Problems of Climate Change-related Hazards in African Coastal Communities

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Abstract

Climate change continues to be a key development concern, being one of the SDGs (Goal 13) which aims at mitigating and adapting to climate change adversities. While there are increasing efforts in reducing development risks and vulnerabilities orchestrated by climate change in many continents, African coastal communities continue to experience complex hazard risks.This study uses a mixed methods appraoch with data from the International Emergency Database to assess climate change-related hazards on the continent. Analysis points to the fact that the communities are exposed to hazard risks that have been intensfied by climate change manifested in global warming and its attendant consequences as witnessed in the rise in sea levels (resulting in the inundation of coasts and sometimes whole islands) and climate vagaries (changes in rainfall patterns, El Nino effect, and extreme weather events) which are further compounded by unplanned urbanisation and environmental degradation. While global collaboration targets climate change from a macro level as witnessed in summits that focus specifically on gas emissions and global warming, local level effects especially in African coastal communities are often overlooked. The increasing frequencies of these hazards calls for the need to collaborate at the global, national and local levels in accelerating and intensifying mitigation and adaptation measures that go down to coastal communities. Improving knowledge on early warning mechanisms based on consistent data records and improved monitoring technologies of weather and climatic phenomena, as well as robust coastal stabilisation programmes are essential in this respect.

Keywords: climate change, hazards, coastal communities,adaptation, mitigation, partnerships

Purpose

With an intricately connected world, coastal areas of Africa, like many others in the world, have been densely populated. They continue to attract humans as a result of multiple advantages and opportunities they present, some of which Neumann, Vafeidis, Zimmermann and Nicholls (2015: 2) indicate to include "…their rich resources, particularly their supply of subsistence resources; for logistical reasons, as they offer access points to marine trade and transport; for recreational or cultural activities; or simply because of their special sense of place at the interface between land and sea." These have encouraged phenomenal development of coastal zones resulting in dramatic socio-economic and environmental transformations (Neumann, *et al.* 2015). These have equally resulted in dramatic increases in demographic growth and urbanisation rates that have already outstripped those of their counterpart hinterlands.

Despite the advantages and opportunities of coastal areas, they equally remain highly vulnerable to a number of shocks especially in Africa, many of which are driven by climate change. Climate change is one of the central issues affecting human wellbeing and safety today (World Bank, 2011). Undeniably, the rate of greenhouse gas (GHG) emissions today clearly indicates that the world is warming and will continue to do so into the 21st Century even if mitigation was possible (IPCC 2022). Climate change remains a threat not only to human wellbeing but also to the health of the planet (IPCC Press Release, 2022). In spite of the global mitigation efforts, global warming has continued unabated with human activities estimated to have caused approximately 1.0°C of global warming (IPCC, 2018). The IPCC (2022: 6) reports that "available evidence on projected climate risks indicates that opportunities for adaptation to many climate risks will *likely* become constrained and have reduced effectiveness should 1.5°C global warming be exceeded and that, for many locations on Earth, capacity for adaptation is already significantly limited. The maintenance and recovery of natural and human systems will require the achievement of mitigation targets."

Consequently, the concern about global warming is largely driven by the fact that it has significantly affected human and natural systems beyond survival levels. Anthropogenic-driven climate change continues to create growing and diverse adverse impacts and related losses and damages to nature and human societies. The severity of climate change impacts significantly depends, in part, on the global mitigation efforts (World Bank, 2011). While successes have been recorded in some development and adaptation efforts in reducing vulnerability, across sectors and regions, the most vulnerable people and systems are observed to be disproportionately affected (IPCC, 2022). This is more especially for developing countries of Africa, Asia and Latin America with increasing vulnerabilities driven by weak and inadequate adaptation capacities.

