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EVALUATION OF THE CAUSES OF FLOOD AND MITIGATION STRATEGIES IN KADUNA SOUTH LOCAL GOVERNMENT AREA, NIGERIA

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Abstract— **Flood disaster has become a significant natural concern to so many rural and urban dwellers in different part of the world, with devastating effects that cannot be overemphasized. Previous studies have discussed causative factors and preventive measures of flooding. However, significant underpinning factors such flood incidence, hazard proximity and delineation of flood vulnerable areas which determine flooding severity and wide scale coverage are often obscured. The situation creates a knowledge gap which this study intends to fill by evaluating the causes of flood in Kaduna South Local Government Area and proffer mitigation strategies. The descriptive survey research design was employed in the study and a total 418 structured questionnaire was shared among residents and professionals in the built environment. Data was presented on tables and analyzed using the relative importance index ranking method so as to determine the severity of the factors that causes flooding and the mitigation measures that are appropriate to tackle the problem. The result of the study showed that 34.36% of the residents have experience flood at least 3 times in single rainy season, while 11.04% and 2.76% of the residents have experience flood at least 6 and 9 times respectively in a single season. Hazard proximity reveals 19.94% of residential buildings located are within 0.1-0.5 km and 13.49% are located within 0.5-1.0 km away from the flood source. Consequently, river overflow with a severity index of 0.31 is the highest cause of flooding in the study area, followed by poor drainage systems and heavy rainfall with Severity index of 0.29 and 0.28 respectively. The study also suggested mitigation measures as good drainage network and stop building on flood plains jointly rank first with a significance index of 0.30, building embankments and implement government policies on flood with 0.28 and 0.27 respectively. Therefore, the authority of Kaduna State Urban Planning and Development should ensure widening and desilting of drainages, the demolition of illegal structures built across the drainage channels and the implementation of government policies on flood.**

Keywords— **Causes of Flood, Mitigation Strategies, Kaduna South, Relative Importance Index**

I. INTRODUCTION

Flooding is one of the greatest long-term challenge facing the international community, even though it might seem an extreme statement in a world trying to cope with pressing challenges of terrorism, famine, wars and diseases, unfortunately its true [1]. [2] posited that in many parts of the world, flood seems to be occurring more often and they seem to be increasing in size, with the consequences vast on the physical environment, economic and social well-being of the inhabitants of the area affected. In Nigeria, the incidents of flood are becoming a reoccurring decimal in most urban areas such as Kaduna South, leading to colossal loss of properties and lives, couple with the deficit and inadequacy of housing supply and that most people are faced with the problem of providing housing that is adequate with respect to standard quality and prices the people and their families can afford [3].

On a typical flooded day in Kaduna South area, roads are rendered impassable to both human and vehicular traffic, residential properties are damaged and occupants are forced to vacate their homes and occasionally lives are made difficult for some times, [4]. The effect of flood on the residents of Kaduna South is such that many lives are lost and property worth millions damaged [5]. Monetary losses recorded as a result of flooding in Kaduna South are enormous; the destructions are complete or partial impairment of

residential property values, goods and services [6]. One of the most devastating flood event happened on the 13th of September, 2012 after a torrential rainfall that lasted for days and swept away at least 178 homes [7]. Another notable flood disaster occurred in 2019, where at least 500 homes were affected by flood and windstorm disaster in Kaduna South as reported by NEMA's zonal coordinator in the North West Zone [8].

The causes of flood in developing nations were identified as unregulated developments, invasion of public areas, lack of institutional capacity at municipal level, unrealistic regulations, economic pressures from developers, ineffectiveness of planning regulation by allowing development on flood plains and lack of standard drainage system on roads, [9]. [10] examines the causes of floods in Ikoyi and Victoria Island, Lagos. The author identified excessive rainfall, faulty drainage designs, and blocked drainage channels by refuse and sediments, obstruction by buildings and inadequate drainage heads to make the drainages efficiently drain off storm water. The topography of the area, land use (LU) and land cover (LC) modifications, and influence of canals, rivers, and streams were identified by (Aderogba, 2012; Aderogba *et al*., 2012). Other factors considered are urbanization and population growth, poor urban planning, and poor environmental management and the indiscriminate disposal of solid waste (Lamond *et al*., 2012; Adeloye & Rustum, 2011).

