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RESEARCH PAPER

Ecosystem destruction and disaster risk incubation– A case of wetland loss and flood disasters in Makurdi town of Nigeria

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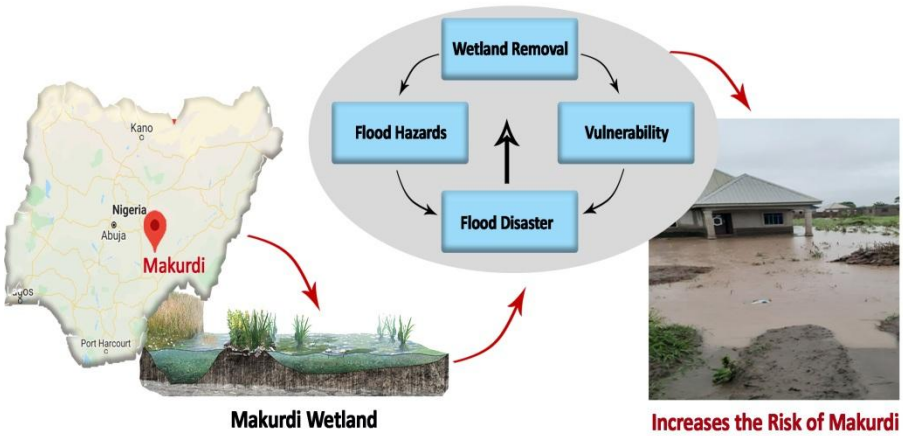
Highlights

- Ecosystem degradation and incubation at risk of natural disasters such as floods.
- The gradual destruction of a diversity of ecosystems leading to the depletion of ecosystem services.
- Disaster risk is incubated through a series of events that shape hazards and vulnerability.
- Floods and their consequences pose serious risks and vulnerabilities in Makurdi.

Graphical Abstract



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Abstract

Disaster risk is incubated through a series of events that shape and reshape hazards and vulnerability. The gradual destruction of a diversity of ecosystems leading to the depletion of ecosystem services is an incubation period for many disasters as the case of Makurdi wetlands and flood disasters. Makurdi wetlands have been destroyed with only a few remaining according to a recent thirty-year study. This suggests the loss of essential ecosystem services that they provide, including defense against surging floodwaters. In the corresponding period, increased flood disaster incidences have been reported in Makurdi, with a corresponding increase in size and intensity of devastating impact on the populations. Surprisingly surveys carried out in Makurdi on the causes of flood demonstrate a minimal knowledge of the significance of wetlands in managing flood disasters. The ability of ecosystems to continue to provide ecosystem services requires deliberate management action through sustainable practices, knowledge, and attitudes of people who live near or within such ecosystems and who draw such services from there. This paper reviews and points to the risk incubation effect of a long period of continuous wetland destruction in Makurdi. It draws scientific interest to the conservation of Makurdi wetlands and answers questions on the importance of wetlands in flood disasters prevention, management, and recovery in Makurdi. It suggests improved wetland management practices and supports the conservation of the remaining Makurdi wetlands.

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1. Introduction

Ecosystems have been at the center of many scientific inquiries across different fields of study. Consequently, there are many attempts at defining and explaining what constitutes ecosystems. The definition by The Millennium Ecosystem Assessment (MEA), which is useful in this study, defines an ecosystem as "a dynamic complex of plant, animal and micro-organism communities and the non-living environment interacting as a functional unit". Ecosystems are vital to the survival of the system in which they are apart. They provide many benefits that support the continued existence and comfort. Ecosystem Services is the term used to refer to all benefits gotten from the ecosystems (Umeuduji et al., 2018). The term was coined by the Millennium Ecosystem Assessment that was commissioned in 2005. It shows and reflects the relationship between the ecosystem's components and how they benefit from the relationship. Like humans, these services can reinforce resilience or shape the vulnerability of humans to disaster risk. Ecosystems Service has become a subject of great social and economic attention. The availability of these services increases and supports the livelihood of communities. They provide recreation and support the physical environment by aiding soil formation and nutrient cycle in other areas. These services, according to the ecosystem assessment, are grouped according to the categories as 1) Provisioning services such as food, freshwater, wood, fuel, and fiber 2) Regulating services that affect climate, flood, disease, and water purification 3) Cultural services that provide recreational, educational, aesthetic, and spiritual benefits; and 4) Supporting services such as soil formation, photosynthesis (primary production) and nutrient cycling.