Africa is all surrounded by water 'empires' and with rising sea levels in the face of increases in the frequencies and intensities of extreme weather and climate events (which are accentuated by climate change), her vulnerability to climatic shocks is therefore a major concern to development stakeholders, researchers, policy makers and the population. The sustainability of policies and their implementation hinges significantly on the quality of research on hazard risks. It is within this context that this paper dissects the various climate change-related hazards affecting coastal areas of Africa in order to understand the varying degrees of vulnerability and the need for robust mitigation and adaptation preparedness to these risks. This is critical given that as in many coastal zones of the world, most of Africa's megacities and metropolises are situated in large deltas and coastal zones in general as defined by the Millennium Ecosystem Assessment, where combinations of specific economic, geographic and historical conditions to date attract people and drive coastal migration (Neumann, *et al.*, 2015).

Changes in urban land use, urban expansion and population growth have been observed not only to be significantly higher in coastal zones than in the non-coastal hinterlands but to continue to be higher in the future (Seto, Fragkias, Güneralp, Reill, 2011; Nicholls, Wong, Burkett, Woodroffe, Hay 2008; Fragkias, Seto. 2012; all cited in Neumann, *et al.*, 2015). Even though already susceptible to coastal hazards, dramatic environmental impacts (resource depletion, pollution and environmental degradation) which accompany these developments (which are dominantly haphazard) in coastal zones of Africa have significantly raised levels of vulnerabilities to hazard risks especially of the dominantly socio-economic marginalised segment of the population. This situation makes these coastal zones unsafe especially without adequate adaptation measures put in place. Reducing these hazard risks in coastal communities through building better adaptation measures and the global commitment to mitigation is essential in the attainment of Sustainable Development Goal No. 13 on Climate Action. Addressing these climate change risks in African coastal communities requires partnerships and commitments at the global, regional, national and local levels. This has been debated at the various Conference of Contracting Parties (COP), specifically COP 21 from which the Paris Agreement was born and that emphasizes on partnership and support to developing countries in addressing climate change adversities. However, much of the discussions and efforts have centred on cutting down on carbon and other greenhouse gas emissions, whereas, coastal communities in Africa continue to suffer from the ravaging effects of climate change on their livelihoods and development infrastructures. This therefore calls for the need to engage more in partnerships to build better and sustainable adaptation and resilience capacities of coastal communities in Africa against the persistent and growing climatic shocks. It is against this backdrop that this paper examines the problems of climate chanced induced hazards in African coastal communities, their adaptations and the attendant challenges.

Methodology

This study uses various data on climate change-induced hazards from a combination of primary and secondary sources. First, the various climate change-related data were identified and studied. These were broadly categorised into climatic, hydrological and meteorological types. From these broad categorisations, six hazards were then selected and studied; these include droughts and wildfires (climatological), floods and landslides (hydrologic), storms and extreme weather events (meteorological). This categorisation has been in line with that of the International Emergency Data Base (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED) at the University of Louvain Belgium from which primary data on the specific data events since the 20th Century were obtained.

Data on deaths, injured, affected number of people and estimated costs of damages were equally obtained from the data base of CRED. Data on the specific climate-change induced hazards covered the period 1900 to 2021. The criteria for a disaster event to be entered into EM-DAT are; ten or more people reported killed, hundred or more people reported affected, declaration of state of emergency and call for international assistance (Mulugeta, 2016). Further, information on sea level rise, other impacts of selected hazards and their management were obtained from secondary sources through literature reviews of online and printed texts.

Primary data on specific hazards and impacts were sorted, organised and analysed using descriptive statistics such as frequencies, averages and percentages of each of the hazard types. Trends in hazard event occurrence frequencies were determined using simple linear regression model in Excel 2016. Further, rates of change in the frequency occurrence of concerned hazards between decades (1900 – 2021) were determined using the formula:

Rate of Change in Hazard Frequency $=\frac{B-A}{A}x^{100}$

where:

B= hazard frequency at current decade

A= hazard frequency at previous decade

The results were presented graphically in line graphs, bar graphs and pie charts using Excel 2016. Secondary data were subjected to thematic and content analysis and discuss in the results section

Findings

Climate change continues to usher in different types of hazard risks which are driven by a number of factors. The following section presents the types and drivers of these hazards, their effects and various adaptation measures put in place in African coastal communities.