Consequently, having critically reviewed past literature on the causes of flooding by different authors [14; 15; 11; 10; 16; 9], significant underpinning factors such as rainfall incidence, hazard proximity and delineation of vulnerable areas were obscured. However, the causes of flood are location specific and as such, peculiar to soil characteristics, slope and drainage pattern. Therefore, the aim of this paper is to critically identify and evaluate the causes of flood that are peculiar to Kaduna South with respect to rainfall incidence, hazard proximity and delineation of vulnerable areas so as to proffer mitigation strategies.

II RESEARCH METHODOLOGY

A Study area

The entire land structure of Kaduna South consists of an undulating Plateau with the major river Kaduna, located between latitude 10^0 28' and 10^0 37' North and longitude 07^0 19' and 07^0 31' East. There are two marked seasons in the area, the Dry season and the Rainy (wet) Seasons. The wet season is usually from April through October with great variations as you move North-Wards. On the average, the area enjoys a rainy season of about six (6) months. There is always heavy rainfall with an average of about 1016mm. The State extends from the tropical grassland known as Guinea Savannah to the Sudan Savannah in the North. The grassland is a vast region covering the Southern part of the State. The prevailing vegetation of tall grasses and big trees are of economic importance during both the wet and dry season. Due to the heavy rainfall experienced during the wet season, the state has suffered from many cases of flooding in the past decade.

B. Research Design

The descriptive survey research design was used in this study due to its suitability for causal studies. This is so because this kind of design enables a researcher to identify the peculiar characteristics of a given location and seek to describe them in a logical and systematic way. The strategy that was employed in this study is to identify locations (as provided by NEMA) with incessant flood cases in Kaduna South and use the stratified sampling techniques to divide each of the locations into two strata of flood risk zone and non-flood risk zones.

C. Sample Frame and Size

The population of the study entails built environment professionals operating in the metropolis and residents with their respective residential dwellings within the sampled flood prone areas will be chosen randomly. In order to effectively administer the questionnaire across the residents, a representative sample was drawned from a sample frame of 584, 105 [17] using the Yamane [18] formula for calculating sample size. Thus, 400 samples was arrived and therefore, 400 samples of questionnaires was administered to residents within each of the four (4) suburbs (Barnawa, Makera, Kabala and Tudun Wada) identified as the most flood prone areas [8] getting a total of one hundred (100) questionnaires. However, the convenience sampling method which involves individuals who happen to be the most accessible to the researcher was used to generate data from 18 professionals in the built environment.

D Method of Data Collection

A structured questionnaire was developed by the researcher to elicit information on the causes of flood in Kaduna South, flooding incidence, relative distance of buildings to flood source, and mitigation strategies. The questionnaire was sectionalized into four parts, the first