This paper focuses on the wetland ecosystem and the regulating services of the wetland ecosystem, which is the regulation against the flood's occurrence and impact (Darrah et al., 2019). Wetlands have many definitions. Most wetland definitions include the area being covered in water for part of the year or having water in the root zone. The most commonly accepted definition of wetlands is as provided by article 1.1 and 2.1 of the Ramsar Convention, 1971, which is as follows "Area of the marsh, fen, peatland or water whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed six meters". Wetlands are categorized into two; Coastal and Inland. Coastal wetlands mix freshwater with saltwater making varying levels of water salinity. The variable salinity has most of these areas without vegetation. In some of the coastal wetlands with tropical climates, salt-loving trees and shrubs can be found. Inland wetlands include flood plains along rivers and streams and playas, basins, potholes, etc (Babcicky and Seebauer, 2017). These areas are surrounded by dry land. Inland wetlands like marshes and wet meadows are covered by herbaceous plants, shrubs, and trees. Many inland wetlands are dry for part of the year. The commonly known wetlands are open coasts, floodplains, freshwater swamp, lakes, peatlands, and swamp forest. Collectively, wetlands occupy about 6% of the world's land surface (Schuyt and Brander, 2004; Acharya, 1998). Wetlands are some of the most diverse ecosystems; they comprise both land ecosystems strongly influenced by water and aquatic ecosystems with unique characteristics due to shallowness and proximity to land (Kennedy and Cheong, 2013). Nigeria has an estimated 18,000km^2 of land as wetland found throughout the various ecological regions of Nigeria. They are found in the Niger River floodplains, the floodplains of River Benue in the guinea savannah, Cross river floodplains in the rainforest and Imo river plains, Lake Chad Basin, Marman Channel Complex, and Nguru Lake in the Sahelian region. They are also found in the Ogun and Osun floodplains. According to the natural resource conservation action plan, the wetlands collectively represent 2.23% total area of Nigeria. Nigeria is also a signatory to the Ramsar Convention; the International convention sets the World's framework for conservation and protects wetlands. On October 2, 2000, Nigeria designated the Nguru lake and Marma Channel Complex, an area estimated to be about 58,100ha, as a wetland of international and historical importance.

1.1. Statement of the problem

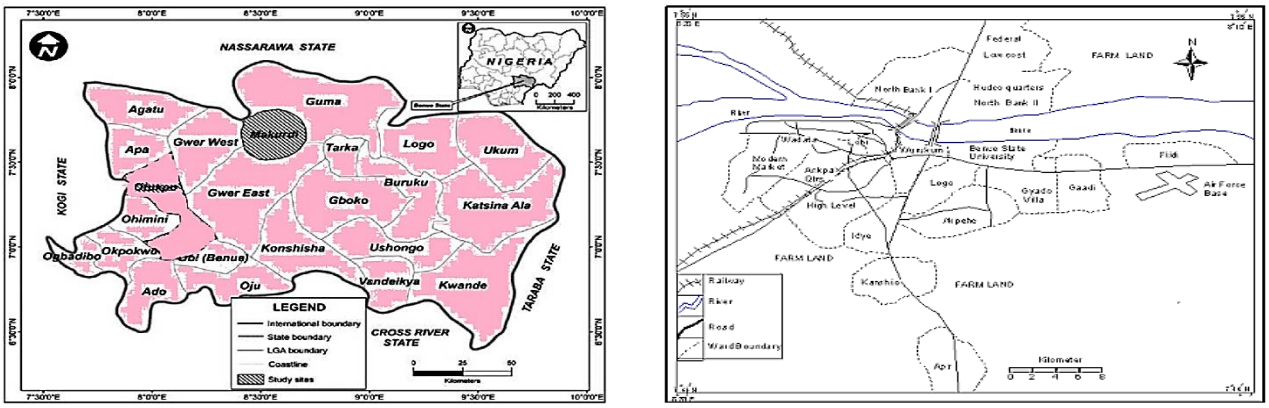
Makurdi is located in a complex of wetlands (Hemba et al., 2017a); one of the wetlands' services is flood amelioration (Elekwachi et al., 2009). It has been discussed that since Makurdi rose from been just a small fishing settlement to becoming a Local government headquarters and eventually a state capital in 1976, Physical

