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Mapping of Flood Incidence and Urban Resilience in Osogbo, Osun State, Nigeria

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Abstract

The urban environment has experienced phenomenal growth in recent times which has compounded urban development problems especially flooding. The study assesses flood incidence and urban resilience in Osogbo with a view to reducing the threats of floods on lives and properties. A total of 1,953 buildings were identified using the Google earth satellite image and 10% was selected for the study. The study adopted a multistage sampling technique where in the first stage, study sites were selected purposively within 100m distance buffer on the drainage channels and in the second stage 195 pretested questionnaires were administered systematically on the residents. Advanced Space born Thermal Emission Reflection Radiation (ASTER) Data of the study area was used to create flood vulnerability maps using geospatial techniques. The study generated a flood vulnerability map categorizing the area into highly vulnerable (0-100 m), moderately vulnerable (100-200m), not vulnerable (200-300m) and high grounds 300 m and above. The data collected was analyzed using descriptive statistics. The study generated an ordered weighted values of significance of the causes of flooding to include; method of waste disposal (4.24), building along flood plains (4.18), lack of drainage system (4.18), poor drainage system (3.88) and heavy rainfall (3.67). The result also revealed that a total of 13.7 km of channels were dredged while 3.6 km of streams were channelized which significantly increased the resilience of the city and reduced the level of flooding in these areas. Similarly, the study identified in order of significance the impact of channelization and dredging on the people to include: livelihood (4.56), safety (4.44),health (4.17) and property value (3.81). The study recommended that to build a resilient city; resettlement, environmental awareness, flood retention and control infrastructure, proper waste disposal, channelization and strict implementation of urban development control measures need to be put in place.

Keywords: Geospatial Analysis, Flood Incidence, Dredging and Channelization, Resilience and Urban Management.

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Background to the Study

It has been predicted that by the year 2050 over 300 million people will face annual coastline flooding due to climate change and that more than two-thirds of the populations of China, Bangladesh, India, Vietnam, Indonesia and Thailand are at risk (AFP, 2019). Wahab and Ojolwo (2017) have identified floods as the major cause of natural disasters and according to Doocy (2013), "it has led to the loss of about 6.8 million human lives in the twentieth century". In the past 30 years the number of people affected by increasingly frequent hydrological events has doubled (World Economic Forum, 2010). According to the International Federation of Red Cross and Crescent Societies (IFRC) (2014), quoted in Whab and Ojolowo (2017), "the African continent has been the most vulnerable experiencing 64.6% of the 686 flood disasters resulting from hydro meteorological disasters, followed by Asia with 52.9% of 1,328 disasters events, Oceania 40.5% of 121 and America 40.5% of 846 disasters events". IFRC (2014) further reported that "176,615 people were affected by hydro-meteorological tragedies in 2004 of whom 66.6% resulted from flood events". Similarly, Jba, Bloch and Lamond, (2012) quoted in Wahab and Ojolowo (2017), reported that "floods in 1998 killed 4,000 people and caused economic losses estimated at $25billion in South China while in July and August 2010, Pakistan was hit by devastating floods that killed 2,000 people affecting more than 20million people. In the same vain floods in January 2011 in South-Eastern Brazil, including Rio de Janeiro and Sao Paulo killed over 800 people".

Whab and Ojolowo (2017) equally identified "Laxity in urban planning particularly development control regulations and enforcement to be responsible for urban development in flood vulnerable areas in Lagos". Development control is one of the vital tools for effective physical regulation and planning of towns and cities. According to Dissanayake (1987), quoted in Wahab and Ojolowo (2017) "the mechanisms of development control include; zoning, subdivision regulations, building codes, space standards and density regulations employed by urban planners to regulate the use and development of land in order to implement local planning policies". ISDSR (2010) quoted in Wahab and Ojolowo (2017) noted "that construction of buildings on the flood prone areas without considering the ecological impacts has exposed the inhabitants to very high vulnerability".