Types and Trends of Coastal Climate Change Hazards

Africa, like other parts of the world, is experiencing hazards amplified by climate change. Mbaye (n. d.: 5) underscores this by indicating that "climate change will undoubtedly present one of the most significant risks to Africa's sustainable development objectives over the next decade, and nowhere is the threat more imminent than on its coastlines." The key climate-change driven hazards in Africa in general include, droughts, floods, storms, heat waves, extreme weather and landslides. Since the 20 Century, a total of 1877 of these hazards have been recorded by the EM-DAT, CRED / UC Louvain, Brussels, Belgium (www.emdat.be). Flood has been most frequent (61%) than all others with the least being extreme weather events (Figure 1).

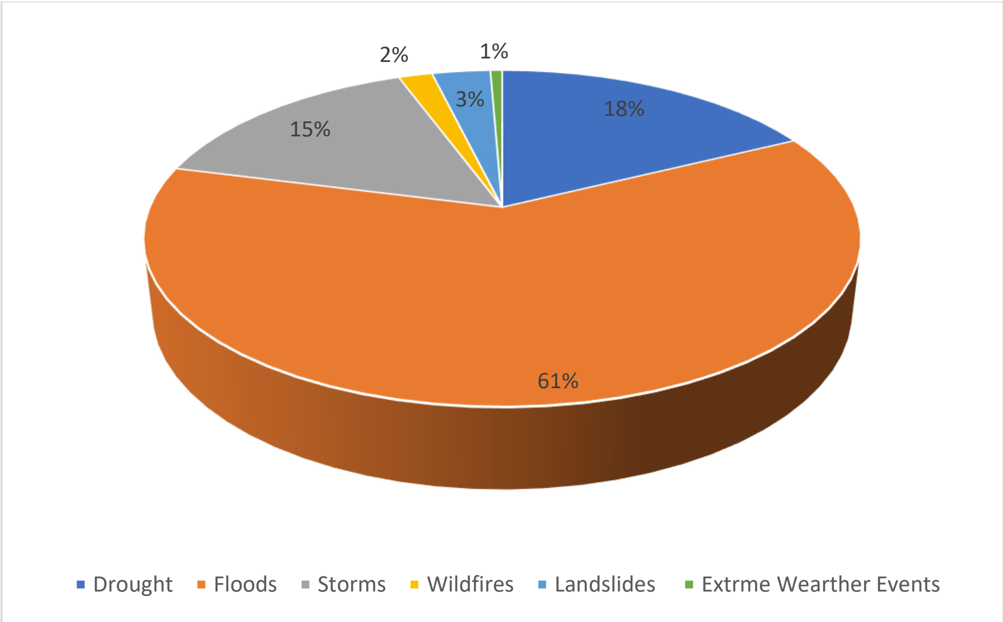

Figure 1: percentage occurrence of climate change-related hazards in Africa since the 20th Century
Source: EM-DAT, CRED / UCLouvain, Brussels, Belgium

Indeed, floods and droughts pose serious threats to lives and livelihoods in Africa including her coastal communities. Indeed, there has been a steady increase in the frequency and impacts of flood hazards (Figure 2). Within this period under study, an average frequency of 17.7 floods has been occurring in Africa every year (Table 1).