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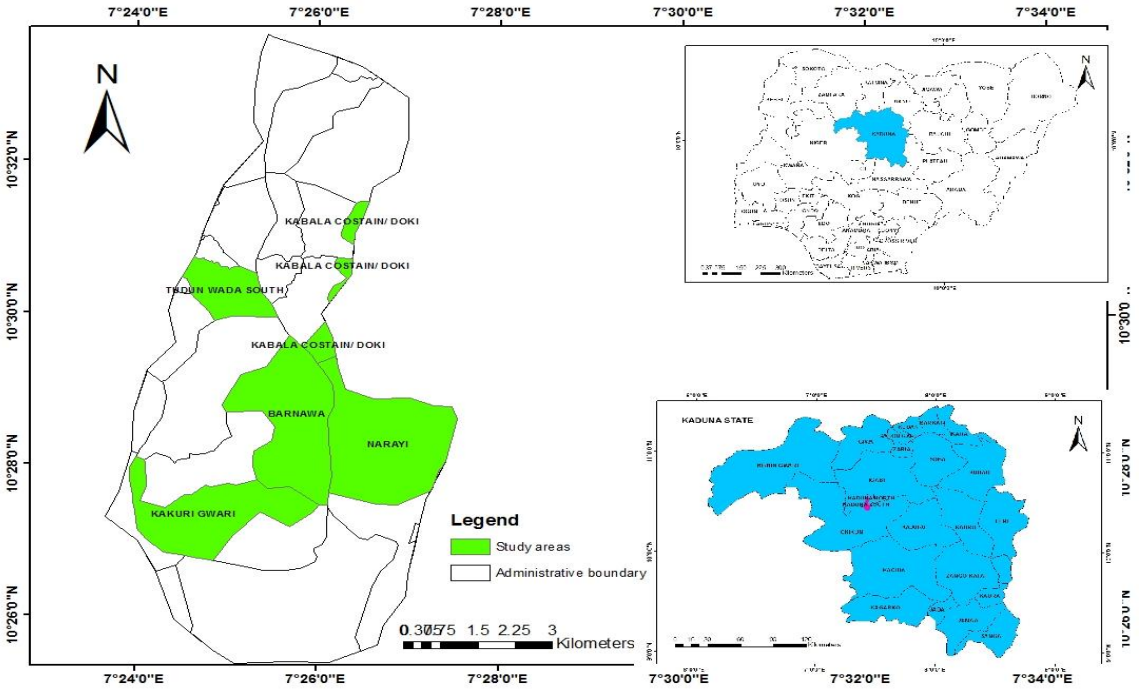