Akinola (2012) reported that in West Africa, the number of people that died due to flood resulting from climate change was highest in Nigeria in the year 2010with (118), followed by Ghana (52), Sudan (50), Benin (43), Chad (24), Mauritania (21), Burkina Faso(16), Cameroon(13), Gambia (12), with other countries reporting less than 10 dead. Similarly, about 1.5milion people were affected: most of them in Benin (360,000), followed by Nigeria (300,000), Niger (226,611), Chad (150,000), Burkina Faso (105,481), Sudan (74,970) and Mauritania (50,815). Other countries had less than 50,000 people who suffered from floods. The floods resulted in cholera epidemics which claimed 1,182 lives in Nigeria, followed by Cameroon, Niger and Chad (UN Office for the Coordination of Humanitarian Affairs – OCHA,2010).The floods of 26th and 27th August 2011 that devastated most of the city of Ibadan and its environs claiming over 100 lives, rendering thousands homeless and destroyingproperty worth billions of Naira is another consequence of climate change(OYOSG, 2011). Similarly,the floods of July 2011that swept accross Lagosand claimed over twenty lives, rendered many homeless and ravaged other parts of South-western Nigeria

is another pointer to theeminent threats of Global climate change (Oladele, 2011; Vanguard, 2012; This day, 2012, Akinola, 2012).

The National Emergency Management Agency of Nigeria (NEMA) (2012) and Office for the Coordination of Humanitarian Affairs (OCHA, 2012) reported that the flood disaster which swept across the country in 2012, a consequence of climate change marked a watershed in the nation's history in disaster management as it was the most devastating. According to NEMA (2012), the 2012 floods affected 7,705, 3078 persons with 363 killed. A total of 18,200 persons were injured, 618.000 houses in 3,870 communities were damaged, 2.3 million were displaced 387, 153 were registered as internally displaced persons (IDPs) while 597, 476 houses were submerged (Ibileke, 2013; Ogboi et al, 2015). The total values of the destroyed physical assets caused in the most affected states were estimated at 1.48 trillion (US $ 9.5billion). NEMA (2012) stated further that the total value of the loss across all sectors of economic activity was estimated at N1.1 trillion ($7.3 billion). The combined value of the damages and losses were estimated to be N2.6 trillion ($16.9 billion) and the overall impact on real GDP growth in 2012 was estimated at 1.4 percent (N570 billion, in nominal terms).

The negative consequences of climate change are already here with us, for instance in 2018 in Nigeria, floods led to the death of about 141 persons, displacing 19,369 persons and destroying 5,732 houses including sources of livelihood (Ndujihe, 2018). According to the National Emergency Management Agency, NEMA, the rainstorms were the worst in the last six years after the 2012 floods. The 2018 floods have gone down memory lane as the most devastating in the last 40 years and could be attributed to human activities and climate change. Osun State was not left out of 2018 flood disaster where in Ile-Ife floods ravaged areas such as Parakin, Mayfair, Damico, Asherifa Estate and along Ede road among other areas where houses were submerged and many properties destroyed (Ndujihe, 2018).

Similarly, the Nigerian Hydrological Services Agency (NIHSA) (2019) had earlier predicted that a total of 74 Local Government Areas across the country would be flooded in 2019, during the peak of the rainy season. The report further stated that 36 states of the Federation including the Federal Capital Territory, are expected to experience different levels of flooding with Osun, Lagos, Benue, Oyo, Cross Rivers, Sokoto, Abia, Plateau, Abia and Edo topping the list. All across the country, the impact of incidence of floods have been devastating with estimated losses worth billions of Naira, lives lost and economies of many truncated. The 2019 floods in Osun state especially in Osogbo have wrecked havoc on so many communities. In Gbodofon area of the state capital the river Osun due to heavy down poor overflew its banks destroying buildings. According to Olaniyi (2019) the incessant rainfall caused the Olooyo river along Ipetu Ille-Ibokun road to over flow sweeping the only bridge linking Obokun Local Government to Osogbo. The route is very strategic to the economy of Osun as it connects Ikirun, Irabeji, Ipetu, Esa-Oke, Ijebujesa, Ilesha up to Ondo, Ekiti, Kogi States and the Federal Capital Territory.

