	09/02/2015	Oyo West	429
23	09/02/2015	Oyo East	251
24	14/02/2009	Ibadan North	2
25	01/04/2012	Egbeda	2
26	22/04/2013	Ibadan South East	22
27	09/01/2015	Ibadan North East	8
28	01/07/2014	Iddo	2
29	12 /03/2014	Iddo	113
30	26/08/2011	Iddo	23
31	01/04/2014	Ibadan South East	243

32	17/02/2013	Egbeda	23
33	16/03/2014	Ibadan South East	25
34	19/04/2008	Ogooluwa	12
35	12/03/2008	Ogooluwa	28
36	20/02/2012	Ogooluwa	66
37	05/03/2014	Ogooluwa	46
38	08/04/2005	Irepo	86
39	20/04/2010	Irepo	20
40	07/04/2014	Irepo	102
41	08/03/2014	Irepo	142
42	26/08/2011	Ibadan North	40
43	10/02/2015	Surulere	197
44	15/05/2006	Itesiwaju	69
45	2014	Itesiwaju	80
46	2014	Orire	110
47	27/02/2009	Afijio	140
48	26/02/2009	Afijio	81
49	02/03/2012	Afijio	91
59	19/03/2014	Atisbo	141
51	22/03/2007	Atisbo	92
52	22/04/2008	Atisbo	62
53	14/03/2009	Atisbo	69
54	24/04/2012	Atisbo	271
55	18/03/2014	Irepo	143
56	27/9/2010	Akinyele	37
57	2nd& 4th /03/2013	Akinyele	114
			6083

Source: OYSEMA (2015); Authors Construct (2015)

Table 3.2: Ibadan Windstorm Incidents, 2005-2015

S/N	Incident Date	Incident Local Government Areas	Building Devastation	Windstorm Classification	Classification Scale
1.	22/05/2005	Ona Ara	40	Weather Event	Not Available
2.	**06/03/2008***	**Ibadan South East**	**1049**	**Disaster**	**UNDP (2004)**
		Ibadan South West	**146**		
		Oluyole	**85**		
3.	14/02/2009	Ibadan North	2	Weather Event	Not Available
4.	**26/02/2009***	**Ibadan North East**	**108**	**Disaster**	**UNDP (2004)**
5.	27/9/2010	Akinyele	37	Weather Event	Not Available
6.	26/08/2011	Iddo	23	Weather Event	Not Available
		Ibadan North	40		
7.	23/02/2012	Ibadan North East	1	Weather Event	Not Available
8.	01/04/2012	Egbeda	2	Weather Event	Not Available
9.	30/06/2012	Ibadan North East	1	Weather Event	Not Available
10.	26/10/2012	Iddo	1	Weather Event	Not Available
11.	17/02/2013	Oluyole	1	Weather Event	Not Available
		Egbeda	23	Weather Event	
12.	**02/03/2013***	**Akinyele**	**114**	**Disaster**	**UNDP (2004)**

13.	22/04/2013	Ibadan City (Various)	22	Weather Event	Not Available
14.	02/05/2013	Ibadan South East	1	Weather Event	Not Available
15.	15/06/2013	Egbeda	1	Weather Event	Not Available
16.	20/06/2013	Akinyele	17	Weather Event	Not Available
17.	**12 /03/2014***	**Iddo**	**113**	**Disaster**	**UNDP (2004)**
18.	16/03/2014	Ibadan South East	25	Weather Event	Not Available
19.	**01/04/2014***	**Ibadan South East**	**243**	**Disaster**	**UNDP (2004)**
20.	01/07/2014	Iddo	2	Weather Event	Not Available
21.	09/01/2015	Ibadan North East	8	Weather Event	Not Available
		Total Devastation	2105		

Source: OYSEMA report, (2015) and Authors Construct (2015)

NB * Focused Disasters

3.2.2 Sample Size

The sample size was drawn from the 1858 sample frame. Van Bennekom (2007) recommended a population spread of 25 % minimum which he asserts guarantees approximately 95% certainty at 0.025 accuracy level in survey research. Four hundred and sixty five (465) is the 25% of 1858. Since the research focused on five windstorm disasters in seven local governments, the researcher increased the percentage to 54.1%. The percentage was expanded to capture more windstorm victims' perspective from the five focal disasters. This expansion has improved the confidence level of the results and has given more victims the opportunity to express their experience, needs and knowledge as found in literature Buckle *et al, (*2000); Ferrier, (2008); and Cutter *et al. (*2003). Therefore, 54.1 % of 1858 i.e 1005 incident buildings, were selected for sampling in 51 affected neighbourhood (table 3.3).

By implication, 689 (68.9 %) of the affected people in the windstorm disaster that ravaged 26 neighbourhoods in Ibadan South West, Ibadan South East and Oluyole local government areas on the 6th of March, 2008 and led to the devastation of 1257 buildings were sampled. The 2009 windstorm disaster that ravaged 13 communities in Ibadan North East Local Government areas on the 26th[th] February, 2009 where 108 buildings were devastated, had 58.43(5.48%) victims interviewed. The disaster that ravaged Moniya community in Akinyele local government areas on the 26[th] August, 2013 where 114 buildings were devastated, had 61.67 (6.13%) of the victims interviewed. The OYSEMA report includes the contact details (Victim`s name, community/neighbourhood/compound/street and house number and in some cases level of devastation) of all the windstorm disasters in Oyo state. This complements and enhances the authenticity and the speed of this research.

Table 3.3: Analysis of Sample SizeDistribution

Date of Incidence	LGAs	Total No Of incident Houses (Sample Frame)	Total No of Buildings Selected 54.1% of sample size (Sample Size, 54.1%)	Percentage of selected samples (%)
6/3/2008	Ibadan South West	146	78.99	7.86
	Ibadan South East	1049	567.51	56.46
	Oluyole	85	45.99	4.58
26/02/2009	Ibadan North East	108	58.43	5.81
26/8/2013	Akinyele	114	61.67	6.13
12 /03/2014	Iddo	113	61.13	6.10
01/04/2014	Ibadan South East	243	131.46	13.1
Total		**1858**	**1005.18**	**100.04**

Source: OYSEMA (2015) and Authors Construct (2015)

Table 3.4: Windstorm Disaster Incidents and Distribution of Respondentsacross Incident Areas

S/N	Incident Date	LGA	Residential Neighbourhood	Buildings Sampled
1	2008	Ib.South-West	Idi-Arere	37
2	2008	Ib.South-West	Bode	41
3	2008	Ib.South-West	Molete	8
4	2008	Ib.South-East	Idi-Arere	161
5	2008	Ib.South-East	Oke Suna Eleta	11
6	2008	Ib.South-East	Idi-Aro	4
7	2008	Ib.South-East	Bode	238
8	2008	Ib.South-East	Elekuro	2
9	2008	Ib.South-East	Owode-Odooba	15
10	2008	Ib.South-East	Odo-Oba	12
11	2008	Ib.South-East	Oke-Olokun	4
12	2008	Ib.South-East	Felele	14
13	2008	Ib.South-East	Odinjo	2
14	2008	Ib.South-East	Yejide Rd.	8
15	2008	Ib.South-East	Molete	4
16	2008	Ib.South-East	Isale-Jebu	2
17	2008	Ib.South-East	Papa Aiyetoro	4
18	2008	Ib.South-East	Ifelajulo	9
19	2008	Ib.South-East	Elere	12
20	2008	Ib.South-East	Islamic Mission	2
21	2008	Ib.South-East	Kudeti	40
22	2008	Ib.South-East	Modina Elekuro	8
23	2008	Ib.South-East	Modina Papa	6
24	2008	Oluyole	Sanyo	11
25	2008	Oluyole	Moslem	11
26	2008	Oluyole	Boluwaji	22

27	2009	Ib.North-East	Labiran	1
28	2009	Ib.North-East	Ojagbo	2
29	2009	Ib.North-East	Adekile	2
30	2009	Ib.North-East	Koloko	3
31	2009	Ib.North-East	Aremo	1
32	2009	Ib.North-East	Gbelekale	11
33	2009	Ib.North-East	Aperin	2
34	2009	Ib.North-East	Ode-Aje	8
35	2009	Ib.North-East	Agugu	10
36	2009	Ib.North-East	Oluyoro	2
37	2009	Ib.North-East	Oke-Ofa	9
38	2009	Ib.North-East	Oje	11
39	2013	Akinyele	Elebu Junction	9
40	2013	Akinyele	Balogun	42
41	2014	Akinyele	Sawmill	11
42	2013	Iddo	Morubo	24
43	2014	Iddo	Papa Area	22
44	2014	Iddo	Oja Area	8
45	2014	Iddo	Station Road	7
46	2014	Ib.South-East	Academy	40
47	2014	Ib.South-East	Orisunbare	18
48	2014	Ib.South-East	Odinjo	20
49	2014	Ib.South-East	Ifelodun Elere	11
50	2014	Ib.South-West	Ajegunle Balaro	19
51	2014	Ib.South-East	Odo Oba	24
			Total	**1005**

Source: Author`s Field Survey (2015)

The windstorm disaster that affected some parts of Apete in Iddo local government areas on the 12th of March, 2014 where 113 buildings were devastated, had 61.13 (6.10 %) of the victims interviewed. Finally, the windstorm incidents that ravaged seven communities in Ibadan South East local government areas on the 1st of April, 2014 where 243 buildings were devastated, had 131.45 (13.1 %) of the victims interviewed. 54.1% of each of the victims in each of the incidents neighbourhoods were sampled to reflect the disaster windfield, wind track and to identify the possible cause of the disaster.

3.2.3 Primary Data

The primary data for this study were obtained through household's interview technique. The household's survey involved collection of basic information relating to past incidence of windstorm disasters and events in the study area. The household survey tool (questionnaire) was administered on the affected households in each of the selected neighborhood. The questionnaire was designed to obtain information on geographic locations/ contact address, neighborhood name, altitude above sea level and on the socio-economic characteristics (sex, age, marital status, occupation, educational status, income level and household house ownership); environmental characteristics (access to neighborhoods facilities, electricity, drainage, road network); dwelling units (building age, dwelling types, length of stay, housing tenure ship, number of rooms, space adequacy, roof, door, ceiling, window, floor condition and material used for construction. Also considered were management, mitigation and responses strategies to windstorm disaster. Further, the research sought the opinion of the respondents on their knowledge of and experience during windstorm disaster using the combination of open and closed ended questionnaire.

Specifically, the questionnaire was sectionalized into;

(a) **Data on spatial characteristics:** Geographical Coordinate, neighborhood name, street name, house number, altitude above sea level.

(b) **Data on the households' socio-economic characteristics:** Variables include: age, gender, employment status, educational status, religion, household size, length of stay in the neighborhoods, type of housing, density and occupancy ratio, housing tenure ship, income, and among others were considered. These data were used to identify social vulnerability indicators in the incidents neighborhood.

(c) **Data on building and household characteristics:** These include variables on windstorm disaster indicators such as the environmental subsystem {road, open space, means of transportation, accessibility, traffic congestion, dominant land use (cutter 2000) consider these variables as lifeline or special needs.}; the dwelling/ buildings subsystem (building age, house tenure and types of dwelling unit, number of rooms and household, occupancy ratio, building setback, building fabric and shape, roof material and shape, door and window materials, building height, building setback from road, water body and open spaces, distance from forested area and physical condition of building) and the management subsystem (water source and distance, toilet facility, kitchen facility, types of waste and method of collection, drainage channel for water flow).

(d) **Data on vulnerability attributes:** There is no contention of the fact that windstorm disaster affected people have diverse social, economic and cultural attributes. They occupy different residential neighbourhoods in the city. These neighbourhoods reflect the social, economic and cultural attributes of their residents (Afon, 2006). Data on these include socio economic, anthropogenic and natural factors. According to Adebimpe (2011) and Becarri *et al*. (2016) natural factors, anthropogenic factors and population concentration could influence the vulnerability of a neighborhood to windstorm disaster.

3.2.4 Procedure for Primary Data Collection

Both simple random sampling and systematic techniques were adopted for questionnaire administration in all the selected neighborhoods. The first building sampled on each neighborhood was selected by balloting (random sampling) and subsequent buildings were selected based on systematic sampling technique. The head of household was selected to complete the questionnaire. When he or she was not available, other adult members of the household were requested to stand in for him or her.

3.2.5 Sampling Technique

The study adopts multi-stage sampling technique. The first stage involves classification of windstorm events to disaster and non-disaster category and selection of the neighbourhoods that fall within the focal windstorm disaster through purposive sampling. The second stage identified the affected neighbourhood. The third stage includes application of random sampling on the list of victims in these neighbourhoods for the purposes of questionnaire adminisration. The sample household in each of the classes were selected by percentile. The five selected windstorm incidents constitute approximately thirty six percent (36.84%) of the 21 windstorm events.

The fourth stage involves the identification of incidents` communities and neighborhoods from the chosen windstorm disaster events. Finally, incidents` buildings were systematically selected in each community for household questionnaire application at regular interval until the required number of sample is completed. The OYSEMA report was helpful in this respect.

3.3 Secondary Data

Both published and unpublished information from textbooks on Climate change, journal articles on windstorm disaster vulnerability and PhD theses on vulnerability to disaster were reviewed. Others are, technical reports, seminars, conference papers on meteorological and weather discourse, maps and satellite imagery of Ibadan and internet web sites. Information from these documents enhanced the research. Also, data on the year, the month and date of disaster occurrence, contact addresses and the amount of the social support received by the windstorm disaster affected people were obtained from the State Emergency Management Agency (OYSEMA). The 1984-2015 satellite maps of Ibadan were sourced from Google earth historical imagery. Topographic map of Ibadan was downloaded from en-ng.topographic-map.com. The geographical location of the sampled buildings were measured with GPS directly during field survey. These information were used to delineate the wind field or boundaries of the selected windstorm disasters. They were also employed to identify devastated neighborhoods, height above sea level, storm path and the possible local causes of windstorm in Ibadan.

3.4Focus Group Discussion (FGD)

The study adopted focused group discussion (FGD) to secure information from people affected by the five focal windstorm disasters in Ibadan. The aim was to obtain information on frequency of windstorm occurrence, coping mechanism and mitigation strategies of the affected people, to verify information collected from the neighborhoods in the five focal incident areas. The research developed an interview guide to elicit information from a group of household heads in one of the major neighborhoods in the study area.

The study randomly selected one neighborhood per focal disaster. This was done to elicit appropriate and comprehensive information for the affected neighborhoods. The days for community meeting was identified, and the focus group was conducted on such day. The study randomly selected Bode, for 2008 windstorm event, Ode-Aje for 2009, Balogun in Moniya for 2013, Morubo in Apete for 2014a and Academy for 2014b.

3.5 Techniques for Data Analysis

Geographical data were queried with Epi Data 2.1 software. This software is designed for spatial data entry and documentation (http:/www.epidata.dk/). Geographic information system (GIS) was adopted in the place vulnerability analysis by combining biophysical and social vulnerability indicators for windstorm disaster in the study area. The inferential and descriptive statistics were employed to strengthen the output generated through GIS analysis. The application of theories, concept and technology in vulnerability studies was adopted to replicate real life situation with GIS in vulnerability mappinbg (Maynard-Ford 2008). Qualitative data were exported to SPSS software package for editing and were analyzed using univariate, bivariate and multivariate statistics. Hypotheses were tested using nearest neighbour analysis and multiple linear regression. Affected peoples' perception and effect of social support were examined using frequency table and percentile statistics.

3.6 Procedure for Examining Windstorm Disaster Place Based Vulnerability

3.6.1 Identifying Biophysical Vulnerability

To identify biophysical vulnerability, windstorm hazards, recurrent rate, and the specific place effects are essential in biophysical vulnerability description. Five sets of data are required for biophysical examination: windstorm identification and the incidents neighbourhood (Table 3.4), Windfield or windstorm zone delineation, windstorm frequency, incidents neighbourhood elevation and vegetation. Indexes were constructed for these indicators to standardise their output. Cutter (2000), employed this approach to evaluate Place Based vulnerability of Georgetown County, South Carolina. Maynard-ford (2008) also adopted the approach in mapping vulnerability to Latin America and the Caribbean. Agbelade, *et al* (2017) used vegetation biodiversity index in his study on tree species richness, biodiversity, and vegetation index for Federal Capital Territory, Abuja, Nigeria.

3.6.2 Windstorm Identification and Frequency

The first step includes the determination of which windstorm events occurred in the study area, the rate of occurrence based on the historical frequency of windstorm events and wind field (Kates and Kasperson 1983). The history of windstorm occurrence in the metropolis were sourced from OYSEMA. The agency mandate is to oversee disaster related issues in Oyo state. The windstorm disaster frequency of occurrence was calculated based on the past information. A division of the total occurrence of windstorm disaster by the years of occurrence gives the frequency of occurrence per given year. As an example, windstorm A, windstorm A has a 10 times frequency of occurrence in a metropolis over a period of 10 years. Sequel to Table 3.5 annual rate of occurrence for windstorm event in Ibadan for a period of 10 years is 21/10 (or 2.1) or more than twice a year. The neighbourhood with highest rate of windstorm occurrence is the most vulnerable area in Ibadan.

3.6.3 Neighbourhood Elevation above Sea Level (asl) and Slope Analysis

The research relates the height of the neighbourhood where the windstorm events occurred, the terrain of the incident areas and devastation per altitude using incident areas slope analysis to determine place vulnerability of the study area (Table 3.6). The windstorm and devastation history were retrieved from OYSEMA. The average elevation of the affected neighbourhood is determined by subtracting the highest altitude from the lowest altitude. Slope index was determined by finding the horizontal differences between the highest altitude point (PA_1) and the lowest altitude point (PA_2). The slope of the neighbourhood was calculated as (A_1-A_2/PA_1-PA_2) x 100 (Table 3.6). The slope was standardised by dividing all the value by the highest slope. This then gives values in 0 and 1 to form the affected neighbourhood slope index. 1 is the most vulnerable while 0 is the least vulnerable neighbourhood.

3.6.4 Windfield Vulnerability Index

Windfield vulnerability index was constructed to determine the extent of Place Vulnerability in Ibadan. The square meter occupied by each of the buildings per locality (i.e the total area of a plot) were determined. This number/sum was multiplied by the total number of the incidents building to arrive at the neighbourhood wind field extent. This was further multiplied by total number of buildings sampled per windstorm event to determine wind field per disaster and the ratio of wind field per locality. The individual ratios were divided by the largest ratio to determine Ibadan wind field vulnerability index. The highest index is one (1) which also represent the most vulnerable neighbourhood in Ibadan (table 3.7).

Table 3.5. Annual Frequency Rate of Windstorm Occurrence in the Sampled Neighbourhoods

S/N	LGA	Residential Neigbourhood	Storm Frequency	No of years	Storm Frequency (% chance per year)	Rate of storm occurrence per year (% chance per year/years in record)
1	Ib.South-West	Idi-Arere	2	7	28.5	4.1
2	Ib.South-West	Bode	2	7	28.5	4.1
3	Ib.South-West	Molete	2	7	28.5	4.1
4	Ib.South-East	Idi-Arere	5	7	71.4	10.2
5	Ib.South-East	Oke Suna Eleta	5	7	71.4	10.2
6	Ib.South-East	Idi-Aro	5	7	71.4	10.2
7	Ib.South-East	Bode	5	7	71.4	10.2
8	Ib.South-East	Elekuro	5	7	71.4	10.2
9	Ib.South-East	Owode-Odooba	5	7	71.4	10.2
10	Ib.South-East	Odo-Oba	5	7	71.4	10.2
11	Ib.South-East	Oke-Olokun	5	7	71.4	10.2
12	Ib.South-East	Felele	5	7	71.4	10.2
13	Ib.South-East	Odinjo	5	7	71.4	10.2
14	Ib.South-East	Yejide Rd.	5	7	71.4	10.2
15	Ib.South-East	Molete	5	7	71.4	10.2

16	Ib.South-East	Isale-Jebu	5	7	71.4	10.2
17	Ib.South-East	Papa Aiyetoro	5	7	71.4	10.2
18	Ib.South-East	Ifelajulo	5	7	71.4	10.2
19	Ib.South-East	Elere	5	7	71.4	10.2
20	Ib.South-East	Islamic Mission	5	7	71.4	10.2
21	Ib.South-East	Kudeti	5	7	71.4	10.2
22	Ib.South-East	Modina Elekuro	5	7	71.4	10.2
23	Ib.South-East	Modina Papa	5	7	71.4	10.2
24	Oluyole	Sanyo	3	7	42.0	6.0
25	Oluyole	Moslem	3	7	42.0	6.0
26	Oluyole	Boluwaji	3	7	42.0	6.0
27	Ib.North-East	Labiran	5	4	125.0	31.3
28	Ib.North-East	Ojagbo	5	4	125.0	31.3
29	Ib.North-East	Adekile	5	4	125.0	31.3
30	Ib.North-East	Koloko	5	4	125.0	31.3
31	Ib.North-East	Aremo	5	4	125.0	31.3
32	Ib.North-East	Gbelekale	5	4	125.0	31.3
33	Ib.North-East	Aperin	5	4	125.0	31.3
34	Ib.North-East	Ode-Aje	5	4	125.0	31.3
35	Ib.North-East	Agugu	5	4	125.0	31.3
36	Ib.North-East	Oluyoro	5	4	125.0	31.3
37	Ib.North-East	Oke-Ofa	5	4	125.0	31.3
38	Ib.North-East	Oje	5	4	125.0	31.3
39	Akinyele	Elebu Junction	4	5	80.0	16
40	Akinyele	Balogun	4	5	80.0	16
41	Akinyele	Sawmill	4	5	80.0	16
42	Iddo	Morubo	5	2	250.0	125
43	Iddo	Papa Area	5	2	250.0	125
44	Iddo	Oja Area	5	2	250.0	125
45	Iddo	Station Road	5	2	250.0	125
46	Ib.South-East	Academy	5	7	71.4	10.2
47	Ib.South-East	Orisunbare	5	7	71.4	10.2
48	Ib.South-East	Odinjo	5	7	71.4	10.2
59	Ib.South-East	Ifelodun Elere	5	7	71.4	10.2
50	Ib.South-West	Ajegunle Balaro	5	7	28.5	4.1
51	Ib.South-East	Odo Oba	5	7	71.4	10.2

Source: Authors Construct (2016)

Table 3.6 Neighbourhood Elevation and Slope Vulnerability Index

Devastation per Residential Neighbourhoods		Highest Altitude asl (A)m	Lowest Altitude asl (B)m	Ave. Elevation A+B/2	Distances between Position A and B (C)m	Slope % = {(A- B)/C}x100 (D)	Slope Index = Dx100/Max. (D)x100
Idi-Arere	37	185	176	180.5	209	4.3	0.5
Bode	41	178	171	174.5	219	3.2	0.4
Molete	8	178	166	177	210	3.3	0.4
Idi-Arere	161	179	171	175	188	4.3	0.5
Oke Suna Eleta	11	200	193	196.5	150	4.7	0.6
Idi-Aro	4	188	187	187.5	99	1.0	0.1
Bode (SW)	238	174	168	171	300	2.0	0.2
Elekuro	2	184	182	183	99	2.0	0.2
Owode-Odooba	15	168	165	166.5	213	1.4	0.2
Odo-Oba	12	168	166	167	210	2.4	0.3
Oke-Olokun	4	164	161	162.5	166	1.8	0.2
Felele	14	195	178	186.5	614	2.8	0.3
Odinjo	2	201	198	199.5	148	2.0	0.2
Yejide Rd.	8	166	162	164	287	1.4	0.2
Molete	4	172	166	169	169	2.1	0.3
Isale-Jebu	2	189	174	181.5	299	5.0	0.6

Papa Aiyetoro	4	207	203	205	221	2.3	0.3
Ifelajulo	9	184	176	180	119	6.7	0.8
Elere	12	190	184	187	115	5.2	0.6
Islamic Mission	2	170	167	168.5	160	1.9	0.2
Kudeti	40	175	170	172.5	255	2.0	0.2
Modina Elekuro	8	211	201	206	177	5.7	0.7
Modina Papa	6	205	203	204	155	1.3	0.2
Sanyo	11	172	168	170	241	1.7	0.2
Moslem	11	229	223	226	234	2.6	0.3
Boluwaji	22	189	177	182.5	293	4.1	0.5
Labiran	1	185	181	183	276	1.5	0.2
Ojagbo	2	194	192	193	123	1.6	0.2
Adekile	2	214	208	211	137	4.4	0.5
Koloko	3	216	210	213	172	3.5	0.4
Aremo	1	210	206	208	170	2.4	0.3
Gbelekale	11	220	208	214	286	4.2	0.5
Aperin	2	218	209	213.5	187	4.8	0.6
Ode-Aje	8	217	214	225.5	273	1.2	0.2
Agugu	10	225	215	220	215	4.7	0.6
Oluyoro	2	216	208	212	171	4.7	0.6
Oke-Ofa	9	223	215	219	262	3.1	0.4
Oje	11	201	192	196.3	153	5.9	0.7
Elebu Junction	9	235	228	231.5	192	3.7	0.5
Balogun	42	238	221	234.5	207	8.2	1
Sawmill	11	229	226	227.5	190	1.6	0.2
Morubo	24	185	181	183	111	3.6	0.4
Papa Area	22	194	183	188.5	164	6.7	0.8
Oja Area	8	186	184	185	102	3.5	0.4
Station Road	7	189	183	186	117	5.1	0.6
Academy	40	231	219	224.5	164	7.3	0.9
Orisunbare	18	205	201	203	147	2.7	0.3
Odinjo 2	20	199	195	197	175	2.3	0.3
Ifelodun Elere	11	192	184	188	198	4.0	0.5
Ajegunle Balaro	19	192	179	155.5	209	6.2	0.8
Odo Oba 2	24	170	166	168	135	3.0	0.4

Source: Author`s Field Survey (2015)

Table: 3.7 Neighbourhood devastation and Disaster Wind Field

Residential neighbourhood	Date of Windstorm Event	A Sampled Buildings	B(msq) Neighbourhood plot size	C (msq) Windfield AxB	D(msq) Total wind field per disaster D=Sum of C per Disaster date	E(msq) Ratio of C to D (E) C/D=(E)	Winfield Vulnerability Index (E/maximum E)
Idi-Arere	2008	37	150	5550	126438	0.044	0.053
Bode	2008	41	150	6150	126438	0.049	0.060
Molete	2008	8	150	1200	126438	0.009	0.011
Idi-Arere	2008	161	150	24150	126438	0.191	0.232
Oke Suna Eleta	2008	11	150	1650	126438	0.013	0.016
Idi-Aro	2008	4	150	600	126438	0.005	0.006
Bode (SW)	2008	238	150	35700	126438	0.283	0.344
Elekuro	2008	2	150	300	126438	0.002	0.002
Owode-Odooba	2008	15	504	7560	126438	0.060	0.073
Odo-Oba	2008	12	150	1800	126438	0.014	0.017
Oke-Olokun	2008	4	150	600	126438	0.005	0.006
Felele	2008	14	540	2100	126438	0.017	0.021
Odinjo	2008	2	150	300	126438	0.002	0.002
Yejide Rd.	2008	8	150	1200	126438	0.009	0.011
Molete 2	2008	4	540	2160	126438	0.017	0.021
Isale-Jebu	2008	2	150	300	126438	0.002	0.002

Papa Aiyetoro	2008	4	504	600	126438	0.005	0.006
Ifelajulo	2008	9	150	1350	126438	0.011	0.013
Elere	2008	12	150	1800	126438	0.014	0.017
Islamic Mission	2008	2	150	300	126438	0.002	0.002
Kudeti	2008	40	150	6000	126438	0.048	0.058
Modina Elekuro	2008	8	150	1200	126438	0.009	0.011
Modina Papa	2008	6	150	900	126438	0.007	0.009
Sanyo	2008	11	504	5544	126438	0.044	0.053
Moslem	2008	11	504	5544	126438	0.044	0.053
Boluwaji	2008	22	540	11880	126438	0.094	0.114
Labiran	2009	1	150	150	9300	0.016	0.019
Ojagbo	2009	2	150	300	9300	0.032	0.039
Adekile	2009	2	150	300	9300	0.032	0.039
Koloko	2009	3	150	450	9300	0.048	0.058
Aremo	2009	1	150	150	9300	0.016	0.019
Gbelekale	2009	11	150	1650	9300	0.177	0.215
Aperin	2009	2	150	300	9300	0.032	0.039
Ode-Aje	2009	8	150	1200	9300	0.129	0.156
Agugu	2009	10	150	1500	9300	0.161	0.195
Oluyoro	2009	2	150	300	9300	0.032	0.039
Oke-Ofa	2009	9	150	1350	9300	0.145	0.176
Oje	2009	11	150	1650	9300	0.177	0.215
Elebu Junction	2013	9	504	4536	25704	0.176	0.214
Balogun	2013	42	504	21168	25704	0.824	1.000
Sawmill	2014	11	504	5544	25704	0.153	0.186
Morubo	2013	24	504	12096	36288	0.333	0.404
Papa Area	2014	22	504	11088	36288	0.306	0.372
Oja Area	2014	8	540	4032	36288	0.111	0.135
Station Road	2014	7	540	3528	36288	0.097	0.118
Academy	2014	40	504	20160	50952	0.396	0.481
Orisunbare	2014	18	504	9072	50952	0.178	0.216
Odinjo 2	2014	20	150	3000	50952	0.059	0.072
Ifelodun Elere	2014	11	504	5544	50952	0.109	0.132
Ajegunle Balaro	2014	19	504	9576	50952	0.188	0.228
Odo Oba 2	2014	24	150	3600	50952	0.071	0.086

Source: Author`s Field Survey (2015)

3.6.5 Vegetation (Tree) Biodiversity Index

Vegetal cover index was constructed as one of the biophysical indicators for Place Vulnerability in Ibadan. All trees with diameter at breast height (dbh) greater than or equal to 10cm were identified and enumerated. The biodiversity density was determined by dividing trees per neighbourhood with total number of trees then multiplied with 100. The neighbourhood density was then divided by the highest neighbourhood density to produce the vegetal cover index for the study area. The neighbourhood with index 1 is the most vulnerable (Table 3.7).

3.6.6 Hazard Zone Delineation

Afterward, a windstorm zone delineation is created and the rate of windstorm occurrence is assigned. Windfield index, slope analysis index, and vegetal index. The area coverage of windstorm occurrence in Ibadan are well-defined and documented in OYSEMA report. Thus, the rates of occurrence and other indexes are overlaid in these geographic delineations based on data in table 3.5-3.7. For example, 4.1% proportional increase per year in the 7-year windstorm zone; 250% proportional increase per annum in the 2-year windstorm zone). The research employed the output from the OYSEMA windstorm report to define windstorm disaster windfield. The 2008 windstorm disaster wind fields for example were derived from modelling historic storm winds using number of buildings devastated, the location of those buildings roof deposit to the north pole, windstorm duration, and the total area devastated by the storm in line with Ramsey model (Ramsey et al. 1998). Ramseymodel used a total number of 1203 devastated buildings (the worst case scenario) and their geographic locations to determine the spatial extent of wind fields (52 knot sustained winds). To construct the windstorm hazard zone, the epicentre latitude and longitude was first entered into a GIS. Then, a buffer was created around the epicentre to identify the "devastated areas." Using GIS, each of the "devastated areas" for the 21 windstorm disasters that affected 51 neighbourhoods were processed and disaggregate into "layers devastated by windstorm disaster" for the city.