Figure 1: ***Map of Kaduna South***
Source: ***Map produce by the researcher***

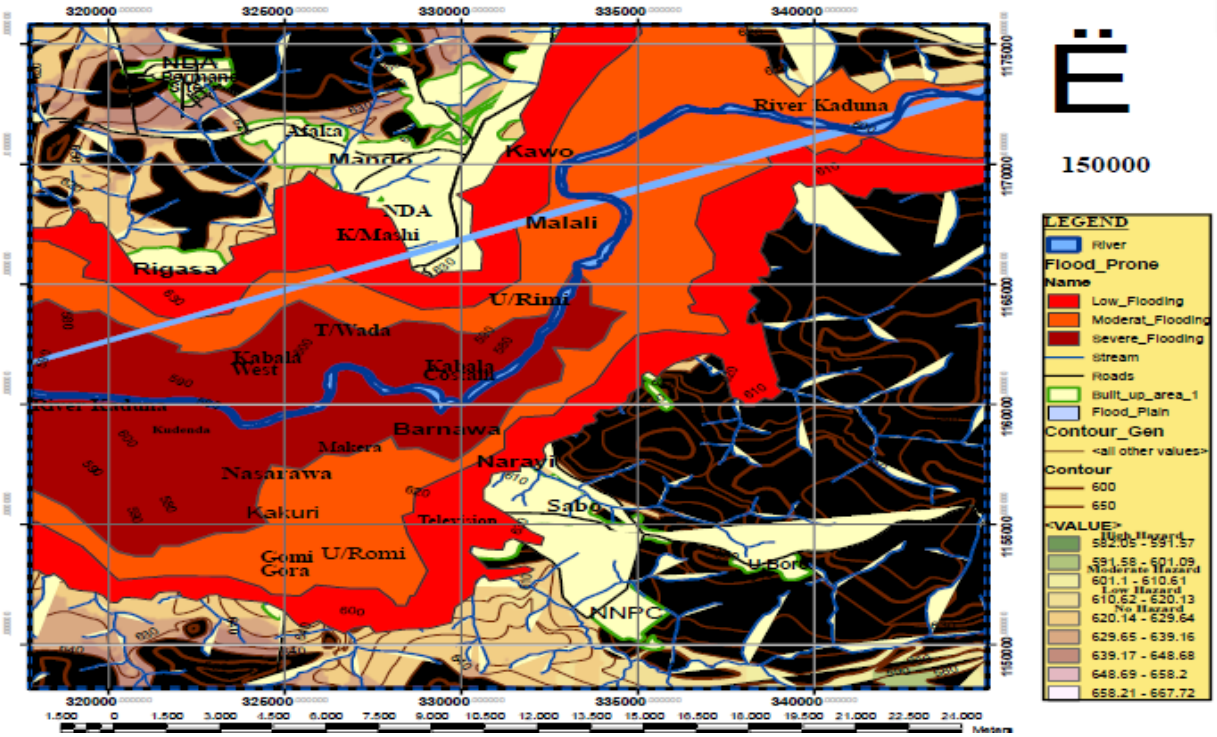

Figure 2: ***Flood hazard map of Kaduna Metropolis***
Source: ***Dept of Geo-informatics ABU,*** **2012**

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part focused on the socio-demograpic profile of the respondent, the second part focused on flooding incidence and hazard proximity, the third part focused on the causes of flood peculiar to the study area, while the fourth part focused on the mitigation strategies.

E. Data Analysis

Data collected from the respondents was subjected to the statistical approach of descriptive statistics. The data on flood incidence, hazard proximity is presented and analyzed on frequency tables. The data on causes of flooding in the study area and the mitigation strategies is presented on tables and analyzed using the relative importance index.

III RESULTS AND DISCUSSION OF FINDINGS

A total number of 418 questionnaires were distributed to the suburbs to elicit answers from respondents after which 341 copies of questionnaires were properly filled and retrieved from the field. With over 80% of the questionnaire properly completed and returned, the study comfortably relied on data recovered. Those not returned or were either poorly completed were not used for the computation.

Table 1: Questionnaire administered and retrieved

Description	Barnawa	Makera	T/Wada	Kabala	Built Environment Professionals	Total
No. Distributed	100	100	100	100	18	418
No. Retrieved	88	73	84	81	15	341
Percentage	21.05	17.46	20.10	19.38	3.59	81.58

Source: Field Survey, 2021

A. Socio-demographic profile of respondents

From Table 2, the respondents constitute 235 (72.09%) males and 91 (27.91%) females. This shows that flood affects male the most because of the activities they mostly engage in, such as farming, building construction, transport services and the likes. Various age groups were also integrated in the study with those within the age range of 36-45 years recording the highest with a percentage of 29.75%, followed by 25.46% and 21.16% for those within the 26-35 and 18-25 age range respectively. Though this age range that forms the majority of the age group are less likely to be vulnerable to flooding due to their resilience and adaptive capabilities than those within the age group of 56 and above who are considered the vulnerable groups. Formal education is vast in Kaduna South Local government as one of the most educationally advance area in the State as the result shows that 65.64% and 25.46 % of the respondents have attained tertiary and secondary education respectively making the study easier to be carried out. The major occupation in the study areas is trading making up 33.13% of the population, with students and civil servants making up 29.14% and 21.78% respectively. However, a majority (29.72%) of the respondents are within the income level of ₦81,000 - ₦110,000 making it more reasonable why residents will prefer to stay in low rent residential dwellings.