Urbanisation has been identified as one of the principal drivers of land use change in the urban areas. It has been projected that by the year 2030, more than two thirds of the world's population constituting about 4.9 billion people will be living in the urban areas and this

trend is expected to grow to 75% by 2050 (Laundry and Burke, 2014). Similarly, the United Nations observed that the African population is expected to grow into the future reaching more than one billion inhabitants by 2009 and may reach two billion inhabitants by 2050 (UN, 2010), hence, increased pressure on infrastructural facilities and resources especially land which will be required to accommodate the timid growing population.

Cities have persistent rate of growth with resultant effects on their carrying capacities and ecological footprints and may not be able to solve their own problems by linear urban management and development strategies. Therefore, it is worth noting that, previous rationalistic, mechanistic and technocratic approaches must be replaced by facilitative, participative, and flexible approaches with emphasis on guiding principles rather than strict rules (Oyesiku, 2009). All these require an urban systems resiliency framework for implementation. Urbanisation leads to the erection of structures such as houses and infrastructure such as roads as well as the replacement of greenery with concrete, asphalt and steel at the expense of agricultural land and forest. These concrete surfaces are known for their heat conduction, radiation and reflection which increase global temperatures and in addition to other human activities generate carbondioxide and methane which induce climate change(Akinola, 2012).

Urban flooding is a condition characterized by its repetitive and systemic impacts on communities whether or not the affected communities are located within floodplains or near any body of water (CNT, 2013). The problem of flooding also emanates from the poor maintenance of roads constructed without good drainages. There is also the negligence and poor attitude of people who dump waste into the drainages located along road side, which eventually blocks flow of both household sewage and storm water.It was at the backdrop of all these, that the study was conceived to assess flooding, and drainage systems in Osogbo metropolis with a view to providing pragmatic suggestions on improving on the present drainage systems to reduce threats to lives and property. The objectives of the study include; identification and characterization of the existing drainage network in Osogbo, assessment of the existing drainage system especially dredging and channelization and its impact on the social and economic status of the residents.

Conceptual Framework

Vulnerability

Vulnerabilityrefers to susceptibility or exposure to physical or emotional harm. Vulnerability is one of the pillars on which resilience is rooted especially as it relates to environment or climate. This is so because people most likely to be vulnerable to impacts of environmental disasters are those who are least capable of developing robust and comprehensive climate resilience infrastructure and response systems i.e those living below the poverty line: thus the most vulnerable. This is so because their means of livelihood (incomes) are low hence they are likely to be those occupying the flood plains with not enough to eat, to cloth, house themselves talk less to have any resources to invest in resilient infrastructure and cleanup after any disasters (Gasu, 2015).

A vulnerability assessment of Nigeria shows that global climate change will have a strong impact on Nigeria particularly in the areas of agriculture, land use, energy, biodiversity, health and water resources (Ologunorisa, 2011). NEST (2006) quoted in Ologunorisa (2011), identified Nigeria's vulnerability to climate change to include the following:

1. High vulnerability due to its long coast line of 850km prone to sea-level rise
2. 2/3 of Nigeria's land cover is prone to drought and desertification
3. Its water resources are under threats which will affect energy sources (HEP)
4. Rain-fed agriculture and fishing activities on which 2/3 of the Nigerian Population depend primarily on for food are under serious threats.
5. Nigeria has a very high population pressure of 140 million people
6. Nigeria lacks the financial and technological capacity to combat the postulated negative impacts of climate change
7. Nigeria does not yet have a fully established institutional and legal frame work to combat climate change.