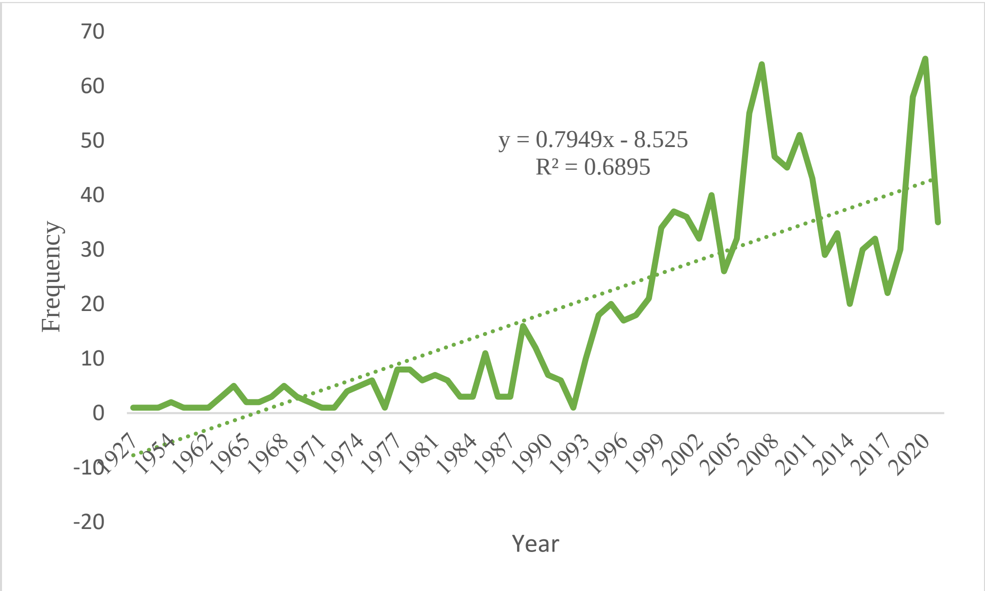

Figure 2: Trends in flood occurrence in Africa
Source: Analysis of data from EM-DAT, CRED / UCLouvain, Brussels, Belgium

These increases in flood frequency have been observed and differ from one decade to another. The decade with the highest frequency and average occurrence of floods is observed to be the 2010 – 2019 decade which recorded a total of 414 floods with an average of 41.4 floods occurring every year. The year with the highest occurrence was 2019 which recorded 58 flood events alone in Africa. However, the decade with the highest rate of change in flood frequency was the 1960 – 1969 decade with 400 rate of change in flood frequency.

Table 1: Decadal Analysis of Flood Events in Africa

Decade	Frequency of floods	Mean	Rate of Change in Hazard Frequency	Highest frequency/year
1950 - 1959	5	1.25	-	2(1954)
1960 - 1969	25	2.78	400	5 (1964, 1968)
1970 - 1979	42	4.2	68	8 (1977, 1978)
1980 - 1989	64	7.1	52.38	16 (1988)
1990 - 1999	152	15.2	137.50	32 (1999)
2000 - 2009	414	41.4	172.37	64 (2007)
2010 - 2019	348	34.8	-15.94	58 (2019)
2020 -	100	50		65 (2020)

Source: Analysis of data from EM-DAT, CRED / UCLouvain, Brussels, Belgium

Another hazard with similar causative factors like flood is landslide. Fifty-two landslides have been recorded between 1960 and 2021 in Africa. These have been caused by heavy and torrential rains. They have been dominant in mountainous areas of the continent such as the East African Rift Valley, the Cameroon Volcanic Line (CVL), and the Fouta Djallon Highlands (FDH) in West Africa just to name but these. Some of the most affected countries include Cameroon, Rwanda, Sierra Leone and Uganda amongst others.

Like floods, drought is another disturbing hazard whose trend has continued to rise as a result of global warming over the years in Africa (Figure 3). A total of 332 drought events have been recorded in Africa since the 20^{th} Century with an average of 5 drought events occurring every year. As shown on Table 2, within this period, 2000 – 2019 recorded the highest frequency of drought events in Africa with 68 droughts. However, 1980 – 1989 had the highest average frequency of occurrence of droughts with an average of 7.9 droughts occurring annually. Indeed, 1980 alone witnessed the highest number of drought event alone with over 19 drought events recorded. This same decade equally witnessed the highest positive rate of change in drought event occurrence (191.30%).

