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Review Article

Floods in Sub-Saharan Africa; Causes, Determinants and Health Consequences

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Abstract

Climate change has become a global issue and affects various regions at different levels. The hydro-climatic conditions and the natural fragility of Sub-Saharan Africa (SSA) make it prone to floods. The review was intended to comprehensively explore the determinants of floods in the continent and their effects on public health. An extensive systematic literature search in English was conducted for peer-reviewed papers, abstracts and internet articles, grey literature, and official Government documents and analysed to identify common themes, findings, and outcomes. Finally, the findings were categorized into common themes.

The review revealed that the frequency and intensity of precipitations have increased in recent decades in SSA. This is worsened by anthropogenic activities including urban sprawl, population growth, and land use changes. The health effects of floods are diverse, varied, and specific to a particular context which can be immediate and long-term. The economic losses due to the flood events in the continent are huge.

In conclusion, Governments across the continent need to give flood management a top priority as part of national disaster preparedness, response, and mitigation. Floods cannot be managed in isolation; it has to be incorporated into national urban planning with urbanization to make cities resilient and sustainable.

Keywords: Floods; Climate Change; Heavy Precipitations; Health Consequences; SSA.

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Introduction

The 54 Nations states that make up the African continent are complexly diverse in geography and climatic conditions from the equatorial, Sahel to the desert. Rainfall and river flows in Africa show high levels of variability across a range of spatial and temporal scales.[1-3] The continent also has large numbers of river basins that account for the significant total run-off. Flooding is the leading natural environmental disaster worldwide and one of the major challenges faced by countries in the 21st century.[4-6]In Kenya, flooding has emerged as

the most common meteorological disaster.[7]Worldwide, floods have increased both in terms of frequency and intensity thereby causing significant environmental destruction, impacts on economies and human activities.[8,9]Flooding poses serious socio-economic challenges, each year, flooding claims about 20,000 lives and adversely affect approximately 20 million people globally.[6,7] Torrential rains and flooding affected 600,000 people in 16 West African countries in September 2007. The worst-hit countries were Burkina Faso, Ghana, Senegal, and Niger. This event was closely followed by the 2007 floods that displaced more than a million people in Uganda, Ethiopia, Sudan, Burkina Faso, Togo, Mali, and Niger and claimed over 500 lives.[10-12]The report of EM-DAT database revealed that floods alone accounted for 38.7% of all incidents, 6.2% of deaths and 43.0% of the population affected by all disaster caused by natural hazards in the world during 2000-2009.[13]Floods are the most frequent environmental disasters affecting over 2.8 billion people globally and causing over 200, 000 deaths over the past decades.[14] Between 1995-2005, the lives of 2.3 billion people were affected by floods, making it account for 47.0% of all weather-related disasters worldwide.[15,16] Flooding is not a new occurrence in sub-Saharan Africa (SSA). Flooding has been reported in the city of Lagos, Nigeria since 1947, and that was described as widespread and is now an annually recurring event.[17]

In the past decade, across sub-Saharan Africa, floods have surged in intensity. The 2018-2019 southwest Indian Ocean cyclone season resulted in a level flood of damage previously unseen in Africa.[18] The resulting cyclone Idai caused devastating flood damage in Mozambique and Zimbabwe with 602 deaths and 299 fatalities respectively and damage to critical infrastructure worth about $1 billion.[3,19] In 2012, 33 of the 36 States of Nigeria were affected by floods with 37 million affected, 2.1 million people displaced, 363 people killed and more than 18,200 injured, and more than 18, 000 houses were damaged or destroyed.[20]

In April 2022 alone, there were reports of at least 8 serious flooding events and twenty deaths in Nigeria and Ghana despite the fact that attention was largely overshadowed by the COVID-19 pandemic.[21] Globally, floods are described in a number of ways depending on location (land surface, hydrology, geomorphology, and duration). Flooding, signifying the consequence of a flood is distinct from the flood itself which is defined as the condition that occurs when water overflows its natural or artificial confines of a stream, river, or other body of water or accumulates by drainage over low-lying areas.[22,23] Since the "long rains" season started in March 2020, more than 13 million people have been affected by flooding in East Africa with about 981,000 displaced.[24] During the same period, 200 people were reported dead as a result of overflowing rivers and mudslides in Kenya with over 40,000 displaced. For the first time since records began 120 years ago, water levels of Lake Victoria reached the highest point, displacing thousands of people, and flooding homes, with the destruction of infrastructure and roads.[25,26]