Table 3.8: Vegetation (Tree) Biodiversity Index for the Sampled Neighbourhood

Residential Neighbourhood	(A) No of trees sighted in the neighbourhood >5m	B Tree Density (A/ sum of A) x100	Index for Vegetation cover (B/maximum B)	Data Transformation. 0 becomes 1 vice-versa
Idi-Arere	0	0	0	1
Bode	0	0	0	1
Molete	0	0	0	1
Idi-Arere	0	0	0	1
Oke Suna Eleta	0	0	0	1
Idi-Aro	0	0	0	1
Bode	0	0	0	1
Elekuro	0	0	0	1
Owode-Odooba	1	10	0.25	0.75
Odo-Oba	0	0	0	1
Oke-Olokun	0	0	0	0
Felele	1	10	0.25	0.75
Odinjo	0	0	0	1

Yejide Rd.	0	0	0	1
Molete 2	0	0	0	1
Isale-Jebu	0	0	0	1
Papa Aiyetoro	0	0	0	1
Ifelajulo	0	0	0	1
Elere	0	0	0	1
Islamic Mission	0	0	0	1
Kudeti	1	10	0.25	0.75
Modina Elekuro	0	0	0	1
Modina Papa	0	0	0	1
Sanyo	0	0	0	1
Moslem	0	0	0	1
Boluwaji	0	0	0	1
Labiran	0	0	0	1
Ojagbo	0	0	0	1
Adekile	0	0	0	1
Koloko	0	0	0	1
Aremo	0	0	0	1
Gbelekale	0	0	0	1
Aperin	0	0	0	1
Ode-Aje	0	0	0	1
Agugu	2	20	0.5	0.5
Oluyoro	4	40	1	0
Oke-Ofa	0	0	0	1
Oje	0	0	0	1
Elebu Junction	0	0	0	1
Balogun	0	0	0	1
Sawmill	0	0	0	1
Morubo	0	0	0	1
Papa Area	0	0	0	1
Oja Area	0	0	0	1
Station Road	0	0	0	1
Academy	0	0	0	1
Orisunbare	1	10	0.25	0.75
Odinjo 2	0	0	0	1
Ifelodun Elere	0	0	0	1
Ajegunle Balaro	0	0	0	1
Odo Oba 2	0	0	0	1

Source: Author`s Field Survey (2015)

3.6.7 Data Integration to Produce Biophysical Vulnerability

The data layers created in the GIS for each wind field or windstorm zone delineation, windstorm frequency, incidents neighbourhood slope index and vegetal index were saved in a separate GIS layer. To produce a typical vulnerability map, incorporate all layers into a single file polygon. A bio-physical hazard grade (based on the rate of occurrence) was given to all of the polygon; those scores had been later categorized into deciles and mapped with the use of hot spot technique to produce biophysical vulnerability map of Ibadan. Thus, a map showing the parts of the study area with biophysical vulnerability hot spots were revealed. Bio-physical vulnerability is thus defined by rate of windstorm occurrence per year index, wind field index, incidents neighbourhood slope analysis and vegetation biodiversity index

3.6.8 Determining Social Vulnerability

Factors influencing the fundamental causes of social vulnerability include the following

- lack of access to resources, including information and knowledge
- limited access to political power and representation
- certain beliefs and customs
- weak buildings or weak individuals
- infrastructure and lifelines

(Blaikie et al. 1994; Cutter et al. 1997; Mileti 1999)

While these fundamental causes are quite variable in time and space, population and building characteristics such as age, race/ethnicity, income levels, gender, building quality, public infrastructure have the capacity to increasing or reduce vulnerability (Blaikie *et al*. 1994; Hewitt 1997). Based on the existing literature, this research examines the population characteristics and the residential building and environments that socially exposes residents to windstorm disaster. This is necessary because the variables are used to define social vulnerability idea Cutter (2000). Identified indicators in Table: 3.8 represent the variable that defines susceptible populations. These data were collected from the Oyo State Urban Project (IDF II), National Population Commission (2006), Ministry of Finance Budget and Planning, (2015) and OYSEMA, (2015).social variable homogeneity was achieved by calculating the ratio of each variable in the neighbourhood population viz-a-viz the amount such variable at the local government level, rather than using simple percentages. To calculate non-reinforced building index (Table 3.12), sum of the buildings devastated in each neighbourhood were tabulated in column A, the total number of total sampled buildings was also tabulated in column C. Total number of devastated buildings ratio to the total per neighbourhood was computed in column 4. Thus,the value in column (C) was then divided by the highest value (C) to determine an index between 0 and 1.00. The most vulnerable neighbourhood has a total of 1 index.

Higher index values show neighbourhoods with greater vulnerability (Table 3.12). The social vulnerability indicators were regularise though with the exception of mean house value as seeing in table 3.12. This idea made negative numbers possible to work with, thus, the absolute value of the difference between neighbourhoods and LGA values was added (Table 3.11). The consistency amid LGA and neighbourhood housing was calculated (column 4) by considering the LGA average of mean house value and subtracting the mean house value for each neighbourhood.In order to eliminate negative values, the absolute value of the maximum X (column 4) was added to create Y (column 5). Finally, the ratio of the new value (Y) to the maximum Y generated the mean house value index (column 6). Higher values additionally suggest extra vulnerability in this case. Those indexes had been grouped, assigned to every block and entered right into a GIS as a statistics layer.It should be noted that mean house value is a surrogate indicator for wealth and resilience.Mean residence price isn't always used to deduce that better priced houses are necessarily less structurally vulnerable (Felele is a high priced neighbourhood, yet, the area is vulnerable to windstorm disaster). Even though those houses may also have safety functions missing in housing units of lesser value, they're regularly built in such a manner that makes them vulnerable to windstorm disaster (e.g., Felele building's roof were mostly not fastened to the wall).

The same technique adopted for biophysical vulnerability mapping for Ibadan was repeated in social vulnerability procedure to arrive at a composite index score for each block, which signifies a total sum of social vulnerability in the city. That is equally the case with the biophysical indicator. Every neighbourhood indicator of social vulnerability are examined independently; however, it is the summary of all the measures that produce an outline of the spatial distribution of social vulnerability in the city.

Table: 3.9 Measure of Socially Vulnerable Populations

Characteristics	Variable
Population and Structure	Total Population
	Total Housing Unit
Access to resources disparity/ greater access to susceptibility to hazards as a result of physical weakness	Number of Females
	No of Population under age 14 years
	Number of people over 65 years old

Wealth or Poverty	Mean House Value
Physical or structural vulnerabilityLevel	Building reinforcement

Source: Adapted from Cutter (2000)

3.6.9 Determining the Place Vulnerability

The evaluation of the mechanisms constituting Ibadan hazard loss interact to produce its overall vulnerability assessment. i.e., the overlap of risky zones and their social vulnerability produces the spatial variant in normal vulnerability for the metropolis. To gain the very last vicinity vulnerability, the social vulnerability layer changed into blended with the Biophysical Vulnerability layer in the GIS. Individual layers were not graded within the GIS environment while loading the composite social and biophysical indices. Rather, all indicators were treated equally, i.e. they all believe to have contributed evenly to overall vulnerability of the city. Although, this approach may be faulted, suggesting a standardized approach based on housing unit at risk or other measures of economic losses, but there are no available statistics to compose this at national level, let alone in Ibadan. The product of the two index ranking (social and biophysical vulnerability) was then reclassified into five categories and mapped. Cutter, (2000) Place Vulnerability mapping was produced using the approach stated here.

Table 3.10 Indexes for Neighbourhood Population Structure (Female, 0-14 years and above 65 years old) in Ibadan

Residential Neighbourhood	A 2016 projected from 1996 at 3.5% per annum {(3.5/100)+1)x1996 NPC projected	B 2016 Female population B={(3.5/100)+1}^{20} x1996 NPC Projected	C INDEX for % Female (B/Max. B)	D Underage 0-14 years at 42.54% D= (42.54/100)x A	E INDEX for Underage (D/max. D)	F Population over 65 years at 3.13% per annum (3.13/100)x A	G INDEX for Old age (F/max. F)
Idi-Arere	5631	2701	0.06	2395	0.07	176	0.07
Bode	20368	13218	0.28	8665	0.24	638	0.24
Molete	12581	6351	0.13	5352	0.15	394	0.15
Idi-Arere	8308	5121	0.11	3534	0.10	260	0.10
Oke Suna Eleta	10326	5526	0.12	4392	0.12	323	0.12
Idi-Aro	23883	12433	0.26	10160	0.28	747	0.28
Bode	10956	5995	0.13	4661	0.13	343	0.13

Elekuro	34300	19890	0.42	14591	0.41	1074	0.41
Owode-Odooba	50120	27240	0.58	21321	0.59	1568	0.59
Odo-Oba	50151	27240	0.58	21334	0.59	1570	0.59
Oke-Olokun	34246	18328	0.39	14568	0.41	1072	0.41
Felele	52619	29874	0.63	22384	0.62	1646	0.62
Odinjo	58655	30431	0.64	24952	0.69	1835	0.69
Yejide	18357	10223	0.22	7809	0.22	575	0.22
Molete 2	25751	13760	0.29	10954	0.31	806	0.31
Isale-Jebu	11016	6211	0.13	4686	0.13	345	0.13
Papa Aiyetoro	2048	1320	0.03	871	0.02	64	0.02
Ifelajulo	2138	1441	0.03	909	0.03	67	0.03
Elere	2038	1190	0.03	866	0.03	64	0.03
Islamic Mission	10956	6123	0.13	4660	0.13	343	0.13
Kudeti	17277	9008	0.19	7350	0.21	541	0.21
Modina Elekuro	34300	19890	0.42	14591	0.41	1074	0.41
Modina Papa	34300	19890	0.42	14591	0.41	1074	0.41
Sanyo	9939	5195	0.11	4228	0.12	311	0.12
Moslem	5626	2768	0.06	2393	0.07	176	0.07
Boluwaji	7426	3998	0.08	3159	0.09	232	0.09
Labiran	7424	3715	0.08	3158	0.09	116	0.09
Ojagbo	31223	17910	0.38	13282	0.37	977	0.37
Adekile	31324	16760	0.35	13325	0.37	980	0.37
Koloko	42506	22100	0.47	18082	0.50	1330	0.50
Aremo	42507	22329	0.47	18082	0.50	1330	0.50
Gbelekale	2664	1700	0.04	1133	0.03	83	0.03
Aperin	16463	8591	0.18	7003	0.10	515	0.10
Ode-Aje	29543	15999	0.34	12567	0.35	924	0.35
Agugu	84513	47392	1.00	35951	1.00	2645	1.00
Oluyoro	21282	12157	0.26	9053	0.25	666	0.25
Oke-Ofa	29392	14911	0.32	12503	0.35	920	0.35
Oje	14473	8717	0.18	6156	0.17	553	0.17
Elebu Junction	29909	17001	0.36	12723	0.35	936	0.35
Balogun	29909	17001	0.36	12723	0.35	936	0.35
Sawmill	29909	17001	0.36	12723	0.35	936	0.35
Morubo	14556	7391	0.16	6192	0.17	456	0.17
Papa Area	14556	7391	0.16	6192	0.17	456	0.17
Oja Area	14556	7391	0.16	6192	0.17	456	0.17
Station Road	14556	7391	0.16	6192	0.17	456	0.17
Academy	45001	24256	0.51	19143	0.53	1408	0.53
Orisunbare	2039	1130	0.02	867	0.02	64	0.02
Odinjo 2	58655	30784	0.65	24952	0.69	1836	0.69
Ifelodun Elere	2038	1038	0.02	866	0.02	64	0.02
Ajegunle Balaro	2228	1670	0.04	948	0.03	70	0.03
Odo Oba 2	50151	27500	0.58	21334	0.59	1570	0.59

Source; *Oyo State Urban Project (IDF II), Ministry of Finance Budget and Planning, 1996. National Population commission, 1996,* **CIA fact book assessed 07/03/2018,** *Authors construct, 2016,*

Table 3.11 Housing Unit Per Neighbourhood Index

N	Sampled Residential neighbourhood	A 2016 Population Projected 3.5% per annum from 1996 projection $\{(3.5/100)+1)^{20}$ x 1996 value	B Average person per building	C Total Housing Unit per neighbourhood C=A/B	D Housing Unit Index C/Max. C	Total buildings sampled (E), Total High rise Buildings (F)	
						E	F
1	Idi-Arere	5631	14	402	0.05	37	18
2	Bode	20368	14	1455	0.19	41	28
3	Molete	12581	14	899	0.12	8	8
4	Idi-Arere	8308	12	692	0.09	161	30
5	Oke Suna Eleta	10326	12	860	0.11	11	11
6	Idi-Aro	23883	12	1990	0.26	4	0
7	Bode (SW)	10956	12	913	0.12	238	61
8	Elekuro	34300	12	2858	0.37	2	6
9	Owode-Odooba	50120	12	4176	0.54	15	14

10	Odo-Oba	50151	12	4179	0.54	12	4
11	Oke-Olokun	34246	12	2853	0.37	4	4
12	Felele	52619	12	4385	0.57	14	14
13	Odinjo	58655	12	4887	0.64	2	2
14	Yejide Rd.	18357	12	1530	0.20	8	8
15	Molete 2	25751	12	2146	0.28	4	4
16	Isale-Jebu	11016	12	918	0.12	2	2
17	Papa Aiyetoro	2048	12	170	0.02	4	3
18	Ifelajulo	2138	12	178	0.02	9	2
19	Elere	2038	12	170	0.02	12	13
20	Islamic Mission	10956	12	913	0.12	2	2
21	Kudeti	17277	12	1440	0.19	40	31
22	Modina Elekuro	34300	12	2858	0.37	8	6
23	Modina Papa	34300	12	2858	0.37	6	5
24	Sanyo	9939	4	2484	0.32	11	2
25	Moslem	5626	4	1407	0.18	11	3
26	Boluwaji	7426	4	1857	0.24	22	12
27	Labiran	7424	11	675	0.08	1	1
28	Ojagbo	31223	11	2839	0.37	2	2
29	Adekile	31324	11	2848	0.37	2	1
30	Koloko	42506	11	3864	0.50	3	3
31	Aremo	42507	11	3864	0.50	1	1
32	Gbelekale	2664	11	242	0.03	11	8
33	Aperin	16463	11	1497	0.20	2	2
34	Ode-Aje	29543	11	2686	0.34	8	4
35	Agugu	84513	11	7683	1.00	10	6
36	Oluyoro	21282	11	1934	0.25	2	1
37	Oke-Ofa	29392	11	2672	0.35	9	6
38	Oje	14473	11	1316	0.17	11	3
39	Elebu Junction	29909	6	4984	0.65	9	7
40	Balogun	29909	6	4984	0.65	42	23
41	Sawmill	29909	6	4984	0.65	11	5
42	Morubo	14556	6	2426	0.32	24	9
43	Papa Area	14556	6	2426	0.32	22	11
44	Oja Area	14556	6	2426	0.32	8	5
45	Station Road	14556	6	2426	0.32	7	3
46	Academy	45001	11	4091	0.53	40	30
47	Orisunbare	2039	11	185	0.02	18	9
48	Odinjo 2	58655	11	5332	0.69	20	12
49	Ifelodun Elere	2038	11	185	0.02	11	6
50	Ajegunle Balaro	2228	14	159	0.02	19	7
51	Odo Oba 2	50151	11	4559	0.59	24	14

Source; *Oyo State Urban Project (IDF II), Ministry of Finance Budget and Planning, 1996. National Population commission, 1996, Authours construct, 2016*

Table 3.12. Calculation of Social Vulnerability Index for Mean Rent Monthly House Value

S/N	LGA	Sampled Residential neighbourhood	Mean three Bedroom House Rent Value/Month (₦) in neighbourhood	Mean three Bedroom House Rent/ Value/Month (₦) in LGA	Value difference (N) of Neighbourhood and LGAs (X)	X + Absolute Value of Maximum X (Y)	Mean house value Vulnerability score (Absolute value Y/maximum Y)
1	Ib.South-West	Idi-Arere	2000	3500	1500	6500	0.6
2	Ib.South-West	Bode	2000	3500	1500	6500	0.6
3	Ib.South-West	Molete	3000	3500	500	5500	0.5
4	Ib.South-West	Ajegunle Balaro	2250	3500	1250	6250	0.6
5	Ib.South-East	Idi-Arere	2000	2500	500	5500	0.5
6	Ib.South-East	Oke Suna Eleta	2000	2500	500	5500	0.55

7	Ib.South-East	Idi-Aro	2000	2500	500	5500	0.55
8	Ib.South-East	Bode	2000	2500	500	5500	0.55
9	Ib.South-East	Elekuro	2000	2500	500	5500	0.55
10	Ib.South-East	Owode-Odooba	2000	2500	500	5500	0.55
11	Ib.South-East	Odo-Oba	2000	2500	500	5500	0.55
12	Ib.South-East	Oke-Olokun	2000	2500	500	5500	0.55
13	Ib.South-East	Felele	2000	2500	500	5500	0.55
14	Ib.South-East	Odinjo	2000	2500	500	5500	0.55
15	Ib.South-East	Yejide Rd.	2000	2500	500	5500	0.55
16	Ib.South-East	Molete	2000	2500	500	5500	0.55
17	Ib.South-East	Isale-Jebu	2000	2500	500	5500	0.55
18	Ib.South-East	Papa Aiyetoro	2000	2500	500	5500	0.55
19	Ib.South-East	Ifelajulo	2000	2500	500	5500	0.55
20	Ib.South-East	Elere	2000	2500	500	5500	0.55
21	Ib.South-East	Islamic Mission	2000	2500	500	5500	0.55
22	Ib.South-East	Kudeti	2000	2500	500	5500	0.55
23	Ib.South-East	Modina Elekuro	2000	2500	500	5500	0.55
24	Ib.South-East	Modina Papa	2000	2500	500	5500	0.55
25	Ib.South-East	Academy	2500	2500	500	5500	0.55
26	Ib.South-East	Orisunbare	2000	2500	500	5500	0.55
27	Ib.South-East	Odinjo	2000	2500	500	5500	0.55
28	Ib.South-East	Ifelodun Elere	2000	2500	500	5500	0.55
29	Ib.South-East	Odo Oba	2000	2500	500	5500	0.55
30	Oluyole	Sanyo	5000	10000	5000	10000	1.0
31	Oluyole	Moslem	5000	10000	5000	10000	1.0
32	Oluyole	Boluwaji	5000	10000	5000	10000	1.0
33	Ib.North-East	Labiran	2000	2200	200	5200	0.5
34	Ib.North-East	Ojagbo	2000	2200	200	5200	0.52
35	Ib.North-East	Adekile	2000	2200	200	5200	0.52
36	Ib.North-East	Koloko	2000	2200	200	5200	0.52
37	Ib.North-East	Aremo	2000	2200	200	5200	0.52
38	Ib.North-East	Gbelekale	2000	2200	200	5200	0.52
39	Ib.North-East	Aperin	2000	2200	200	5200	0.52
40	Ib.North-East	Ode-Aje	2000	2200	200	5200	0.52
41	Ib.North-East	Agugu	2000	2200	200	5200	0.52
42	Ib.North-East	Oluyoro	2100	2100	100	5100	0.5
43	Ib.North-East	Oke-Ofa	2000	2200	200	5200	0.52
44	Ib.North-East	Oje	2000	2200	200	5200	0.52
45	Akinyele	Elebu Junction	5000	4000	-1000	4000	0.4
46	Akinyele	Balogun	5000	4000	-1000	4000	0.40
47	Akinyele	Sawmill	5000	4000	-1000	4000	0.40
48	Iddo	Morubo	5000	4000	-1000	4000	0.40
59	Iddo	Papa Area	5000	4000	-1000	4000	0.40
50	Iddo	Oja Area	5000	4000	-1000	4000	0.40
51	Iddo	Station Road	5000	4000	-1000	4000	0.40

Source: Author`s pre-field survey and construct, (2015) Note, the highest rent index is the most vulnerable area in the metropolis.

Table 3.13:Mud and non-reinforced Buildings Vulnerability Index

S/N	Residential neighbourhood	non-reinforced Buildings per neighbourhood (A)	Total Number of Sampled Buildings (B)	Ratio of Sampled Buildings to Sampled Population (C) A/B=(C)	Mud and non-reinforced Buildings Vulnerability Index (C/maximum C)
1	Idi-Arere	37	1005	0.037	0.16
2	Bode	41	1005	0.041	0.17
3	Molete	8	1005	0.008	0.03
4	Idi-Arere	161	1005	0.160	0.68
5	Oke Suna Eleta	11	1005	0.011	0.05
6	Idi-Aro	4	1005	0.004	0.17
7	Bode (SW)	238	1005	0.237	1.00
8	Elekuro	2	1005	0.002	0.01

9	Owode-Odooba	15	1005	0.015	0.06
10	Odo-Oba	12	1005	0.012	0.05
11	Oke-Olokun	4	1005	0.004	0.02
12	Felele	14	1005	0.014	0.06
13	Odinjo	2	1005	0.002	0.01
14	Yejide Rd.	8	1005	0.008	0.03
15	Molete 2	4	1005	0.004	0.02
16	Isale-Jebu	2	1005	0.002	0.01
17	Papa Aiyetoro	4	1005	0.004	0.02
18	Ifelajulo	9	1005	0.009	0.04
19	Elere	12	1005	0.012	0.05
20	Islamic Mission	2	1005	0.002	0.01
21	Kudeti	40	1005	0.040	0.17
22	Modina Elekuro	8	1005	0.008	0.03
23	Modina Papa	6	1005	0.006	0.03
24	Sanyo	11	1005	0.011	0.05
25	Moslem	11	1005	0.011	0.05
26	Boluwaji	22	1005	0.022	0.09
27	Labiran	1	1005	0.001	0.00
28	Ojagbo	2	1005	0.002	0.01
29	Adekile	2	1005	0.002	0.01
30	Koloko	3	1005	0.003	0.01
31	Aremo	1	1005	0.001	0.00
32	Gbelekale	11	1005	0.011	0.05
33	Aperin	2	1005	0.002	0.01
34	Ode-Aje	8	1005	0.008	0.03
35	Agugu	10	1005	0.010	0.04
36	Oluyoro	2	1005	0.002	0.01
37	Oke-Ofa	9	1005	0.009	0.04
38	Oje	11	1005	0.011	0.05
39	Elebu Junction	9	1005	0.009	0.04
40	Balogun	42	1005	0.042	0.18
41	Sawmill	11	1005	0.011	0.05
42	Morubo	24	1005	0.024	0.10
43	Papa Area	22	1005	0.022	0.09
44	Oja Area	8	1005	0.008	0.03
45	Station Road	7	1005	0.007	0.03
46	Academy	40	1005	0.040	0.17
47	Orisunbare	18	1005	0.018	0.08
48	Odinjo 2	20	1005	0.020	0.08
49	Ifelodun Elere	11	1005	0.020	0.08
50	Ajegunle Balaro	19	1005	0.019	0.08
51	Odo Oba 2	24	1005	0.024	0.10

Source: OYSEMA 2015, Authors construct, 2016. (Note, the highest index represent the most vulnerable neighbourhood.

3.7 Statistical Data analysis

The data collected was analysed using SPSS computer software version 21. Both descriptive and inferential statistics were used to describe and explain the data obtained. The descriptive statistics such as frequency table, charts and inferential statistics were used in analysing qualitative data obtained for the study. The quantitative data were content analysed.

The number of buildings affected in the study area is not a function of affected

Hypothesis	Variables	Operational definitions

neighbourhood, building height and vegetal cover. This hypothesis was tested using multiple linear regression. The statistics is parametric, it measures the relationship between two or more variables and determine the actual rate of change of one variable when the other is increasing or decreasing at a given rate. Multiple linear regression was used to model windstorm disaster vulnerability against biophysical vulnerability indicators. SPSS was used to compute the model.

1. The number of buildings affected is a function of biophysical factors in the study area in the study area	Dependent Variable (Windstorm disaster devastation) Independent variables (Biophysical Indicators) Rate of Windstorm occurrence per year index	Ratio Variables: 1=2009 devastation (108 buildings) 2=2014a devastation (113 buildings) 3=2013 devastation (114 buildings) 4=2014b devastation (234 buildings) 5=2008 devastation (1280 buildings)
	Affected neighbourhoods heights (asl) index	Categorical Variables. 1=Less vulnerability (1.0-25) 2=Low vulnerability (25.1-50) 3=Medium vulnerability(50.1-75) 4=High vulnerability (75.1-100) 5=Extreme vulnerability (100.1-125)
	Windstorm disaster wind field index	Categorical Variables. 1=Less vulnerability (0.0-0.2) 2=Low vulnerability (0.21-0.4) 3=Medium vulnerability(0.41-0.6) 4=High vulnerability (0.61-0.8) 5=Extreme vulnerability (0.81-1.0)
	Vegetal cover index	Categorical Variables. 1=Less vulnerability (0.0-0.2) 2=Low vulnerability (0.21-0.4) 3=Medium vulnerability(0.41-0.6) 4=High vulnerability (0.61-0.8) 5=Extreme vulnerability (0.81-1.0)
		Categorical Variables. 1=Less vulnerability (0.0-0.2) 2=Low vulnerability (0.21-0.4) 3=Medium vulnerability(0.41-0.6) 4=High vulnerability (0.61-0.8) 5=Extreme vulnerability (0.81-1.0)

Table 3.14: Linear Regression's Variables Definition

Source: Authors` Construct, 2015

3.7.1Pattern of Windstorm Disaster Vulnerability in Ibadan

The hypothesis, (pattern of windstorm disaster occurrence in Ibadan is not random)was tested using nearest neighbour analysis. This model was used in establishing the spatial pattern among the affected neighbourhoods in the study area. The model was found to be useful when examining the distances between each point and the closets point to it. It is also useful to compare expected value for a random sample of point from a complete spatial randomness pattern.

GIS was used to calculate the model.

3.7.3 Operational Definition of qualitative Variables

3.7.4 Variable types and the measurements

Table 3.9 provides the list of dependents and independents variable and their operational definitions.

Table 3.15: Operational Definition of Variables

S/No	Variable	Operational Definitions
Contact and Geographical Details		House No. Street Name. Neighborhoods. Coordinate. Altitude (asl).
	Dependent Variables	

1.	Windstorm occurrence	Categorical variable:- 1=2009 , 2= 2014 (March), 3=2013, 4= 2014 (April) 5= 2008
	Independent Variables	
	SOCIO-ECONOMIC CHARACTERISTICS	
1	Length of stay in this area	Categorical variables:- Length of stay in years
2	Age	Categorical variable :- Total age of respondents in years
3	Gender	Nominal variable:- 1= Male 0= Female
4	Religion	Categorical variable
5	Ethnicity	Dichotomous variable
6	Marital status	Dichotomous variable
7	Household size	Continuous variables:- Total number of persons in the households
8	Educational attainment	Categorical variable
9	Occupation	Categorical variable
0	Income	Continuous variables
	HOUSING CHARACTERISTICS	
11	Type of Residential Neighborhood	Categorical variables: - 1. Low Density 2. Medium 3. High
12	Type and age of Building	Categorical variables
13	Type of Tenure	Categorical variables 1. Owner Occupier 2. Rented 3.Institutional Property 4.Family House 5. Squatter 6. Others(specify)
14	Types of Dwelling Unit	Categorical variables 1. Compound 2. Rooming Apartment 3.Flat 4.Duplex
15	Total Number of Rooms in Building	Categorical variables
16	Total Number of Household	Categorical variables
17	Average Number of Persons per Room	Categorical variables
18	Distance of Building to Adjacent Structure	Categorical variables
19	Material used for Construction	Categorical variables 1. Plank and Iron sheet 2. Mud 3. Burnt Brick 4.Cement Block 5. Stone 6. Others Specify
20	Is wall Plastered	Dichotomous variables:-1=Yes 0= No
21	Building Shape	Categorical variables
22	Roof Materials	Categorical variables 1. Thatch 2. Asbestos 3.Aluminium 4.Currugated Iron sheet 5. Reinforced concrete block (Decking) 6. Others(specify)
23	Roofing style	Categorical variables1= Gabble 2= Hip Roof 3= Flat roof
24	Material Used to seal roof Underside	Categorical variables:- 1= Asbestos 2= Plank 3= Concrete Finishing
25	Estimated Roof Pitch	Categorical variables
26	Materials Used for Doors and Windows	Categorical variables 1. Wooden Frame and wooden panel 2. Wooden frame and glass louvers3.Aluminium door and window 4.Metal frame and glass panel/ louver 5. Metal sheet 6. Others(specify)
27	Building Height	Categorical variables
28	Building setback from stream/river/pond	Categorical variables

29	Building setback from road	Categorical variables
30	Distance of building/street from forested areas	Categorical variables
31	Physical Conditions of building	Categorical variables:- 1= need minor repair 2= need major repair 3= good 4=others specify
		HOUSING FACILITIES
32	Access to building (road)	Dichotomous variables :- 1= with access 0= No access Tarred
33	Condition of road	Categorical variables:-1=poor 2= fair 3=good
34	Street width	Categorical variables
35	Street length	Categorical variables
36	Open Space types	Categorical variables:- 1= undeveloped plot 2= children play ground 3= football field 4=others specify
37	Dominant land Use	Categorical variables
38	Estimated distance of building from main road	Categorical
39	Estimated distance of Emergency service to your locality?	Categorical
40		
	DISASTER RELATED INFORMATION	
41	Do you have information prohibiting people from living in any area of this locality?	Dichotomous variables :- 1= Yes 0= No
42	What is your definition of disaster?	Categorical
43	What are the disasters earlier experienced by you in this locality?	Categorical variables:-
44	How do you mitigate them?	Categorical variables:-
	WINDSTROM RELATED INFORMATION	
45	Have you ever experienced windstorm in the area?	Categorical variable:- 1=very unsatisfactory, 2= unsatisfactory, 3= just satisfied, 4= satisfactory, 5= very satisfactory
56	What time of the year does windstorm occur in this area?	Continuous variable:- 1=onset of rain season , 2= end of rain season, 3=occasionally when it rains, 4= Anytime it rains 5= others specify
47	Can you recount the numbers of windstorm in this area?	Categorical variables :-
48	When last were your buildings devastated by windstorm occurrence?	Continuous variables :-
49	How long did it last?	Continuous variables :-
50	Were the adjacent buildings affected?	Dichotomous variables :- 1= Yes 0= No
51	From your experience, what was the frequency of occurrence per year?	Categorical variable:- 1=Once, 2= Twice, 3= more than twice, 4= others specify
52	What are the causes of windstorm?	Categorical variable:- 1=Natural, 2= Human Induced, 3ct of God, 4= others specify
53	If human induced, which of the following is correct?	Categorical variable:- 1=Building Location, 2= Improper Planning, 3= Absence of Windstorm related Law, 4= Poorly constructed building 5= others specify
54	Has there been any measure by government to combat windstorm	Dichotomous variables:- 1= Yes 0= No

	disaster in this locality?	
55	What is the government Agency`s response time to your windstorm disaster? If yes, list them.	Categorical variables :-
56	Why do you still live in this house or community despite your experiences with windstorm devastation?	Continuous variables :-
57	What can be done to prevent reoccurrence of windstorm disaster?	Categorical variable:- 1=cannot be prevented, 2= Property relocation, 3= Adequate Design and construction process, 4= better community planning and management 5= Adherence to building code 6= others specify
	INCIDENT BUILDING RELATED INFORMATION	
58	Have you ever experienced building collapse or roof rip-off before?	Dichotomous variables:- 1= Yes 0= No
59	Can you recollect the experience of what you witnessed?	Continuous variables :-
60	What is responsible for roof rip-off or building collapse in your area?	Continuous variables :-
61	Which parts of your building are mostly affected by windstorm?	Categorical variable:- 1=door, 2= widow, 3= roof, 4=others specify
62	During windstorm, what other facilities are affected aside buildings	Continuous variables :-
	SOCIAL SUPPORT /MITIGATION MEASURES	
63	Do you know of any disaster management Agency in Nigeria?	Dichotomous variables:- 1= Yes 0= No
64	if yes, What is the name of the Agency?	Continuous variables :-
65	Has the Agency done anything relating to windstorm, prevention and or management within your locality? If yes, name them.	Continuous variables :-
66	In your assessment, how efficient/ effective is the agency in carrying out its responsibility?	Categorical variable:- 1=not efficient, 2= averagely efficient, 3= efficient, 4= very efficient
67	Have you ever received help or support from government due to windstorm disaster?	Dichotomous variables:- 1= Yes 0= No
68	If yes, from which Organization?	Categorical variable:- 1=Individual 2= Community organization, 3= Government Disaster Agencies 4= NGOs, 5=international organization 6=others (specify)
69	Who do you think will help in militating or reducing the danger of windstorm vulnerability in your area?	Categorical variable:- 1=Individual / resident association, 2= NGO/Philanthropist organization, 3= Community, 4= LGA, 5= State government, 6=Federal Government 7=international organization/foreign government, 8=others (specify)
70	Personally, what can be done to improve on windstorm disaster management in your neighbourhood?	Continuous variables :-

Source: Authors` Construct, 2015

CHAPTER FOUR

FINDINGS

4.1Characteristics of the Neighbourhoods Affected by Windstorm Disaster

This chapter presents the characteristics of the spatial pattern and condition of the affected neighbourhood in Ibadan. The examination of the affected neighbourhood's characteristics is required. As it helps us to validate the findings in literature. Literature has it that the pattern of settlement puts building at risk of wind disaster (Centre d`Etude et de Internationale (CECI), 2003). For example, iron grid pattern layout exposes buildings to windstorm because the design creates no obstructions to wind-flow. The information retrieved during the field survey are analysed for this purpose.