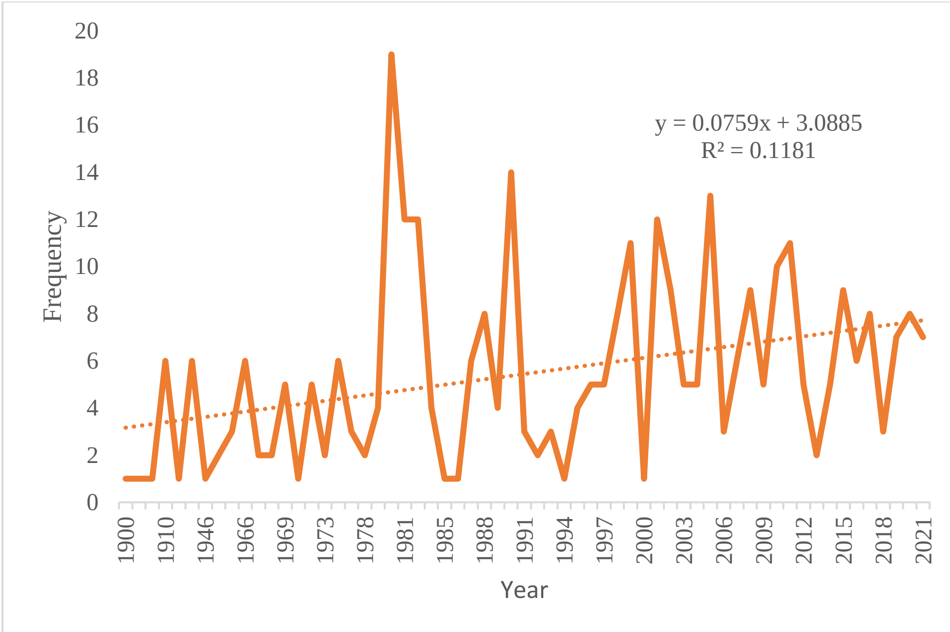

Figure 3: Frequency of droughts in Africa
Source: Analysis of data from EM-DAT, CRED / UCLouvain, Brussels, Belgium

Table 2: Analysis of Drought Occurrence in Africa by Decade from the 19th Century

Decade	Frequency of Droughts	Mean Occurrence	Rate of Change in Hazard Frequency	Highest frequency (year)
1900 - 1959	17	2.43		6 (1910)
1960 - 1969	20	3.3	17.65	6 (1966)
1970 - 1979	23	3.3	15.00	6 (1976)
1980 - 1989	67	7.9	191.30	19 (1980)
1990 - 1999	56	4.6	-16.42	14 (1990)
2000 - 2009	68	6.9	21.43	13 (2005)
2010 - 2019	66	6.9	-2.94	11 (2011)
2020 -	15	7.5		8 (2020)

Source: Analysis of data from EM-DAT, CRED / UCLouvain, Brussels, Belgium

Another climate-change-enhanced hazard affecting coastal communities and areas in Africa has been storms whose frequency trends is equally on the rise (Figure 4). Within the study period, a total of 289 storms have occurred in Africa, with an average of 5 storm events occurring every year.