Table 2: Socio-demographic profile of respondents

Profile	Frequency	%
Gender		
Male	235	72.09
Female	91	27.91
Total	326	100
Age group		
18-25	69	21.16
26-35	83	25.46
36-45	97	29.75
46-55	51	15.64
56-65	19	5.83
66+	7	2.15

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Total	326	100
Educational level		
Tertiary	214	65.64
High school	83	25.46
Primary	17	5.21
No formal education	12	3.68
Total	326	100
Occupation		
Civil servants	119	21.78
Farming	25	15.95
Trading	103	33.13
Students	79	29.14
Total	326	100
Average monthly income		
20-50	25	9.65
51-80	57	22.01
81-110	77	29.72
111-140	54	20.85
141-170	24	9.27
171-200	16	6.17
Above 200	6	2.32
Total	259	100

Source: Field Survey, 2021

Table 3 shows the response of residents that have experience flood events and those that have no experience. This shows that 48.16% of residents in flood prone areas have experience flood and the remaining 1.84% that make up the 50% did not experience flood making it 51.84% residents in areas that are not flood-prone.

Table 3: Residents that experienced flooding

Flood experience	Frequency	Percentage
Yes	157	48.16
No	169	51.84
Total	326	100

Source: Field Survey, 2021

The Table 4, shows how long residents have lived in the area to determine their years of experience with the event. The study requires data from residents that have lived for at least five year period to establish data on causes of flood in the area. The result shows that over 90% of residents have lived in the area for over 6 years making the data valid and reliable for the study.

Table 4: Length of stay in the Study Area

Number of years	Frequency	Percentage
0-5 yrs	21	6.44
6-10yrs	52	15.95
11-15yrs	57	17.48
16-20yrs	84	25.77
21yrs & above	112	34.36
Total	326	100

Source: Field Survey, 2021

B. **Flood Incidence and Hazard proximity**

Table 5 shows the incidence of flood experienced by residents within a season. The data shows that 34.36% of the residents have experience flood at least 3 times in single season, while 11.04% and 2.76% of the residents have experience flood at least 6 and 9 times respectively in a single season. 51.84% of the residents are those that reside in flood free areas and have never experienced flooding. This further suggests that the more the frequency of flood, the more devastating and severe it becomes.

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Table 5: Incidence of flooding

Frequency of flooding	Barnawa (N)	(%)	Makera (N)	(%)	T/Wada (N)	(%)	Kabala C(N)	(%)	Row Total (N)	(%)
1-3 Times	35	39.77	26	35.61	24	28.57	27	33.33	112	34.36
4-6 Times	12	13.63	7	9.58	12	14.29	5	6.17	36	11.04
7-9 Times	0	0	0	0	5	5.95	4	4.93	9	2.76
10 Above	0	0	0	0	0	0	0	0	0	0
Not Applicable	41	46.59	40	54.79	43	51.19	45	55.56	169	51.84
Total	88	100	73	100	84	100	81	100	326	100

Source: Field Survey, 2021

Table 6 shows the distance of residential properties to the flood source and the properties that falls within such distance as determined by the global positioning system. 19.94% of residential buildings who are the highest are located within 0.1-0.5 km from the flood source followed by 13.49% located within 0.5-1.0 km from the flood source. Residents who reside closer to the flood source tend to be affected the most.

Table 6: Hazard proximity

Distance (km)	Barnawa (N)	(%)	Kabala (N)	(%)	T/Wada (N)	(%)	Makera (N)	(%)	Row Total (N)	(%)
0.1-0.5	14	15.91	11	15.07	23	27.38	17	20.99	65	19.94
0.5-1.0	17	19.31	7	9.59	9	10.71	11	13.58	44	13.49
1.0-1.5	12	13.63	2	2.74	4	4.77	2	2.47	20	6.13
1.5-2.0	9	10.22	5	6.85	4	4.77	6	7.41	24	7.36
2.0-2.5	4	4.55	8	10.96	1	1.19	0	0	13	3.99
Not Applicable	41	46.59	40	54.79	43	51.19	45	55.56	169	51.84
Total	88	100	73	100	84	100	81	100	326	100