4.2 Characteristics of the Sampled Neighbourhoods

The 51 sampled neighbourhoods form a contiguous area in Ibadan. The areas ware located mostly between Ogunmola road (Molete-Bere-Gate road) and the Lagos Ibadan-Express road. The windstorm disaster affected neighbourhoods fall on a region with rough terrain. About seven ridges and two hills were identified in the affected region. The area is drained by several streams, but the Kudeti stream remained the major stream traversing the incident areas (Fig. 4.1). Two zones outside this cluster are Apete and Moniya which are sprawl neighbourhoods at the outskirts of the city (Fig. 4.2).

The 51 sampled neighbourhood falls under high density residential area. Most of the neighbourhoods are in the traditional core (old quarters) areas of Ibadan. These areas predates westernization. Most buildings there are above 80 years. They are aged, crowded, constructed with mud, weak, inaccessible and in dilapidating state. Buildings constructed with cement and block were sighted around Owode Academy to the Express road, Moniya and Apete and at Felele. There are no access roads, sanitation policies and in most cases, it is almost impossible to mark the boundary between two buildings. The foot path and or street width in the core areas ranges between one to two metres (Table 4.1). Cutters, (2008) considered accessibility as a lifeline. Thus, a community without accessibility is susceptible to delayed evacuation during disaster and inaccessibility contributes to increasing risk of hazard which makes such neighbourhood vulnerable. Adelekan (2010), considers aged, crowded and mud buildings as being vulnerable to wind disaster in Ibadan. The degenerating state of the buildings at the traditional core and the quality of building in the sprawling neighbourhoods around Apete and Moniya have made it more susceptible to higher magnitude of windstorm devastation per square metre. Most devastated buildings in the relatively modern neighbourhoods such as Felele, Molete, Apete, Owode, Academy, Boluwaji and Sanyo Areas were found adequately repaired and in most cases with introduction of fastening belt. However, repair works carried out on neighbourhoods in traditional core (Old Quarters) areas such as Idi-Arere, Bode, Kudeti Aremo, Agugu, Gbelekale, Isale Osun, Oranyan, Oja-Gbo and others were defective. The present conditions of the repaired buildings in these neighbourhoods is more hazardous to the neighbouring residents. Buildings between 41-60 years are found immediately after the traditional core and are mostly inhabited by the indigenes. Less old buildings are found immediately after the core areas. Such neighbourhoods are Molete, Felele and part of communities along Lagos-Ibadan express road inhabited mostly by other Yorubas other than the indigenous people of Ibadan. The most recent areas where minimal incident had occurred were found around Moniya, Apete and parts of Lagos-Ibadan express road such as Soka (Fig. 4.2). The aged, weak and expired buildings found in the core areas explains the predisposition of the neighbourhoods in this area to windstorm disaster.

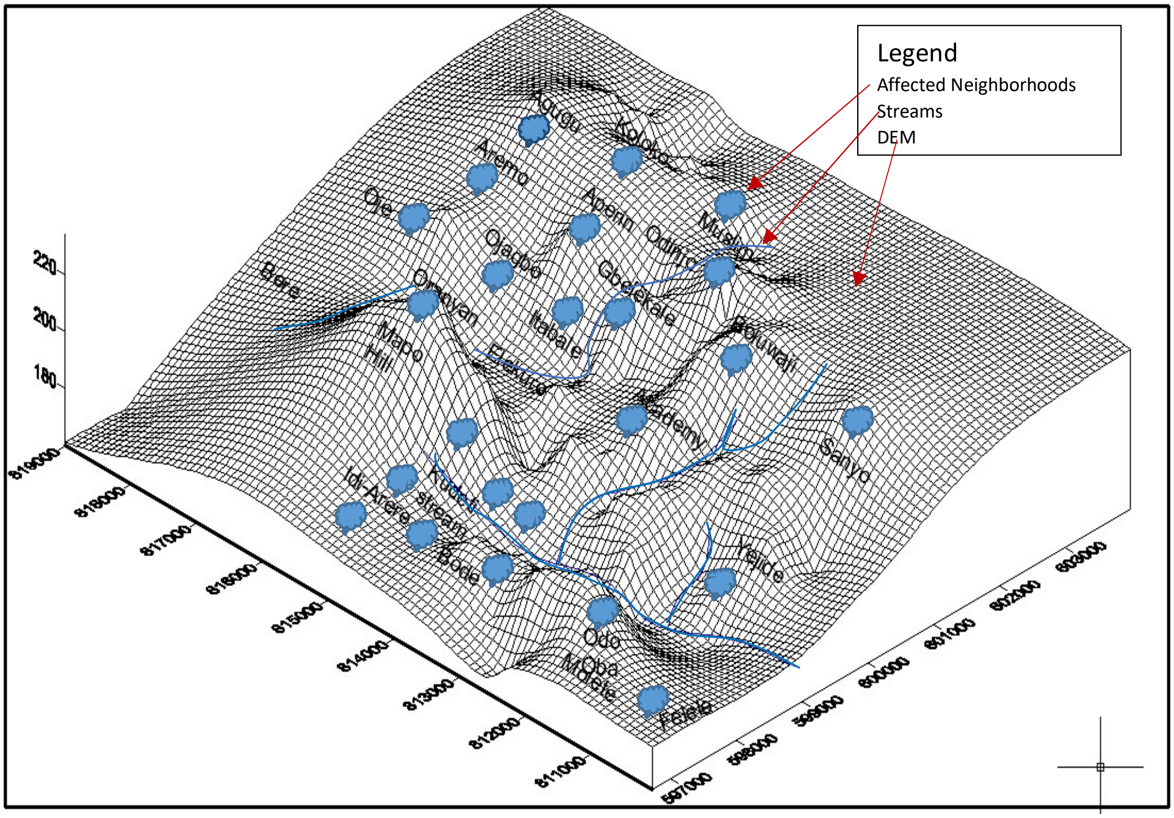

Fig. 4.1: Digital Elevation Model (DEM) of the Windstorm Incident Areas, Ibadan

Source: Author`s Field Survey (2016)

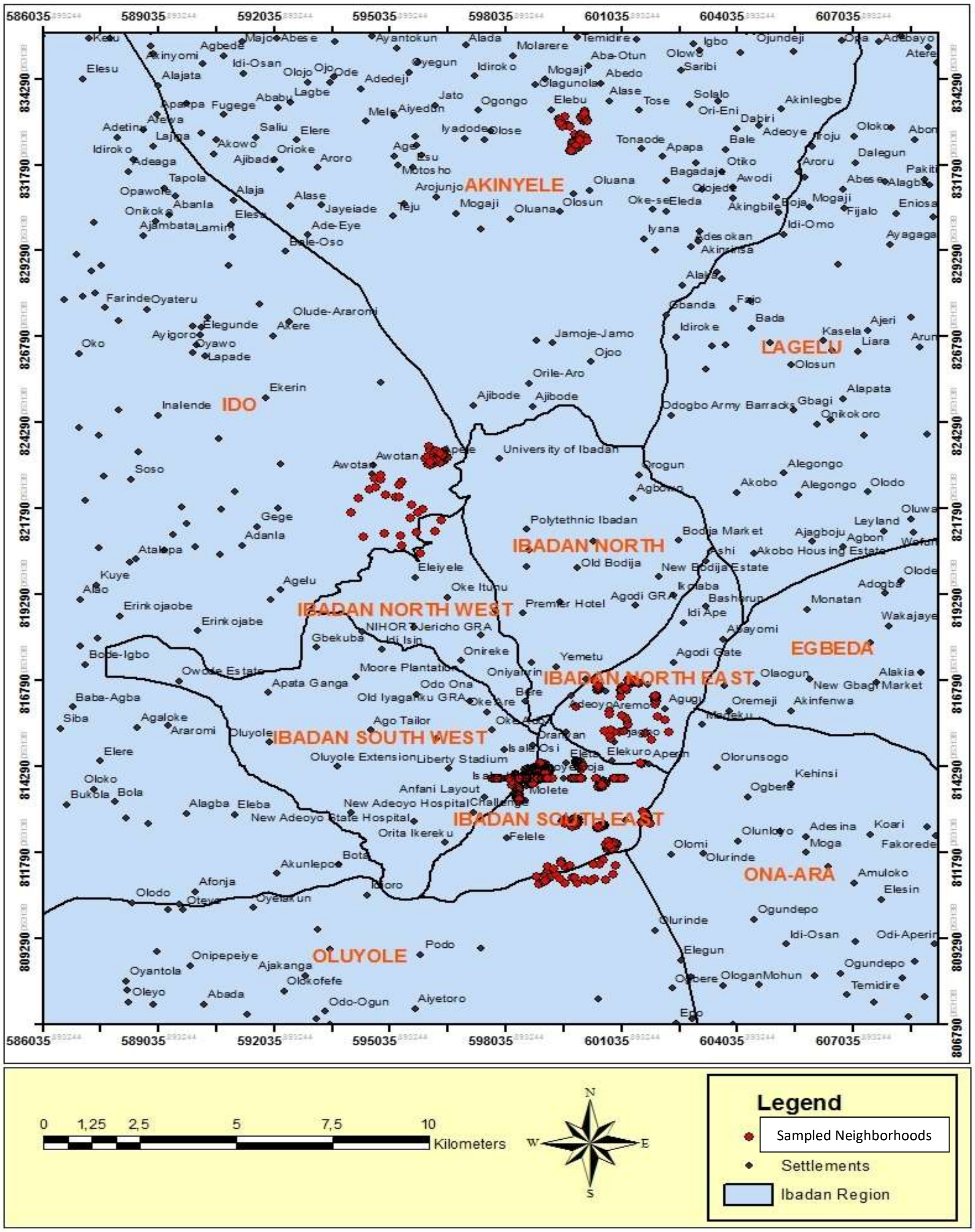

Fig. 4.2: Spatial Distribution of Sampled Neighbourhoods in Ibadan

Source: Author`s Field Survey (2016)

Table 4.1: Characteristics of the affected Neighbourhood

Socio-Economic characteristics	Number of respondents	Frequency
Density of the Area		
High Density Area	357	35.5
Traditional Core Area	648	64.5
Total	1005	100.0
Distance of building to opposite Structure		
1-2)m	337	33.5
2.1-4)m	124	12.3
4.1-6)m	29	2.9
6.1-8)m	23	2.3
8.1-10)m	21	2.1
Above 10.1m	471	46.9
Total	1005	100.0
Building Condition		
Good	362	36.0
Needs Minor Repairs	138	13.7
Needs Major Repairs	505	50.2
Total	1005	100.0
Material Used for Wall		
Block	453	45.1
Mud	552	54.9
Total	1005	100.0
Building Age		
<20 years	4	.4
21-40 years	146	14.5
41-60 years	250	24.9
61-80 years	42	4.2
> 81 years	563	56.0
Total	1005	100.0

Source: Author`s Field Survey (2016)

4.2 The Pattern of Buildings in the Affected Neighbourhoods

Buildings are appreciated mostly from their designs. In Ibadan, most sampled buildings are of rectangular shape (Table 4.2). Literature has it however that long rectangular-shaped buildings are not predisposed to windstorm disaster devastation. T-shape, L-shape and U-shape plans are more likely to be destroyed because these shapes create wind-suction bags during wind storm (CECI, 2003; Duy *et al*., 2007). Most of the sampled buildings were roofed in hip roof style with corrugated iron sheets. Reversed twin roof according to the length of building create larger areas of gable walls, which are dangerously exposed to strong winds. Also, most houses have their roofs, which are quite flat with roof angles smaller than 30^{o}. This creates more wind pressure on roof during windstorm (Duy et al., 2007). Buildings without their roofs underside sealed create loopholes for easy penetration of wind underneath the roofs thus exposing buildings to windstorm devastation. Those buildings finished with concrete cornice are however not easily vulnerable to windstorm disaster. They rather suffer roof peeling as against roof ripping. Also, storey buildings are mostly vulnerable to windstorm disaster in Ibadan.

'It was revealed by a respondents during focus group discussion at Kudeti that all the storey buildings in their neighbourhoods were devastated by 2008 windstorm disaster'.

CECI, (2003).Affirmed that Building height with more than 3.6m are more vulnerable to windstorm disaster. The study found a corresponding proportion of windstorm devastation with height of building in the sampled communities.

Table 4.2: Physical Characteristics of the affected Buildings

Characteristics	No. of Buildings	Percentage
Building proximity to structure at right the side	289	28.8
(0-1)m	333	33.1
(1.1-2)m	312	31.0
(2.1-3)m	27	2.7
(3.1-4)m	12	1.2
(4.1-5)m	14	1.4
(5.1-6)m	18	1.8
Above 6.1m	1005	100.0
Total		
Building proximity to structure at the left side	288	28.7
(0-1)m	337	33.5
(1.1-2)m	311	30.9
(2.1-3)m	28	2.8
(3.1-4)m	11	1.1
(4.1-5)m	14	1.4
(5.1-6)m	16	1.6
Above 6.1m	1005	100.0
Total		
Building proximity to structure at the back		
0-1)m	377	37.5
1.1-2	95	9.5
2.1-3)m	183	18.2
3.1-4)m	104	10.3
4.1-5)m	75	7.5
5.1-6)m	141	14.0
Above 6m	30	3.0
Total	1005	100.0
Building Proximity to structures at in the front	337	33.5
1-2)m	124	12.3
2.1-4)m	29	2.9
4.1-6)m	23	2.3
6.1-8)m	21	2.1
8.1-10)m	471	46.9
Above 10.1m	1005	100.0
Total		
Shape of Building		
Rectangular	934	92.9
Square	71	7.1
Total	1005	100.0
Roof Material		
Interlocking Tiles	24	2.4
Corrugated Iron Sheet	913	90.8
Aluminium roofing sheet	68	6.8
Total	1005	100.0
Roofing Style		
Gabbled Roof	121	12.0
Hip Roof	847	84.3
Flat Roof	37	3.7
Total	1005	100.0
Roof Underside status		
Sealed	524	52.1
Not Sealed	481	47.9
Total	1005	100.0

Material Used to Seal off the Underside	376	37.4
Asbestos	67	6.7
Plank	8	.8
Concrete Finishing	83	8.3
Carton	471	46.9
No Response	1005	100.0
Total		
Estimated Pitch of the Roof in Meters		
1-2	979	97.4
3-4	26	2.6
Total	1005	100.0
Building Height		
2 Storey Buildings (3 floors)	117	11.6
Storey Building (2 floors)	335	33.3
Bungalow (1 floor)	553	55.0
Total	1005	100.0
Average Building Height in the street		
3-5m	529	52.6
5.1-8m	278	27.7
8.1-11m	198	19.7
Total	1005	100.0

Source: Author`s Field Work (2016)

4.3 Setback to adjoining Buildings and Infrastructures in the affected Neighbourhoods

The study investigated the factors responsible for massive devastation especially as it has to do with complete roof rip-off and building collapse during windstorm disaster in Ibadan. The study identified building proximity as an important factor. Buildings were found crowded with very high density per hectare. The setback of buildings in all directions found buildings in close proximity at the right side, the left side, at the rear and front especially in the core neighbourhood clustered. This is an indication that the affected neighbourhoods are crowded. The minimum setback between buildings at the left and right sides in Oyo state is three meters, three metres to rear boundary and 6 meters from the road from the building faces (Lawal and Ogunsesan, 2017). An airspace of six metres is the minimum expected gap between two buildings in high density areas in Oyo state. Many buildings fall short of this scale (Table 4.1). The crowded buildings at the core and the close proximity generally found in the study area shows that the site and situation around the crowded neighbourhood may have contributed to windstorm disaster vulnerability in the study area. Hartley, (2015) identified crowded neighbourhood as a major factor for increased rate of windstorm disaster.

4.4: Characteristics of the affected neighbourhood's lifeline

Lifelines are vulnerability indicators defined as the networks that provide for the circulation of people, goods, services, and information upon which health, safety, comfort, and economic activity depend (Cutter, 2000). Roads, utilities, bridges, dams, airfields, railroads, and emergency response facilities are parts pf this. Inadequacy and or lack of these infrastructures have the capacity to compound hazard of a place during emergency. This research examined road conditions, accessibility and means of transportation of the affected neighbourhood (Table 4.3). Also, the point pattern and the relative distance of the neighbourhood to each other were examined. The affected neighbourhoods were found to be connected with fairly good secondary arterial road and or distributor roads. Service access roads were mostly found neglected; damaged and in most cases not passable (Plate 4.1, 4.2, 4.3).

Plate 4.1: Secondary Arterial Road, Ogunmola Way, Bode-Idiarere-Bere road Ibadan
Source: Authors` Field Survey (2016)100

Plate 4.2: A typical example of Failed Service Access Road at Balaro Community, Owode Academy, Ibadan
Source: Authors` Field Survey (2016)

Plate 4.3: An impassable Access Road (Path) at Mogana, Idi-Arare Ibadan
Source: Authors` Field Survey (2016)

Average street widths found in the study area were generally narrow. An average car width measures 2.5 meters. Thus, for a road to accommodate two cars conveniently, average width of 6 meters must be observed. Though the road leading to district were found to be in fairly good conditions, those in the neighbourhood and precolonial areas were not. Collapsed roads were sighted around Ajekunle Balaro and in some cases, neighbourhoods are totally cut off from the distributor road. In the old quarters, the traditional core, accessibility to a building is through an existing building. Narrow footpath serves as street thus has the ability to compound vulnerability. Therefore, it will take a lot of efforts, to rescue lives, in this type of neighbourhoods. These areas become vulnerable due to restriction in evacuation in the cases of emergency (Table 4.3).

`Drawing fromthe response of a male respondent at Mogana Compound, Idiarere,the narrow street/footpath in the old quarters evolved from gentrification of a traditional compound settings to bungalow. The respondent, an over 80 year's old man is the 16thchild of his late father. The male childreninherited a parts of their fathers compound to construct individual housing unit, resulting in narrow street defined by footpath`

The study also found that most of the respondents trek to earn their daily income. The means of transportation in the sampled areas is mainly Taxi and Scutter (*Okada*). The transport modes (Micra and okada) have limited space for massive evacuation of victims in the case of windstorm disaster. Most of the respondents are either artisans or petty traders. Most of them carry out their businesses close to their homes. So, the need to travel long distances to transact businesses is removed. However, these put the income and livelihood of the sampled neighbourhood at risk of windstorm disaster. Factors such as trekking, use of okada and Taxi, dual usage of residence show the low income status of the people at risk of windstorm disaster. It is concluded therefore that the affected neighbourhoods harbour people of low income. They lack the capacity and ability to consult building professionals for the construction of their buildings. Therefore, their buildings are susceptible to windstorm disaster (Table4.3).

Table 4.3 Road Condition and Accessibility

Characteristics	No. of Buildings	Percentage
Class or Types of Road Servicing your Locality		
Ring Road (Outer by-Pass)	22	2.2
Primary Arterial Road	159	15.8
Secondary Arterial Road	449	44.7
Distributor Road	245	24.4
Service Access Road	130	12.9
Total	1005	100.0
Condition of Road		
Good	522	51.9
Fair	359	35.7
Poor	124	12.3
Total	1005	100.0
Average Width of Street		
1-(2.9)m	225	22.4
3-(5.9)m	151	15.0
6-(8.9)m	310	30.8
Above 9m	319	31.7
Total	1005	100.0
Average Length of Street		
Less than 40m	150	14.9
41-80m	57	5.7
81-120m	114	11.3
161-200m	8	0.8
Above 200m	676	67.3
Total	1005	100.0
Major Means of Transportation in this Area		
Walking	272	27.1
Okada (Monocycle)	228	22.7
Car (Private)	47	4.7
Taxi	251	25.0
Bus	153	15.2
Keke (Tricycle)	54	5.4
Total	1005	100.0
Neighbourhood Accessibility		
motor able and accessible	270	26.9
Not motor able	735	73.1
Total	1005	100.0
What is Responsible for the Inaccessibilityif not motor able		
No Access Road	125	12.4
Compound setting/traditional Quarters	8	.8
Bad Road	89	8.9
Bad or lack of bridge	74	7.4
No Reponses	709	70.5
Total	1005	100.0

Source:

Nearest neighbour analysis of the 51 points, each representing neighbourhood as shown in (table 3.4) and the mean nearest neighbour distance calculated in meters as 0.003183. the expected mean nearest neighbour is calculated as 0.006596. Comparing this values using normally distributed Z score statistics, the Z value is -7.069538. Most of the neighbourhoods were found in close range. This is an indication that most of the neighbourhoods possibly share similar pattern and characteristics. Observed mean distance is found shorter than the expected mean distance. This distances is expected because the nearest neighbour ratio is 0.482538. Since the ration is smaller than one (1), then, the windstorm disaster affected neighbourhoods spatial pattern is clustered. This spatial cluster pattern has implication for hot spots windstorm disaster devastation within the city. The cluster is significant since Z-score -7.069594 is below 0.05 significant level (table 4.4). The H_0hypothesis which stated that ‘The spatial pattern of windstorm disaster affected communities in Ibadan is not random’ is accepted.

Table 4.4**Average Nearest Neighbour Summary**

Observed Mean Distance	0.003183
Expected Mean Distance	0.006596
Nearest Neighbour Ration	0.482538
Z-Score	-7.069538
P-Value	0.000000

Source: Authors` Field Survey (2016)

4.5 Elevation, Building Height, Vegetation and Windstorm Disaster Affected Neighbourhoods in Ibadan

This section discuses windstorm disaster affected neighbourhood's vulnerability and housing devastation viz-a-viz affected neighbourhood elevation above sea level, building heights, windfield and vegetation cover in Ibadan. The section is subdivided into; affected neighbourhoods' elevation and building devastation, building height and windstorm devastation, vegetal cover and windstorm devastation.

4 5.1 Elevation

The physical setting of Ibadan consists of ridges and hills that run approximately in northwest – southeast direction. Most parts of these ridges lie in the central part of the city. The elevation of these hills range from 160 to 275 metres above sea level (Ayoade, 1988). The topographic model for the study area indicate that the terrain of the sampled neighbourhoods are generally undulating, alternating between hills, ridges and valleys (Fig. 4 .3).

The relationship between the affected neighbourhood`s elevation, wind direction and building devastation were examined for 2008, 2009, 2013, and 2014a and 2014b windstorm disaster in Ibadan. Westerly winds were found prominent and may be the most dangerous wind direction in Ibadan (Table 4.7). Ayoade, (1988) stated that vulnerability`s to windstorm disaster in Nigeria south west region is influenced by tropical maritime air masses, a warm moist south-westerly air mass that originates over the ocean. Mijinyawa and Awogbuyi, (2011) confirmed South West wind (westerly wind) as the prevailing wind in Ibadan.

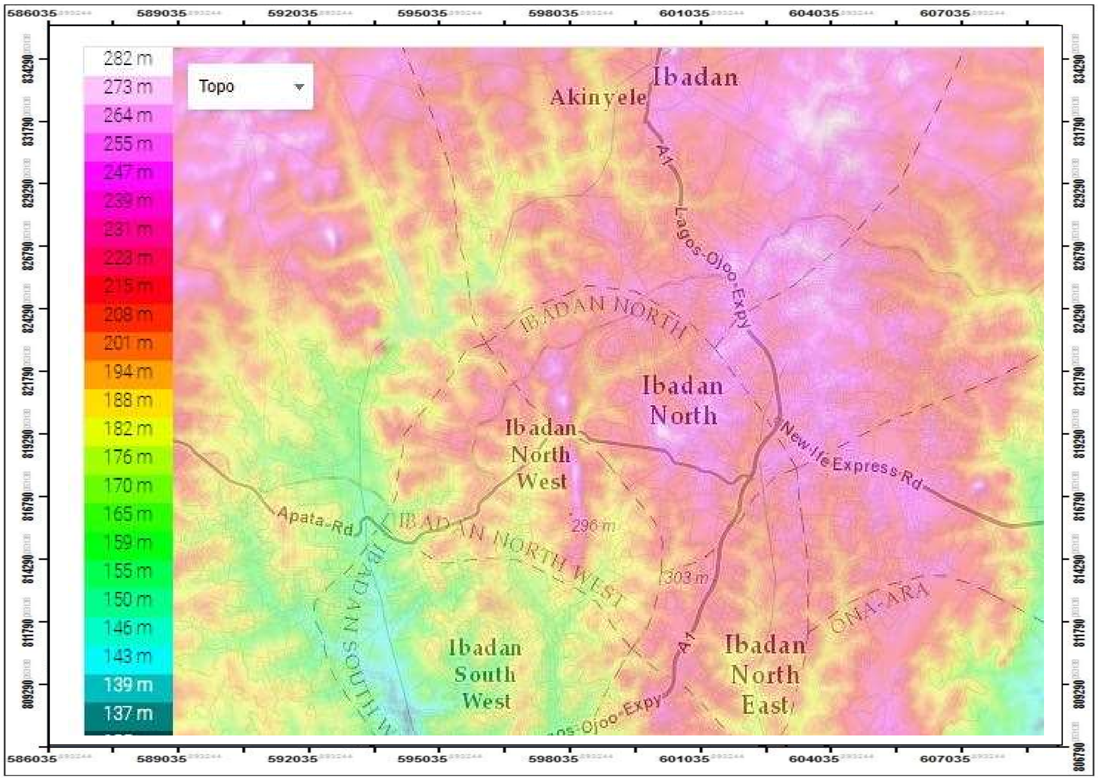

Fig. 4.4; Topographic Model of the Sampled Neighbourhoods

Source: http://en-ng.topographic-map.com retrieved on 24/03/ 2018

4.5.2 The 2008 Windstorm Disaster, Windfield, Direction and affected Neighborhoods Elevation (asl)

The 2008 windstorm disaster devastated three local governments and 26 neighbourhoods in Ibadan. The storm spread across 9.54sqkm. The affected neighbourhoods are Alagba, Olomi, Oke Irorun, Elere, Oke Suna, Idi-Aro, Kudeti, Idi Arere and Isale-Jebu Axis (Fig. 4.5). The storm touches down around Alagba near Ibadan-Lagos express road. The storm blew in north-westerly direction. Building devastation was high both on the hill and at the valley (Table 4.5 and 4.6) as shown in previous chapters. Maharami et al. (2009)`s, findings show that wind generally increases its speed when it moves up the windward slope of a hill or a ridge, and that the maximum increase in wind is usually experienced at or near the crest. Also, greater impact were observed at the valley. For example, at Idi-Arere, Bode, Kudeti and Idi-Oro area, there are more building devastation. The higher devastation downslope may not necessarily connote increase in wind speed but hazard of structures in the neighbourhoods in these areas. The buildings are old, weak, and non-reinforced. Adelekan (2012), found that severe impact of the windstorm events in Ibadan in 2008, were due to high concentration of residents in residential units, age of building and the state of disrepair of the residential buildings in the core area of Ibadan.