Resilience

Resilience comes from the Latin word "resilio" which means to spring back. The British dictionary of Current English defines it as "the physical property of material that can resume its shape after being stretched or deformed; elasticity". Similarly, the same dictionary defines it contextually as the positive ability of a system or company to recover or adapt itself to the consequences of a catastrophic failure caused by power outage, fire, a bomb, flood or similar event". The Intergovernmental Panel on Climate Change (IPCC) defines resilience as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and the capacity of self-organization, and the capacity to adapt to stress and change" (Tyler and Moench, 2012). In disaster management, "urban resilience is defined as the capacity of the urban environment to bounce back to normal life after a major disaster" (Coaffee, 2013). According to the Headington Institute, "resilience is the ability to bounce back or return to normal functioning after adversity". From the foregoing, "resilience can bests be defined as the ability of a system to absorb disturbances and still retain its basic function and structure" (Walker and Salt, 2006) has "the capacity to change in order to maintain the same identity" (Folke *et al,* 2010). Hence resilience encompasses both physical/natural and human systems (Ogbazi, 2015).Resilience is the capacity to mitigate, prepare for, respond to and recover from the impacts of disaster in a way which leaves communities stronger than before (Gasu, 2015).

Wilbanks, (2007) defines Urban resilience as the "capability to prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to public safety and health, the economy, and security of a given urban area". Studies have shown that urban resilience focuses on three distinct threats; climate change, natural disasters and terrorism (Coaffee, 2008; Cadenasso et al, 2004). Prominent amongst the urban environmental management challenges is climate change which varies widely across geographical and developmental scales. A recent "study of 616 cities (home to 1.7 billion people, with a combined GDP of USD 35 trillion, half of the world's total economic output), found that floods endanger more city residents than any other natural peril, followed by earthquakes

and storms" (Wikipedia, 2014). It has equally been observed that the alarming growth of urban population and the poor response of government are factors that have partly contributed to high rate of physical development mishap in cities (IFPRI, 2002; Helaakoshi and Merilainen, 2001 and Egunjobi, 1999).

According to Umberto (2012) "the capacity to transform at smaller scales draws on resilience from multiple scales, making use of crisis as windows of opportunity for novelty and innovation and recombining sources of experience and knowledge to navigate social-ecological transition". It is therefore, important to note at this point in time "that resilience is not only about being persistence or robust, it is also about opportunities that disturbances open up in terms of recombination of evolved structures and processes, renewal of the system and emergence of new trajectories" (Folke, 2006).

Therefore a resilient city or community is conceived as a "sustainable network of physical systems and human community" while "the physical systems are the constructed and the natural environment components of the city such as buildings, infrastructural facilities, as well as soil, topography, geology and other natural systems" (Godschalk, 2003). The human communities are formal and informal, permanent and ad hoc socio-institutional components of the city such as family community organisations and agencies. Furthermore, "he conceives the physical systems as the body of the city, its bones, arteries and muscle while the human communities are the brain of the city" (Godschalk, 2003). According to Colding and Barthel (2013) quoted in Ogbazi (2015) "the key attributes of resilience are knowledge, diversity and self-organisation; and the interplay between disturbances and these three attributes are the key linkages for building resilience and adaptive capacity in social-ecological systems" as illustrates in figure 1.

According to Ogboi, et al., (2015), building resilience communities requires robustness (ability to withstand stress), redundancy (resource diversity), and rapidity (the ability to mobilise resources quickly). All these will ensure that communities, especially poor and vulnerable have the ability to plan their community and respond quickly to disaster and return to normalcy without any delay. Research has identified a number of individual and community institutional attributes of resilience which include but not limited to: self-efficacy, action coping, outcome expectancy, community participation, articulating problems, empowerment and trust as illustrated in Fig 1.

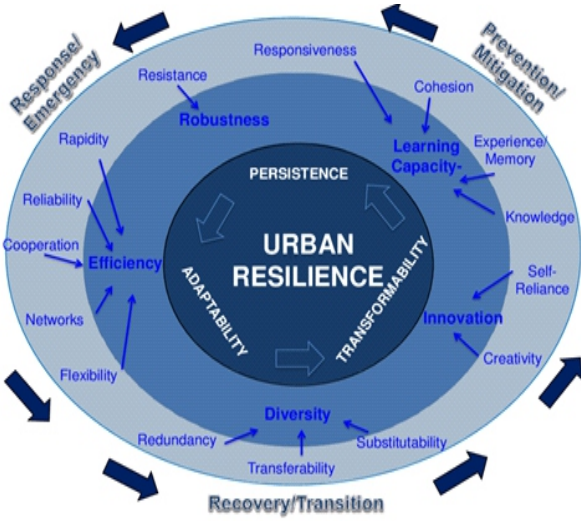

Figure 1: Integrated model for Urban Resilience: Adapted from Galderisi, 2014 in Ogbazi 2015.