Source: Field Survey, 2021

C. Causes of flood

Table 7 reveals that, river overflow with RII of 4.63 was ranked first among the factors that cause flooding in the study area. This is due to the overflow of the popular river Kaduna on low lying areas across the city. The second factor that causes flooding is poor drainage systems with RII of 4.31. The effect of poor drainage results to cracking of concrete, retaining walls, fence and foundation. Third in rank among the factors that cause flooding was heavy rainfall with RII of 4.21. Rainfall in Kaduna is seasonal, with August and September having the highest frequency of occurrence. Heavy downpour usually affects crops, farmland, residential buildings and movement around the city during this period. Buildings along water channel with RII of 4.01 are ranked as the fourth factor that causes flooding. A lot of residents are guilty of building along water channels in cities around the world. Due to the high cost of land and the need for proximity to work places and markets, people choose to build on any land available to them even when they are being stopped by development control. Next in rank is improper waste disposal having a RII of 3.75. Waste is any material that is no longer important and the need to dispose of it. Improper waste disposal is the situation whereby waste is not properly disposed to the appropriate place, but rather wastes are being disposed in drainage systems leading to blockage. Adequate waste disposal systems that are wide enough will reduce flooding in so many communities and cities. Sixth rank is deforestation having RII of 3.10 causing retained water to builds up resulting to flooding. Erosion was ranked seventh having an RII of 2.78 among these factors. Erosion is a hazard which washes the top soil gradually. Continuous washing off of the top soil weakens the buildings and exposes them to flooding. Dam failure and soil topography with RII of 1.69 and 1.27 respectively are

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among the causes of flooding in various literatures, however they are not significant to this area of study. This findings conforms with the work of [19], having identified the causing of flooding as river overflow, heavy rainfall, poor drainage systems, building on waters also postulated that it is very imperative to examine the causes, forms and types of flood that affect property values, so as to have a clear understanding of the various ways to mitigate the menace. Though [5] grouped the causes of flooding as natural causes (heavy torrential rains or storm, ocean storms and tidal waves, usually along the coast and blockade of river or drainage courses by waste) and human causes (lack of meteorological data for weather forecasting, burst of main pipes, dam burst/levee failures, dam spills, property development along river setbacks and indiscriminate waste disposal). As opined by [10], he examines the causes of floods in Ikoyi and Victoria Island, Lagos. The author identified the causes of flood in these areas as excessive rainfall, faulty drainage designs, and blocked drainage channels by refuse and sediments, obstruction by buildings and inadequate drainage heads to make the drainages efficiently drain off storm water. Also, [20] on his study examine three schools of thought about the prevalence of flood above other natural disaster worldwide. The first school of thought suggest that flood is caused by the frequency of adverse weather condition which increases the level of precipitation and the melting of ice thereby leading to the discharge of water run-of which is relative to the point of flood. The second school of thought seeks to assert the lapses and abuse of sustenance and management, environmental planning, inappropriate waste disposal scheme, and inadequate drainages provided in cities have contributed to flood. Lastly, the combination and incorporation of weather condition and global warming, environmental degradation and abuse has led to the goaded occurrence of flood worldwide.

Therefore, the findings in this study highlighted the major causes of flood in the study area as river overflow, poor drainage systems, and heavy rainfall. Though other factors are significant; the three major factors with the highest significance index are largely considered.

Table 7: Causes of flooding on residential properties

S/N	FACTORS	E.S 5	V.S 4	S 3	S.S 2	N.S 1	N.R	T.S	RII	SI	RNK	RMK
1	Poor Drainage	178	94	53	6	10	341	1447	4.31	0.29	2	S
2	Dam failure	40	18	8	14	261	341	585	1.72	0.11	8	N.S
3	Erosion	84	61	23	104	69	341	907	2.78	0.19	7	S
4	Heavy rainfall	152	120	57	15	12	341	1373	4.21	0.28	3	S
5	Soil topography	71	11	9	21	214	341	414	1.27	0.08	9	N.S
6	Improper waste disposal	91	85	137	8	5	341	1224	3.75	0.25	5	S
7	River overflow	241	58	20	5	2	341	1509	4.63	0.31	1	S
8	Deforestation	53	39	136	83	15	341	1010	3.10	0.21	6	S
9	Building along water Channel	135	90	72	27	2	341	1307	4.01	0.27	4	S
	Total							**9700**	**29.8**	**1.99**		
	Mean							**1077.8**	**3.31**	**0.22**		