Table 4.5. Neighbourhood Elevation and Slope Vulnerability Index

Residential Neighbourhoods	Date of Windstorm Event	Building Affected Frequency	Percentage (%)	Highest Elevation	Lowest Elevation	Average Elevation	Remark	
Idi-Arere	2008	37	5.4	185	176	180.5	Low-land	2
Bode	2008	41	6.0	178	171	174.5	Low-land	2
Molete	2008	8	1.2	178	166	177	Low-land	2
Idi-Arere	2008	161	23.4	179	171	175	Low-land	2
Oke Suna Eleta	2008	11	1.6	200	193	196.5	Up-hill	2
Idi-Aro	2008	4	0.6	188	187	187.5	Up-hill	2
Bode (SW)	2008	238	34.6	174	168	171	Low-land	2
Elekuro	2008	2	0.3	184	182	183	Up-hill	2
Owode-Odooba	2008	15	2.2	168	165	166.5	Low-land	1
Odo-Oba	2008	12	1.7	168	166	167	Low-land	1
Oke-Olokun	2008	4	0.6	164	161	162.5	Low-land	1
Felele	2008	14	2.0	195	178	186.5	Up-hill	2
Odinjo	2008	2	0.3	201	198	199.5	Up-hill	3
Yejide Rd.	2008	8	1.2	166	162	164	Low-land	1
Molete	2008	4	0.6	172	166	169	Low-land	1
Isale-Jebu	2008	2	0.3	189	174	181.5	Low-land	2
Papa Aiyetoro	2008	4	0.6	207	203	205	Up-hill	3
Ifelajulo	2008	9	1.3	184	176	180	Low-land	2
Elere	2008	12	1.7	190	184	187	Up-hill	2
Islamic Mission	2008	2	0.3	170	167	168.5	Low-land	1
Kudeti	2008	40	5.8	175	170	172.5	Low-land	2
Modina Elekuro	2008	8	1.2	211	201	206	Up-hill	3
Modina Papa	2008	6	0.9	205	203	204	Up-hill	3
Sanyo	2008	11	1.6	172	168	170	Low-land	1
Moslem	2008	11	1.6	229	223	226	Up-hill	4
Boluwaji	2008	22	3.2	189	177	182.5	Up-hill	2
Total 2008 Building Sampled		**688**	**100.0**	**Total Average Elevation**		**182.4**		
Labiran	2009	1	1.6	185	181	183	Low-land	2
Ojagbo	2009	2	3.2	194	192	193	Low-land	3
Adekile	2009	2	3.2	214	208	211	Up-hill	4
Koloko	2009	3	4.8	216	210	213	Up-hill	4
Aremo	2009	1	1.6	210	206	208	Low-land	3
Gbelekale	2009	11	17.1	220	208	214	Up-hill	4
Aperin	2009	2	3.2	218	209	213.5	Up-hill	4
Ode-Aje	2009	8	12.9	217	214	225.5	Up-hill	4
Agugu	2009	10	12.1	225	215	220	Up-hill	4
Oluyoro	2009	2	3.2	216	208	212	Up-hill	4
Oke-Ofa	2009	9	14.5	223	215	219	Up-hill	4
Oje	2009	11	17.1	201	192	196.3	Low-land	3
Total 2009 Building Sampled		**62**	**100.0**	**Total Average Elevation**		**209.0**		
Elebu Junction	2013	9	10.46	235	228	231.5	Up-hill	4
Balogun	2013	42	48.8	238	221	234.5	Up-hill	4
Sawmill	2013	11	12.8	229	226	227.5	Up-hill	4
Morubo	2013	24	27.9	185	181	183	Low-land	3
Total 2013 Building Sampled		**86**	**100**	**Total Average Elevation**		**219.1**		
Papa Area	2014	22	59.5	194	183	188.5	Up-hill	2
Oja Area	2014	8	21.6	186	184	185	Low-land	2
Station Road	2014	7	18.9	189	183	186	Low-land	2
Total 2014 March Building Sampled		**37**	**100.0**	**Total Average Elevation**		**186.5**		
Academy	2014	40	30.3	231	219	224.5	Up-hill	4
Orisunbare	2014	18	13.6	205	201	203	Up-hill	3
Odinjo 2	2014	20	15.2	199	195	197	Up-hill	3
Ifelodun Elere	2014	11	8.3	192	184	188	Low-land	2
Ajegunle Balaro	2014	19	14.4	192	179	155.5	Low-land	1
Odo Oba 2	2014	24	18.1	170	166	168	Low-land	1
Total 2014 April Building Sampled		**132**	**100.0**	**Total Average Elevation**		**189.3**		

Source: Author`s Field Survey (2015)

Table 4.6Frequency Distribution of Neighbourhood Elevation

Elevation	Neighbourhood	Building Affected	Percentage
151-170 Relatively low	Owode-Odooba, Odooba, Oke-Olokun, Yejide Molete, Islamic mission, sanyo, Akekunle Balaro	115	11.43
171-190 medium	Idi-Arare, bode, Molete, Oke Sunna eleta, Idi Aro, bode, Elekuro, Felele, Isale-Jebu, Ifelajulo, Elere, kudeti, Boluwaji, Labiran, Apete, Ifelodun Elere	662	65.84
191-210 (Relatively high)	Odinjo, Papa Aiyetoro, Modina Elekuro, Modina Papa, Ojagbo, Aremo, Oje, Morubo, Orisunbare, Odinjo	102	10.22
211-230 (High)	Moslem, Adekile, Koloko, Gbelekale, Aperin, OdeAje. Agugu, Oluyoro, OkeOfa, Elebu Moniya Balogun Sawmill, Academy	126	12.51
	Total	1005	100.00

Source: Author`s Construct, 2016

Table 4.7 Wind Direction, Windfield in the affected neighbourhoods

Date of Windstorm Event	No of Affected Residential Neighbourhood s	Windfield (Total Area Covered) (Sqkm)	No of Buildings Sampled	Roof Deposit (Wind Direction)	Frequency (%)
2008	26	9.54	688	North-West	68.4
2009	6	5.64	33	North-West	3.3
2009	4		26	North-East	2.6
2009	2		3	North	0.3
2013	4	2.57	86	South-East	8.6
2014a	3	3.62	37	North-West	3.7
2014b	6	5.10	132	South East	13.1
Total	**51**	**26.47**	**1005**		**100.0**

Source: Author`s Field Survey (2015)

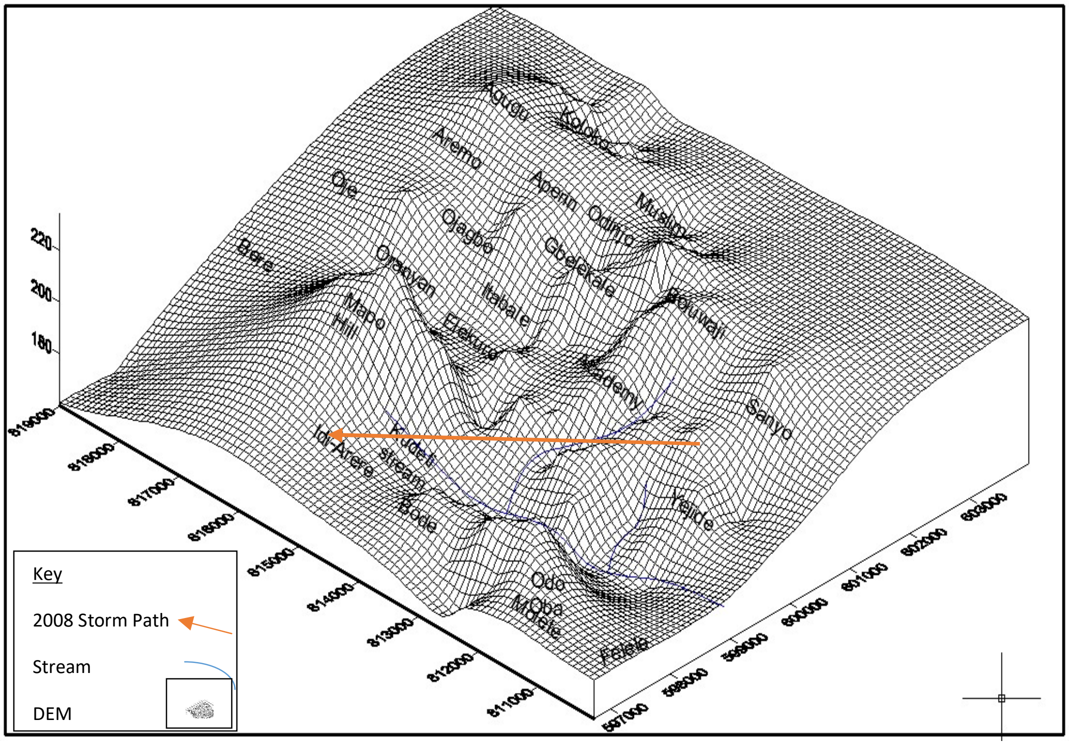

Fig. 4.5:Digital Elevation Model (DEM) showing 2008 Windstorm disaster (Wind Field, Direction amd Elevation of the affected Neighbourhoods)

Source: Author`s Construct, 2016

4.5.3 The 2009 Windstorm Disaster, Windfield, Direction and affected Neighbourhood Elevation (asl)

The 2009 windstorm incident occurred in Ibadan North East Local Government Area. The windfield covers an area of 5.64 sqkm. Seventy (17) neighbourhoods were affected (Fig 4.6). The windstorm roof deposit was in 3 different directions. The storm possibly touches ground around Aperin. The wind directions were North West, North and North East. Thunderstorm downburst is suspected to have produced straight-line wind resulting in wide spread out. Aperin, the suspected area, where the storm hit Ibadan is densely populated. The community is in close proximity to the Lagos-Ibadan express road and is situated on a hill. The windstorm affected 11 buildings at Gbelekale. Gbelekale is a community located on 205m above sea level upslope a hill that is 219m above sea level. The devastation around Aremo and Ode-Aje were very minimal. While a building was affected at, Ode-Aje, eight were affected at Aremo. Although these communities were at the higher altitude against Gbelekale and Aperin, yet the devastation at Ode Aje, a community tending toward a valley is synonymous with the devastation in 2008 at Idi-Arere, Bode and Kudeti. These communities are located in the low land and flood plain area. The devastation per hectare in this area is up to 29.8% (Fig. 4.7). Of the 51 neighbourhoods, only 17 are highly and extremely vulnerable to windstorm disaster in conformity with the height above sea levels. According to Klimanek et al (2008) on the geo-information analysis of factors affecting wind damage in the Suvanna national park, the researcher found minimal impact between higher elevation and wind devastating power. They found higher damage in the valley and around gentle slope sites of 8-15 degree.

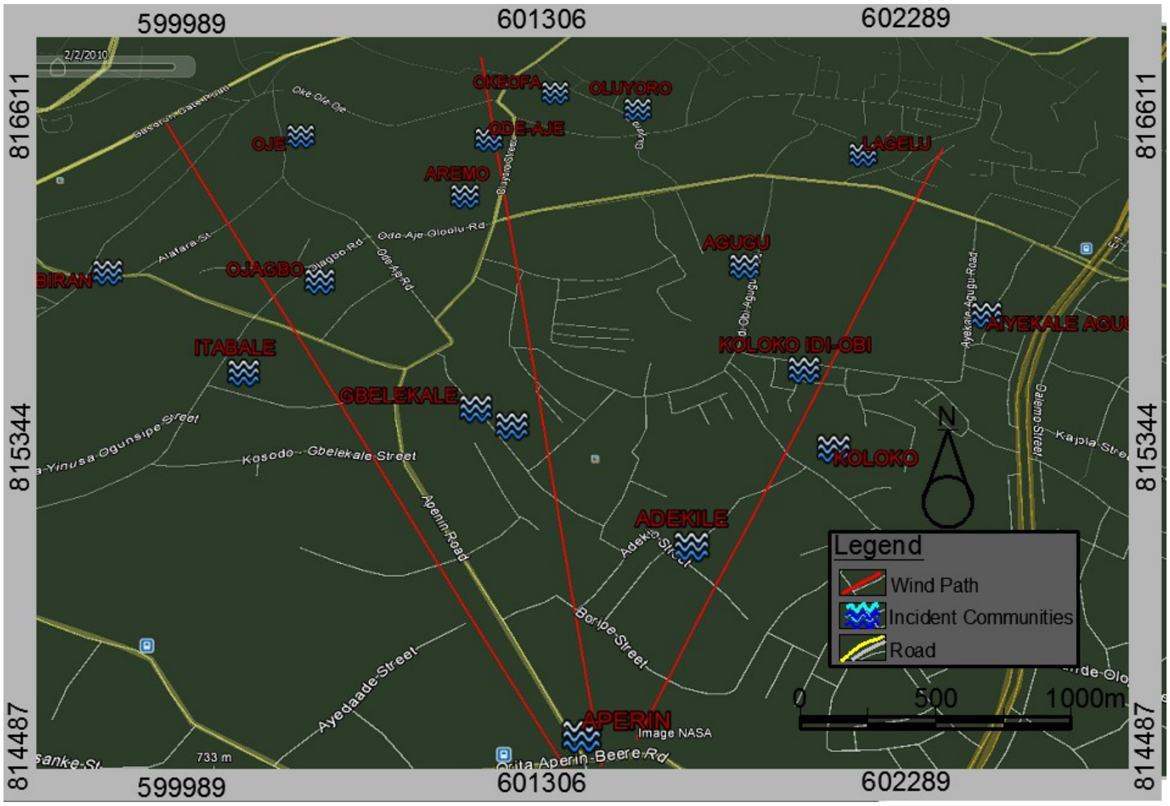

Fig. 4.6: 2009 Windstorm (Wind Field, Direction, Elevation of the affected Neighbourhoods)

Source: Google Map (2015) and Author`s Field Survey (2016)

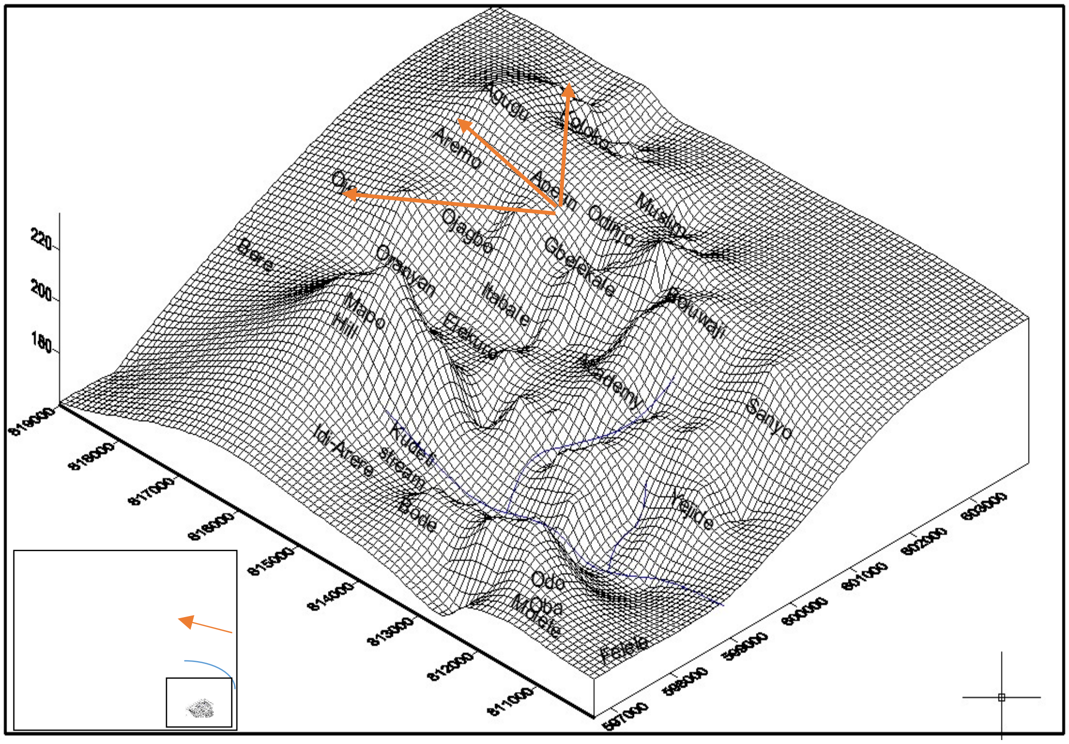

Fig. 4.6.1:Digital Elevation Model (DEM) showing 2009Northerly Windstorm disaster (Wind Field, Direction and Elevation of the affected Neighbourhoods)

Source: Author`s Construct, 2016

4.5.4 The 2013 and March 2014 Windstorm Disaster, Wind field, Direction and affected Neighbourhood Elevation (asl)

The 2013 windstorm disaster occurred in Moniya, Akinyele local government, Ibadan. The area coverage average was 2.57qskm. Also, the March 2014 event at Apete, Iddo local government area covered 3.62sqkm (Fig. 4.8 and 4.9). The terrain at Apete and Moniya are closely related. Although the situation at Apete has a direct relationship with Eleyele Dam, the Moniya terrain could only be explained as a result of rising slope. The terrain in each of these areas showed that the elevation at Morubo and Papa neighbourhood in Apete community rises gently from the shore of Eleyele Dam from 180m above sea level to the affected neighbourhoods in Apete at 185m above sea level. The neighbourhoods in this area are located on a rising slope. The unrestrained force created on the surface of Eleyele most probably contributed to the devastation experienced at Morubo and Papa neighbourhoods at Apete.

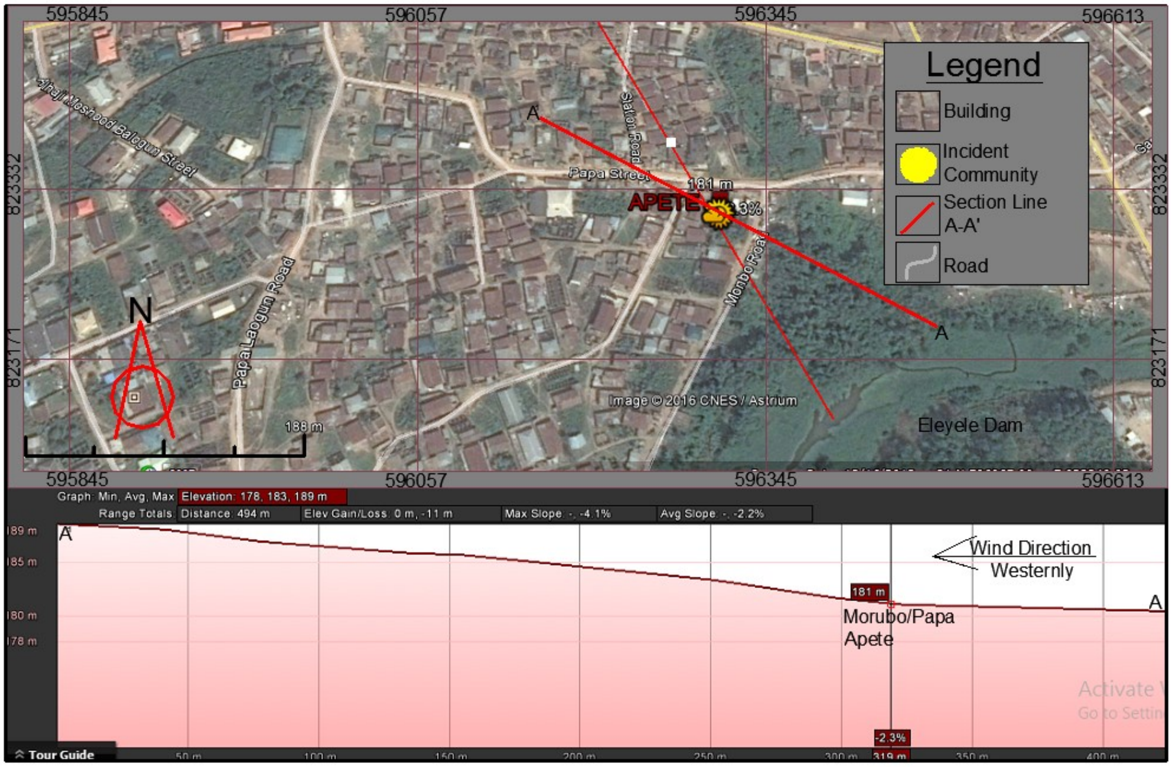

Fig. 4.8: 2014 Windstorm Disaster, Direction and its Elevation Profile at Apete

Source: Google Map (2015) and Author`s Field Survey (2016)

Specifically, 114 buildings were devastated during 2013 windstorm event in Akinyele LGA, Moniya as a result of an Easterly storm wind. The area devastated by the wind was located on a rising slope in different neighbourhoods within the locality. At Moniya, the windstorm touches ground around Elebu Village. Buildings were devastated at Elebu junction, a community located on a hill at an altitude of 232m above sea level. The storm further devastated buildings at Sawmill, a neighbourhood on a valley and finally hit Balogun where most buildings were devastated. Balogun is located on an elevation of 231m above sea levels.

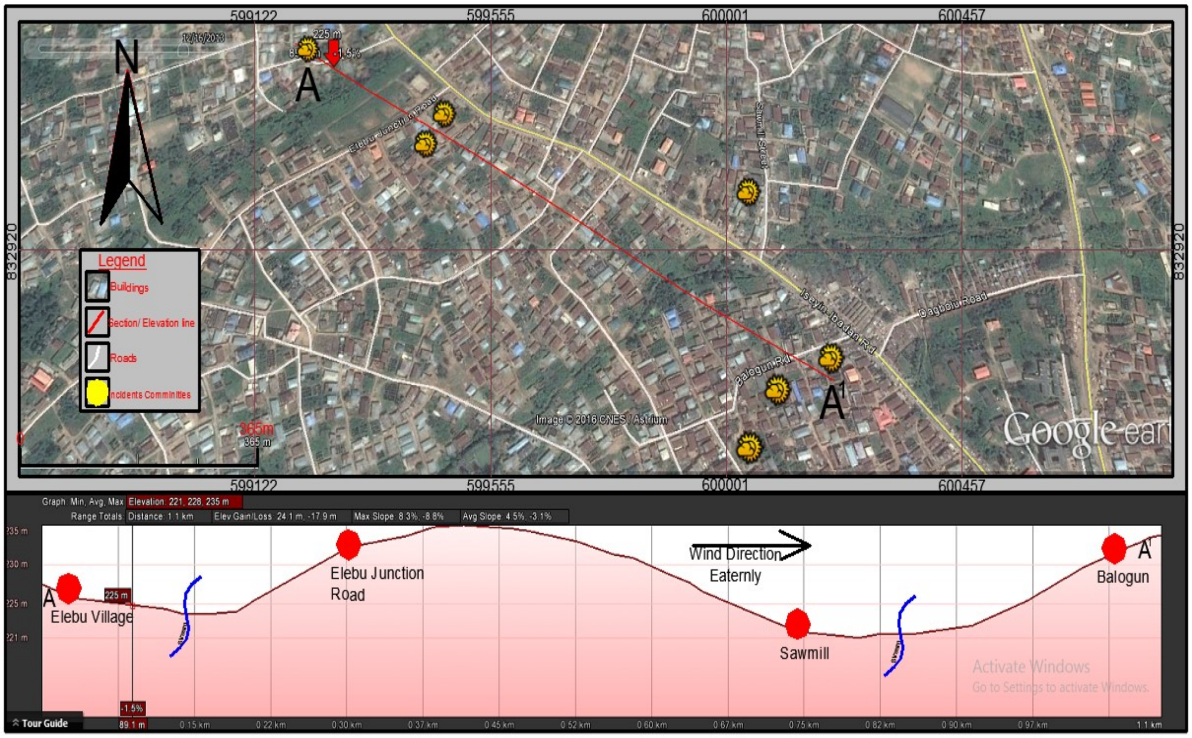

Fig. 4.9: 2013 Windstorm Disaster, Direction and Path at Moniya

Source: Google Map (2015) and Author`s Field Survey (2016)

4.5.5 The April 2014 Windstorm Disaster, Wind field, Direction and affected Neighbourhood Elevation (asl)

The April 2014 windstorm disaster affected 343 buildings in eight (8) neighbourhoods in Ibadan South East LGAs. The area coverage of the storm is 5.10sqkm. The south-easternly wind commences around Sakapena area in Idi-Arere and runs through to Academy. The storm wind blew through a rough terrain upto a hill in Academy where a lot of devastation was observed. The second most devastaing effect was observed in Ifelodun Elere, a down slope neighbourhood. At Ajegunle Balaro, a community which has an altitude 195m above sea levels, 13 buildings were devastated. At Ifelodun Elere, a community at altitude 190m above sea level, 37 buildings were devastated. The condition of the buildings here are same and the distance between the two communities is about 241m. The wind blew up hill again through Orisunbare at 205m above sea level where 13 buildings were devastated before hitting Academy, a community located on 218m above sea level where 57 buildings were devastated (Fig. 4.10).

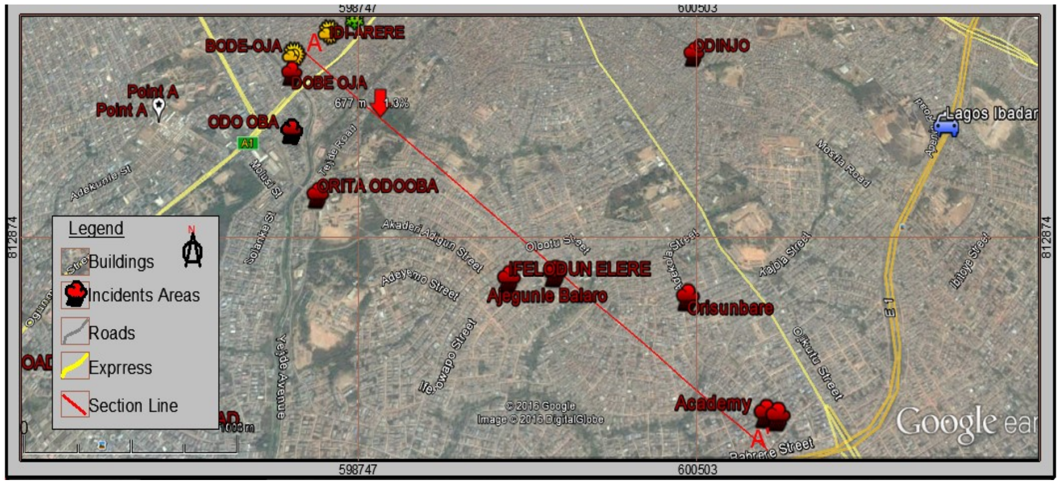

Fig. 4.10: 2014 Windstorm Disaster Incident Communities and Windstorm direction

Source: Google Map (2015) and Author`s Field Survey (2016)

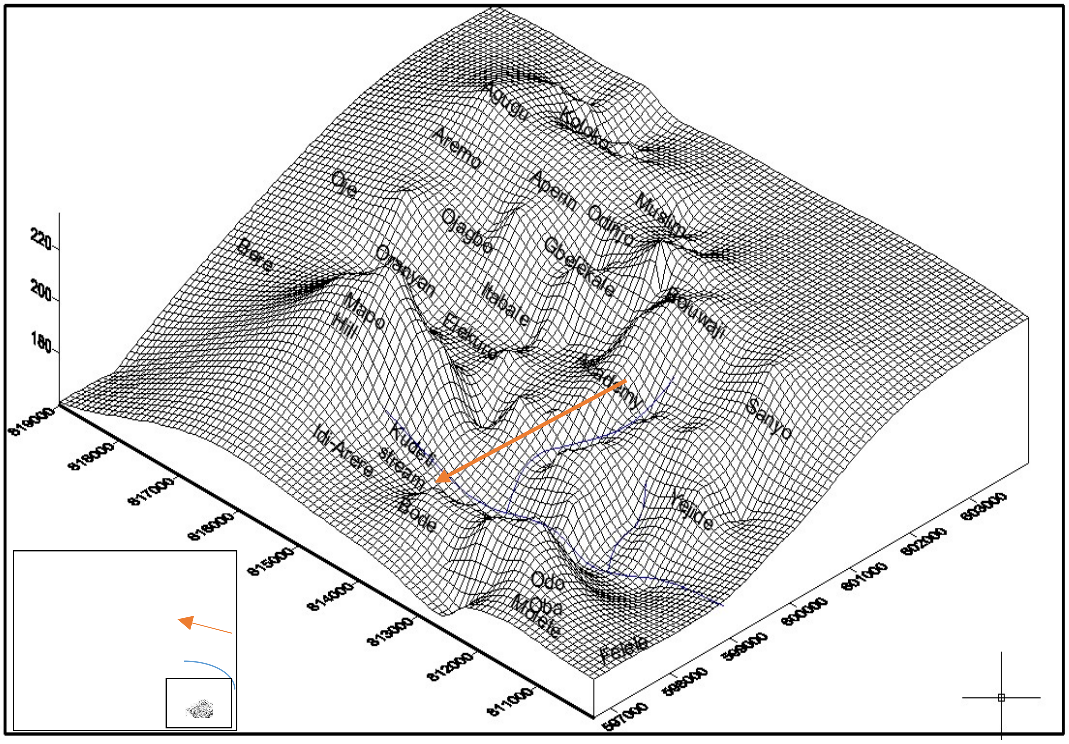

Fig. 4.10.1:Digital Elevation Model (DEM) showing 2014Westerly Windstorm disaster (Wind Field, Direction and Elevation of the affected Neighbourhoods)

Source: Author`s Construct, 2016

The April 2014 windstorm disaster also ravaged Felele locality and some parts of Molete (Fig 4.10). The storm hit Felele, cut through the Felele road, and went on to Aluko/Abimbola Area before it finally hit Molete near Ayola Avenue. At Felele, a total of 15 buildings were completely devastated while a building was affected at Molete Area. The roof deposit direction of the affected buildings were North West. The devastation commenced from a downhill at about 182m above sea level where 3 buildings were devastated and moved up hill at 195m above sea level precisely at Felele road area where about 7 buildings were devastated and then descended a hill to hit Aluko/Abimbola area at 187m above sea level to devastate 5 buildings. The storm dispersed towards a valley in Molete at 172m above sea level where a building was devastated. Although the location at Molete aligns with Felele incidents especially when the section line was drawn across the area, yet, it appeared as if there were two storms that day. While the roof deposits in Felele were all in North-West direction, the evaluation of the repondents in Molete claimed easternly direction. Athough, windstorm could change direction anytime, yet, if we consider the wind direction, then, the Felele incidents follow other findings where there are high devastation down stream and where windstorm fiddles out. Thus, the pattern of devastation at Felele road where 7 buildings were devastated were almost same with Aluko area, a down hill street where 5 buildings were devastated.

The study found increasing wind speed and devastation up hill in some of the neighbourhoods sampled. However, the study also observed massive building devastation at the downslope. In some cases, the study found the point at which wind terminates dangerous. Klimanek etal (2008) found no rigid relationship between elevation and wind throw at Suvanna National Park. Thunderstorm ignited winds is suspected to have been responsible for devastation both on the hill crest and in the valley in Ibadan. Downburst wind is a vertical wind that first touches the buildings on the mountains. At the valley, more devastation may be recorded because the wind met with a dead end and in attempt to turn back destroyed buildings downslope (Fig. 4.11). In figure 4.13, the dotted line is a model of the possibility of downburst wind forcing an air plane to crash. This obviously indicates that downburst wind could touch the ground from the sky. In (Fig. 4.12,) also, there are proofs that downburst wind has the capacity to devastate built up urban area. The site and situation in Ibadan fit in to Haberlie (2015) description where he found building concentration, heat island, and pollution as factors igniting increasing rate of windstorm disaster in the urban area.

Fig. 4.11: 2014 Windstorm Disaster Incident Communities and Windstorm direction at Felele

Source: Google Map (2015) and Author`s Field Survey (2016)

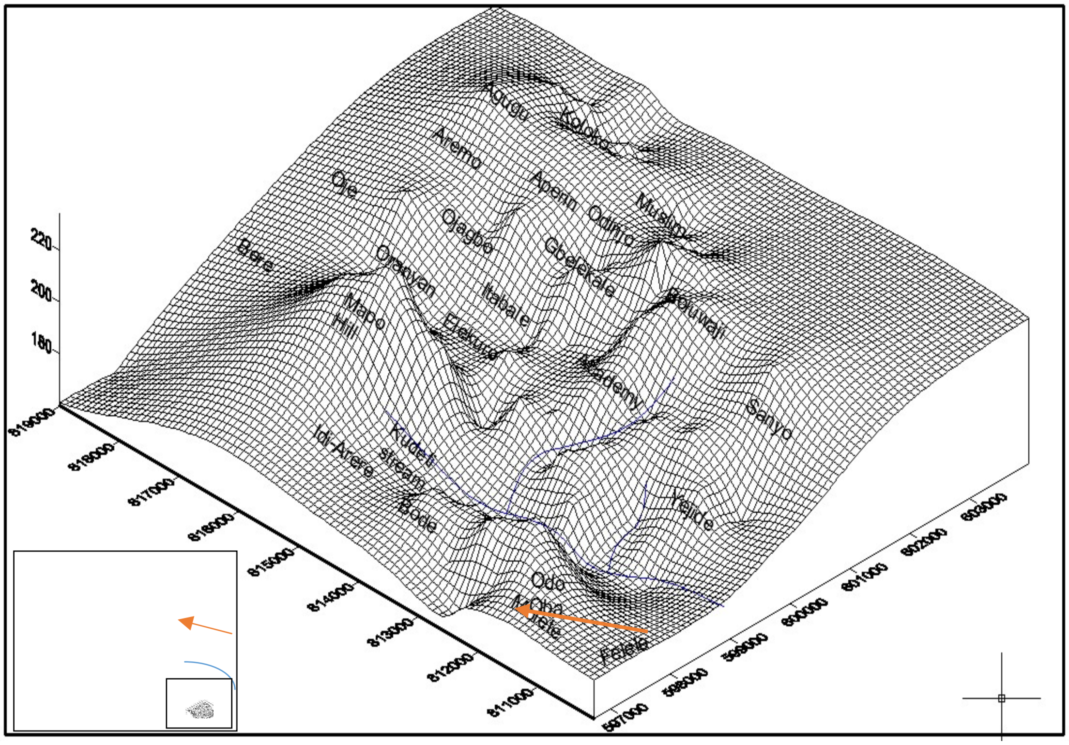

Fig. 4.11.1:Digital Elevation Model (DEM) showing 2014WesterlyWindstorm disaster (Wind Field, Direction and Elevation of the affected Neighbourhoods)

Source: Author`s Construct, 2016

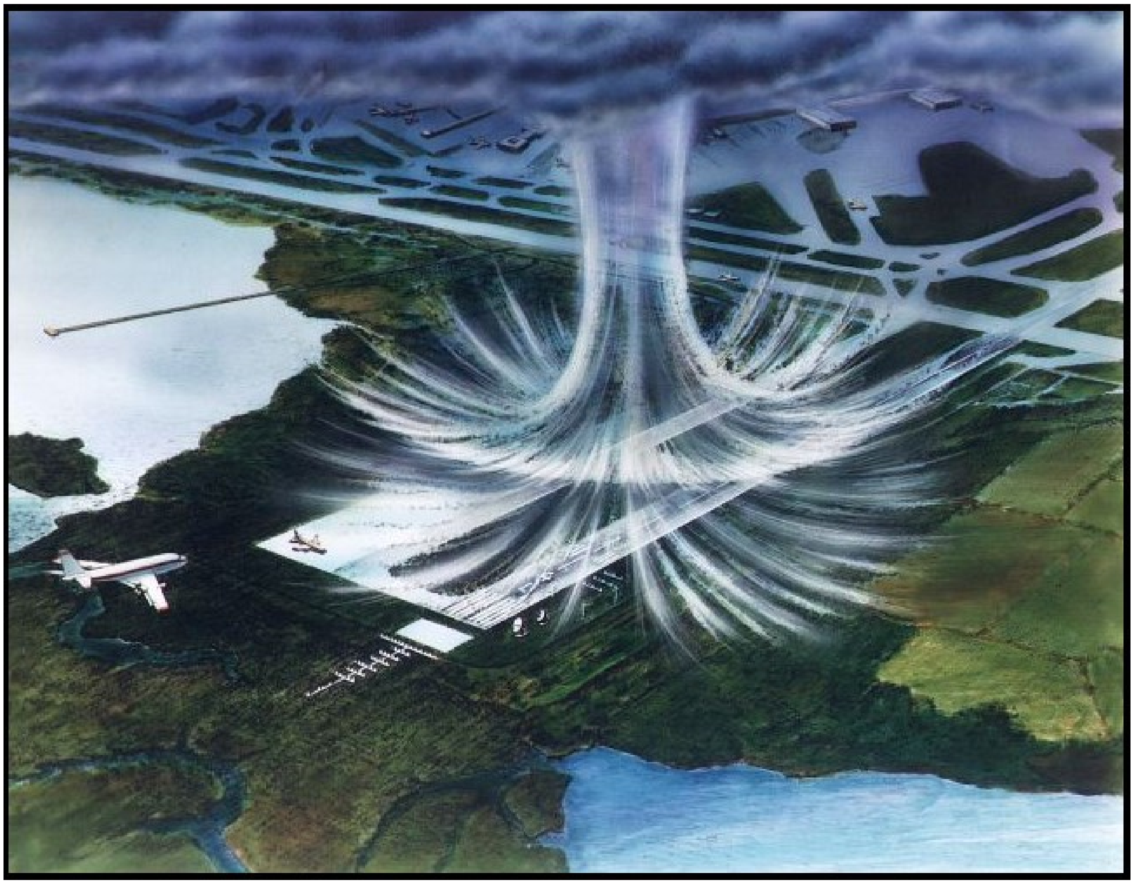

Fig. 4.12: Model of Down Bust Wind Impact on an Urban Settlement

The downward motion from the air hit the ground, then spread outwards in all direction.