growth and expansion of Makurdi town has caused a significant reduction in the total amount of wetlands in Makurdi town (Hemba et al., 2017b). This reduction has been caused by the direct and indirect conversion of wetland areas to urban land uses. This has a significant impact on these wetlands' capacity to continue to provide services, including flood control. It implies that Makurdi town floodwaters could overwhelm the capacity of the remaining wetlands. On the other hand, there is a reported increase in the number of floods in Makurdi town, which potentially increases the risk of Makurdi. Increases in magnitude and frequency of flood events have raised scientific questions on the possible causes. Various causes have been identified with the dumping of waste in drainages, and climate change topping the list. However, it is well known that a series of events occurring separately or together link and exacerbate the occurrence and magnitude of events like floods. The role of the continuous removal of the wetland ecosystem in the increased frequency and magnitude of flood events in Makurdi has not been discussed. Based on the disaster incubation theory, this review looked at how the removal of wetlands increases disaster risk in Makurdi. It will increase the understanding of the impact of wetland removal on the incidence of flood in Makurdi and could be useful in planning and flood management and ecosystem protection, especially wetlands (Gelso et al., 2008).

1.2. Study area

1.2.1. Location and brief history

Makurdi is the capital city of Benue state. Smaller settlements around Makurdi have been constituted into a single administrative unit of Makurdi local government with Makurdi as the headquarters. It lies in the River Benue's flood plains within Nigeria's middle belt region about the middle of the eastern half of Nigeria between latitude 07038' N and 7050' N and longitude 08024'E and 8038'E. In the pre-colonial era up to 1920, Makurdi has just scattered Tiv settlements and Jukun fishers. By 1927 it became the Benue province's provincial headquarters, and later in 1970, it became the headquarters of the Makurdi division. Upon the creation of Benue state in 1976, Makurdi became the Benue state's capital city and headquarters of the Makurdi local government. Within these periods, Makurdi underwent relatively various levels of urbanization and beginning from 1976, its status as the capital of Benue state accelerated its urbanization on a sustained basis for the past three decades, which is the interest of this study (Wang and Upreti, 2019).



(a) (b)

Fig. 1. (a) Map Benue state showing Makurdi Town (b) Map of Makurdi (Hemba et al., 2017b).

1.2.2. Climate

Makurdi climate is characterized by wet and dry seasons dominated by N.E and S.W monsoon. The convergence of these wind masses is the highest influencing factor of rainfall within Makurdi. The rain begins in April and stops in October. The rainy season's mean duration is 182 days, with the highest monthly rainfall total of 221mmis recorded in August. Umeuduji et al., (2018) has identified three temperature periods of the cold, dry season (November to January), hot, dry season (February to April), and hot wet season (May to October). Seasonal atmospheric humidities are 80% for the wet and 30% for dry seasons. Wind speed is

generally light to moderate except the squall lines that often gust at 66km/h. This climate system can support biodiversity, which the destruction of wetlands may affect tremendously (Umeuduji et al., 2018).

1.2.3. Geology and soil

Makurdi is geologically comprised of sedimentary rocks with sandstones as the dominant rock type. The sandstone is divided into micaceous and feldspathic sandstone. Some of these are exposed in some parts of the town like the old GRA. Soils in Makurdi reflect the geology. There are two major soil types: hydromorphic soils, developed on alluvium sediments, found along the River Benue, and red ferralsols developed on sedimentary rocks away from the immediate river channel. Urbanization activities have significantly affected this geology and soils already.