Thus, flooding is the most common environmental natural disaster ravaging the SSA and a threat to achieving sustainable development with the continent's current level of development. The aim of the review is to assess the trends of flooding events and the impacts of floods on the health of the human population in SSA. Its objectives are to describe the causes of floods, flood types, what are its drivers (determinants), and finally describe the health impacts of floods. This study is an analysis of literature and published reports including grey literature, technical reports, and journal articles. A search was conducted on health databases– PubMed/Medline, ScienceDirect, Web of Science, Environmental Science and Pollution, and Google Scholar. A manual search of reference lists of selected articles was carried out for further relevant studies. This comprehensive review looked at the trends of flooding events across SSA with a particular focus on public health and to re-awaken the focus of Governments on the urgent need for more proactive and sustainable measures to curtail this recurrent environmental natural catastrophe in the continent.

Types of floods

Floods can be classified in a number of ways. Different types of floods can have different effects in terms of their impacts, property damage, and their impact on the affected community. Broadly, floods are classified into pluvial (overland), fluvial (river), and coastal (surge) floods, groundwater floods, or failure of artificial water systems.[27,28] It is difficult and or almost impossible to describe the commonest type of flood in any area. This is because a flooding event is often always a mixed event. A combination of flood types can occur within

a country and city. Thus, flash flooding can occur in almost any area. Again, the low-lying topography of Lagos City, its coastal location, and its network of rivers provide the context for three different types of flood hazards. This is not peculiar to Nigeria alone. However, riverine (fluvial) flooding is reported to be one of the most common types of flooding[24]

Pluvial floods can cause surface water and flash floods. Surface water floods occur when the urban drainage system is overwhelmed and water floods onto the streets. On the other hand, flash floods are sudden and appear unnoticed as a result of torrents of water triggered by intense rainfall (or a sudden release of water from a dam.) Often, they are very destructive because of debris that is swept along with the stormwater. In January 2020, heavy rainfall in south-eastern Tanzania resulted in a flash flood with major destructive damage and fatalities; 18,000 people were affected, 1746 houses were destroyed, 1,074 latrines collapsed, 13 people died and 5 were reported missing.[24,29] The same heavy rainfall in May 2022 resulted in flash flooding in Kwazulu, South Africa with the destruction of houses, roads, and bridges.

The unprecedented, rapid urbanization in SSA is worsening flash floods as it increases the vulnerability to floods of some 238 million people who live in informal settlements.[30]In Ibadan-Nigeria and in many cities across Africa, the blockage of watercourses and drainage ditches as a result of dumping of refuse was seen as a significant factor in causing floods.[31]The same factors have been reported as operating in Africa's economic capital city of Lagos.[32] A report from Ouagadougou, the capital of Burkina Faso revealed that floods were due not only to extreme rainfall but also a consequence of human and environmental factors including unplanned urbanization.[33]Urban flooding is a pressing issue on the continent and in almost all the countries requires urgent drastic policies to combat it in the face of a changing climate. In Africa's rapidly urbanizing cities, flood risks need to be taken into consideration together with other environmental factors in formulating future plains to make cities more resilient and sustainable. Such floods have a devastating impact because of their destructive phenomenon affecting human settlements and infrastructure.[24]

Fluvial (river water) floods are frequently associated with violent convection storms of brief duration falling over a little area. It occurs when heavy torrential rain creates a flood event independent of an overflowing water body. Several hydrological factors are critical to the occurrence of fluvial floods: soil type, terrain gradients, vegetation cover, anthropogenic activities, etc.

This usually unfolds over days or even months. Fluvial floods are the commonest type of flood and occur when water in a river, lake, or stream rises and overflows onto the surrounding banks, shores, and land. The drainage from a river can be widespread, as the flow affects smaller and bigger rivers downstream, often causing dams and dykes to break and overflow into nearby areas. In Uganda, river flooding displaced communities living close to the shoreline and created challenges to the country's hydropower infrastructure. In western Tanzania, 180 houses, home to 1655 people were affected by flood water in Lake Tanganyika which also affected the country's electricity resulting in huge power deficits.[24,34] This flood often causes damage to farmlands and destruction of livestock resulting in food insecurity and malnutrition. The damage to infrastructure like roads and bridges results in restriction of movement and transportation of goods and services.