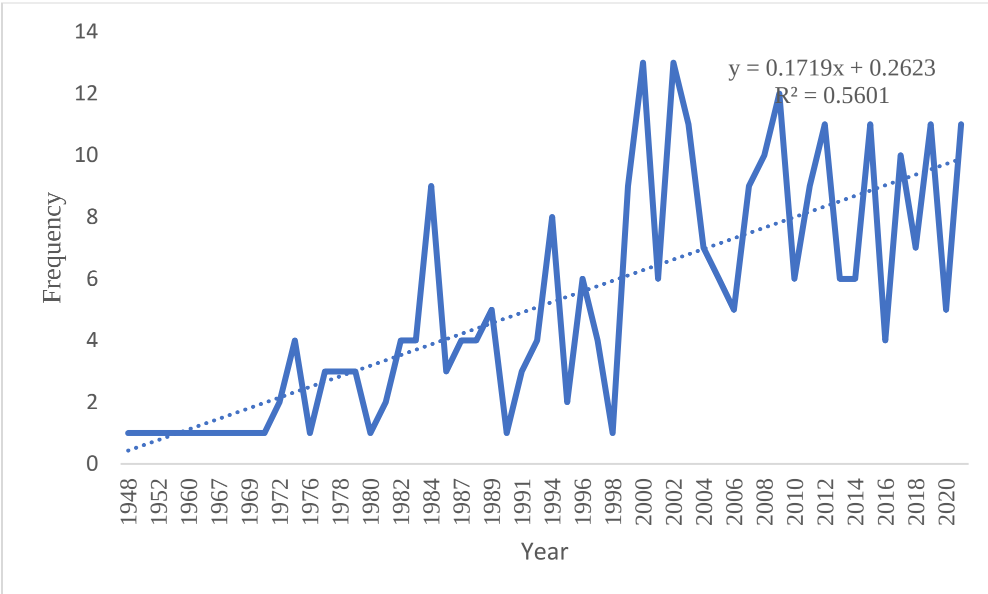

Figure 4: Trends in storm frequency in Africa since the 20th Century
Source: Analysis of data from EM-DAT, CRED / UCLouvain, Brussels, Belgium

In the same period, unlike other hazards, there has been very few extreme weather events in Africa, with a total of 12 recorded ones (Figure 5). The most affected areas by extreme weather events are Northern and Southern Africa. Sixty-six per cent of these events are heat waves with an average extreme temperature of 48.4^{o}C and with Nigeria twice experiencing the highest temperatures of 60^{o}C in 2002 in its Maiduguri District (Bornu Province). Frostbite events make up 40% of extreme weather events affecting Northern African countries such as Algeria, Egypt and Morocco. The lowest temperature (-13^{o}C) was recorded in Morocco in 2017.

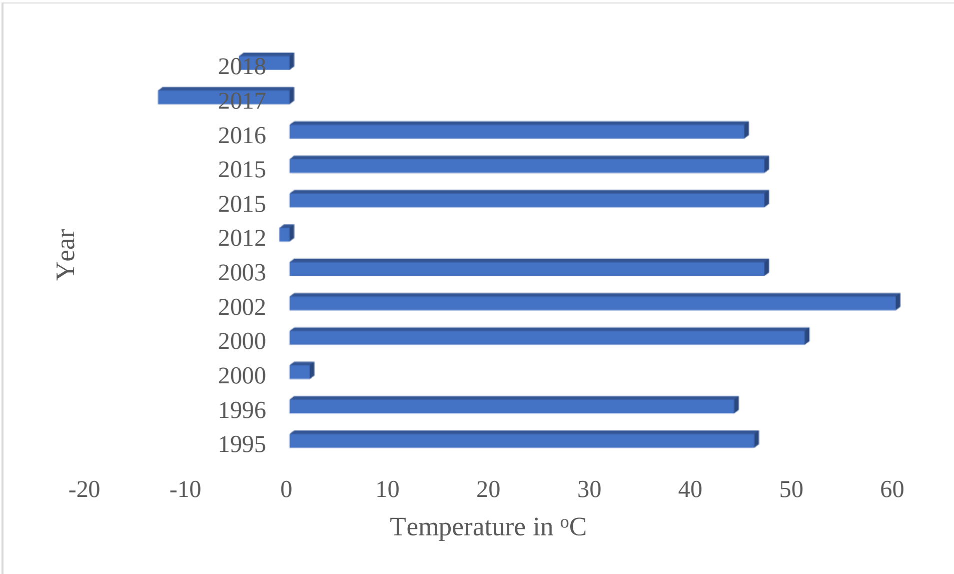

Figure 5: Occurrence of extreme weather events in Africa
Source: Analysis of data from EM-DAT, CRED / UCLouvain, Brussels, Belgium

Heatwaves have been responsible for many of the wildfires that have also ravaged some parts of Africa. A total of 34 wildfires have been recorded in every region (Northern, Southern, Eastern and Western) of Africa. Their occurrence has had serious adverse effects on forests and wildlife especially in Eastern and Southern Africa where they have been critical for ecotourism.