1.2.4. Relief and drainage

Makurdi town lies entirely in the Benue plain, which makes the relief generally low- laying. However, several interfluves at the High Level, Mission Ward, Old GRA areas where the elevation is above 92 meters. River Benue is the primary drainage channel in the region. Other streams and tributaries of river Benue which drain Makurdi include; River Ake, Idye, Demekpe, Abum, Aso, Baa and Kpege, Mu, and Uwurudu.

1.2.5. Vegetation

Makurdi is located within the guinea savannah, which has mostly been replaced with artificial vegetation due to human activities like agriculture and urbanization. Pockets of natural secondary vegetation are still standing at the town's periphery and other developed areas, including river and stream courses. Some of the dominant trees include Parka Biglobosa, Mahogany, etc. while dominant grasses include Northern Gamba grass, Elephant grass, Guinea grass, and others.

1.2.6. Economic activities

Makurdi is an administrative town as the capital of Benue state and headquarters of Makurdi local government. Trading also occurs in the town with several markets such as Makurdi modern market, the North Bank Market, Wurukum Market, and Wadata Market as significant trading points. Agricultural activities take place in urban agriculture in the open spaces within the town and the periphery. Crops cultivated are vegetables and cereals. Other economic activities include market gardening and fishing at the river Benue. Makurdi also has a few industries of various scales producing various goods like the Benue Brewery, Agro millers, etc (Woodward and Wui, 2001).

1.2.7. Disasters risk

How and why disasters occur has been the concern of scholars leading to particular discussions that dissect the variables that act together to produce a disaster (Turner, 1976). Prominently in the discussion on disaster risk. Risk in itself is defined as the probability of the occurrence of harm like property damage, disruption of economic activities, or even death due to the interaction of vulnerable conditions and hazards (Djalante et al., 2012). Therefore, disaster risk is the probability of such a harmful occurrence classified as a disaster. In the same manner, flood risk could be conceived as the possibility of a flood incidence occurring. There is a consensus among scholars that disaster occurs due to the interaction of hazards and vulnerability (Nkwunonwo, et al., 2015). On the other hand, vulnerability, as "the key characteristics of a person or group and their situation influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard". Therefore understanding how hazards build and how the vulnerability is developed is critical in understanding and interpreting disasters (Ojigi, et al., 2013).

1.2.8. Incubations theory

Disaster risk incubation has its origin from different works (Rawat et al., 2017). Rawat recognized that accidents are preceded by a sequence of events occurring gradually over time. He described the period when

this takes place and before the accident strikes as the incubation period. The incubation is characterized by sets of events that may not be noticed or taken for granted but accumulate gradually, leading to the accidents itself. As considered, the incubation period is a gradual build-up of risk, leading to an accident and has been applied to the understanding of disasters. This paper's position that this approach can be used in understanding how the destruction of ecosystems over some time can increase the risk of disasters in a geographical location. The gradual destruction of individual ecosystems or a group of ecosystems erodes ecosystem services and incubates disaster risk.

1.2.9. Wetland lost and Makurdi flood disasters conceptual model

According to the United States Environmental Protection Agency, wetlands' ability to store large amounts of water is significant in flood abatement (Muzan, 2018). It reported that 'one-acre wetland is capable of storing one million gallons of water. The studies regarding the ecological functions of specific wetlands in Nigeria are lacking, and it is not easy to establish the number of individual water wetlands, including Makurdi wetlands, could store; however, inferring from this study there would be an increase in the amount of surface water when wetlands are removed. This review has drawn a conceptual framework in understanding how the removal of wetlands links with the flood in Makurdi (Orimoloye et al., 2019).