Key: **E.S** = Extremely Severe, **V.S** = Very Severe, **S** = Severe, **S.S** = Slightly Severe, **N.S** =Not Severe **N.R** = Number of Respondent, **T.S** = Total Score, **R.I.I** = Relative Importance Index, **S.I** = Severity Index, **RNK** = Ranking, **RMK** = Remark, **S** = (**S.I** ≥0.15**)** Severe, **N.S** = (**S.I** ≤ 0.15) Not Severe

The Table 8 shows the effects that resulted from flood events using the relative importance index to determine how important or relevant a particular effect is as it affects the lives and wellbeing of the residents. Residents are prevented from moving around the neighborhood any time there is a flood event being ranked first with a significant index of 0.24. This is often seen in many urban areas with the incidence of

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flood as roads will be rendered impassable for both vehicular and pedestrian movement hindering economic activities and students from going to school. Houses are often flooded with water during flooding which affects household properties like mattresses, chairs and carpets with a SI of 0.18 and 0.17 respectively. Most times when flood occurs and no one or adult is around to save essential properties like electronics, mattresses food stuffs and the likes, it normally lead to a devastating aftermath. That is why residents who reside in such locations that have history of flood take the risk in exchange for a low rent. Source of water is often polluted which results to health problems with a joint SI of 0.16. When water is been flooded, it comes with sediments, debris and bacteria from all over the surrounding and it enter into sources of water such well, reservoir and streams leading to colossal health challenges in the community. Though building collapse is not prevalent, it occurs on a small scale with a SI of 0.15. Mostly the properties that often collapse are those close to the flood source or those without strong structural base such as the mud buildings.

Table 8: Effects that resulted from the flood

S/N	EFFECTS	E.S 5	V.S 4	S 3	S.S 2	N.S 1	N.R	T.S	RII	SI	RNK	RMK
1	House flooded with water	108	35	11	17	155	341	902	2.77	0.18	2	S
2	Prevented people from moving around	128	75	32	29	62	341	1156	3.55	0.24	1	S
3	Source of water polluted	83	57	24	13	149	341	890	2.46	0.16	4	S
4	Health problem arises	41	62	38	32	153	341	784	2.40	0.16	4	S
5	Household properties affected	112	22	17	2	173	341	832	2.55	0.17	3	S
6	Total building collapse	73	28	12	25	188	341	739	2.27	0.15	6	S
	Total							**5298**	**16.0**	**1.06**		
	Mean							**883**	**2.67**	**0.17**		

Key: **E.S** = Extremely Severe, **V.S** = Very Severe, **S** = Severe, **S.S** = Slightly Severe, **N.S** =Not Severe **N.R** = Number of Respondent, **T.S** = Total Score, **R.I.I** = Relative Importance Index, **S.I** = Severity Index, **RNK** = Ranking, **RMK** = Remark, **S** = (**S.I** ≥0.15**)** Severe, **N.S** = (**S.I** ≤ 0.15) Not Severe