Drivers of Coastal Climate Change Hazards

A number of factors continue to enhance the occurrence and magnitude of coastal hazards in Africa. One of such drivers is sea level rise (SLR). Sea level rise arises partly from natural factors and compounded by human induced changes in coastal zones of Africa and the impacts of sea level rise includes; declining sediment and fresh water inputs arising from increased catchment regulation, destruction of wetlands, mangroves, coral degradation and eutrophication of coastal and shelf sea waters (Robert, 2003).Within the past 15 years, global warming has accelerated sea levels rise at 3.6mm/year, more than 2.5 times the mean rate of 1.4mm/year which was sustained throughout the 20th Century (Nyadzi , Bessah & Kranjac-Berisavljevic, 2020). The coastline of Africa that is largely located within the tropics is highly susceptible to climate change-induced sea level rise. For example, the Gulf of Guinea in West Africa is expected to experience an increase in sea level rise from +0.21m to 0.36 in 2000 to +0.55 and +1.1m during the mid and end of the 21st Century, respectively (Kebede et al. 2018, cited in Nyadzi, *et al*., 2020)

The vulnerability of Africa's coastal communities to climate change-related hazards is significantly linked to the growing urbanisation trend in the continent. Many of Africa's fast growing towns and cities are located within the coast. Demographically, Africa's populations in low-elevated coastal zones (LECZs) is projected to rise at an annual rate of 3.3 percent between 2000-2030, which is more than double the world's average (Mbaye, n. d.).

Urbanisation itself presents serious risks to human health and livelihoods. Such risks have been further compounded by climate change through continued sea level rise, storms, coastal flooding and erosion amongst others. These effects are largely felt in economically and socially marginalised segments of the populations (IPCC. 2021) that dominate these cities and mostly residing in LECZ. The urban development process in these areas is largely unplanned, anarchical and with grossly inadequate infrastructural developments such as coastal stabilisation schemes and rural-urban linkages necessary to bring about inclusivity in the whole process. These are, in essence, factors that have increased the vulnerability of coastal communities to climate change risks such as floods, storms and coastal erosion.

The urbanisation process in Africa in general is driven by population growth (both natural increase and soaring rural exodus) with limited efforts to provide commensurate or adequate housing, energy and infrastructural developments essential to ensure the safety of the population from climate change risks. Indeed, since 2000, there has been a steady increase in the populations of LECZs in Africa (Figure 6). This trend is projected up to 2030 with the highest rates of population growth and urbanisation in the coastal zone expected, particularly in Egypt and sub-Saharan countries in Western and Eastern Africa (Neumann *et al.*, 2015).