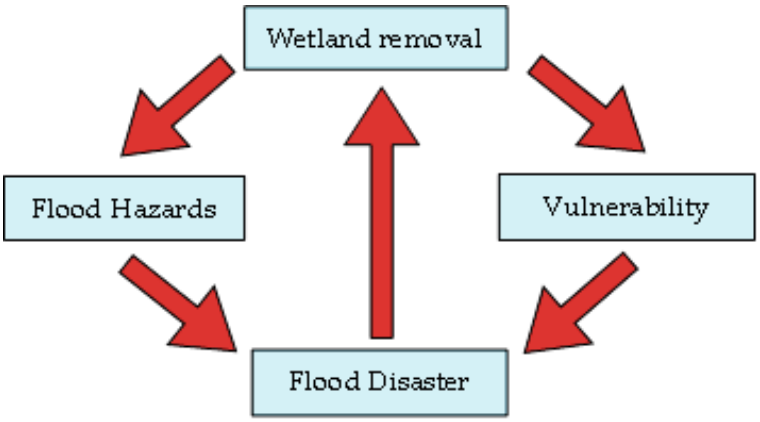


Fig. 2. A conceptual framework for wetland degradation and floods in Makurdi.

As shown in Fig. 2, the removal of wetland will increase both social and physical vulnerability by increasing surface runoff, which increases flood hazards. It will also dislocate livelihood and other economic benefits derived from the wetlands and decrease the ability of people to cope and recover from flood disasters. Flood disasters may also increase the degradation of wetlands by displacing populations and other sources of livelihood which will result in the removal of wetland for settlement, conversion to agricultural use and furthering a reduction in the total amount of wetlands and its capacity to ameliorate flood.

2. Materials and Methods

This paper is based on a review of literature, secondary data, and primary data obtained on personal field observation. The review was carried out to discuss the linkage between wetland loss in Makurdi town and flood disasters based on the disaster incubation theory. An extensive document review was conducted involving a literature review on the topic. Keywords such 'wetland loss in Makurdi town' 'wetlands degradation' 'causes of flood in Makurdi' 'flood risk and management in Makurdi town' 'impact of flood' were used to search and identify journal publications for this review. The quality of the information was considered if the source of the publication is peered reviewed. A similar approach has been used amongst other researchers, to identify literature for a review (Nkwunonwo, 2016). Other sources of information for this review include Benue State government publications and personal observations. Thematic analysis was used to examine and discuss the linkage between wetland loss and flooding in Makurdi town and how this vital factor has been neglected in scientific discussions on flood disasters in Makurdi town (Oyatayo et al., 2016).

2.1. Wetland loss in Makurdi town

There is currently no particular inventory to comprehensively and precisely account for the total wetland lost in Makurdi. However, researched evidence shows that wetlands lands have been gradually destroyed through conversion for agricultural use or urbanization processes (Hemba et al., 2017a). Some of the studies have estimated quantities, which examined wetland land lost in Makurdi and environs (Hemba et al, 2017b). According to their study, between 1976 and 2006, Makurdi town and environs have lost about 60% (Figs. 3 and 4) of her wetlands.

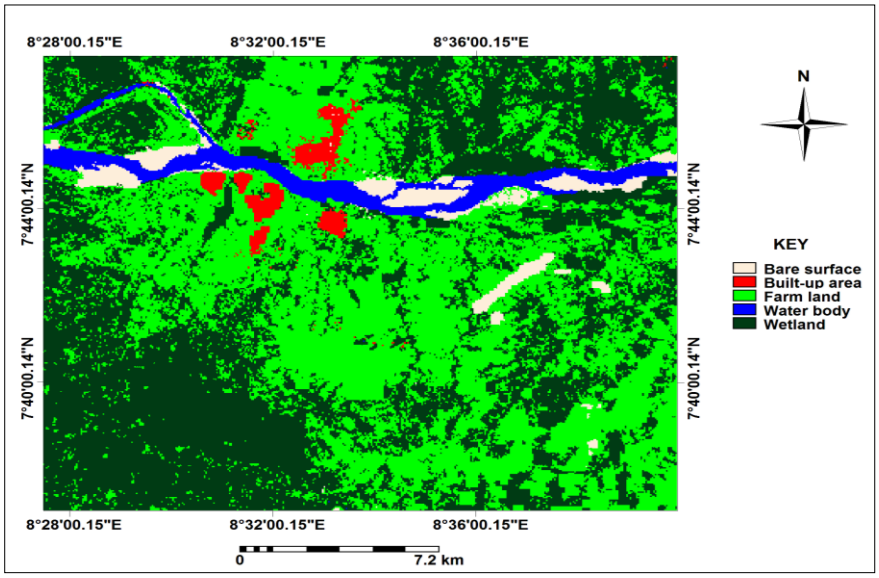


Fig. 3. Image of Makurdi Wetlands 1976 (Hemba et al., 2017a).