Source: NASA 2018

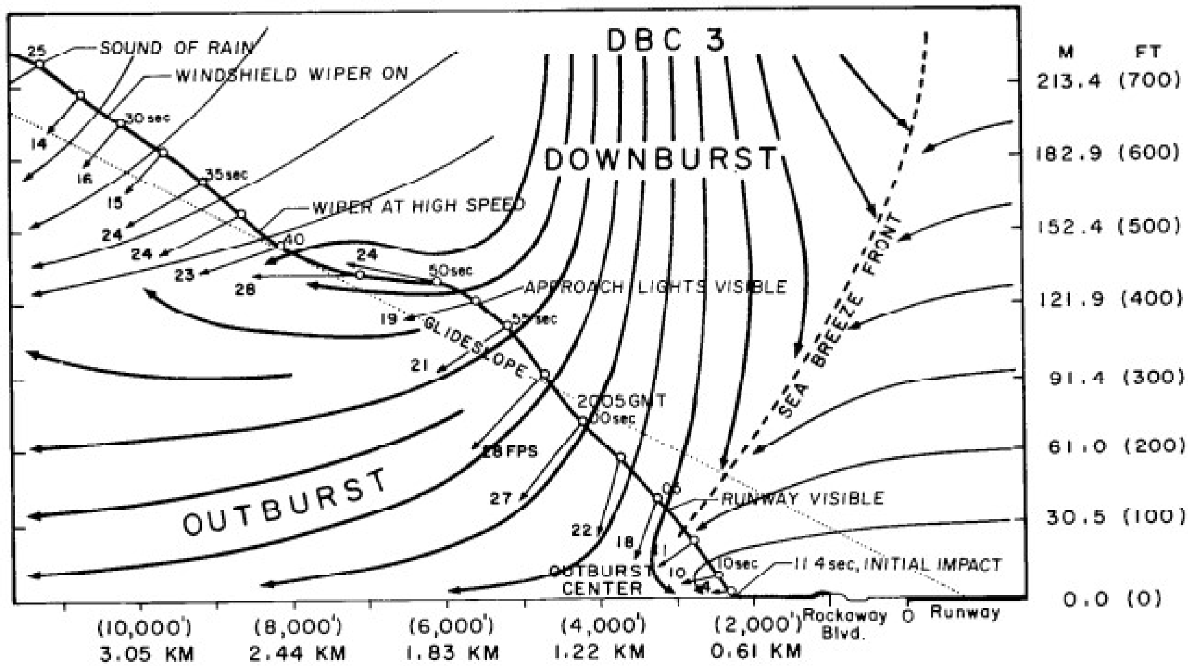

Fig. 4.13: A Down Bust Wind and its Impact on a Plane

Source Fujita and Carecena, 1977

4.5.6**Building Height and Windstorm Devastation in Ibadan**

High rise buildings are particularly vulnerable to windstorm devastation in the study areas. Most buildings in the sampled neighbourhoods are bungalows. However, there are pockets of high rise buildings among the 1005 sampled buildings in the 51 affected neighbourhoods (Plate 4.4-4.6). In most cases, all high-rise buildings in a neighbourhood are devastated (Table 4.8). The wind load is suspected to be greater at the higher altitude. Most of the sampled buildings are non-reinforced and in most cases, the buildings were not fastened to the wall until after their first experience of windstorm devastation (Plate 4.6). Thus, buildings with higher heights are more vulnerable to windstorm disaster in the study area (Table 5.2).

4.5.7 Vegetal Cover (Tree) and Windstorm Devastation in Ibadan

The effects of trees in sustaining human existence is unquantifiable. Generally, trees release oxygen in exchange for carbon dioxide released by human. In urban and regional planning, Trees are an important consideration for land cover for the regulation of local atmospheric condition of a place. The beautification of city is incomplete without trees. Trees also have the capacity to provide organic food for man which consequently reduces urban poverty. Thus, research found vegetal cover an important vulnerability indicator. Tress serves as wind breaker and reduces urban area surface temperature. The 2008 windstorm disaster devastated 1257 buildings in 26 neighbourhood, in Ibadan. The storm was an eye opener and one of the major reasons behind 2008 windstorm disaster behind the creation of OYSEMA in 2008. Windstorm disaster occurred only a year after *Igbo NITEL*, a forest reserve adjacent to the incident area known as NITEL forest was deforested.

> *During a group discussion at Isale Bode, it was authoritatively asserted that the neighbourhood began to experience incidents of windstorm only after the forest popularly known as Igbo-Nitel (Nitel Forest), was depleted in 2007*.

There are several forest reserves scheme initiated by the colonial government between 1916 and 1941 in Ibadan. However, most of the forest reserves especially at the core areas where windstorm disaster is more pronounced had been converted for residential purposes. The vegetation along the streams have been cut down for domestic use, thus, making the city suceptible to windstorm disaster. The conversion of these forests except in few places have contributed significantly to the reduction in the city carbon gain, urban food insecurity, and increase in the city heat island and

Table 4.8: Building Set Back to Adjacent Structures and Physical Characteristics

Characteristics	No. of Buildings	Percentage
Building Height		
2 Storey Buildings (3 floors)	117	11.6
Storey Building (2 floors)	335	33.3
Bungalow (1 floor)	553	55.0
Total	1005	100.0
Average Building Height in the street		
3-5m	529	52.6
5.1-8m	278	27.7
8.1-11m	198	19.7
Total	1005	100.0

Source: Author`s Field Work (2016)

have promoted neighbourhood vulnerability to windstorm disaster in the study area. Study found that urbanised areas are more prone to frequent thunderstorms than rural areas of the same size. Study on the 'births' of thunderstorms - known as storm initiations - between 1997 and 2013 found a significant increase in densely populated cities such as Atlanta. This has been said to increase pollution, (e.g rising temperature) in these regions compared to rural areas in the same geographical locationHaberlie, *et al* (2015).Part of the effects of thunderstorm is vertical wind shear, a dangerous microburst wind capable of causing massive devastation. In Ibadan, it is regrettable that an insignificant percentage of the affected people appreciates trees as one of the solution to vulnerability to windstorm in the study area. The affected persons attach little value to the importance of trees in the city (Table 4.9). Most of the forest reserves in the city were tagged *Igbo.* A deadly forest is originally referred to as Igbo in Yoruba linguistic. The windstorm disaster affected neighbourhoods are devoid of trees and the effect of the pocket of trees found in some of the neighbourhoods are insignificant to break the flow of storm wind. Standalone trees are as well vulnerable to windstorm disaster. They serve as potential hazards rather than wind breaker.

There are no reported cases of windstorm in some parts of the city where the vegetal cover are still available. E.g, Igbo Agala (Agala Forest), Railway Forest around Dugbe. Also the neighbourhood where trees abound only experience wind-throw. Although this also has its challenges (trees falling on buildings, branches falling and damaging packed vehicles), yet, the effects are minimal and are hardly reported. Example of such neighbourhood are University of Ibadan, Agodi Residential Quarters, Gate residential Quarters, Old and New Bodija and IITA. The buildings in the aforementioned neighbourhoods are reinforced, and the neighbourhood are in low density residential areas.

Plate 4.4: A Devastated High-Rise Building along Kudeti Stream, Ibadan

Source: Authors Field Survey (2016)

Plate 4.5: Devastated and non-reinforced high rise building at Buildings at Idi-Arere Ibadan

Source: Authors` Field Survey (2016)

Plate 4.6: Non-Reinforced and Retrofitted High-Rise Building at Isale Bode, Ibadan
Source: Author`s Field Survey (2016)

Plate 4.7: Devastated building and a standalone tree at Morgana Compound, Idiarere, Ibadan

Source: Author`s Field Work (2016)

Table 4.9: Respondents Opinion on Trees as Windbreaker in Ibadan

Characteristics	No. of Buildings	Percentage
Individual Strong Winds Mitigation Strategies		
Planting trees as Wind Breaker	17	1.7
Use of Tight Belt /Anchor Belt	217	21.6
Fix Roof Leakages	226	22.5
Prayer	218	21.7
Nothing Can be Done	327	32.5
Total	**1005**	**100.0**
Indigenous Windstorm Disaster Mitigation Strategies		
Use of Diabolical Power	48	4.8
Placing Heavy Material on the Roof	106	10.5
No Known Method	426	42.4
No Response	377	37.5
Planting Trees	39	3.9
Use of Red Wood	9	0.9
Total	**1005**	**100.0**
Expected Government Actions Against Windstorm Disaster		
Enlightenment/ Advocacy program	43	4.3
Nothing Can be Done	243	24.2
Plant Trees	280	27.9
disallowing people from living in prone areas	177	17.6
Urban Renewal	61	6.1
Help to Reconstruct devastated buildings	45	4.5
No Response	156	15.5
Total	**1005**	**100.0**
Observed Government Actions against Windstorm Disaster	55	5.5
Community Enlightenment Program	45	4.5
Media Advocacy Program	2	.2
Tree Planting Program	903	89.9
No/t Applicable / Response	**1005**	**100.0**
Total		

Source: Author`s Field Survey (2016)

Justifying the above findings with an hypothesis which stated that; the number of buildings devastated in the study area is not a function of the affected neighbourhoods' elevation, building height and vegetal cover.

Using linear regression analysis (Table 4.0),R square indicated that only 51% of windstorm devastation thereabout can be explained by the affected neighborhood elevation, vegetal cover and high rise buildings. For every unit increase in elevation, there is a 0.04 unit decrease in windstorm disaster. For every unit increase in vegetation, a 0.39 unit decrease in windstorm disaster is expected, holding other variables constant. For every unit increase in high rise buildings, an approximately 0.05 point decrease in windstorm disaster is expected.

The elevation coefficient at -0.043 is not significantly different from 0 because its P-Value 0.573 is greater than 0.05. Thus, elevation does not significantly explain windstorm disaster devastation in Ibadan. The alternative hypothesis that stated that elevation is not a function of windstorm disaster devastation in the study area is accepted.

The coefficient for vegetation is -0.039. This is not significantly different from Zero (0) because its P-value 0.481 is greater than 0.05. Vegetation cannot also significantly explain windstorm disaster devastation in Ibadan. The alternative hypothesis that stated that vegetation is a function of windstorm disaster devastation in the study area is rejected.

The high-rise building coefficient is 0.608. This is significantly different from zero (0). Its p- value 0.000 is less than 0.05. Its intercept is also significantly different from 0 at the 0.05 alpha level.

It is only high-rise building that significantly contribute to windstorm disaster devastation in Ibadan. The alternative hypothesis that states that high rise buildings is not a function of windstorm disaster devastation in the study area is rejected.

The purpose of all construction work is to create a structural system that meets human needs of protection from extreme weather and security. For this, a structure must be designed to avoid failure, which may result in the loss of life, property, waste of resources or damage to the environment. Not minding all the efforts being made by the stakeholders to avoid failures, structures fail over time as a result of design flaws, ageing, material fatigue, negligence, accidents, terrorist attacks, extreme operational and environmental conditions, and natural hazards, such as storm (Ede, 2011). Since it has been established that high rise buildings are susceptible to windstorm disaster vulnerability in Ibadan, the onus lie on the town planners to utilize development control tools more effectively in order to ensure strict adherence to building code in Ibadan.

Using one way Anova, the numbers of residential buildings devastated by windstorms varied significantly across residential neighbourhoods (F=3.275) at (at p=.001) i.e $F_{(2,1004)}=3.275$. However, F-Ratio (3.275) is less than 5. The model though significant but may lack the statistical integrity to appropriately fit in for this prediction. Ordinarily, F-ratio should be greater than 5 before the model predictive ability could be reckon with (Table 4.11).

Table 4.10: Factors Explaining Windstorm Disaster Devastation in Ibadan

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.257	.453		.568	.573
	Elevation (asl)	-.043	.060	-.073	-.710	.481
	vegetation vulnerability	.039	.083	.047	.464	.645
	High Rise Building	.608	.090	.698	6.765	.000

a. Dependent Variable: Windstorm Disaster Vulnerability

Source: Author`s Field Survey (2016).

Table 4.11**Factors Explaining variance Windstorm Disaster Devastation in Ibadan using one way Anova**

ANOVA

If Yes, When did you Experienced Windstorm Disaster?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1153.055	42	27.454	3.275	.000
Within Groups	8063.944	962	8.382		
Total	9216.999	1004			

Source: Author`s Field Survey (2016).

4.6.0 Mitigation and Perception of the Victims of Windstorm Disaster in Ibadan

4. 6.1 Victims` Experience and Knowledge of Disaster

This section evaluates the victims` perception of windstorm disaster, their ability to cope with, mitigate and avert windstorm disaster re-occurrence. The research sought after the victim's knowledge of all occurring disaster in their neighbourhoods (Table 4.12). Flooding, fire incident, building collapse, accident and heat waves were identified as other common disasters in the sampled neighbourhoods. The heat wave usually commences between February and March and or towards the end of harmattan. Research had linked heat wave to the birth of thunderstorm in the city (Haberlie, *et al,* 2015). Haberlie findings revealed that urbanised areas such as Atlanta are 5 per cent more likely to be hit by thunderstorms. Densely populated urban area where heat waves and pollution are high is said to be vulnerable to windstorm disaster during warmer months, in the late afternoon and early evening. The findings also confirmes the role of rising temperatures leading to the higher frequency rate of storms in Ibadan (Haberlie, *et al* 2015).

Building collapse was also mentioned. Building collapse could expose the core areas to other forms of disaster vulnerability. Buildings can collapse during windstorm, flooding, fire incidents and even when accidents occur. Most buildings in the core areas are old and weak because they have completed their life cycles. Windstorm is a major catalyst for building collapse in the vulnerable neighbourhoods in Ibadan (Adelekan, 2012). OYSEMA reported windstorm disaster first in 2005. However, higher percentage of the respondents had experienced windstorm disaster earlier than the base year. For example, 1980 was mentioned by a very good proportion of the respondents. This is an indication that government data may not have captured earlier occurrences. Newspaper cutting may be a good alternative to collect pre 2005 windstorm data history in Ibadan.

Table 4.12: Windstorm Disaster and Victims` Perception

Characteristics	No. of Buildings	Percentage
Types of Hazard Experienced in the Locality		
Fire	242	24.1
Building Collapse	11	1.1
Windstorm	230	22.9
Heat wave	45	4.5
Flooding/windstorm	62	6.2
Fire, Building Collapse	12	1.2
Fire, Building Collapse, Accident, Heat Wave	69	6.9
Windstorm/Fire	41	4.1
No Response	293	29.2
Total	1005	100.0
Windstorm Disaster and Years of Occurrence		
1980	2	.2
2008	641	63.8
2010	66	6.6
2012	90	9.0
2014	96	9.6
2008, 2012	3	0.3
2008.2012,2013,	37	3.7
2008,2012,2013,2014	46	4.6
Noon of the Above	8	0.8
2008, 2015	16	1.6
Total	1005	100.0
Usual Occurrence of Wind Storm in this Area		
At the beginnings of Rainy Season	527	52.4
At the End of Rainy Season	47	4.7
Occasionally when it Rains Heavily	371	36.9
Anytime it rains heavily	8	0.8
1 & 2	52	5.2
Total	1005	100.0
Windstorm disaster last Occurrence		
2008	318	31.6
2010	31	3.1
2011	35	3.5
2012	180	17.9
2013	81	8.1
2014	249	24.8
2015	111	11.0
Total	1005	100.0
Causesof the Windstorm		
Occurred Naturally	501	49.9
Human Induced	155	15.4
Act of God	301	30.0
Sin	48	4.8
Total	1005	100.0
If Human Induced, identify the most Appropriate		
Location of Property in Hazard Prone Area		
Improper Planning or Design	303	30.1
Lack of Windstorm related Laws	151	15.0
Poorly Constructed Buildings	65	6.5
No Response	164	16.3
Total	322	32.0
	1005	100.0

Prevention of Windstorm Disaster Strategies		
Cannot be Prevented	388	38.6
Property Relocation	21	2.1
Adequate Design and Construction Process	264	26.3
Better Community Planning and Management	170	16.9
Adherence to Building Code	1	.1
Repent From sinful ways	161	16.0
Total	1005	100.0
Manners of Windstorm disaster Occurrence		
	24	2.4
Sudden Occurrence	359	35.7
Total Community Devastation	265	26.4
Very Bad Experience, scared of death	129	12.8
Sales Shed becomes flying Weapon	228	22.7
Ripped Roofs were Placed on Other Houses	1005	100.0
Total		
Part of the Buildings Mostly affected		
Roof	997	99.2
Doors	8	0.8
Total	1005	100.0
Other Facilities Devastated by Windstorm		
Electric Poles	557	55.4
Mast	16	1.6
Bill Board	19	1.9
Sales Shed attached to Building	130	12.9
Filling Station	33	3.3
Electric poles and Sales Shed	19	1.9
Electric Poles, Bill Board and Sales Shed	48	4.8
All of the Above	183	18.2
Total	1005	100.0

Source: Author`s Construct (2016)

Although there is no official report where these claims are captured, yet, the 1980 flood popularly known as 'Omiyale' in Ibadan must have been accompanied by windstorm. Flooding alone may not have been responsible for the very high proportion of buildings devastation during that incidents.

In an attempt to reconcile the period of the year with higher vulnerability to incidents of windstorm disaster, the research found that most all the windstorm disaster incidents occurred at the beginning of rainy season (February-early April). This complements the information retrieved from the OYSEMA where most of the windstorm occurrence falls between February and March. The thunderstorm activities are also high around this period. Disaster was considered an act of God by the residents of Ibadan. Most respondents believe it is an avenue for the Supreme Being (God) to vent His anger. This is not out of place because the word disaster itself originated from the French words, a derivation of two Latin Words (dis, astro)-roughly, "formed on a star." (Quarantelli, 1987). Disaster was originally referred to as an unfavourable or negative event, usually of a personal nature resulting from unfavourable alignment of the stars and planets. For example, the word was applied to major physical disturbances such as earthquakes and flood which were wrapped up traditionally as the Acts of God. Acts of God were viewed as divine retribution for human misdeeds and failings (White *et al*., 2001). Some of the sampled respondents however associated disaster with human activities.

Although the idea that windstorm disaster is caused by human activities, are not popular, yet, the research further probe this perception. Respondents were asked if they thought factors such as location of properties, poorly constructed buildings, improper planning or design and lack of windstorm-related laws were responsible (Table 4.12). The sampled communities are high density area. The building density in the traditional core is particularly dense while the setback between buildings is less than one meter in most cases. This increases heat island. Also the water management system of the state is poor. This increases pollution. There are no drainages, water flows on the surface. The combination of these factors induces thunderstorm. Microburst wind resulting from thunderstorm develop into high wind that often causes devastation to the vulnerable communities in Ibadan. A filthily, polluted environment with high temperature could ignite windstorm (Haberlie, *et al* 2015).

Prevention of windstorm disaster is possible only through adherence to due process in design and construction. Ibadan should have a master plan that enhances development control. Properties found in the hot spot areas should be relocated and the building code should adhered to. Of importance to this study are the temporary shed situated along the road which respondents identified as flying weapons during windstorm disaster. The setback to most roads in Ibadan is lined with these illegally erected low quality temporary sheds which cannot withstand wind forces, thereby exposing residents injury and death (Plate 4.9 and 4.10).

At Felele, during group discussion, flying roof was the cause of injury of a commercial Okada operator and his passenger when an air lifted roof from Aluko street, a distance of about 200 metre landed on them while in motion on Abimbola, during 2008 windstorm disaster incident.

This scenario is responsible for most of the injuries resulting from windstorm occurrence in the study area. The parts of the building which suffer more destruction during windstorm were identified as the roof and windows.The study further found that windstorm devastation is not limited to only buildings. Other facilities vulnerable to windstorm disaster are the electric poles, sales sheds, billboards, filling station's canopy and communication mast /radio tower.

Table 4.13: Windstorm Disaster Mitigation

Characteristics	No. of Buildings	Percentage
Windstorm Mitigate Approaches		
Tree Planting		
Use of Fastening Belt	17	1.7
Under roof ceiling	217	21.6
Prayer	226	22.5
Use of Diabolical Power	218	21.7
Total	327	32.5
	1005	**100.0**
Indigenous Mitigation Strategies		
Use of Diabolical Power		
Placing Heavy Material on the Roof	48	4.8
No Known Method	106	10.5
No Response	426	42.4
Planting Trees	377	37.5
Use of Red Wood	39	3.9
Total	9	0.9
	1005	**100.0**
Recommended State Actions to Mitigate Windstorm		
Enlightenment/ Advocacy program		
Nothing Can be Done	43	4.3
Plant Trees	243	24.2
disallowing people from prone areas	280	27.9
Urban Renewal	177	17.6
Help to Reconstruct devastated buildings	61	6.1
No Response	45	4.5
Total	156	15.5
	1005	100.0
Availability of Local Measures to Withstand Windstorm		
Yes, there are measures		
No known measures	113	11.2
Total	892	88.8
	1005	100.0
Identified Measures		
Community Enlightenment Program	55	5.5
Media Advocacy Program	45	4.5
Tree Planting Program	2	.2
No/t Applicable / Response	903	89.9
Total	1005	100.0
Suggested Measures to Prevent Windstorm		
Use of Appropriate Building Materials	536	53.3
Employment of Quality Professional to Supervise the Project	128	12.7
	59	5.9
Designing Windstorm Resistant Building	54	5.4
Demolition of Structurally Inadequate Buildings	184	18.3
Sensitising the populace	44	4.4
Nothing	1005	100.0
Total		

Source: Author`s Field Survey (2016)

Plate 4.9: Devastated Sales Shed along Oremeji-Idiobi Road Ibadan

Source: Author`s Eye witnessed event, May (2015)

Plate 4.10: Sales Sheds along Ojaba-Molete (Ogunmola) Road, Idi-Arere Ibadan
Source: Author`s Field Work January (2016)

Plate 4.11: Filling Station Devastated by Windstorm Disaster in 2014, Academy, Ibadan

Source: Author`s Field survey (2016)

4.6.2 Windstorm Disaster Mitigation Strategies

The research investigated strategies employed to manage windstorm disaster in the study area. Strategies used in the study areas include; construction of building repairs prior to the onset rain, building retrofitting (e.g fastening roof to the wall plate 4.14), offering of prayers and supplication to God to earn His mercies, planting of trees to serve as windbreaker, placing of heavy materials on the roof, use of diabolical power (dark magic) to make windstorm inactive and use of red for building construction (Table 4.14). The respondents believe windstorm disaster could be prevented by purchasing standard building materials. Most of the buildings susceptible around the seemingly new neighbourhoods allude their vulnerability to the use of substandard building materials for construction. The need for sensitisation may equip the respondents with adequate knowledge to mitigate windstorm disaster. Engagement of qualified building professionals for construction supervision was also advocated. Most importantly is the construction of windstorm disaster resilient buildings which must be included into the curriculum of Architecture and Town Planners to avoid incessant devastation of neighbourhoods in Ibadan. The respondents also called for the demolition of structurally inadequate and non-reinforced buildings. These categories of buildings dominate the old quarters where mud, non-treated woods and white woods were used for construction.

Plate 4.12: Anchor /Tight Belt Nailed to Window Frame and Openings at Isale Bode, Ibadan
Source: Author`s Field Survey (2016)

Plate 4.13: Heavy Material Placed on the Roof to Prevent Roof from Windstorm Damage in Idi-Ayunre

Source: Author`s Field Survey (2016)

The research also attempted to evaluate the responsiveness of Oyo state government to disaster management in the state from the victims' perception. The victims were of the opinion that the State Emergency Management Agency has been performing excellently well. In most cases, OYSEMA, visited the affected person in less than 24 hours. The research discovered that the emergency incidents that were responded to between 12 and 24 hours were storm disaster that occurred the previous day in the evening and or windstorm disaster that occurred during the weekend. The responsiveness of the Oyo State Government Disaster Management Agency to emergency situation is commendable.

4.6.2People`s Perception of Social Grantsand Disaster Management Agencies

The state through OYSEMA had responded to a number of windstorm disaster. In most cases, relief material were given to the affected people. Roofing sheet, timber, nails, blankets and food materials were the relief materials usually given to the affected people in the study area (Table 4.14). The study found that the sources of the relief materials is usually from the State through (OYSEMA) and in some rare cases, relief materials were given out directly through National Emergency Management Agency (NEMA). International organisation/foreign aids and gifts from individuals and or residents` association were not left out. However, fastening of roof, planting trees along major corridors or streams and building high quality housing will go a long way to mitigate windstorm disaster in the sampled communities (Table 4.14).

Table 4.14: Windstorm Disaster Management

Characteristics	No. of Buildings	Percentage
Knowledge of Disaster Management Agency		
Yes, I know	639	63.6
No, I don't know of any	366	36.4
Total	**1005**	**100.0**
Name of Disaster Management Agency		
OYSEMA	572	56.9
NEMA	57	5.7
No Response	376	37.4
Total	**1005**	**100.0**
Responsiveness of Agency		
Responsive	513	51.0
Not Responsive	492	49.0
Total	**1005**	**100.0**
Responsiveness Style		
Visiting / Accessing Incidents Areas	11	1.1
Distribution of Relief Materials	1	0.1
All of the Above	565	56.2
No Response	428	42.6
Total	**1005**	**100.0**
Vulnerable Buildings Distance to Emergency Outfit		
0-999m	45	4.5
3000-3999m	114	11.3
4000-4999m	68	6.8
5000-5999m	346	34.4
above 6000m	166	16.5
No Response	266	26.5
Total	**1005**	**100.0**
Emergency Outfits Response Time to Windstorm ObservationOccurrence		
0hr.00min-12hrs	219	21.8
12hr01m-24hrs	606	60.3
No Response	180	17.9
Total	**1005**	**100.0**
Observed Disaster Agencies Efficiency		
Not Efficient	380	37.8
Averagely Efficient	107	10.6
Efficient	393	39.1
Very Efficient	75	7.5
No Response	50	5.0
Total	1005	100.0
Distribution of Relief Materials		
Received	786	78.2
Never Received	219	21.8
Total	**1005**	**100.0**
Relief Materials Distributed		
Nail	**9**	**0.9**
Timber	**11**	**1.1**
Corrugated Iron Roofing Sheet	**58**	**5.8**
Nail, Timber, Corrugated Iron Roofing Sheet,	**783**	**77.9**
Nail, Timber, Corrugated Iron Roofing Sheet and Cement	**61**	**6.1**
Cement	**20**	**20.**
Above with Blanket and Raw Food Material	**63**	**6.3**
Total	**1005**	**100.0**

Possible Way Forward for Disaster Management in Ibadan		
Prayer/stop sin	396	39.4
Nothing Could be Done	82	8.2
Fix my House	63	6.3
UsingRoof Strap	133	13.2
Plant Trees Along major Corridors e.g. Roads and Streams	58	5.8
Build high Quality Housing Unit	261	26.0
introduce ceiling	12	1.2
Total	**1005**	**100.0**

Source: Author`s Field Survey (2016)

4.7.0Mapping Neighbourhood at Risk of Windstorm Disaster in Ibadan

This section evaluates the social and biophysical vulnerability indicators of the neighbourhoods at risk of windstorm disaster in Ibadan. Social vulnerability indicators considered are non-reinforced buildings percentage of women population, proportion of underage population (children between 1-14years), fraction of old age population (people that are 65 years old and above), housing density and mean house rent per neighbourhood. The biophysical fabric evaluated are rate of windstorm disaster occurrence, affected neighbourhood elevation above sea level, windfield and vegetation cover. The combination of social vulnerability indicators and biophysical fabrics reveals the neighbourhood at risk of windstorm disaster and its track in Ibadan.

4.7.1 Social Demographic Characteristics of the Sampled Neighborhoods

Social demographic vulnerability is derived from the accomplishments and conditions of everyday lifestyle or its modification" (Hewitt 1997). Poverty of information and know-how, politically irrelevancy, negative tradition and beliefs, inappropriate housing units or vulnerable individuals, poor infrastructure and non-availability lifelines are major factors influencing many of the fundamental causes of social vulnerability (Blaikie et al. 1994; Cutter et al. 1997; Mileti 1999). There is spatial and seasonal variation in the above highlighted factors as demonstrated by most researchers, population characteristics and building features, age of vulnerable persons and type of ethnic group, income, sex, public infrastructures influences and or have the capacity to amplify or reduce overall vulnerability to hazards (Blaikie et al. 1994; Hewitt 1997; Tobin and Montz 1997). This study further examines the types of population and neighbourhood characteristics increases social vulnerability based on the views and perception of respondents in sampled neighbourhoods in Ibadan. The socio-economic characteristics of affected people identified in this category include age, sex, religion and ethnicity, marital status, household status of respondents, educational status, occupation and income level.

The household survey sampled mature and experienced persons. Most of the respondents are female, Muslim, Yorubas, married, and live in their repaired building. The affected respondents' samples show that their responses are dependable. They are mature, experienced and capable of providing adequate information about incidences of windstorm disaster (Table 4.15). There are more female respondents than male. This is an indication that means of livelihood of the respondents (the women who are petty traders conduct their business in their homes) corroborate Adebimpe`s, (2011) claim that most of the people affected by disaster use their houses for both residential and commercial. Once a building is devastated, both means of livelihood and residency are lost. An ethic affinity of the Yoruba's are found in the sampled neighbourhoods. Ethnicity is a strong social vulnerability indicator. The quality of building and compound setting found in the sampled neighbourhoods show that the culture and traditional belief of the dominant tribe is a factor which can expose them to disaster. For example, the importance Yorubas attache to house ownership (Adisa *et al,* 2008) may incite the construction of substandard buildings in the study area. A building hurriedly constructed may be vulnerable to windstorm disaster. Non-indigenes were not common in the sampled areas. Most sampled persons are Muslims. The slogan;

Amuwa Oloun which literarily means 'God decides human fate', is a common saying repeated amongst the local, especially those who practice Islamic religion during the field survey and focus group discussion sessions.

By implication, windstorm disaster may continue to devastate the affected neighbourhoods in Ibadan. Except, a scientifically-based sensitisation programme is require to dissuade the general belief that windstorm disaster is an act of God. The occupancy ratio is a reflection of the high density residential area, a major characteristics explaining economic status of these neighbourhoods.

A very high level of ignorance of windstorm disaster is displayed among the affected persons. This is an outcome of low level of education of the respondents (Table 4.15). The low level of education may predispose the affected persons to repeated windstorm disaster in the study area. For example, respondents openly display their ignorance by alluding incident of windstorm disasters to high rate of infidelity among the resident.