Coastal (**surge**) floods occur where low lying normally dry lands is flooded by seawater. Storm surges are the leading cause of coastal flooding and are formed when high winds push the water on shore. Areas along the coast get flooded often due to phenomena like tsunamis, hurricanes, and unusually high tides. Flooding on the East African coast can hinder port activity and damage the mangrove forest which helps to prevent erosion, while the salinity can affect the productivity of the agricultural lands.[35] The city of Lagos is located on the share of Atlantic Ocean on low-lying terrain which is less than 2 metres above sea level and consist of Lagoons and Creeks with a network of rivers.[36] This makes it susceptible to both coastal and fluvial floods.[37-39] Since 2000, the frequency, spatial extend and severity of flooding caused by rainfall and storm surges has increased with coastal and mainland areas of the city experiencing increased flooding during the rainy season. Sea level rise associated with climate change, estimated to reach 59cm by 2100 is likely to worsen problems of coasted

inundation, flooding and intrusion of sea water into fresh water sources and ecosystems in Lagos.[37,40] Also, the city of Dares Salaam, the economic capital of Tanzania is vulnerable to coastal flooding as 8% of it lies in a low elevation coastal zone that is more than 10m below sea level (Figure 1).[24] The seawater being salty causes significant damage to infrastructure including buildings and disruption of communities forcing them to retreat inland. It can also permeate into groundwater supply.

Figure 1: Effects of flooding in Da res Salaam

Understanding flood events in SSA

Climate change will have a huge impact on flooding around the world. Sub-Saharan Africa (SSA) is prone to climate change because it suffers from natural fragility, it is thus exposed to droughts and floods.[41]Natural fragility is related to topography, unpredictable weather trends and uncertain variations in precipitation patterns. The occurrence of a flood depends on a variety of factors; meteorology, topography, land use, soil type and antecedent moisture conditions.[27,42]It is difficult to separate the effects of natural climatic fluctuations and anthropogenic influences. Floods are often caused by a variety of mechanisms, but the major cause in SSA is heavy and torrential rainfall. Rising temperatures and precipitations are considered as proxies of climate change. Heavy precipitations, melting glaciers and thermal expansion of the oceans causing a rise in sea levels and inundations of coastal lands. Flood is a natural phenomenon that can be accentuated by anthropogenic activities and occurs at irregular, unpredictable intervals and varies in size area of extent and duration. Flood produces damage through the immense power and force of moving water and deposition of dirt and debris when flood water finally recedes.[27]There are many determinants (drivers) of flooding in SSA. These determents are multi-factorial and often overlapping.

Urbanization: There is no doubt that SSA is undergoing rapid and unprecedented urbanization. Urbanization is the rate of movement of people from rural to urban areas for better opportunities, it has been seen as leading cause of flooding in flood-prone African urban areas. Currently, African continent has a population growth rate of 2.6% per annum and is expected to double by 2050.[43]Africa's urban population is expected to triple from 548 million in 2018 to 1.5 billion in 2050.[44] Urbanization has huge social, economic and health gains, but it is neither planned nor effectively managed in SSA. The urban stampede and increasing need for housing has resulted in a surge for informal and unplanned settlements. People with limited income who cannot afford housing in flood free areas tend to settle within flood-prone areas. They accept and cope with flooding due to limited alternatives.[45,46] The African continent is rapidly urbanizing without requisite infrastructural base required to sustain the growing population. This has its own challenges as the convergence of climate change, floods and COVID-19 pandemic in the region reverse the gains in poverty reduction and sustainable development. All the three threaten development as a result of diversion of critical resources to combat them and thus, they block pathways out of poverty.

The unprecedented and unplanned nature of urban growth has made many African cities hotspots of health and environmental problems including flooding.[3,47] The expansion and densification of cities change the natural landscape of a place as land use modifications are implemented to meet human needs. These changes increase impervious areas and reduce vegetative cover that acts as buffer against floods by absorbing surface water.[48] When the natural vegetative cover is cleared for construction purposes, the impervious surfaces do not absorb water thereby increasing storm water flood.[27]Thus the city of Accra, Ghana lost more than half of its vegetation between 1986-2013[49]which has impacted on its flood risks.[50] While in Nigeria, agricultural settlements and forest land use are the most significant contributions to the changes in the level of flood risks.[21,51]

Urban floods cannot be managed in isolation, responses to ameliorate their impacts are complicated by interlinked socio-economic, political and environmental changes.[12] Poor governance and institutional weaknesses in the system at all levels of government has made it difficult to discharge constitutional responsibilities in managing the cities across the continent. The roles and responsibilities are not clearly delineated, there is poor inter-sectoral coordination and capacities of agencies to manage floods are weak. So, for urban cities in SSA, managing flood risks need to be considered when formulating future plans to make cities more resilient, sustainable and liveable.