D. Mitigation Strategies

Table 9 shows concerted efforts that flooding in the areas and other flood prone locations can be reduced and prevented. The relative importance index shows the ranking in opinion of the residents and Surveyors of the factors they perceive can help prevent flood events in their locality. Residents should stop building on flood plains and good drainage network were jointly ranked first with a RII of 4.54. Due to population explosion and lack of developable lands in most urban cities of developing nations, the need for greener pasture has driven people to urban centres in search of better standard of living. And when people come to these urban centres, they begin to build anywhere available leading to blockage of water ways that result to flooding when there is heavy rainfall. However, good drainage system is seriously lacking in major cities and communities across Nigeria which will have greatly reduce flooding, but lack of political will to provide drainage infrastructure has left so much to be desired. Building embankments with RII of 4.16 is ranked third. River overflow was ranked number one cause of flooding in the study area, and as such, building embankments along low lying areas will ameliorate the incidence of flood. Implement government policies on flood are ranked fourth with RII of 4.06. There are so many policies on flood control in Nigeria that are just on paper but not workable in the real sense. Proper dumping of refuse was ranked fifth having an RII of 3.66, building canals was next having an RII of 3.51. Next in rank was soil erosion prevention with RII of 3.36 and afforestation with RII of 2.80. All these factors will mitigate flooding if properly and adequately implemented within Kaduna South, and will greatly reduce the effect of flooding on residential building.

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Table 9: Flood mitigation strategies

S/N	FACTORS	E.S 5	V.S 4	S 3	S.S 2	N.S 1	N.R	T.S	RII	SI	RNK	RMK
1	Proper Dumping of waste	137	51	83	40	15	341	1193	3.66	0.24	5	S
2	Afforestation	95	69	73	85	5	341	913	2.80	0.19	9	S
3	Good drainage network	190	107	8	19	2	341	1480	4.54	0.30	1	S
4	Building embankments	152	85	81	5	3	341	1356	4.16	0.28	3	S
5	Soil erosion prevention	57	120	50	82	17	341	1096	3.36	0.22	7	S
6	Implement government policies on flood	144	109	38	20	15	341	1325	4.06	0.27	4	S
7	Stop building on flood plains	217	84	9	16	0	341	1480	4.54	0.30	1	S
8	Building canals	88	51	133	48	6	341	1145	3.51	0.23	6	S
9	Flood warning systems	105	32	90	85	14	341	1107	3.39	0.23	7	S
10	Flood task force	77	42	38	152	17	341	988	3.03	0.20	8	S
	Total							**9988**	**26.97**	**1.79**		
	Mean							**1246**	**3.37**	**0.22**		

Key: **E.S** = Extremely Significant, **V.S** = Very Significant, **S** = Significant, **S.S** = Slightly Significant, **N.S** = Not Significant **N.R** = Number of Respondent, **T.S** = Total Score, **R.I.I** = Relative Importance Index, **S.I** = Significance Index **RNK** = Ranking, **RMK** = Remark, **S** = (**S.I** ≥0.15**)** Significant, **N.S** = (**S.I** ≤ 0.15) Not Significant

IV. CONCLUSION

The study has established that flood is an annual event which has become a major challenge in Kaduna South Local Government Area. Flood waters have impacted upon the local population, destroyed critical infrastructure, residential buildings and disrupted economic activities in the study area. However, based on the global current practice in flood management and flood risk reduction in the context of "living with floods", the actions of the state government and other stakeholders towards addressing the challenge of flooding in the Kaduna South have arguably been limited. Unfortunately, relevant data on flood events are not readily available and the means of building a community resilient to flood threats have continued to elude present efforts. Therefore, this research is an attempt towards addressing the challenges of flooding in and around Kaduna South.

V. RECOMMENDATION

The study recommends the need for the authority of Kaduna State Urban Planning and Development in ensuring the demolition of illegal structures built across the drainage channels within flood prone areas in particular and the whole of the State in general to forestall the incessant occurrence of flooding. In addition, the State Government should intensify construction of proper drainage systems in the whole of the state while citizenry of the State are to be discouraged from the act of dumping their refuse indiscriminately in the drainage channels provided in the State.

Thus, structural and non-structural solutions such as flood mitigation projects like river improvement work and the widening and deepening of the river, drainage

and river bund should be carried out in residential areas that experience severe flood. Such projects could help reduce repeated floods in their areas and ensure the property loss caused by the flood is minimized.

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