Table 4.15: Socio-Economic and Demographic Characteristics of the Windstorm Victims

Socio-economic variables	Number of Respondents	Percentage
Length of stay in neighborhood		
0-20	216	21.5
21-30	158	15.7
31-40	224	22.3
41-50	180	17.9
51-60	146	14.5
>61	81	8.1
Total	**1005**	**100.0**
Age (Years)		
21-30	8	0.8
31-40	73	7.3
41-50	215	21.4
51-60	258	25.7
>61	451	44.9
Total	**1005**	**100.0**
Gender		
Male	465	46.3
Female	540	53.7
Total	**1005**	**100.0**
Religion		
Christianity	391	38.9
Islamic	534	53.1
Traditionalist	80	8.0
Total	**1005**	**100.0**
Ethnicity		
Yoruba	951	94.6
Hausa	46	4.6
Igbo	8	0.8
Total	**1005**	**100.0**
Marital Status		
Single	11	1.1
Married	879	87.5
Widower	104	10.3
Divorced	11	1.1
Total	**1005**	**100.0**
Persons in Household		
1-3	224	22.3
4-6	439	43.7
7-9	172	17.1
10-12	54	5.4
Above 13	116	11.5
Total	1005	100.0
Highest Education Status		
None	359	35.7
Primary/Adult Education	458	45.6
Secondary Education	133	13.2
Post-Secondary Education	55	5.5
Total	1005	100.0
Occupation		
Unemployed	54	5.4
Trading/Business	745	74.1
Artisan	135	13.4
Farming	3	0.3
Civil Servant	62	6.2
Professional	6	0.6
Total	1005	100.0

Income range per month		
<₦ 10,000	245	24.4
₦ 11,000 - ₦ 40,000	638	63.5
₦ 41,000 - ₦ 70,000	29	2.9
₦ 71,000 - ₦ 100,000	54	5.4
>₦ 101,000	39	3.9
Total	1005	100.0

Source: Author`s Field Survey (2015)

The various occupations of the respondents presented is an indication that most of the windstorm disaster affected persons in Ibadan are in the non-formal sector of the economy. The affected person`s income per month is low. People living in high density areas give birth to more numbers of children. The ability to construct a reinforced building or to retrofit a divested building by someone whose monthly income average forty thousand naira (114 dollars) may be difficult. Thus, the abode of such persons is vulnerable to windstorm disaster. The financial strength and the amount of resources available to the affected persons also reflect in the quality of their environment. For example, the study found that the types of material used for construction are of low quality, the physical state of their building are degenerating, and the occupancy ratio and housing density are very high. The presence of rooming apartments also confirms the low neighbourhood status of the incident communities. Rooming apartments are building styles popularly called Brazilian style, which does not require many technical inputs (Table 4.16).

Table 4.16: Residential Tenure, Use and Characteristics of Buildings

Characteristics	No. of Buildings	Percentage
Types of House Tenure		
Owner /Occupant	534	53.1
Rented	126	12.5
Institutional Property	8	0.8
Family House	337	33.5
Total	1005	100.0
Types of Dwelling Unit		
Compound	149	14.8
Rooming Apartment	690	68.7
Flat	146	14.5
Duplex	20	2.0
Total	1005	100.0
Total Number of Rooms in Building		
1-2	34	3.4
3-4	397	39.5
5-6	289	28.8
7-8	95	9.5
Above 9	190	18.9
Total	1005	100.0
Total Number of Household in Building		
1-2	278	27.7
3-4	590	58.7
5-6	137	13.6
Total	1005	100.0
Average Number of Persons Per Room		
1-2	388	38.6
3-4	469	46.7
5-6	116	11.5
7-8	25	2.5
Above 9	7	0.7
Total	1005	100.0
Material used for wall		
Block	453	45.1
Mud	552	54.9
Total	1005	100.0
Wall Status		
Plastered	984	97.9
Not Plastered	21	2.1
Total	1005	100.0

Source: Author`s Field Work (2016)

Flats and duplex are few in number in the sampled neighbourhoods. This is an indication that buildings mostly susceptible to windstorm disaster in the study area are the old and aged buildings. These category of buildings are found in the traditional core and the transitional zone area between the old quarters and the modern areas of the city. Even in Felele community, where buildings appear firm and standard, the fewer numbers of buildings devastated in the neighbourhood were mostly buildings that were not fastened to the building wall. Devastation in Felele was restricted to roof ripping. No block wall was damaged. These findings validate earlier studies on the City of Chicago (Burgess, 1923; Harris and Ullman, 1945) which observed the tendency of low-income earners to cluster in residence close to the central business district at the city centre. The traditional Central Business Area in Yoruba Land is the *Ojaba*, an area located immediately after the Palace (Ojo 1976). The study identified higher number of old and weak buildings made of mud in the sampled neighbourhood (Plate 4.14). The lifecycle of high quality mud building averages of 100 years. However, most of the mud used for building in the study area are of low quality. Most of them become weak after 50 years. The buildings, especially at the core (old quarters) are around 100years, thus, their susceptibility to windstorm disaster. Adelekan (2012) said vulnerability to wind hazard in Ibadan is due to aged, weak and high density buildings. Thus, the study found that the higher proportion of devastation experienced in the core areas of Ibadan has direct bearing with the structural inadequacy of the buildings in the old quarters.

In the relatively new neighbourhoods that were affected, the study found defectively reinforced buildings as the cause. The inability of government institutions such as Town Planning Authorities to adequately police the city has led to development and expansion of sprawling in Ibadan. Development control tools could be used as a measure to deter erring members of the society against construction of low quality buildings. Unfortunately, report has it that

a Commissioner in the 1980s made a pronouncement 'prohibiting housing construction above lintel from being demolished in Oyo state'.

Thus, the resident of the incident areas who wish to cheat on the government would commence construction of their buildings on Friday evening and by Monday morning, they are already on the lintel level. This has rendered useless the power of development control in Ibadan for over 35 years.

Plate 4.14:Windstorm Devastated Mud Building at Morgana Compound, Idiarere, Ibadan

Source: Author`s Field Work (2016)

H_0; Vulnerability to windstorm disaster is not a function of income, occupation, neighborhood type and building location (asl) roofing style, roofing materials vegetal cover and types of building materials.

The above factors are capable of putting Ibadan at risk of windstorm disaster. However, only roofing types and building materials are significant at p value less than .05. The 0 (low) are the hip roof, and the cement and block while the 1 (high) are the gable/flat roof, and mud/makeshift buildings. Although both the value of mud/makeshift buildings and hip roofs contribute significantly to the residential building at risk of windstorm devastation in the study area, the odd ration of these values showed a negative relationships.

Therefore, the hip roofing style and building material types (mud) contributed significantly to windstorm disaster vulnerability at p=.000 and .001 respectively. The value of their odd ratios (.066 and .305) are lesser than 1. Residential buildings with gable and flat roof style and those constructed with cement and block were therefore at lesser odds of being vulnerable to windstorm disaster. Thus, the probability of hip roof and mud buildings vulnerability to windstorm disaster in Ibadan are 0.936 and 0.695 respectively. A building roofed in hip style is 93.5% more vulnerable to windstorm disaster in Ibadan while those constructed with mud are 69.5% vulnerable to windstorm disaster (6.3). Other variables; location, neighbourhoods types, income, occupation and presence of trees are not significant. Its thus concluded that factors such as roofing style, (ß=-.2.74), materials used for construction (mud buildings) (ß=-1.19), vegetal cover (ß=17.16) and elevation, (ß=-.66) significantly influenced residential buildings vulnerability to windstorm disaster in Ibadan (Table 4.17).

Table 4.17 Binary Logistics prediction for factors aiding Building Vulnerability in Ibadan

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Roofing	-2.738	.315	75.706	1	.000	.065
	Building materials	-1.189	.360	10.903	1	.001	.305
	Elevation	-.659	.465	2.008	1	.156	.517
	Neighbourhoods types	.184	1.113	.027	1	.869	1.202
	income	-.080	.333	.058	1	.810	.923
	occupation	-18.149	4518.530	.000	1	.997	.000
	vegetal	17.161	7994.021	.000	1	.998	28373327.127
	Constant	22.598	4518.530	.000	1	.996	6517357201.721

Source: Field Work, 2016

4.7.3 Social Vulnerability Indices and Hazard of a Place in Ibadan

Indices were constructed to specifically examine the "hazard of a place" social vulnerability indicators in Ibadan where 1 represents very high vulnerable areas. Indicators based on percentage population of women, total housing unit, percentage of children under 14 years old, percentage of people over 65 years old, mean house value and non-reinforced buildings in Ibadan were evaluated (Tables. 3.8. 3.9, 3.10, 3.11, 3.12, 3.13). Indexes for women, children, senior citizens are 1 in Agugu. Other areas where they are highly vulnerable are Academy, Aremo, Koloko, Modina Elekuro, Odinjo, Felele and Odo Oba. Place vulnerability based on housing unit density, identified Agugu, Aremo, Koloko, Odinjo, Felele, Odo-Oba and Moniya as neighbourhood that are highly vulnerable to windstorm disaster in the study area. Further, Mean house rent was also considered. All Neighbourhoods were highly susceptible to windstorm disaster with the exception of Sanyo, Boluwaji in Oluyole LGA. The neighbourhood around Idi-Arere, Bode and those in Ibadan South West, South East and North are highly vulnerable. The vulnerability due to non-reinforced building indicated all neighbourhoods in Idi Arere, Bode, and Oke Suna as being extremely vulnerable (Figs 4.14-4.20).

The population of women, children, the aged and housing density are factors that make Agugu neighbourhood highly vulnerable. It is suspected that the vulnerability of this neighbourhood is due to the ratio of its landmass to population. Compared to other neighbourhood in the core, Agugu landmass is relatively smaller. However, the occupancy ratio here is 35 persons per building. The dense population of this neighbourhood makes it extremely vulnerable to windstorm disaster in Ibadan (Fig 4.14-4.17).

Boluwaji/Olomi neighbourhoods jointly exhibit extremely high vulnerability as a result of mean house rent in Ibadan. While the mean house rent in neighbourhood in the core looks regular in all its neighbourhoods, same is not obtainable in Oluyole. Oluyole is a LGA with both highbrow and downtown neighbourhoods. The disparity between the rents in these two differential residential status made Boluwaji and Olomi extremely vulnerable to windstorm disaster in Ibadan (Fig. 4.18).The very aged core sampled in the neighbourhoods at Idiarere, Bode, Kudeti, Odo-Oba are extremely vulnerable to windstorm disaster. Their vulnerability balls out of the aged structures and the quality of mud used in construction. Other neighbourhoods at Ode-Aje for instance are still relatively strong to withstand windstorm disaster (Fig. 4.19)

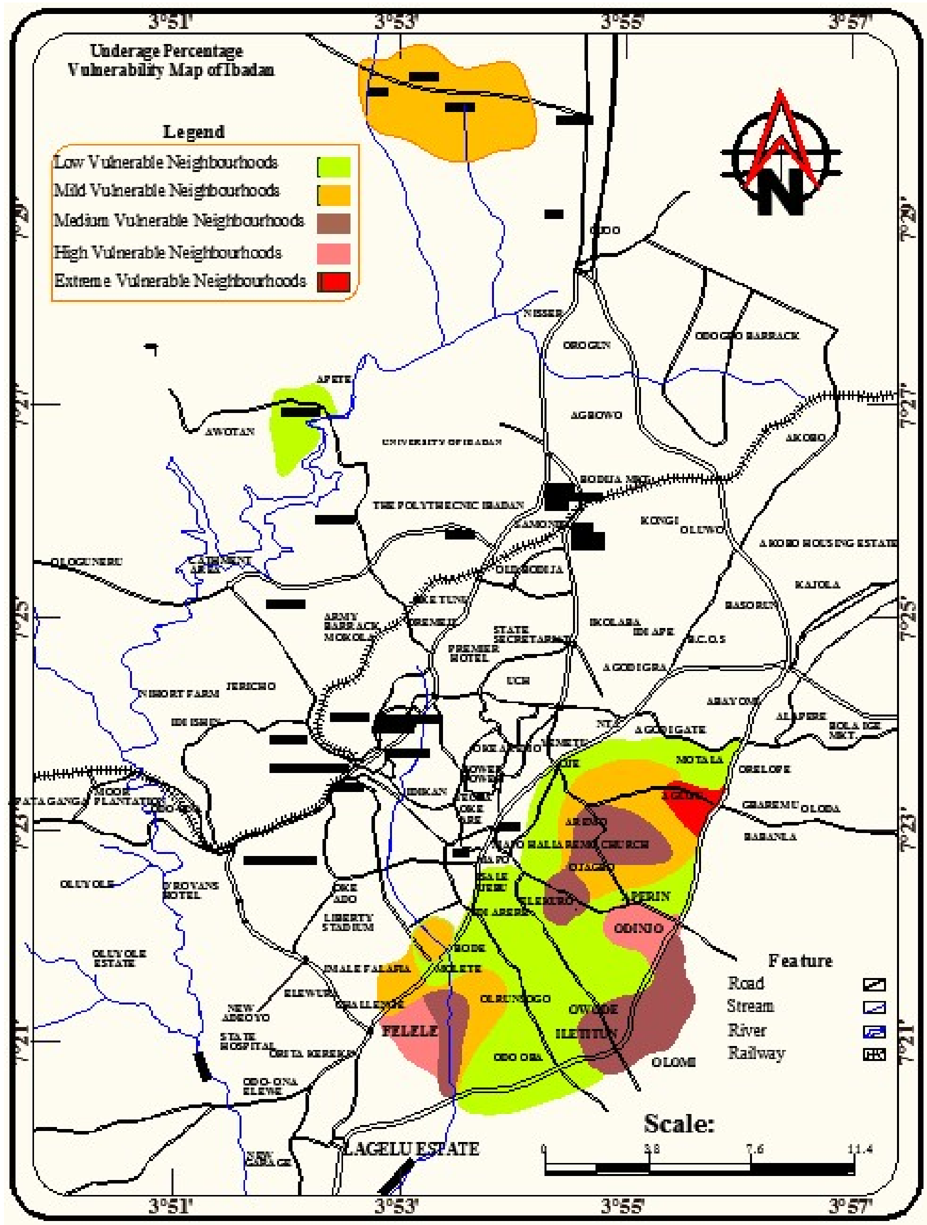

Fig. 4.14: **Percentage of Under-Age Population (0-14 years) Vulnerability Map**

Source: Author`s Field Survey (2016)

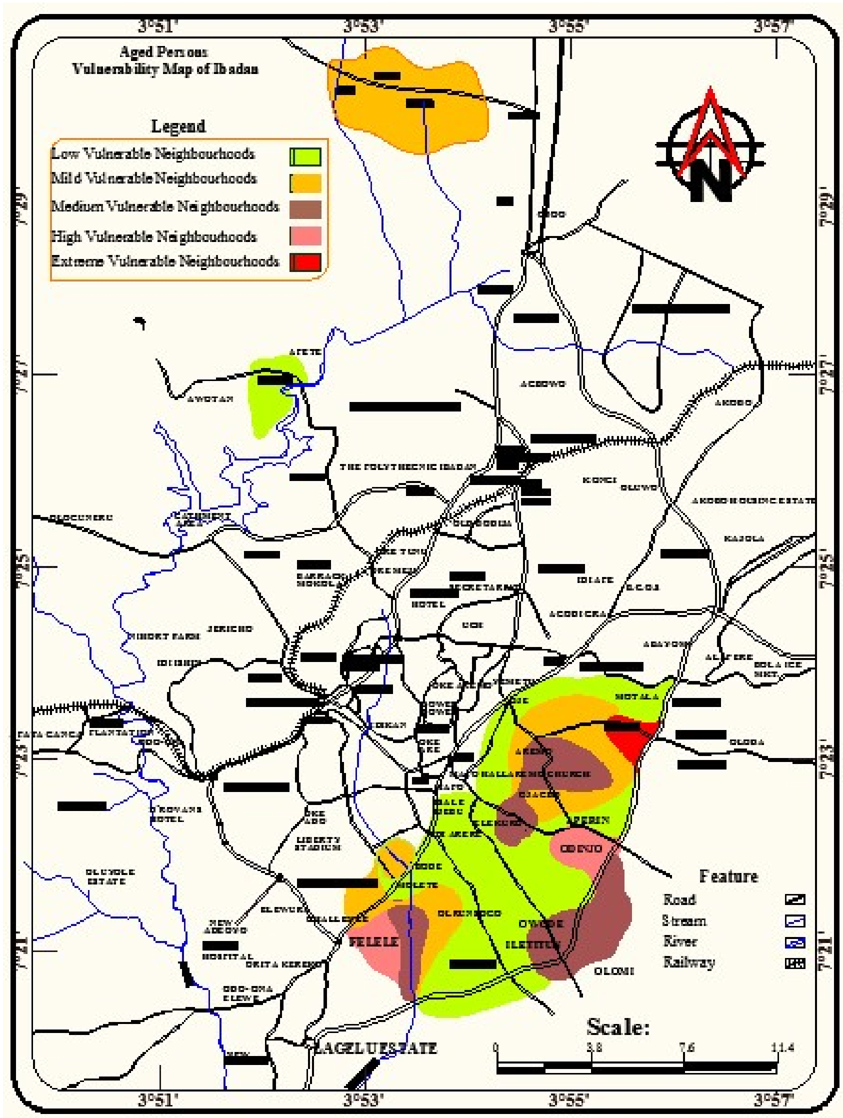

Fig. 4.15: **Percentage of Aged Persons` Population (above 65 years) Vulnerability Map**

Source: Author`s Field Survey (2016)

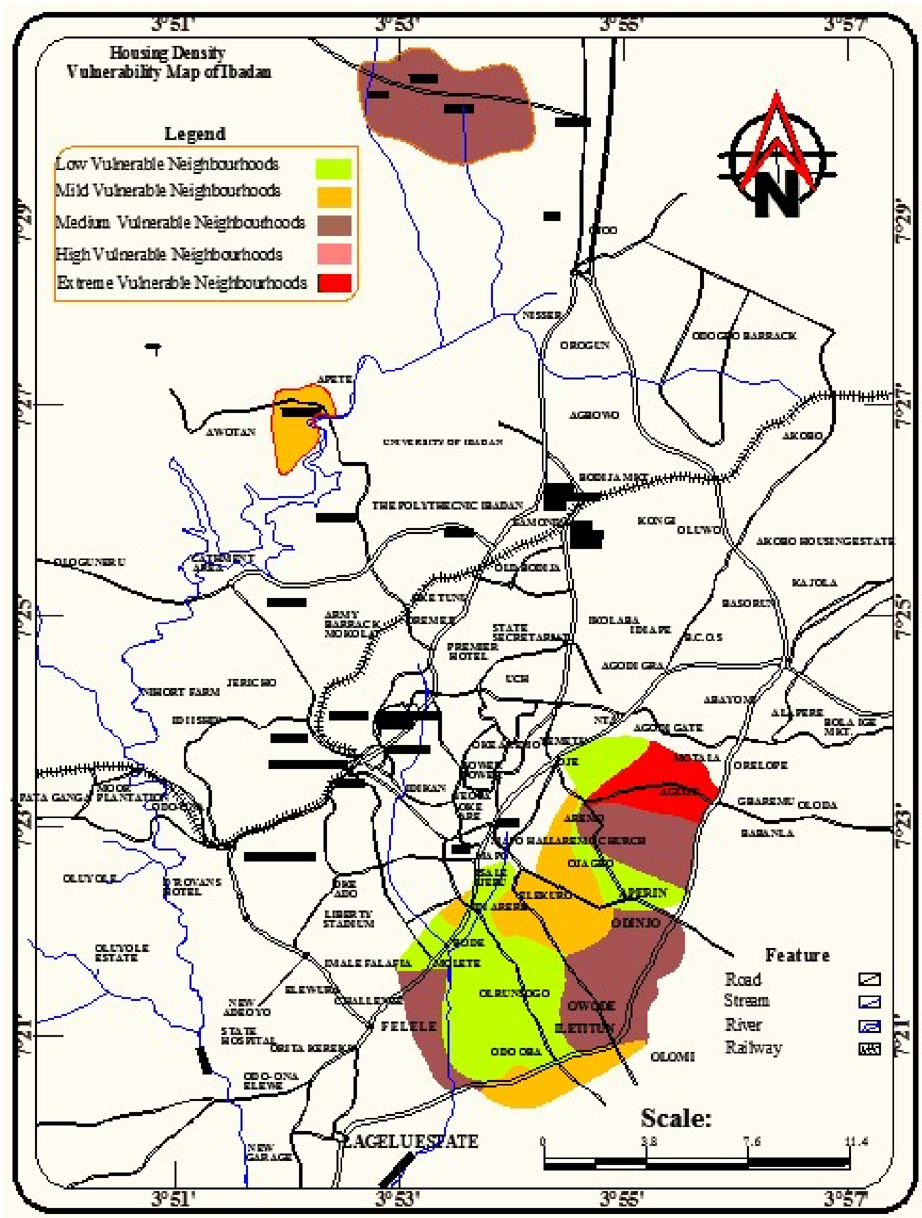

Fig. 4.16: **Housing Density Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

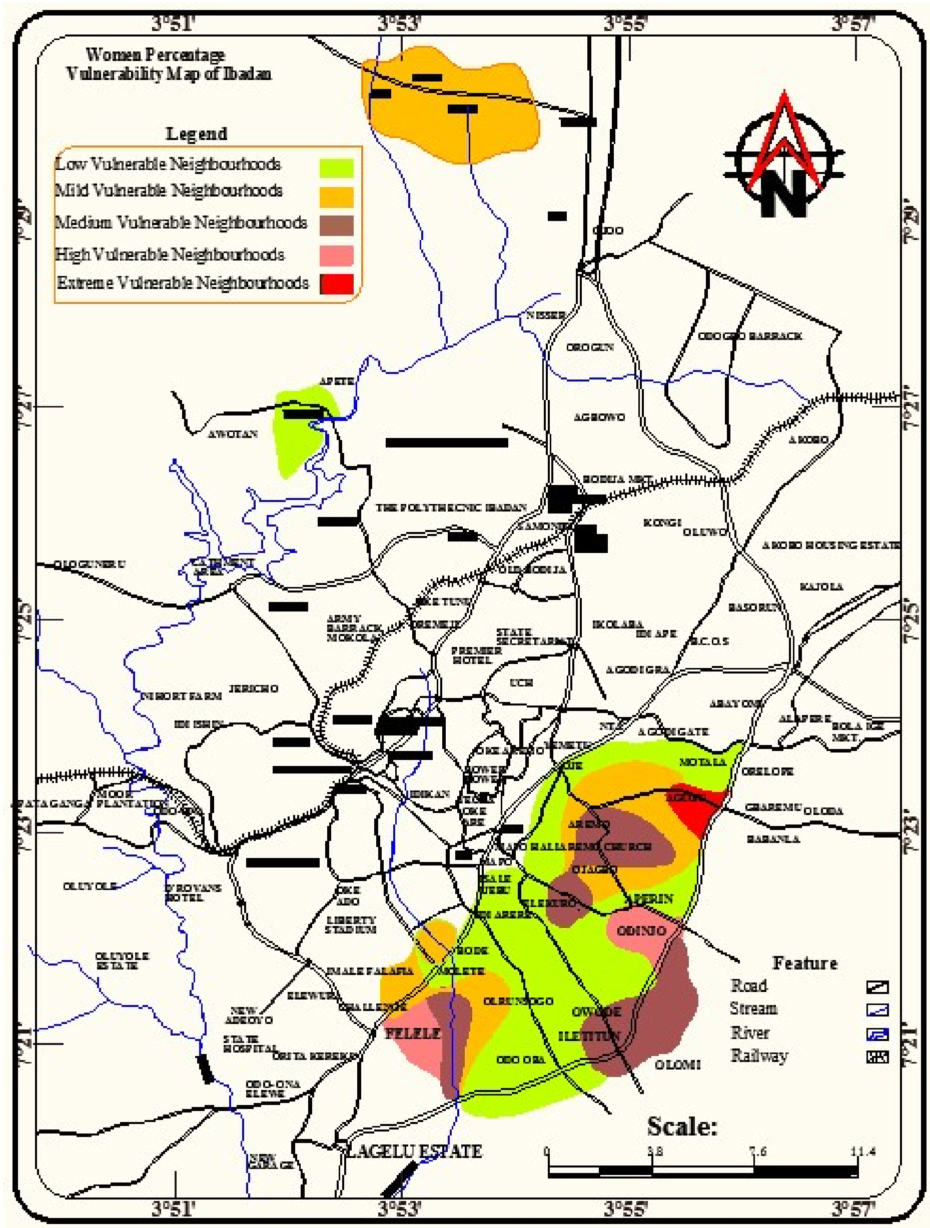

Fig. 4.17: **Percentage of Women Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

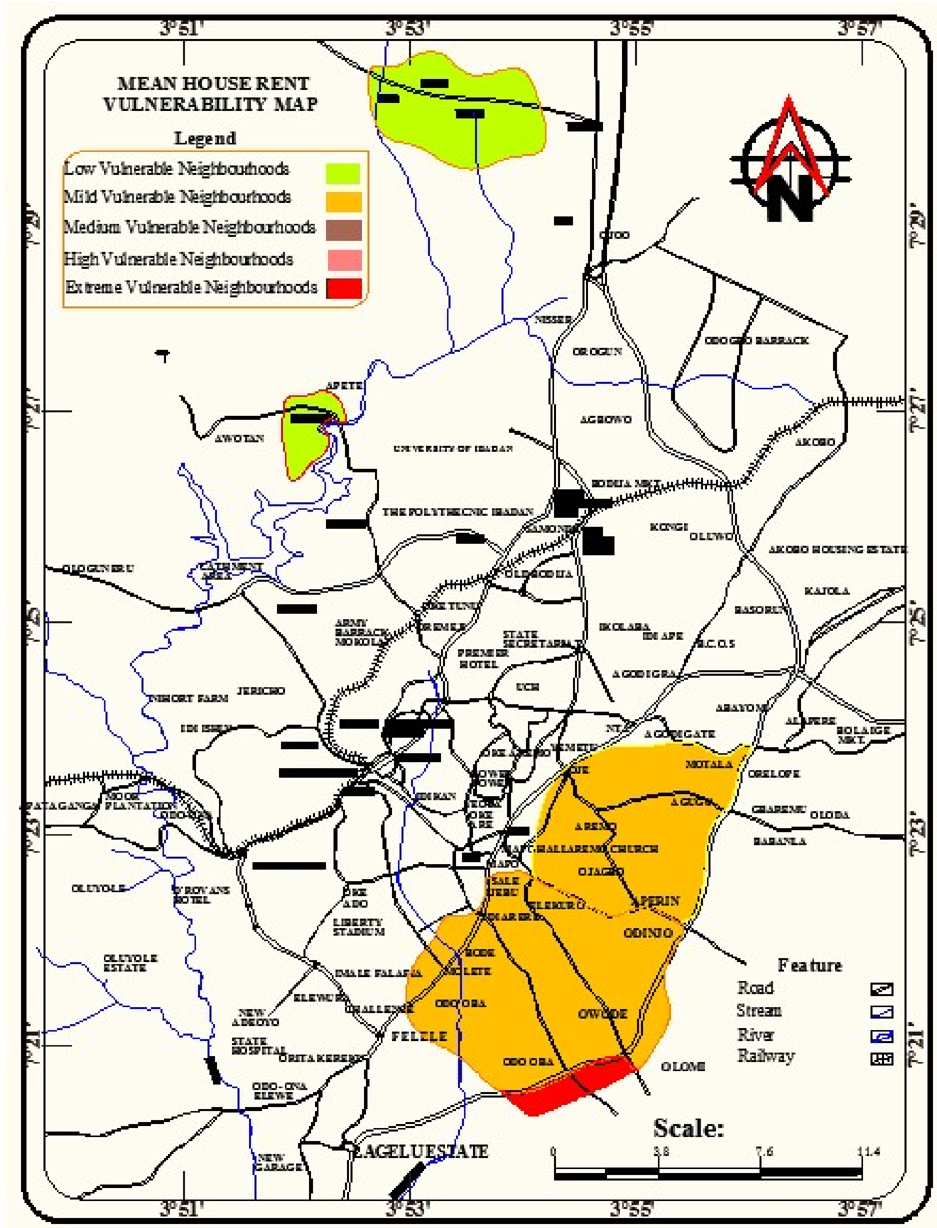

Fig. 4.18: **Mean House Rent Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

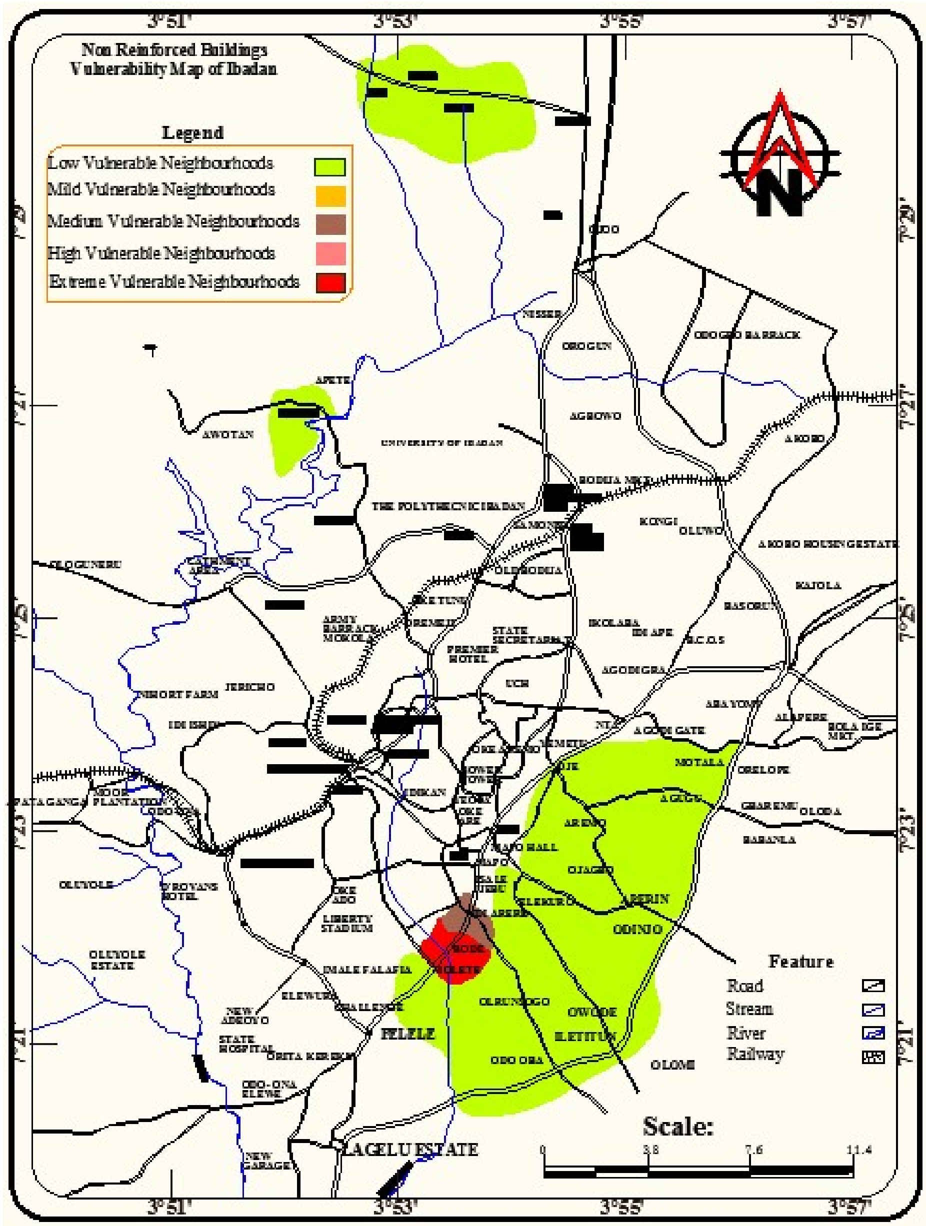

Fig. 4.19: **Non Reinforced Buildings Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

4.7.4 Social Vulnerability Map of Ibadan

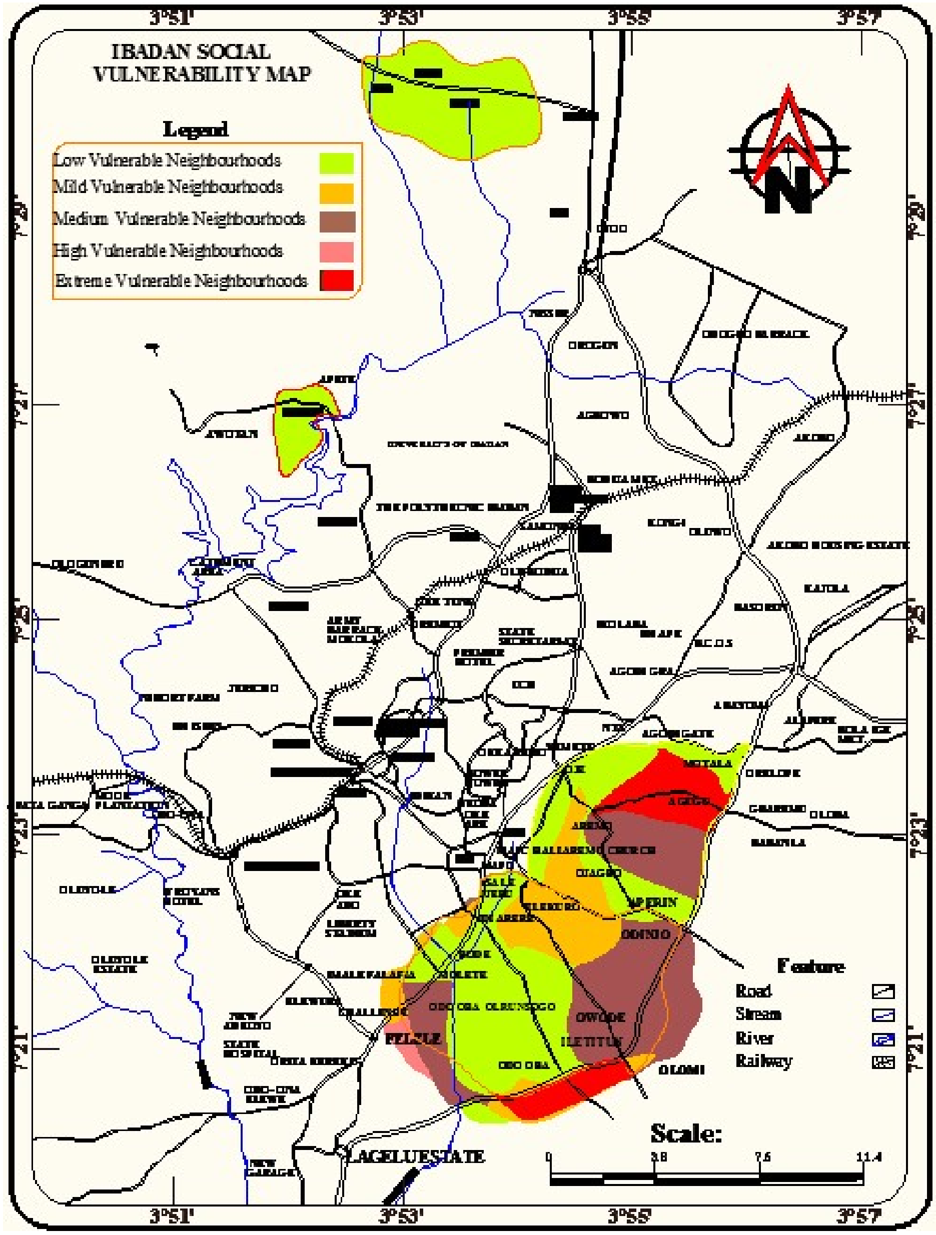

Fig. 4.20: Social Vulnerability map of the sampled neighbourhood of Ibadan

The Social Vulnerability map of Ibadan is a product of the combination of the six maps produced out of the social vulnerability indices in Ibadan. The neighbourhoods at the core are socially vulnerable to windstorm disaster in Ibadan.