Waste management and drainage systems: Generally, the developing countries have a poor waste management system especially for solid waste. This is quite pervasive in SSA as the practice of dumping refuse on every available land, including roadsides, and drainages is quite common. In many cities, refuse spreads across the road thereby blocking traffic.[52]This is compounded by the ever increasing millions of tonnes of refuse generated as a consequence of population growth and urbanization. For instance, in Nigeria alone, over 25 million tonnes of municipal solid waste are generated annually. The wastes are commonly dumped in open dumps, uncontrolled landfills and dumps located along or beside major roads.[42,52] This practice is not peculiar to Nigeria alone and waste dump sites dots the urban landscape of SSA (Figure 2).[21]

Figure 2: Open dump site in a Nigerian city

Municipal waste management, a key function of urban governance is poor and ineffective in SSA.The situation is worsened by the dearth of drainage systems and adequate storm water management infrastructure[53,54] Poorly constructed and managed drains are the hallmarks of the majority of Nigeria and Ghanaian cities (Figure 3).[21]

Figure 3: Blocked drain a Ghanaian city

Furthermore, the drainages are open, narrow and lacks connectivity within the catchments, thus cannot contain large volumes of water during heavy rainfall. Since the drains are open, it makes them liable to easy blockade through dumping of waste items by humans. A recent addition to this problem is the consumption of "sachet water" erroneously referred to as pure water (common in West African sub-region) that is sold in polythene packs which are a major source of plastic waste. They are mostly discarded indiscriminately thereby ending in drains resulting in blockade.[55]

Urban physical planning: Properly planned urban settlements with adequate and well maintained drainage systems are a sinequa non for urbanization and urban renewal. Urban planning presents great opportunities for planned, regulated city expansion, regulating the environment, mitigating global warming and achieving sustainable development. But the detachment of urban planning and implementation from reality has worsened the environmental problems faced by African developing nations.[56] Poor governance and political meddling are also common.[57] The regulation of development is the purview of urban and physical planning and where there is a rise in informal settlements, urban planning has failed.[21]

Health Consequences

The effects of flooding on health is quite diverse. Health consequences occur directly through contact with flood waters and the flooded environment resulting in injuries from debris, chemical contamination and drowning. Indirectly, the health consequences are from damage to ecosystems, infrastructure, food and water supplies or support systems. This causes infectious diseases, malnutrition, poverty-related diseases and diseases associated with overcrowding.[22]

It can be classified into immediate when the flood water is still present, medium term this occurs in days to weeks after the flood event and long term from months to years often after flood water might have receded. However, it has been reported that there is no clear cut definition of these terms. Indeed, in many situations these periods overlap.[22]

Disruption of health care services: Flooding can significantly damage critical infrastructure of health care facilities directly disrupting the provision of health services, (Figure 4).[33] Indirectly, it can hinder access to the facilities due to damaged roads and bridges. The damaged health facilities may result in displacement of

patients and staff. Also, patients can suffer from destruction/loss of medications, medical devices and consumables.

Figure 4: Yalgado Teaching Hospital, Ouagadougou, B/Faso after 2009 floods

Globally, two-thirds of flood-related deaths are from drowning and one-third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning or fire. Other effects include outbreak of communicable diseases like cholera, gastroenteritis, dengue fever, malaria and poor mental health etc[4,29,59]

Water-borne diseases: Flood is associated with diseases transmitted through faeco-oral route. This occurs as a result of contamination of drinking water supply. The flood water conveys pathogens (bacteria, viruses and parasites) into the potable water system resulting in outbreak of water-borne diseases.[4]