According to Ogbasi (2015) in Nigerian cities, the human resilience systems are obviously better developed than the physical system. This is because even in environments of scare or non-existent physical systems, many cultural structures of traditional societies such as strong family and kinship value, self- organisation, as well as socio-cultural identity that make up the human systems are still present to a reasonable extent in the cities.

Research Method

The Study Area

Osogbo is the capital of Osun State created in 1991. Osogbo Township is located almost at the centre of Osun State in South western Nigeria. It is about 88 kilometres by road northeast of Ibadan, 100 kilometres by road South of Ilorin and 115 kilometres northwest of Akure (Eades, 1980). It is situated between Longitudes 4° 28' 43" and 4° 40' 12" East and Latitudes 7° 42' 10" and 7° 51' 10' North (figure 2). It is a vast area with an extent in excess of 4700 hectares with an urban population of 156, 694 inhabitants based on the 2006 Population Census and projected to 195,433 in 2014. Osogbo has an average rainfall of 1150mm a year which lasts from April to late October or early November; though it eases off in July or August (Osogbo Meteorological Station, 2015).

The dry season lasts from December to March which is the period of intense heat. The climate is less humid and hot than it is in greater part of Southwestern Nigeria although the effect of the harmattan wind is strongly felt in the dry season. It lies mainly in the deciduous forest area which spread towards the grassland belt of Ikirun, north of Osogbo. Osogbo is situated on a raised land which is well over 500 meters (800 feet) above the sea level and is drained by River Osun and its tributaries such as River Ogbaagba, River Gbodofon, River Okoroko (okooko), Olohunkoro, and other streams. It is a city built on hills (Oke) such as Oke-balee,

Oke-Onitea, Oke-Ayepejust to mention but a few. Geologically the land is made up of Precambrian rocks, the so-called basement complex from which the fairly fertile clayey loam of the surrounding district is derived.

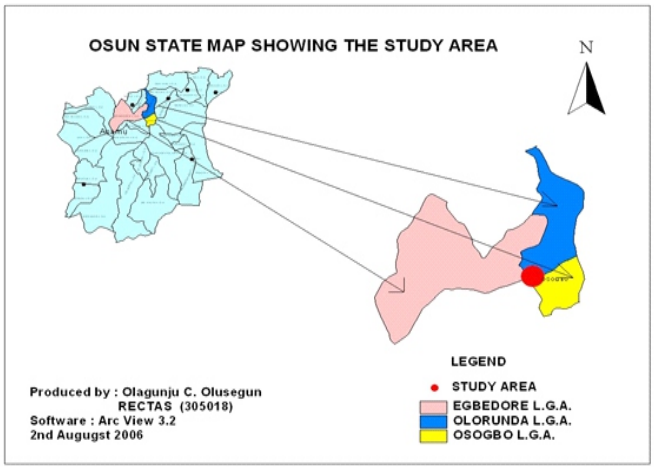

Figure 2: Map of study area
Source: Updated from Olagunju 2006 in 2019

Method for Data collection

The study made use of primary and secondary data to assess flood incidence and urban resilience in Osogbo. The buildings within the radius of 100 m of the flood plain were identified and counted using Google earth to be 1,953 while the streets were equally identified. Therefore, 10 % of the population was sampled where a total of 195 questionnaires were administered systematically on every 5th house after every third street located within 100m range of the flood plain. Moreover, 185 questionnaires were returned for analysis to evaluate the impact offlood incidence, urban resilience on the human environment. The questionnaires captured information on the following; socio-economic characteristics of respondents, method of waste disposal, drainage conditions and possible causes of flooding just to name but a few. Other information was gotten through directly observation from areas that have been experiencing flood overtime such as; Rasco/Old-garage, Gbonmi, Obate-Okebaale, Ita-Olookan, Alekuwodo etc. The data was analysed using simple descriptive statistics. Likert scale made use of responses like; Very Significant (VS), Significant (S), Fairly Significant (FS), Less Significant (LS), and Not Significant (NS), the which responses were attached with weighted value of; 5,4,3,2, and 1 respectively to assess the possible causes of flooding in the study area. Advanced Spaceborn Thermal Emission Reflection Radiation (ASTER) data of the study area was used to create flood vulnerability maps using geospatial techniques. It was projected to the UTM coordinate system and clipped to the extent of the study area.