Source: Author`s Field Survey (2016)

4.7.5 Biophysical Vulnerability and Hazard of a Place in Ibadan

The GIS analytical output carried out to determine the affected neighbourhoods` biophysical vulnerability shows that neighbourhoods in Apete, most vulnerable to frequent occurrence of windstorm. Up to 125 windstorm could occurred at Oja area, station road and Morubo neighbourhoods in Apete. The neighbourhoods' elevation makes them susceptible to windstorm disaster. Based on the windfield factor, Balogun in Moniya is identified as the most susceptible. All the sampled neighbourhoods are vulnerable to windstorm disaster due to absence of vegetal cover. The presence of vegetal cover is what exclude a fraction of Oluyoro, Tejide and Yejide from windstorm. The trees in Oluyoro Catholic Hospital, Ibadan Grammar School and other non-residential axis protect these areas from windstorm (fig. 4.21-4.23).

The increasing rate of windstorm occurrence at Apete may be as a result of uncontrolled growth which has bedeviled Apete in recent years. The cheap accommodation in this neighbourhoods has drawn the attention of the students of the polytechnic, Ibadan. Private developers have not helped matters either. In other to make quick money, they identify any plot of land of interest, buy and develop to serve as surrogate hostel for students. The high density coupled with the presence of Eleyele dam provides free arena for storm winds to attain full speed, thereby increasing the occurrence of storm and the susceptibility of the neighbourhoods to windstorm (fig. 4.24)

The Balogun elevation above sea level and windfield makes it vulnerable to windstorm. The number of buildings devastated per hectare in these neighbourhoods complement the original concept in which physical factors were the only indicators used for the explanation of the windstorm hazard. This area has shown that the higher the altitude, the more the intensity of the wind force, thus the number of buildings devastated per hectare (Fig. 4.25-4.26). All neighbourhoods except those along Tejide and Yejide road are extremely vulnerable to windstorm disaster in Ibadan. The neighbourhoods around Tejide and Yejide are less vulnerable because of the presence of tress in Ibadan grammar school and the Anglican Church at Kudeti. This church occupies more than 25 hectares of land. Over 80% of the land are covered with vegetation. This situation in these neighbourhoods has given credence to the importance of vegetation in Ibadan (Fig 4.26).

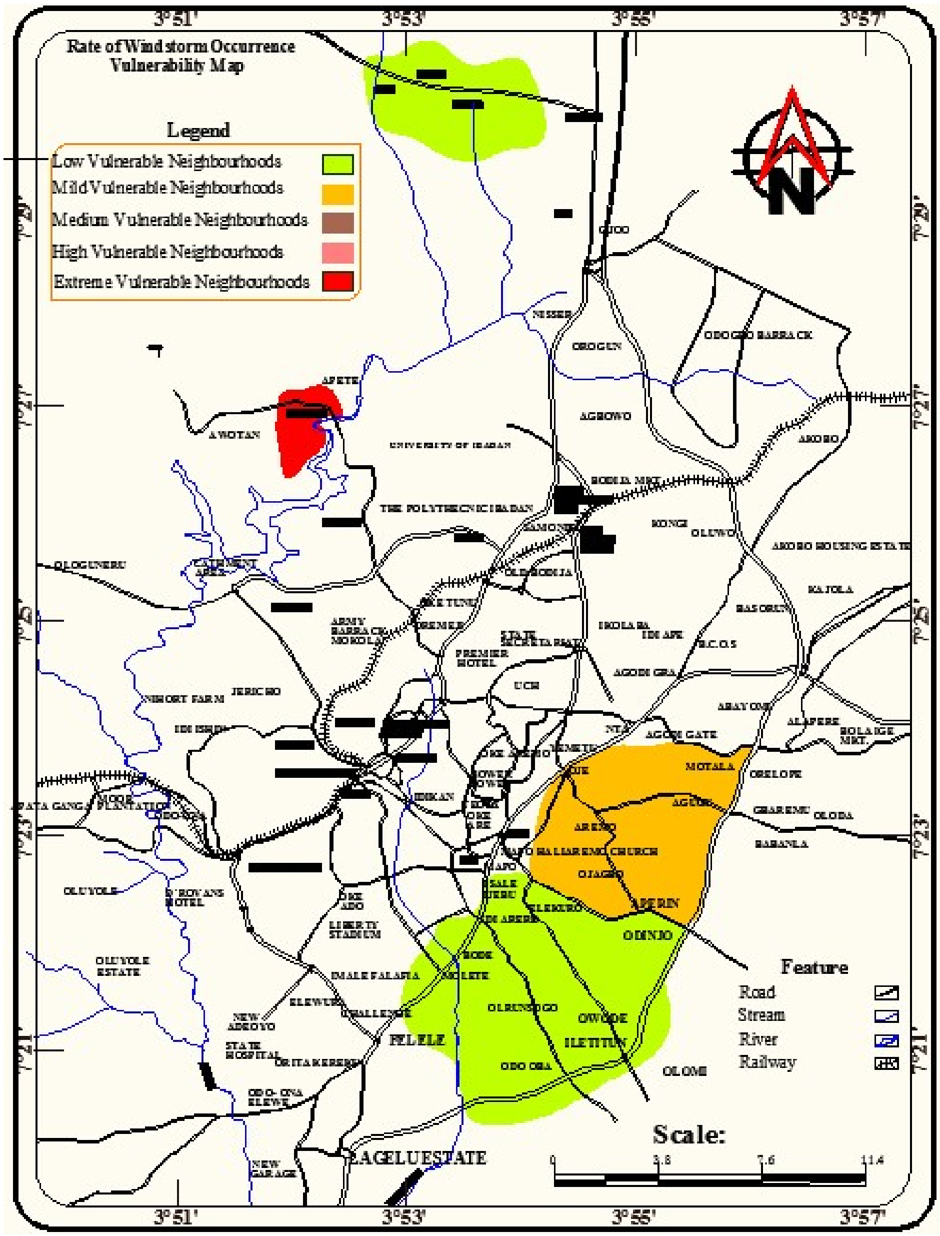

Fig. 4.21: **Rate of windstorm Frequency Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

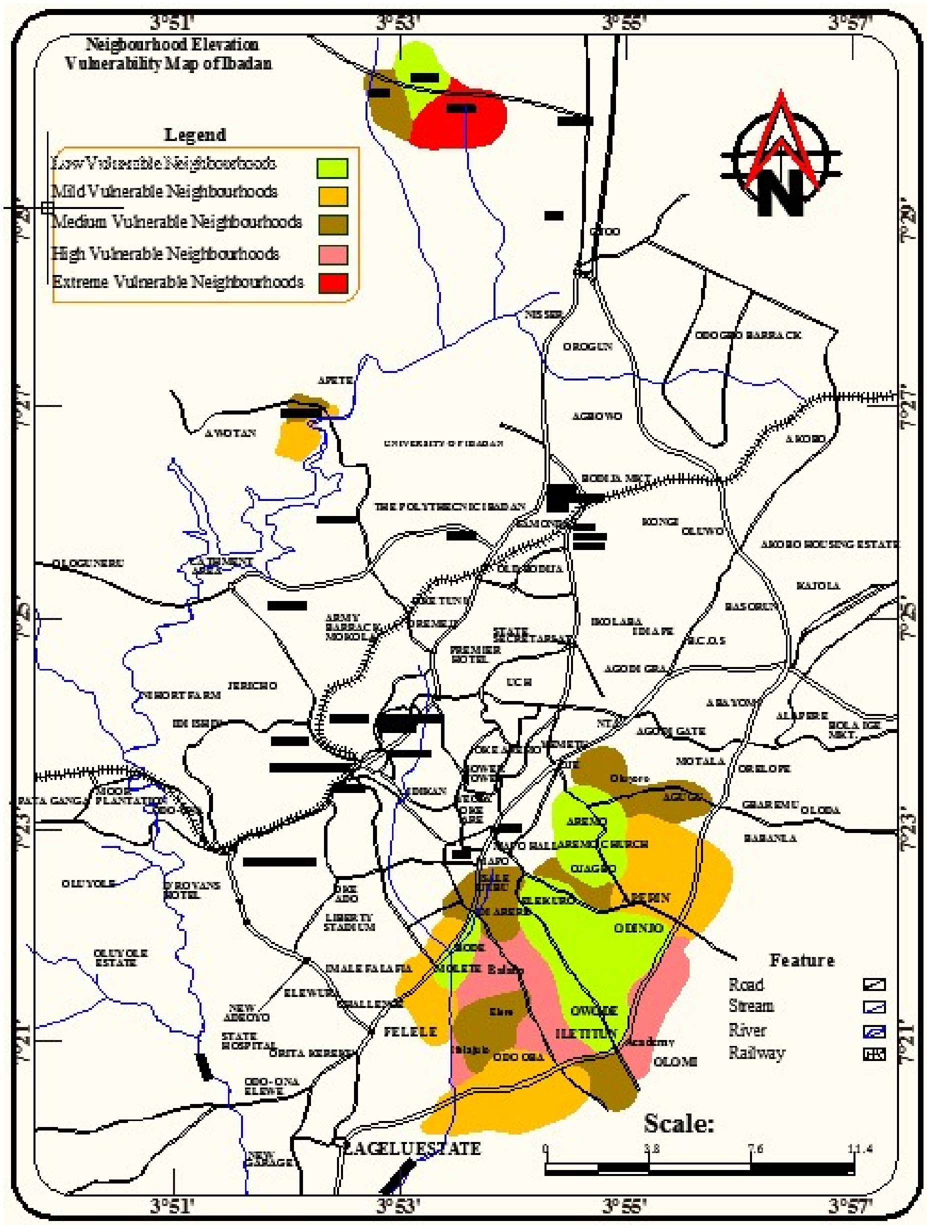

Fig. 4.22: **Affected Neighbourhoods Elevation Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

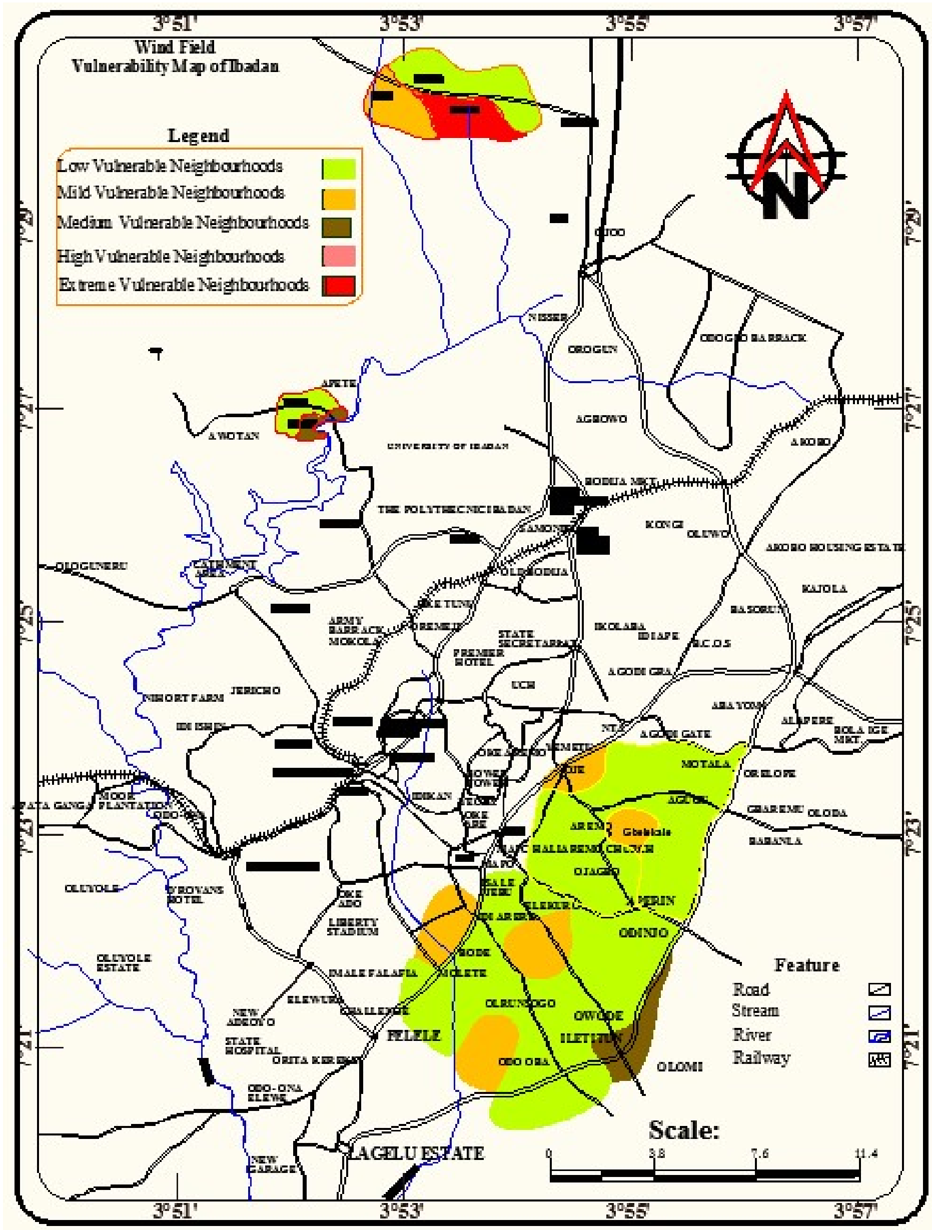

Fig. 4.23: **Wind Field Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

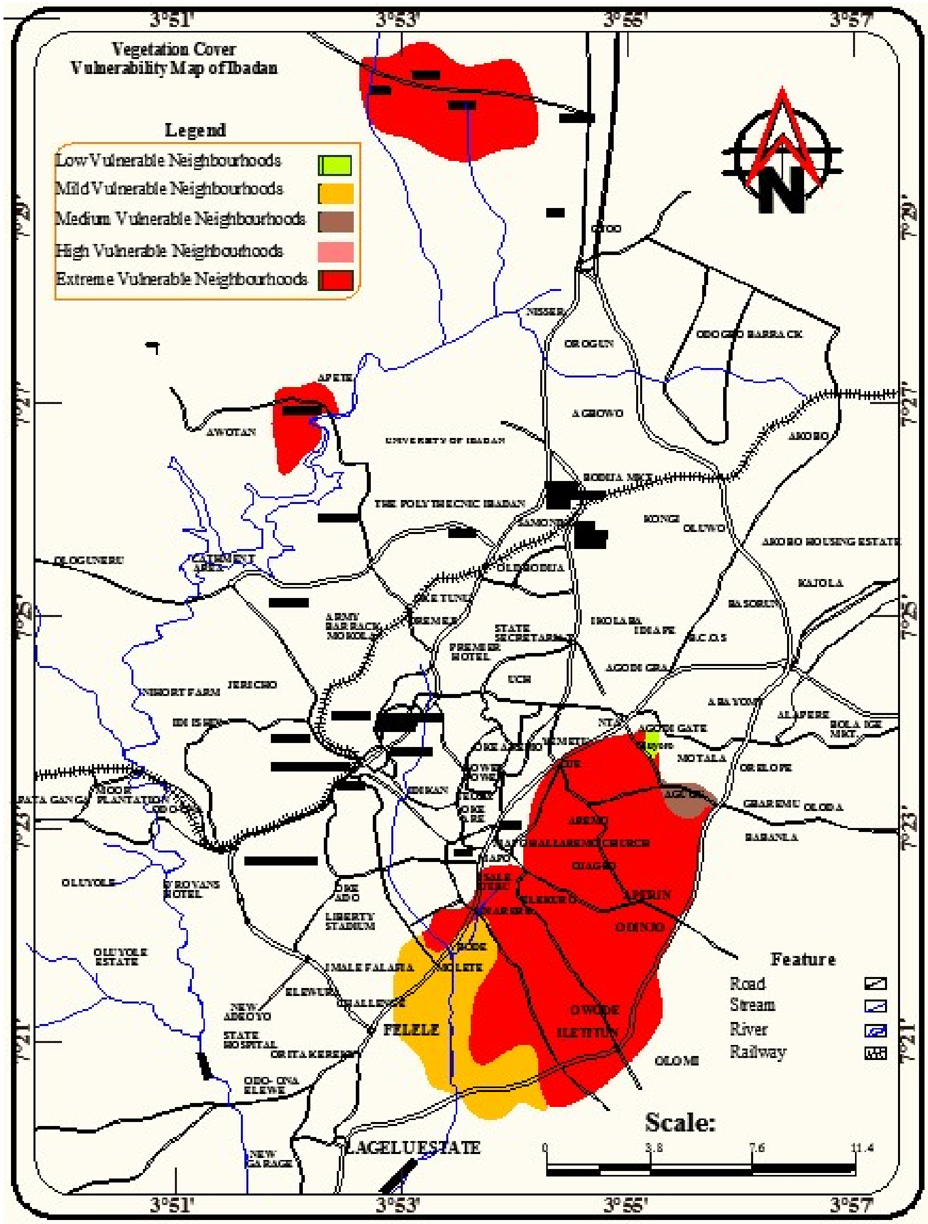

Fig. 4.24: **Vegetation Cover Vulnerability Map of Ibadan**

Source: Author`s Field Survey (2016)

4.7.6 Biophysical Vulnerability in Ibadan

Ibadan biophysical map show that the neighbourhoods at the city outskirts are the vulnerable ones because of Ibadan physical features. However, all neighbourhoods are biologically vulnerable.

The intersection of physical and social vulnerability gives the overall place vulnerability of Ibadan. Ibadan`s place vulnerability identifies the city core areas, the Sanyo/Boluwaji axis, the Agugu area, Apete and Balogun Area in Moniya as the neighbourhood with the highest vulnerability. The storm track appear semi-cycled. The track starts around Idi Arere/Kudeti, through Bode, to Odo Oba/ Felele. It continues along Yejide road through Sanyo/Boluwaji Axis to Academy, Muslim to Koloko and terminates at Aremo Ode Aje area enroute Agugu. Other isolated areas with minimal track are the Apete Arola Axis and Elebu Balogun Axis in Moniya.

The most socially vulnerable neighbourhoods in Ibadan are found in the old quarters. The most physically vulnerable neighbourhoods are found in Moniya, and neighbourhoods found towards the outskirts of Ibadan north in Akinyele local government area. All affected neighbourhoods are biologically vulnerable as there are no vegetal cover. The socially vulnerable areas are found in Idi-Arere, Bere, Kudeti, Idi-Aro, Odo-Oba and Popo area. Social or human or anthropogenic factors are responsible for the 2008 windstorm disaster that devastated most of the buildings in these neighbourhoods. The devastation in these areas were above six buildings per hectare. Statutorily, a hectare of land could only be sub-divided into 18 plots. But in these communities, up to 25 buildings were found on a hectare of land. The buildings found here are old, weak, constructed with loose mud and can best be described as lacking in building code.

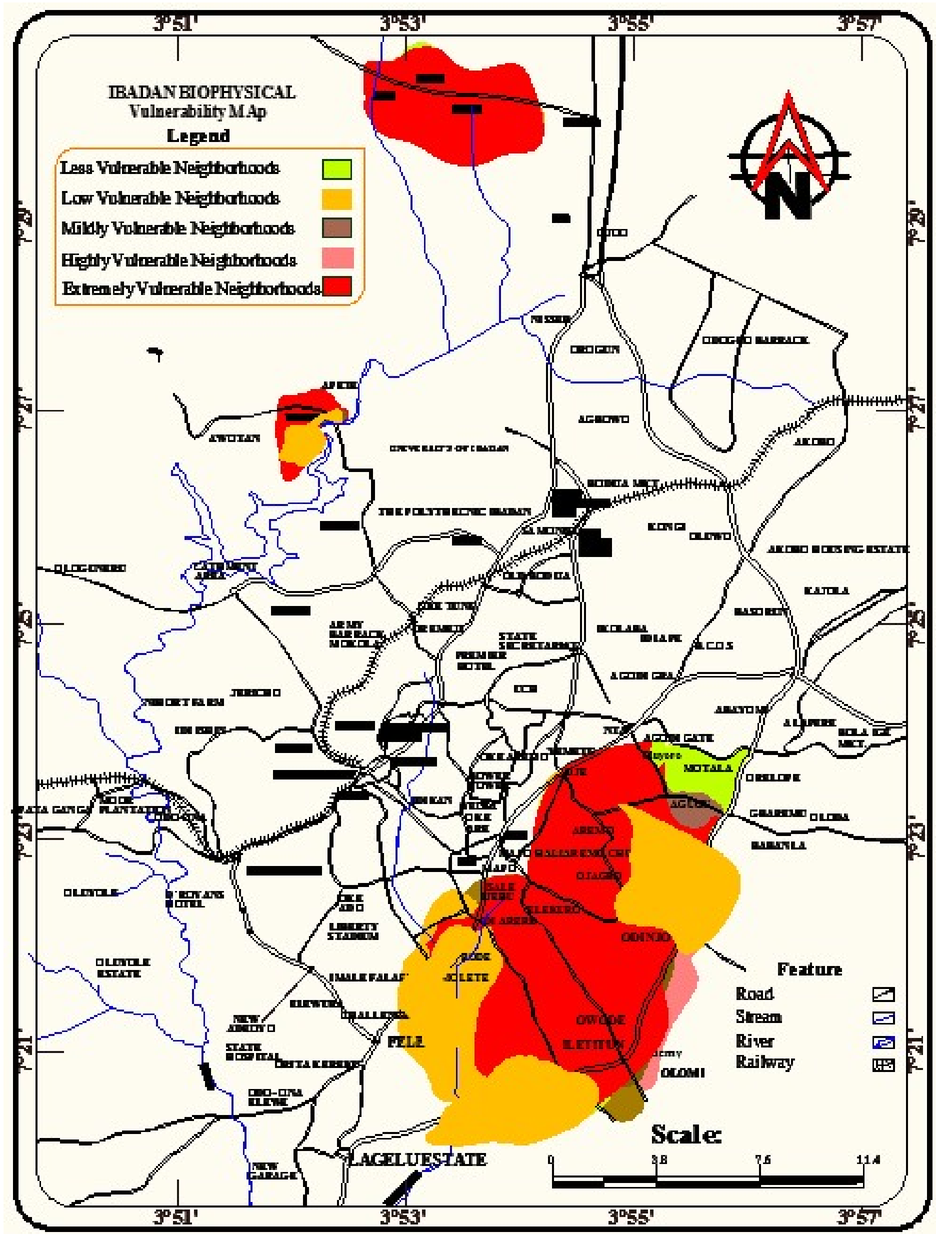

Fig 4.25: Hazard of a Place Biophysical Vulnerability Map for Ibadan

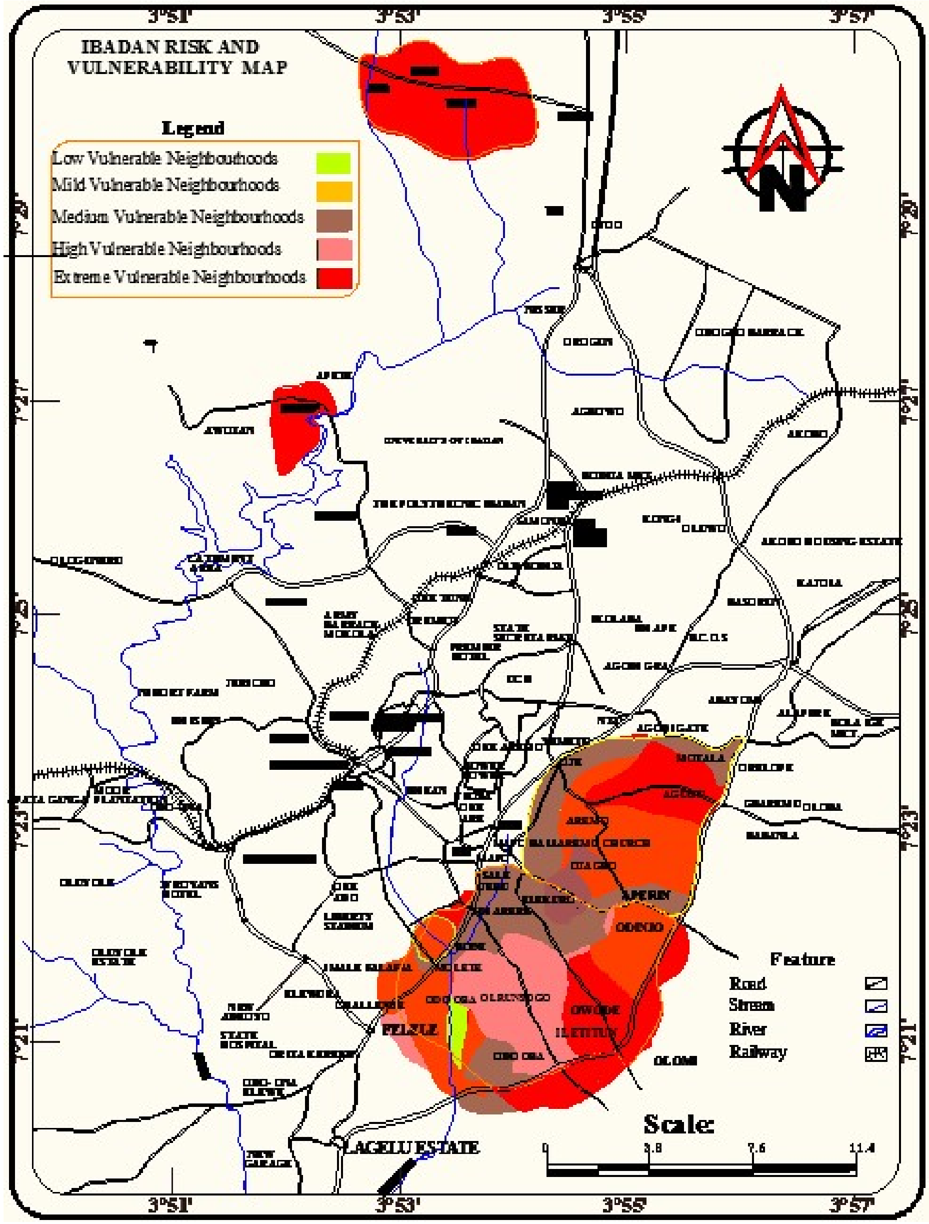

Fig. 4.26: Windstorm Disaster Risk and Vulnerability Map of Ibadan

Source: Author`s Construct (2016)

CHAPTER FIVE

Summary of Findings, Conclusion and Recommendations

The study identified and analysed factors leading to vulnerability to windstorm disaster in Ibadan. Ibadan has a total of 11 local government areas, all prone to windstorm disaster. The research focused only on windstorm events where the building devastation were in excess of 100 housing units. This was necessary to establish basis for sample collection, and was based on UNDP (2004) windstorm disaster scale. Windstorm disaster incidents numbering 52 occurred from January 2005 to January 2016 when this research was conducted. The study population were the 2105devastated buildings found in the 21 windstorm events between 2005 and 2015. The sampling frame is the 1858 incident buildings in the five focal windstorms where building devastation is in excess of 100 housing units. The survey sample size is 1005 buildings i.e. the 54.1% of the sample frame. The respondents were sampled to determine the socio-vulnerability and biophysical (Biological and Physical) vulnerability of the study area. Incident buildings and their cluster in relation to the elevation of the study area and the neighbourhoods' vulnerability to windstorm disaster were analysed first by constructing index for each of the indicator, by turning the index to vulnerability maps and by overlaying the maps in GIS. Ibadan vulnerability map through hotspot analysis of 12 separate maps were used to produce the city vulnerability and windstorm track. GIS was also used to calculate the cluster pattern in the windstorm affected neighbourhoods in Ibadan. The windstorm disaster vulnerability map of Ibadan was generated to identify hazard of a place in Ibadan. This chapter presents the summary of major findings, the implication of the findings and recommended vulnerability mitigation strategies to windstorm disaster in Nigeria.

5.1 Summary of the Major Findings

The complex nature of vulnerability to windstorm disaster requires a systematic evaluation of biological, physical and social environments make Ibadan susceptible windstorm disaster. In order to appreciate the probability of hazards as a result of windstorm disaster in Ibadan, it is important we examine the particular context in which Hazard of a place takes place in Ibadan. It is necessary to understand factors exposing buildings to windstorm disaster in Ibadan. The concept considers the threat from all indicators in Ibadan, thus, providing the opportunity to mitigate windstorm disaster hazards specific to a neighbourhood in the city. The study harnessed spatial, analytical and mapping tools such as GIS and Auto-Cad, to examine the spatial dimension of windstorm disaster and the buildings that are variously affected in Ibadan. The research is anchored on an idea that focuses on biological, physical (Bio-physical) and social dimensions of vulnerability. The importance of this method and its application, on statistical and spatial information system was explored to determine the hazardousness of a place in affected neighbourhoods in Ibadan, Oyo state Nigeria.