Vector-borne diseases: Epstein[60]used epidemiologic triad to explain the occurrence of infectious diseases after floods vis-à-vis agent (vector/pathogen), transmission environment and host (man). After flooding, the environment is altered and becomes conducive breeding ground for the development of vectors and pathogens. These are diseases that require vehicular transfer from host to host (waterborne) and or vector/host as part of its life cycle (vector borne).[61,62] For vector-borne diseases, the reproduction, development, behaviour and population dynamics of arthropod vectors, their pathogens and nonhuman vertebrate reservoir are affected by changes in precipitation.[62] The incidence of mosquito borne diseases like Malaria, Rift valley fever and West Nile fever[63]etc are known to increase. For instance, the prevalence of malaria along Kenyan coast increased after heavy rains.[4] Periods of heavy rainfall and flooding have been associated with outbreak of Rift valley fever.[64] The favourable environment promotes the breeding of species of mosquitoes known as floodwater aedes. Infected aedes eggs hatch in the persistent stagnant water and matures into infective adult mosquitoes.[65] After the floods that occurred in Mozambique in 2000, the number of malaria cases within the displaced population increased by a factor of 1.5 to 2 times the previous level together with incidence of diarrhoeal diseases.[66] Several studies have reported increased number of cases of malaria after flooding across the continent.[67-69]

Rodent-borne diseases: These are also known to increase during period of heavy rainfall and associated flooding due to altered patterns of human pathogen- rodent contact.[70] It has been reported that heavy rainfall encourages excessive wild grass seed production that support increased outdoor rodent population[71], while flooding forces rodents out from their burrows into built environment and closer to human habitations thereby increasing the risk of rodent-borne infectious diseases like Leptospirosis.[72] High prevalence of Leptospirosis was reported in Garisa, Kenya after El Niño rains[4], in North Eastern Kenya, a prevalence rate of 41.8% of

Leptospira bacteria was found among rodents[73], 18.3% was reported in Kibera slums in Nairobi[74] and 25% rate was found among Somali pastoralists in Northeast Kenya.[75]

Physical health problems: Cuts, injuries and malnutrition etc are increased during or after floods. A study reported that women in low income areas had a higher likelihood of injury than women in higher income areas of Lagos.[76] Contaminated water supplies as a result of flooding and or to treatment or storage systems[77] and sewage system increases the risk of exposure to and transmission of water borne diseases.[78,79]

Mental Health: According to WHO mental health consequences following floods have not been fully addressed.[70] However, in recent times, this has become an important issue of public health concern. Flooding has negative effects on mental health and wellbeing.[70] Factors associated with mental health after flood include among others previous experience following flood, vacating homes after flood and poor health at the time of flood. Deteriorated mental health resulting from floods is usually due to comorbid health problems, financial losses and community or social disruption.[79] Despite a global increase in awareness of the importance of mental health, it has not been a prime focus in SSA due to the dominant role played by other diseases.[80] Thus the paucity of literature on flooding events and its impact on mental health of affected victims. This is an area for future research.

Conclusion

The review revealed that floods have in recent decades increased as a result of climate change and worsened by anthropogenic activities with significant impact and different social, economic and health outcomes in SSA. Africa's low contribution but high vulnerability to climate change calls for global cooperation and effective international response.[79]Climate change and its impact in Africa require governments and policy makers to act now on many pathways for mitigation. Risk factors such as informal settlements, housing on flood planes, communities living in close proximity to water bodies together with rapid unprecedented urbanization, population growth and environmental determinants exacerbate the vulnerability to floods in SSA.[67,80-86]

There is urgent concern on the causes and effects of urban floods in the face of rapid urbanization in Africa as well as the coping strategies of those affected (particularly informal urban settlements), it is essential to comprehend the nature of the floods and associated risk factors in urban areas. Thus, there is need for a paradigm shift in governance and sustainable urban planning. Governments at all levels and residents most come together through appropriate fora to remove the distrust and limited community engagement that has hindered sustainable urban development. The opportunities for urbanization and its dividends are there, SSA cannot afford to be left behind. Developments on flood risk zones, flood planes and wetlands must be resisted against the backdrop of political interests. It is important to continuously create publicity awareness to citizenry of the consequences of flooding, promote health education on building codes and better housing and proper solid waste management. The issue of housing policies requires revisiting in order for governments across the continent to provide affordable housing for all on a sustainable basis. This will go a long way to move people away from flood prone areas, construct adequate drainages, green infrastructural development and urbanization. Flood management as part of management of natural disasters needs to be given top priority in SSA.

Lessons learnt

Floods as environmental natural disaster compounded by anthropogenic activities in SSA have increased in frequency due to heavy precipitations. Climate change has resulted in changed winds and precipitation conditions that pose a threat to the achievement of sustainable development goals (SDGs) in the continent. Management of floods and its aftermath needs to be given top priority in the National disaster preparedness, response and mitigation continuum. Flooding events and its impact on mental health of affected victims is a potential area for research in SSA.

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