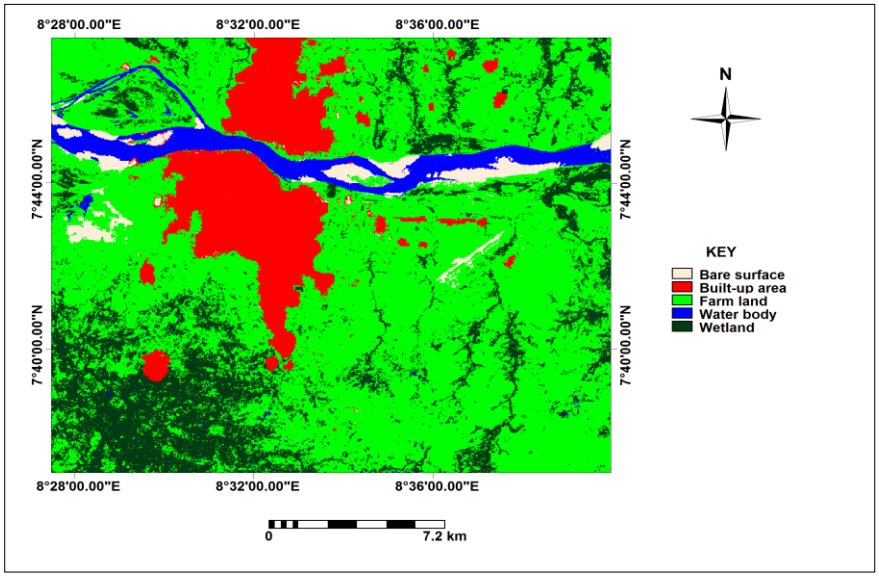


Fig. 4. Image of Makurdi wetland 2006 (Hemba et al., 2017b).

The loss is attributed to the conversion of wetlands to agricultural and urban land uses. Figs. 5 and 6 show flooded buildings in a wetland area in Ungondo Layout in Makurdi. Similarly, in another study, have reported an 18.1% loss of wetland area between 1996 and 2016 (Anule and Ujoh, 2017). The study projected a further decline of about 22.57%) by 20126. The loss in wetlands means that the wetland's ecosystem services, including flood amelioration, are lost along with the wetland. Also in other research, reported land cover change from rural landscape to urban or built land cover (Acha and Aishetu, 2018). They suggested that increased urbanization was responsible for the land cover change. The study reported progressive change from all land cover types to urban land cover.

Fig. 5. Flooded buildings in wetland area in Ugondo Layout Makurdi.

Fig. 6. Flooded buildings in the wetland area in Ugondo Layout Makurdi.

3. Results and Discussion

3.1. Floods in Makurdi

Researchers have classified flood into coastal floods, river flood, and urban flood (Ologunorisa and Tersoo, 2006). While coastal flood refers to a flood occurring in the coastal areas, river flood occurs along river banks, and in the flood plains of major rivers, it is similar to the description of the fluvial flood (Nkwunonwo et al. 2015). Urban flood is experienced in towns and where low laying terrains suffer excess water due to the absence of blocked drainages. Makurdi floods fit the urban and river flood (Ojigi, et al., 2013). In another study, identified flood-prone areas consistent with proximity to the rivers (Clement, 2013). Makurdi has witnessed several flood incidences, although there is no existing database where the incidences of floods in Makurdi could be accessed. Nkwunonwo and colleagues, who reported flood records for most of Nigeria major urban areas from actual flood databases, were unable to report for Makurdi because of its non-existence (Nkwunonwo et al., 2016). This suggests that flood records of Makurdi are poorly kept. However, researchers have reported flood incidences across many years including 1996, 2000, 2005, 2007 and 2008, 2012, 2013, 2015, and 2017 (Isma'il and Kersha, 2018; Shabu and Tyonum, 2013). The 2012 flood was considered the most devastating in four decades (Nkwunonwo et al, 2016). The floods studied in Makurdi; residents reported an increase in flood frequency (Ahile and Ityavyar, 2014). Equally, the data on the impact of the flood is missing. The Benue state government presented some data on the number and type of persons affected by flood incidences in Makurdi between 2012 and 2017, as shown see Table 1.