Three vulnerability indicators identified in the affected neighbourhoods are elevation, high rise buildings and vegetation. These trio were employed for statistical evaluation of the vulnerability of the sampled neighbourhoods. Elevation, a physical factor and vegetal cover, a biological factor cannot explain the occurrence of windstorm disaster in Ibadan because their contributions were not statistically significant. The only factor found statistically significant is the High-rise buildings which contribute to windstorm disaster in Ibadan.

A GIS examination of indexes of physical indicators (rate of windstorm occurrence, affected neighbourhood elevation above sea level), biological indicator (vegetation cover) overlaid on indices of socially vulnerable neighbourhoods (percentage of women, children, old-age, housing density, mean house rent, and mud building) identified spatial variability in vulnerability to windstorm catastrophe in Ibadan. The hotspot areas resulting from biophysical analysis do not overlap with the hotspot areas from vulnerable populations due to social analysis. However the findings in Ibadan shows a unique combination of medium levels of biophysical vulnerability and medium-to-high levels of social vulnerability definedby the overall vulnerability of the study area. Social costs of hazardous events in a given city is reflected in this findings. While there would be great economic losses for urban residents in areas prone to biophysical hazard in

Ibadan, victims' recovery will be aided by greater means of income or greater wealth and access to economic livelihood. However, it would take only a moderate windstorm event to disrupt the economic gains and wellbeing of the majority of residentsat the old quarters in Ibadan and impede long term recovery from disasters in this area. The terrain of the study area does not have a particular influence over the vulnerability of the city. The terrain was significant only in one out of the 51 neighbourhoods. The city is however vulnerable due to lack of vegetal cover. Of the 51 neighbourhoods, only two (Yejide and Tejide) neighbourhoods were partially covered and it is due to the presence of institutions around these neighbourhoods. The research found a semi cycled windstorm storm track spanning several kilometres from Idiarere Kudeti axis through Yejide Road to Sanyo, to academy, through Muslim, Koloko and ended up around Aremo Ode Aje enroute Agugu.

The research found vulnerability cluster around the old quarters caused by the high concentration of buildings, heat island and pollution. Haberlie, *etal* (2015) consider high concentration of building, heat island and pollution as having about 5 percent higher chance to initiate a thunderstorm. Thunderstorm produces a downburst wind which is capable of devastating urban neighborhoods (Geer, 1996), thus, the vulnerability of the core areas popularly called the old quarters. The need for town planners to utilize development control tools to ensure adherence to building code, and the initiation of lay-out plan to control building concentration thus become necessary. The ongoing master plan of the city is a commendable way to start preparing Ibadan against future wind storm disaster.

The research illustrates the need to consider both social, physical and biological factors when determining and evaluating the place vulnerability and offers a model for other integrated place based vulnerability research in Nigeria. The study establishes how Town Planners can contribute significantly in the overall public policy arena. Also, the research establishes the significance of combining the practical aspects of Planning with academic partners in demonstrating the relevance of spatial analysis to natural/societal interactions.

5.2 Research Challenges

One of the challenges faced was the issue of data availability. For example, National Population Commission demographic data at neighbourhood level is not available for

2006 census. It is also observed that temporal dimension in windstorm disaster events shows that windstorm disaster in Ibadan is seasonal. The contribution of ocean current and thunderstorm to instigating windstorm disaster were neither sampled nor tested in this research. It is suggested that such should be included in subsequent study to broaden knowledge. Regardless of these challenges, the research proves the posibilities therefore contributes to our understanding of what makes people and places vulnerable to windstorm disaster in Ibadan.

This research provides government agencies such as NEMA and OYSEMA with a mechanism for identifying those areas most susceptible to windstorm disaster and any other hazard of concern within their jurisdiction. The approach will help the state and national disaster management agencies to exploit other causative factors (social) aside the traditional physical characteristics by identifying those social groups who are differentially vulnerable, in order to incorporate them into disaster planning. Although one of the main challenges to the implementation of disaster planning in Nigeria may be the lack of and or late release of funds for training and data collection, however, the importance of this approach as a planning and training tool for emergency preparedness and response cannot be underrated.

In conclusion, it is recommended that this research is expanded in scope to region or the nation as a whole. All the state capitals, the local government capitals, the major cities and towns in Nigeria should be analysed to identify national, regional and local variation in social vulnerability and biophysical risk in order to evolve harmonised reactions to windstorm event capable of affecting both urban and rural communities. The application and understanding of human environment relations, the conceptualization of windstorm vulnerability and its intricacies, and the use of spatial methods to represent vulnerability offer Town Planners an edge to formulate and implements excellent public policies on disaster related issues. The research demonstrates the need to equip Town Planners with a knowledge of both physical and human systems and spatial analysis technique skills that are required to resolve current environmental problems such as those posed as a result of vulnerability to windstorm disaster in Nigeria.

5.3 Theoretical Implications of the Research

The Multi-Hazard Model of Severe Storm Risk, a concept that emphasizes the interplay of hazard and vulnerability in defining risk, was reviewed in this study. The model developed by Desmond Mark Pyle in 2006 to study Severe Convective Storm Risk in the Eastern Cape Province of South Africa was employed to examine hazard, vulnerability and risk, in the knowledge that disasters arise from a combination of hazard and vulnerability i.e.,. A hazard is not the single causal agent of windstorm; rather it is viewed as a "trigger" which sets off a disaster. Risk was seen as the product of both hazards and vulnerability (R = H x V). The research satisfies this model. The unprecedented reoccurring windstorm disaster in the study area (Hazard) and the underlying poor and uninhabitable housing condition, poor environmental condition, weak and derelict infrastructures, lack of basic livelihood facilities in the state of disrepair especially at the old quarters in such areas as Idi-Arere, Bode, Kudeti, Labiram, Aperin etc. are triggers to storm impacts in the study areas bringing the study areas to a state of unprecedented risk. The model confirmed poor neighbourhood as a windstorm trigger.

The drastic reduction in the vegetal cover of the study area conforms to one of the tenet of the vulnerability concepts. It was found that while the colonial government established forest reserve to cool the city, prevent evaporation, preserve the flora and fauna of the city, to clean the city by sucking its/her carbon dioxide and ultimately serve as wind breaker, the military government in the 80s and 90s ordered the conversion of these reserve for residential purpose. This system has led to increase in heat island, building concentration and has further increased pollution in the city. Thus, the increase in the rate of windstorm disaster occurrence causing massive devastation in the study area. The Nitel Forest around scout camp, Molete Ibadan was cut down in 1987 and the reoccurring devastating wind commence in 2008.

Vulnerability is the degree to which a system or unit is likely to experience harm due to exposure to hazard or stress (Pelling, 2003). Since these poorly constructed buildings are exposed to overwhelming stress, then they easily breakaway during windstorm. It is indeed necessary to mention that Vulnerability in the social sciences is typically identified in terms of three elements: system exposure to crises, stresses and shocks; inadequate system capacity to cope; consequences and attendant risks of slow (or poor) system recovery. This perspective suggests that the most vulnerable individuals, groups, classes, and regions or places are those that: experience the most exposure to hazard (most likely to suffer from exposure); and have the weakest capacity to respond and ability to recover. This is exemplified in the areas that are most exposed to windstorm disaster in Ibadan. Within this extended vulnerability framework, there is formal recognition that macro forces – broad-scale environmental and human systems within which the local system resides – come together to affect the local system and, simultaneously, influence the pressures that act upon it. Different pressures across scales come together in various sequences to create unique bundles of stress that affect local systems. A major hypothesis holds that when perturbations emanating from the environment coalesce with those arising from society, significant consequences can result. For example, when socio economic parameters meet with biophysical parameters as is the case of Ibadan, then, the vulnerability of the system is enlarged. The risks resulting from such vulnerabilities emerge from multiple sources, and at different scales. These risks cascade through interacting human (social) and environmental systems (Biophysical) to create adverse consequences (Wisner, 2001; Pine, 2003).

The cause and effect concept ascribed to Aristotle was also validated in this research. It states that the cause and effect of any event had to be present at the same point in space with the cause preceding the effect by only a very short time (Zebrowski, 1997). In the case of the study areas, the cause and effect of damaging the forest reserves has helped to heat up the surface of the city. The buildings in the old quarters are so closely packed that even grass cannot grow there. Also, since most of the drainages are free flowing, evaporation easily takes place leading to warm moist air which moves up as vertical winds. The consequence of the moist hot air and the heat island is windstorm occurrence through thunderstorm that occurs as a result of rapid upward movement of warm, moist air, sometimes along a front. As the warm, moist air moves upward, it cools, condenses, and forms a cumulonimbus cloud that can reach heights of over 20km. As the rising air reaches its dew point temperature, water vapour condenses into water vapour or ice, reducing pressure locally within the thunderstorm cell. Any precipitation falls all the way through the cloud towards the earth surface. As the droplet falls, they collide with other droplets and become larger. The falling droplets create a downdraft as it pulls cold air with it, and this cold air spreads out on the earth surface, occasionally causing strong wind that are commonly associated with thunderstorm (McCarthy, et al 1979). Strong wind resulting from heat island and pollution through thunderstorm finally hits the earth through torrential precipitation leaving its marks as windstorm (Bentley 2010). This storm only leads to disaster when lives and properties are devastated. The trees and the forest reserves that would have served as windbreakers are no longer available, and the full effect of the wind felt in massive community devastation.

Thunderstorm can form and develop from any geographical location. But most frequently within the mid latitude, where warm, moist air from tropical latitude collides with cooler air from polar latitudes. Thunderstorms are responsible for the development and formation of many severe weather phenomena that occur along with them, to pose great hazards. Damage that results from thunderstorm is mainly inflicted by downburst wind and others. Stronger thunderstorms are capable of producing tornados and waterspouts.

5.4 Conclusion and Recommendation

The noxious social disruptions, massive economic losses and mortality resulting from windstorm disaster vulnerability in Ibadan call for quick political action/intervention, policy development and pragmatic solutions. The role of urban development in forest reserve depletion, poor housing and environmental conditions of the study area cannot be overlooked. This research focuses on the interplay between the biophysical vulnerability parameters and social vulnerability indicators and lifeline factors among affected residential neighbourhood in Ibadan. The research has demonstrated how residential social and biophysical factors stimulate vulnerability to windstorm disaster in Ibadan. The research revealed the degree of the contribution of elevation, high rise buildings and vegetal cover to vulnerability of the sampled neighbourhoods in Ibadan.

The combination of the study of biophysical and social vulnerability indicators found a high degree of spatial variability in overall vulnerability to windstorm disaster in Ibadan. The research found that the combination of medium levels of biophysical vulnerability and medium-to-high levels of social vulnerability characterize the overall vulnerability of the study area. To therefore ensure sustainable windstorm management planning and mitigation against vulnerability to windstorm disaster in Ibadan, the following recommendations are proffered:

1. The Oyo State Government should invest in windstorm forecasting, mapping and zoning regulations, particularly on quality of buildings, built in the windstorm prone areas. The Oyo State Emergency Management Agency should work hand in hand with the Nigeria Meteorological Agency at Samonda, to enable dissemination of reliable information on impending windstorm and other convective hazards. The Office of the Surveyor General of Oyo state should work with OYSEMA and Urban and Regional Planning Bureau to produce map of the areas vulnerable to windstorm in Ibadan. The map should be embedded with details of the building profile. The map should be made available to the public to enable free access to information about windstorm disaster vulnerable areas in Ibadan.
2. The relationship amongst ministries, agencies and departments in Oyo state must be improved upon. This becomes necessary for the effective management of any policy initiated to control windstorm disaster in the state. E.g., the OYSEMA is in charge of disaster management in the state. These agencies should always consult with the Bureau of Physical Planning and Development Control to aid their spatial decision as regard windstorm disaster management in the state.
3. The forest reserve scheme initiated by the colonial government between 1916 and 1941 in Ibadan should be revisited and re-enacted to become law. All setbacks to the stream in the city should be converted to forest reserves. The action will reduce the number of neighbourhoods vulnerable to windstorm. The flood plain of Kudeti Stream, Odo-Oba Stream, Ogunpa Stream, and Ona Stream should not be converted. The Bureau of Town Planning should ensure that all set back to these streams are reclaimed and converted to forest reserves. The department should also ensure that no permit is granted to both individual and corporate body to urbanise these areas by ensuring that development permit is not granted to any other land use other than forest reserves. This would not only protect the city, but also contribute significantly to carbon gain, urban food security and, at the same time, reduce the risks of heat island.

   The beautification and tree planting on the Lagos –Ibadan Express road i.e Challenge to Ojoo should be completed and extended to other dual carriage roads in the city. These trees form a system of certain level of friction to wind free flow thus limiting its devastation power and adding to the scenery and beauty of the city.

4. The development of guidelines for integrating windstorm risk into land use planning is imperative. Therefore, development within 10 metres from the base of any major hill and or ridges should be discouraged. It is established that wind ward side of hills and mountains suffer untold devastation. Thus, since wind storm direction is not determinate, 10 meters radius of all ridges and hill should be protected and turned to reserves. The above analogy is applicable to valley where it was also observed that windstorm devastation is high in the study area. In cases where government needs to allow construction, flood-resistant materials recommended by Federal Emergency Management Agency (FEMA) (2011) include: glazed brick, concrete, concrete block, steel trusses, headers, beams, natural decay resistant lumber, clay, cement board, metal doors, and metal window frames be adopted.
5. The Oyo State Bureau of Town Planning should always liaise with OYSEMA before granting permit to the construction of high rise building amidst bungalows. Also, adherence to the following recommendation would also help in their decision making activities
    a. Granting independent Town Planners permission to investigate the proposed sites and to submit detail site analysis report Town Planning Authority
    b. allowing officials of OYSEMA to jointly visit proposed sites for development with Town Planning officers before development permit is granted would go a long way in reducing, if not exterminating, compromise that often leads to approval of development in unsuitable places in the city.
6. The officials of the OYSEMA and Bureau of Urban and Regional Planning should be empowered to employ remote sensing and GIS technologies in their operations to be able to make objective spatial decisions for windstorm disaster vulnerable areas in Ibadan. The institution should organise workshops and seminars for these officials to learn basic terminologies in remote sensing and GIS. The agency should also be adequately equipped to improve on monitoring of development in windstorm prone area.

7. The Oyo State Government should introduce a policy that would enable all stakeholders to be involved in windstorm disaster management and mitigation process. This should be done by:
    - Scheduling periodic meetings before the rainy season to discuss issues with key stakeholder groups. For example, policymakers, operations managers, technical advisors, social scientists, economists, farmers, agricultural extension workers, health and sanitation experts, and utility managers, etc.;
    - Raising awareness on threshold limits of structures, operation and warning procedures (using radio, TV, volunteer networks, and so on). Ensuring that people are aware that there are still risks and should never become complacent to the
    prospect of windstorm in the future;
    - Introducing tight belt to fasten roofs to the building, fixing of roofs, under ceiling and window against loop holes; and conducting public awareness campaigns to ensure that people are conscious of these warning signs during windstorm;
    - Creating awareness of emergency evacuation plans in case of structural failure or roof rip off from structures during windstorm.
    - Empowering appropriate departments or agency to ensure the city is clean.
    - Initiating urban renewal programme to phase out the old quarters.
    - Planting windstorm disaster proof trees and special cooling herbs such as Aloe-vera etc. to reverse the rising urban temperature and cool the city.
8. The retrofitting of those buildings which have outlived their life cycle in the core areas will go a long way to mitigate windstorm problems in Ibadan.

5.5 Contributions of the Study to Urban and Regional Planning Knowledge

This study analysed both social and biophysical vulnerability factors leading to windstorm disaster and mapped out the windstorm disaster vulnerable neighbourhoods in Ibadan. The quality of housing and the environment conditions in urban areas, affected neighbourhoods` elevation, building height, proportion of female and aged population, total number of inhabitants underage population, non-reinforced buildings, mean house rent and effects of land change in windstorm vulnerable areas were examined with both inferential statistics and GIS. The study revealed very high rate of low quality buildings, poor and filthy environment lack of vegetal cover, heat island, pollution and high concentration of buildings as factors fuelling vulnerability to windstorm disaster in Ibadan. Consequently, buildings erected on hill cliff, ridges cleft and on the flood plain were among the most devastated buildings in Ibadan. In most cases, there are more devastation experienced down slope. The frequency, intensity and destructive capacity of windstorm continue to increase as the vegetal cover continues to give way for various urban developments in the city. The windstorm of 2008 devastated 26 communities, destroyed 1257 buildings valued in several hundreds of millions in Naira. The storm occurred only a year after *Igbo NITEL*, a forest adjacent to the incident area known as NITEL forest, was cleared for other pressing needs and uses.

The study also found that aside the fact that there is a cluster of incident area around the old quarters, most of the windstorm disaster vulnerable buildings in the incident areas have outlived their life cycle. Thus they are weak; in the state of disrepair and would remain vulnerable to wind disaster. Based on the evaluation of the determinants of windstorm, there is need to continue with the tree planting policy of the current government of Oyo state in the city, to protect the conversion of the hills and ridges to residential quarters, and the need to initiate policy to guide the approval of the quality and types of buildings that must be permitted in the wind disaster vulnerable areas in the city. Also, there is a need to urbanise the old quarters. The Bureau of Town Planning must approve buildings that have inputs of OYSEMA in the windstorm prone areas and the forest reserve scheme must be re-enacted.

This study clearly revealed the contributions of poor quality building, down slope terrain and land cover change to windstorm disaster vulnerability in Ibadan. The relationship between conversion of cliff to residential areas and to low quality housing susceptibility was identified. The study also presented feasible, actionable and sustainable recommendations for reducing windstorm disaster in Ibadan.

The windstorm track is semicircle. It forms a semi ring around the old quarters. Neighbourhoods such as Idi Arere, Bode, Tejide and Yejide, Odo Oba, Olomi, Boluwaji, Academy, Muslim, Koloko, Agugu and Oje were identified as neighbourhoods along Ibadan windstorm track.

This study, contributed to body of knowledge on vulnerability to windstorm disaster, by analysing windstorm disaster vulnerability indicators in Ibadan and by producing the windstorm disaster vulnerability map and track in the city. This was achieved through the assessment of the vulnerability of a place to hazard in Ibadan by considering both socio and biophysical vulnerability indicators and lifelines parameter in the city. Also considered is the possible role played by the thunderstorm via the increasing temperature of the city, very high building concentration and pollution in engendering windstorms.

5.6 Suggested Areas of Future Study

This research observed that there is need to further conduct a study on specific factors that can ignite windstorm disaster in Ibadan. This should help policy makers in emergency management to appropriately plan for an informed scientific mitigation strategies to combat vulnerability of the study area to windstorm disaster.

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APPENDIX

DEPARTMENT OF URBAN AND REGIONAL PLANNING

FACULTY OF THE ENVIRONMENTAL DESIGN AND MANAGEMENT

UNIVERSITY OF IBADAN, NIGERIA

HOUSEHOLD QUESTIONNAIRE

Dear Respondents,

This questionnaire is designed as part of research instrument to seek information on Analyses of windstorm data in Ibadan Metropolis. Your honest response will be highly appreciated.

Instruction: Please mark or tick the options in the column as deemed fit.

A. Socio–Economic Characteristics

1 Geographical Coordinate N……………….…………..E…………………..……………….

(i) Name of Community ……………………….. [ii] LGA/Ward……………………………….

[iii] Street Name………………………… [iv] House Identification Number……………..........

[v] Density of the area (1) High density (2) Medium density (3) Low density

2 How long have you been living in this area ………………………………………………

3 Age of respondent ………………………………………………………………………

4 Gender: Male…………………...................
Female………………………………………..

5 Religion: (a) Christianity (b) Islamic (c) Traditionalist (d) Atheist

6 Ethnicity (1) Yoruba (2) Hausa (3) Igbo (4) Others Specify………………….

7 Marital Status: (1) Single (2) Married (3) Widower (4) Divorced (5) Separated

8 Number of person(s) in the household (1) 1-3 (2) 4-6 (3) 7-9 (4) 10-12 (5) above 13

9 Highest Level of Education (1) None (2) Primary /Adult Education (3) Secondary Education (4) Post-Secondary education (5) Others Specify…………………………….

10 Occupation (1) Unemployed (2) Trading/Business (3) Artisan (4) Farming (5) Civil Servant (6) Professional (7) Retired (8) other (specify)………………………………………………

11 Income per month (1) <₦ 10,000 (2) ₦ 11,000-40,000 (3) ₦ 41,000-70,000 (4) ₦ 71,000-100,000 (5) above ₦ 100,000

B. Housing and Household Characteristics

12 Age of building (1) <10 years (2) 11-20 years (3) 21-30years (4) 31-40years (5) >41

13 Type of house tenure (1) Owner-Occupier (2) Rented (3) Institutional Property (4) Family House (5) Squatter (6) Others Specify ……………………………………………………

14 Types of dwelling unit (a) Rooming Apartment (b) Flat (c) Duplex (d) Compound

15 Total number of rooms in the building? (1)1-2 (2) 3-4(3) 5-6 (4) 7-8 (5) 9 and Above

16 Total number of households in the building? (1)1-2 (2) 3-4(3) 5-6

17 Average number of persons per room? (1)1-2 (2) 3-4(3) 5-6 (4) 7-8 (5) 9 and Above

18 Distance of building (in metres) to the adjacent structure on the (a) Right …………………
(b) Left …………….…… (c) Rear ………………………. (d) Front ………………………

19 Material used for wall (a) Block (b) Mud (c) Plank and Iron Sheets (d) Stone (e) Burnt Brick (f) Others (Specify)…………………………………………………………………

20 Is the wall plastered? ....

21 Shape of building?(a) Rectangular (b) Square (c) Circular (d) Hexagon (e) Triangle

22 Roof material (a) Interlocking Tile (b) Corrugated Iron Sheet (c) Thatched Roof (d) Reinforced Concrete Block (e) Others (Specify)………………...…………………………..

23 Roofing style (a) gabbled roof (b) Hip roof (c) Flat roof

24 Is the underside of the roof sealed from airflow? (a) yes (b) No

25 If yes, what is the material used to seal off the underside? (a) asbestos (b) plank (c) concrete finishing

26 What is the estimated pitch of the roof in meters? (a) 1-2 (b) 3-4 (c) 5-6

27 Door and window material (a) Modern Frame and Wooden Panel (b)Wooden Frame and Glass/ Louvres (c) Metal Frame and Glass Panel/Louvres (d) Aluminum Doors and

Window (e) Metal Sheet (f) Others (Specify)……………………………………………..

28 Height of building (a) High-Rise Building (No of floors)……………… (b) Storey Building (c) Bungalow (d) Others (Specify)……………………………………………………..

29 Average height range of building in street (…………….floors) (*field officer to insert*)

30 Drainage channel for water flow around building (a) Available (b) Not Available

31 If available, in what condition (a) Free and Flowing (b) Blocked (c) Others (specify)……..

32 Setback of property from (streams, rivers, ponds) (a) 0-10m (b) 11-20m (c) 21-30M (d) 31-40m (e) 41-50m (f) Above 50m

33 Set back of Property from road……………………………………………………………

34 Average distant of street to forested Area (a) 0-1000m (b) 1001-2000m (c) 2001-3000M (d) 3001-4000m (e) 4001-5000m (f) Above 5000m

35 Physical condition of the building (a) Good (b) Needs Minor Repair (c) Major Repair (d) Others (specify)………………………………………………………………………………

C. Housing Facilities, Convenience and Sanitation

36 Source of water for domestic use: (a) Tap/Piped Water (b) Well/Borehole (c) Stream / Pond (d) Street Hawkers (e) Others (specify)……………………………………………………

37 Distance to source of water (a) Within the compound (b) Outside Neighbourhood (c) Within the Neighbourhood (d) Others (specify)……………………………………………

38 Distance of well or other sources of water to soak-away or refuse dump etc. (a) 0-10m (b) 11-20m (c) 21-30m (d) 31-40m (e) 41-50m (f) Above 50m

39 Location of well or other sources of water in relation to soak away or refuse dump (a) Up Hill (b) down Hill (c) Same Level (d) Others (Specify)……………………………………

40 Toilet facility (a) Water Closet (Separated) (b) Water Closet (Shared) (c) Pit Latrine (d) Pail Latrine (e) Bush (f) None (g) Other (Specify) …………………………………………

41 Number of person(s) per toilet facility (a) 1-2 (b) 3-4 (c) 5-6 (d) 7-8 (e) above 9

42 Kitchen facility (a) Open Space (b) In Built, Within the House (c) In Built, Within the House but Shared (d) None (e) Other (Specify) ……………………………………………

43 What are the types of waste generated in the house ……………………………………....

………………………………………………………………………………………… ……..

44 Method of waste collection (a) Government Agency (b) Organized Private Collector (c) Local Cart Pushers (d) Other (Specify)……………………………………………………

45 Frequency of collection: (a) Daily (b) Twice a Week (c) Every Other Day (d) Weekly (e) Other (Specify)……………………………………………………………………………….

46 If waste are not collected by: government agency; organized private collector and or local cart pushers, how do you dispose waste (a) Communal Dumps (b) In the Bush/Open Space (c) Dump in Water Drainage/Channel or Stream (d) Burnt in a Communal Open

Space (e) Road Side or Medium (f) Other (Specify)………………………………………………..

47 What are the effects of non-collection of waste in your neighborhood …………………… …..…………………………………………………………………………………… …

48 Class or types of road servicing your locality: (a) Ring Road (Outer by-pass) (b) Primary Arterial Road (c) Secondary Arterial Road (d) Distributor Road (e) Service (Access) Road

49 Condition of road: (a) Good (b) Fair (c) Poor

50 Average width of street…………………………………………………………………

51 Average length of street…………………………………………………………………

52 Types of open space in your street (a) Children play ground (b) football field (c) undeveloped plots (d) Other (Specify)……………………………………………………

53 What is/are the major means of transportation: (a) Walking (b) Okada (Motorcycle) (c) Car (Private) (d) Taxi (e) Bus (f) Other (Specify)……………………………………………..

54 Do you have difficulty in accessing your locality: ………………………………………….

55 If yes, what is responsible for the inaccessibility: ………………………………………...

56 Situation of traffic congestion in the neighbourhood: (a) Frequently (b) Occasionally on Most Roads (c) Frequently on Few Roads (d) Occasionally on Few Roads (e) Does not Occur at All

57 Dominant Land Use in this Area (1) Commercial (2) Residential (3) Educational (4) Agricultural (5) Industrial (6) others (Specify) …………………………………………..

D. Disaster Related Information

58 Do you have information prohibiting living in any specific part of your locality ……………………………………………………………………………………………..

59 If yes, from which agency or organization ………………………………………………..

60 What is your definition of a disaster...
……………………………………………………………………………………………….

61 Is your area vulnerable to any form hazard or disaster (a) Yes (b) No

62 If yes, list them ………………………………………………………………………… ………….……………………………………………………………………………

63 Have you ever experienced any form of hazards /disasters in your locality (a) Yes (b) No

64 If yes list them ………………………………………………………………………………

65 Have you ever experienced wind/windstorm disaster (a) Yes (b) No

66 If yes, when? …………………………………………………………………………

67 How do you mitigate very strong wind to prevent your properties from damaging…………………………………………………………………………………….
...
68 What are the traditional methods passed on to you to mitigate strong wind………………………………………………………………………………………….
69 What do you think government can do to stop wind devastation?......................................
Information on Windstorm
70 Have you ever experienced windstorm in this area? (a) Yes (b) No
71 How often do you experience windstorm in this area? (a) At the beginning of raining season (b) At the end of raining season (c) Occasionally When it Rains Heavily (c) Anytime it Rains heavily (d) Others (Specify) ……………………………………………
72 when and where was the occurrence of windstorm?..
73 How long did it last……………………………………………………………………………..
74 Were the adjacent buildings affected during the windstorm incident in the locality? (1) Yes (2) No
75 When last did any windstorm occur? ………………………………………………………
76 From your experience, what was the frequency of occurrence per year? (a) Once (b) Twice (c) More than Twice (d) Others (Specify)………………………………………….....
77 What do you think caused the windstorm (a) Natural Causes (b) Human Induce Causes (c) Act of God (d) Other (Specify) ……………………………………………………………
78 If human induced, which of the following(s) is/are correct? (a) Location of Property in Hazard Prone Area (b) Improper Planning or Design (c) Lack of windstorm related laws (d) Poorly constructed buildings (e)Others (Specify)….……………………………………
79 What is the estimated distance of your house from the main road?...............................
80 What is the estimated distance of Emergency services to your locality? ……………………
81 What is the response time to your observed windstorm devastation? ….……………………
82 Has there been any measures by the community or government to combat windstorm in the locality? (a) Yes (b) No
83 If yes, list the measures……………………...………………………………….......................
……………………………………………………………………………………………..…
84 Despite the occurrence of windstorm, give reason(s) why you still live in this house or locality (a) Nearness to Place of Work (b) Cheaper Rent (c) Family House (d) Personal House (e) Others (Specify) …………………………………………………………………
85 What can be done to prevent the reoccurrence of windstorm? (a) Cannot be Prevented (b) Property Relocation (c) Adequate design and construction process (d) Better community Planning and Management (e) Adherence to Building codes (f) Others (Specify) ……………………………………

Information on Windstorm Devastated Building

86 Have you ever experienced or witnessed building collapse or roof rip off before? (a) Yes (b) No

87 If 'yes' can you recollect the experience of what you witnessed?…………………………....

…………………………………………………………………………………………….

88 Is building collapse or roof rip off during wind/windstorm frequent in your locality? (a) Yes (b) No

89 If yes, how frequent is the occurrence yearly in this area? (a) Once (b) Twice (c) More than Twice

90 What is responsible for roof rip-off and or building collapse? (a) Natural Causes (wind/windstorm devastation) (b) Human Failure or Mistake (c) Age of the Building (d) Structural Defects (e) Substandard Building Materials Location of Building (f) Others (Specify) ……………………………………………………………………………..

91 Has there been any measure by the community or government to curb roof rip-off/ building collapse in Oyo state (a) Yes (b) No

92 If 'yes' what is/are the measure(s) ……………………………………………………………

93 What can be done to prevent future occurrence of building collapse/ roof rip-off be? (a) Use of Appropriate Building Materials (b) Employment of Qualify Professionals to Supervise the Project (c) Designing windstorm resistant Building (d) Demolition of Structural Inadequate Buildings (e) Others (Specify)……………………………………

94 Which parts of the building are mostly affected by windstorm? (1) Roof (2) Window (3) Doors (4) Others

95 During windstorm, what other facilities are been destroyed in this area? (1) Electric Poles(2) Masts (3) Bill Boards(4) Trees (5) Others (Specify)………………………………………..

E Windstorm Mitigation Measures

96 Do you know of any disasters management agency in Nigeria? (a) Yes (b) No

97 If yes what is the name of the agency?..

98 Has the agency done anything relating to windstorm disasters prevention and or management within your locality before? (a) Yes (b) No

99 If yes, list what the agency had done……………………………………………………….

………………………………………………………………………………………………

100 In your own assessment, how efficient/effective is the agency in carrying out her responsibility? (a) Not Efficient (b) Averagely efficient (c) Efficient (d) Very Efficient

101 From the windstorm /windstorm disaster or hazard events you had witnessed or affected, did the affected populace receive help from any organization (a) Yes (b) No

102 If yes, from which organization? (a) Individual/Residents Association (b) NGO/Philanthropist Organization (c) Community (d) L.G.A. (e) State Government (f) Federal Government (g) International Organization/Foreign Government (h) Others (Specify)………………………..

103 Who do you think will help in militating or reduce the danger of windstorm hazard /disaster in your locality? (a) Individuals (b) Community Organizations (c) Government Disaster Agencies (d) NGOs (e) International Organization (f) Others (specify)………………………….…

104 Personally, what can be done to improve on windstorm disaster management in your neighbourhood

……………………………………………………………………………………………
……………………………………………………………………………………………

Thank you