Result and Discussions

Incidence of Flood in Osogbo

The study generated a flood vulnerability map categorizing the area into highly vulnerable (0-100 m), moderately vulnerable (100-200m), not vulnerable (200-300m) and high grounds 300 m and above as shown in figure 3. In line with NISHA (2019) warnings and the reports of Olaniyi (2019), in the highly vulnerable and therefore, least resilient areas, the flood destroyed 20 hectares of farm land in Obokun, as the flood covered over 3 kilometers along Osogbo-Obokun-Ijesha road submerging many community farms and plantain plantations. Similarly, fish farms were swept by the over flow of the 264 dam along the Ring road. So many churches were submerged including the CAC church at Gbonmi, the Redeem church at Gbodofon and the CAC below Guaranteed Trust bank along Gbogon-Osogbo road just to name but a few. Schools were equally flooded amongst which were, Adekids and Rehoboth nursery and primary schools just to name but a fewas illustrated if plate 1.

The flood also damaged the only bridge linking four rural communities: Coker, Omu, Iyere and Osogbo along Osun Sate University Campus. Similarly, River Osun and its tributaries flooded over 200 houses, submerged several cars, buses, shops and workshops at Gdodofon area. Other areas affected include, Akindeko market, Alekuwodo area, Igbona, Old Garage Area, Rasco Area, Awosuru Area, Agunbelowoo, Mallam Tope area, , Idowu Ajibola area, Gbonmi area, Arungbo Estate, Ibu Amo community Gbodofon and Oniro-dunu Barruwa community as illustrated in plate 2. The Alekuwodo river overflew and took over the streets, market, residential houses and shops nearby sweeping away several food items. The Baale of Ibu-Amo of Awosuru area of Osogbo was displaced from his residence by the floods alongside many of his communities' members with their property submerged (Olaniyi, 20190). On the spot assessment confirmed that so many buildings have encroached on the flood plains and therefore do not have building permits which further reduces their resilience and increases their vulnerability.

This was as a result of poor response of government to physical development mishap which is in tandem with studies by IFPRI, 2002; Helaakoshi and Merilainen, 2001; Egunjobi, 1999 and Whab and Ojolowo, 2017. Osogbo is blessed with a hilly topography which is not expected to face any serious challenge with drainage but due to the poor land management especially from development control department of urban planning, the town is experiencing a high magnitude of flooding. According to Osun State Capital Development Authority,Town Planning Regulations in Nigeria require that a setback of 45 meter from a river and 15 meters from a stream be observed before construction but this is not the case as illustrated by plate 3 where buildings are sharing a common boundary with the river Osun at Gbodofon meaning there is no setback.

Plate 1: Adekids School flooded along the river Gbodofon flood plain in Osogbo.
Source: Authors Field Survey, 2019

Plate 2: Houses flooded along the flood plains along Baruwa Street behind Methodist Church, Osogbo.
Source: Authors Field Survey, 2019

Plate 3: Buildings constructed along the flood plain in Gbodofon area of Osogbo.
Source: Authors Field Survey, 2019