Table 1. The number of persons affected by floods according to years (Jakeway et al., 2008).

Year	Males	Females	Children	Infants	Pregnant women/ Nursing mothers	Aged	PLWD	Total
2012	7325	10148	22881	666	341	-	8	41069*
2013	2533	3734	2367	471	706	159	77	10,047
2015	2684	1788	7663	534	207	100	32	13,018
2017	9966	7557	12218	3090	993	-	93	39,864

* The 2012 flood was reported as a unique occurrence and had more impact.

As shown in Table 1, the impact of flood in terms of numbers of persons affected has continued to rise progressively. Although the 2012 flood appears unique but described that the particular flood, is very different from the nature of floods experienced in Nigeria (Nkwunonwo et al., 2016). It affected more people and was blamed on the over flooding of the Rivers Niger and Benue and Cameroon's Ladgo Dam. The impact of the flood on both economic activities and infrastructure is not to be taken for granted. Figs. 7 and 8 show how public infrastructures and businesses have been affected by floods in Makurdi. Increases in the number of persons affected suggested that all possible causes of floods be evaluated to develop practical management approaches; however, the impact of wetland removal on Makurdi flood has not been explored.

Fig. 7. Flooded Commercial Area in Makurdi.

Fig. 8. Flooded Road in Makurdi.

3.2. *Reported causes of flood in Makurdi*

Various researchers have attempted to investigate the causes of flood in Makurdi, a topic that appears to dominate research interest in flood generally across Nigeria (Nkwunonwo et al., 2016). The causes of identified are presented in Table 2.

Table 2. Causes of Flood reported in the literature.

Cultural factors • Blocking of drainages (with solid waste) • Low awareness of flood hazard	(Ojigi, et al., 2013; Shabu and Tyonum, 2015)
Conversion of the rural landscape • Land cover change (increased surface runoff)	(Acha and Aishetu 2018)
Climatic factors • Heavy rainfall (due to climate change)	(Ojigi, et al., 2013; Shabu and Tyonum, 2015)
Planning factors • Building on water channels • Lack of drainages	(Ojigi, et al., 2013; Shabu and Tyonum, 2015)

4. Conclusion

This paper has attempted to link the ecosystem's gradual destruction with increased disaster risk by explaining the impact of wetland removal on flood in Makurdi town Benue State. It could now be understood that ecosystems are very significant in increasing disaster risk and shaping hazards and vulnerability. Since Makurdi became the state capital from 1976, as shown by the literature reviewed in this paper, there has been a progressive decline in its wetlands taken over by urbanization processes. The gradual take-up of wetland areas is an incubation period for flood disaster because it gradually reduces the potential of the wetland areas to ameliorate floodwaters' impact and increase disaster risk by increasing residents' vulnerability. Correspondingly, the literature reviewed showed a progressive increase in flood incidence and the number of persons affected.

However, there appears to be less research attention to examining the relationship between wetland areas and floods in Makurdi. Disaster risk reduction depends significantly on a deep understanding of factors that increase risk, making responsible decisions for practical actions. Various studies that have attempted a look at the causes of flood in Makurdi have not been able to relate their findings to the wetland degradation. This review draws attention to the need to investigate the importance of wetland areas in flood management in Makurdi. It shows that ecosystem conservation and management is central to the management of disaster risk.

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