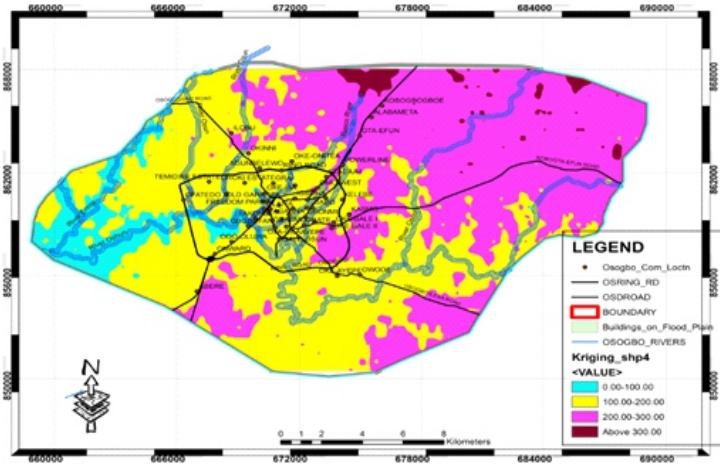

Figure 3: Flood vulnerability map of Osogbo.
Source: Authors Field Survey, 2019

Table 1: The possible causes of flooding in the area

SN	VARIABLES	RANK					NR	SWV	MWV	RANKING
		VS (5)	S (4)	FS (3)	LS (2)	NS (1)				
1	Method of waste disposal	410	292	66	16	0	185	784	4.24	1st
2	Building along flood plain	284	332	102	20	2	185	774	4.18	2nd
3	Lack of drainage system	400	280	72	22	0	185	774	4.18	2nd
4	Topography	135	188	312	14	0	185	649	3.51	5th
5	Poor drainage system	325	248	87	58	0	185	718	3.88	3rd
6	Heavy rainfall	390	148	175	62	13	184	675	3.67	4th
	Total	1944	1488	832	192	15		4374	23.66	

Mean of ∑MWV/n = 3.94
Source: Author's fieldwork, 2019.

The result in Table 1 shows that the possible causes of flooding in the study area in order of significance were their method of waste disposal which was ranked first (4.24), buildings constructed along flood plains (4.18), lack of drainage system (4.18) which were more significant all above the mean value of 3.9. Similarly, poor drainage system (3.88), heavy rainfall (3.67) and topography which were ranked the least (3.51) were fairly significant factors that contributed to flooding in the study area. The planning implication is that waste disposal was the most significant factor responsible flooding in the study area. It was observed that people dump waste in drainages and rivers which clog the channels and cause overflow into adjoining land uses thereby causing flooding as illustrated in plate 4. Poor drainage system and topography which were below the mean average and therefore less significant need to be improved upon to increase the resilience of the area for a better sustained human environment safe for human habitation. Therefore, flood resilient measures such as construction of drainages, flood retention and control infrastructure proper and channelization of the main rivers and streams should be undertaken.

Plate 4: Image flood incidence in Osogbo clogged with waste.
Source: Authors Field Survey, 2019

Table 2: Impact of dredging and channelization

SN	VARIABLES	RANK					NR	SWV	MWV	RANKING
		VS (5)	S (4)	FS (3)	LS (2)	NS (1)				
1	Life	630	148	63	2	0	185	843	4.56	1
2	Economic Activities	265	380	96	6	2	185	749	4.05	5
3	Social Security	300	336	69	12	12	185	729	3.94	7
4	Environment	400	248	78	34	0	185	760	4.11	4
5	Health	500	132	114	24	2	185	772	4.17	3
6	Property Value	265	320	84	18	14	184	701	3.81	8
7	Aesthetic	180	228	246	16	2	185	672	3.63	11
8	Urban Agriculture	150	212	225	22	16	185	625	3.38	12
9	Flooding	170	340	108	46	6	184	670	3.64	10
10	Residential Accommodation	180	372	120	22	5	185	699	3.78	9
11	Aquaculture	200	160	216	34	16	185	626	3.38	12
12	Mobility	210	420	84	12	4	185	730	3.95	6
13	Safety	545	208	63	6	0	185	822	4.44	2
	Total								50.84	

Mean of ∑MWV/n = 3.91
Source: Author's fieldwork, 2019.

Table 2 reveals the impact of dredging and channelization of flood plains on the social and economic lives of the people. It was deduced that the study identified in order of significance the impact of channelization and dredging on the people to include: livelihood (4.56), and safety (4.44), health (4.17), Environment (4.11), Economic activities (4.05)Social security (3.95),) and mobility (3.95) which were all above the weighted mean value of 3.91 thereby enhancing their resilience. Similarly, property value (3.81), Residential accommodation (3.78), flooding (3.64), Urban Agriculture (3.38) and Aquaculture (3.38) were all below the mean value. This shows that the impact of flooding in the area does not only put them in a state of unrest but also affect their health, safety and mobility. It should however be noted that their resilience has been enhanced which has reduced their vulnerability through dredging and channelization of the flood plains by the State Government. Face to face interaction with some of them revealed that they have lived in the area for the past 24 years and this is probably the first time they are experiencing flooding of this magnitude.It was observed in the study area that most of the buildings that were affected by flooding were as a result of building on the flood plain, high intensity of rainfall and increased run-off which could be attributed to climate change as was corroborated in an earlier study by Yusuf *et al*., 2013 in Lokoja Kogi State, Nigeria.

Table 3: Channelized and dredged water channels in Osogbo.

Location	Mitigation Measure	Length(m)	Width(m)
Gbonmi – Obate/Okebaale	Channelization	2,120	12
Ita-Olookan – Osun River	Dredging	148	15
Rasco-Alekuwodo	Channelization	798	11.7
Testing Ground - Gbonmi	Dredging	1,480	15.6
Asubiaro	Dredging	123	13.7
Rasco – BCJ	Dredging	2,170	14.8
Freedom Park-Olaiya	Channelization	676	10.6
Osun River - Olaiya	Dredging	1,128	15.3
Africa – Dada Estate	Dredging	4,200	14.2
Powerline - Kobongbogboe	Dredging	2,720	15.3
Ebunoluwa - Africa	Dredging	1,640	14.2

Source: Author's fieldwork, 2019.

Results in Table 3 revealed that flood have been well controlled in the areas that were channelized in Osogbo from 2011 till 2019 when the city experience flooding again. The result also revealed that a total of 13.7 km of channels were dredged while 3.6 km of streams were channelized which significantly increased the resilience of the city and reduced the level of flooding in these areas.It would be curious to observe that since 2011 of all the channelized streams only the section between Rasco and Alekuwodo experienced serious flooding in 2019 and this was as a result of the collapse of the of the '264 dam' which flows into this area. However, human attitude towards waste disposal affects the impact of dredging which could have reduced flooding in areas like Ogo-oluwa, Awosuru and BCJ. Plate 5 and6 show typical drainage channel and water channel study area at Obate and Rasco areas clogged with rubbish reduces channels and divert run-off into other areas thereby causing flooding.

Plate 5. Drainage channel blocked by waste at Obate area of Osogbo
Source: Authors Field Survey, 2019

Plate 6. River channel blocked by waste at Rasco Area of Osoogbo in the dry season
Source: Authors Field Survey, 2019

Conclusion

The study produced a flood vulnerability map categorizing the area into highly vulnerable (0-100 m), moderately vulnerable (100-200m), not vulnerable (200-300m) and high grounds (above 300m) which could serve as a guide to planners, development experts and policy makers. The study concluded that dredging and channelization has enhanced the resilience and reduced the vulnerability of the people in the study area. Similarly, channelization and dredging has also reduced the negative impact of flooding thereby enhancing the social and economic liveability of the people in the area as well as contributed in making the area safe, healthy, and conducive for human habitation.

Recommendation

Residential buildings withino-100 m above sea level along the drainage channels, rivers and streams representing the high vulnerable areas within the flood plain, are recommended to be removed for safety of lives and property and to give room for dredging and channelization to enhance the resilience of the communities.The study also recommended that to build a resilient city; resettlement, environmental awareness, flood retention and control infrastructure, infrastructural development, proper waste disposal, channelization and strict implementation of urban development control measures need to be put in place early. It is important that more publicity should be made towards raising the awareness of people living on the flood plains on the danger of living in such vulnerable areas and on how household waste can be managed instead of dumping into drainage channels through the 3Rs (Reduce, Reuse and Recycle) to reduce flooding and enhance the resilience and the functional efficiency of drainage systems and enhance the liveability of the city.

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