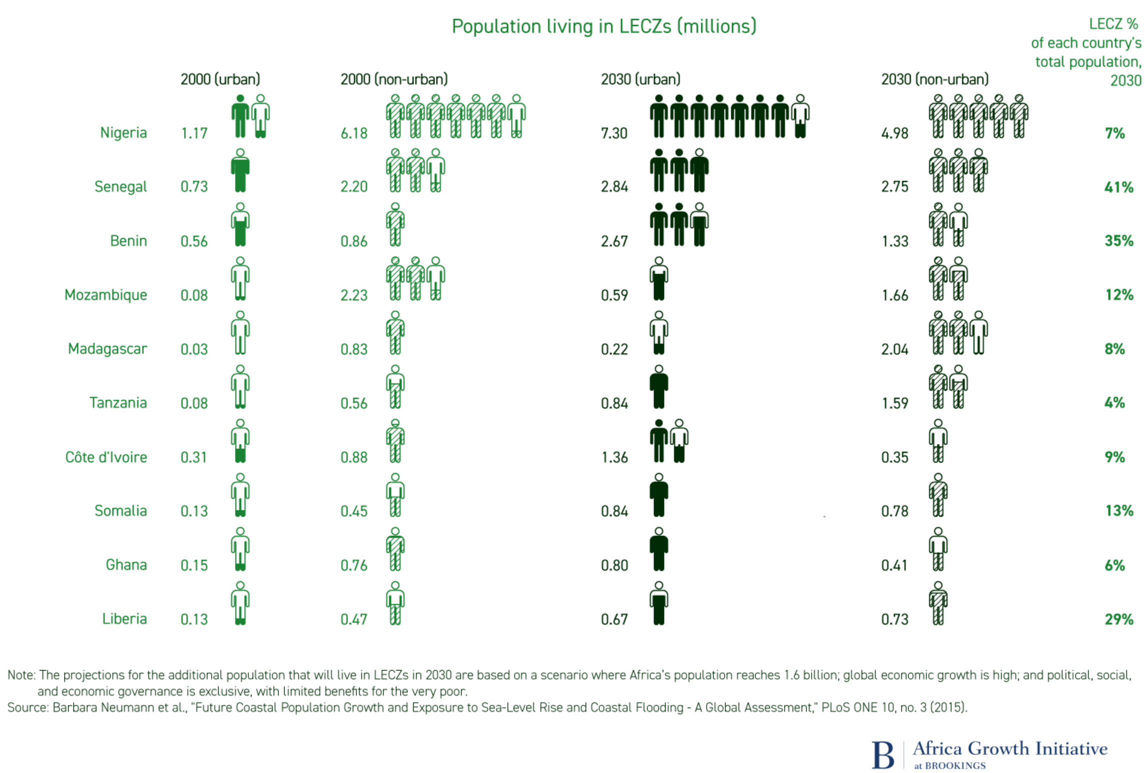

Figure 6.: Populations in low elevated coastal zones in Africa by 2030
Source: Neumann *et al.*, 2015

One of the drivers of storms, floods, droughts and wildfires has been the occurrence of El Nino Southern Oscillations (ENSO). Many drought years have coincided with ENSO occurrences.

Climate change has increased the frequency and intensity of ENSO events with significant local, regional and global consequences in livelihoods such as fishing, food security as well as critical infrastructure as a result of floods and droughts that accompany ENSO events.

Effects of Hazards on Coastal Communities

Hazards continue to inflict direct and indirect effects on peoples and communities in Africa's coasts. Based on the analysed hazards above, Table 3 presents the direct effects of hazards in terms of deaths, injury, homelessness and material costs.Overall, the recorded climate-change related hazards have led to more than 9 hundred thousand fatalities in Africa with 61,000 injured. Over half a billion have been affected by the six hazards considered within the timeframe of the study. In terms of damages, they have caused the continent over 44 million US Dolars. Droughts, even though second in frequency to floods, by far, is responsible for more fatalities and damages than any other hazards. The least of the hazards in terms of fatalities and the injured is extreme weather events.

Table 3: Statistics of Effects of Concerned Hazards in Africa

Hazard	Fatalities	Injured	No. Affected	Homeless	Damages, Adjusted ('000 US$)
Drought	867131	0	489,869,007	0	11999141
Floods	31750	36527	86176221	7037484	17591671
Storms	7855	23882	21857331	1910585	14167555
Wildfires	427	773	111788	32088	1021207
Landslides	3146	464	212948	33784	63418
Extreme Weather Events	372	216	3727500	0	98745
Total	910681	61862	601,954,795	9013941	44941737

Source: Analysis of data from EM-DAT, CRED / UC Louvain, Brussels, Belgium

Further, sea level rise has significant signatures in African coastal communities. Based on the Third IPCC Report, there has been a rise in sea level from 1900-2010 from 9cm to 88cm with a mid-estimate of 48cm (Church *et al*., 2001 in Robert, 2003). Sea level rise has direct impact on coastal communities in Africa due to increasing concentration of people resulting in rapid urbanization (Cian *et al*., 2019 and Dodman *et al*., 2017), as well as the growth in economic activities along the coast adding to the natural values located in these areas (Robert, 2003). Coastal communities are prune to certain hazards such as floods, landslides, earthquakes, sea level rise, hurricanes, typhoons, droughts, and heat waves. Sea level rise will have different effects along various portions of coastal communities in Africa depending on conditions such as sediment types and coastal platform (Hughes 1992).

The importance of wetlands especially mangroves in provisioning, regulation, and even cultural services cannot be unrecognized. Thus with the destruction of wetlands by sea level rise in coastal communities, these vital services diminish and in some cases they are lost completely. Sea level rise have equally lead to increase loss of property and coastal habitats, increase flood risks and potential loss of live and damage to coastal protection work and other infrastructure, loss of renewable and subsistence resources, loss of tourism potentials, and transportation functions as well as agriculture and aquaculture as is the case with most African coastal cities such as Nigeria, Mozambique, coastal province of Western Cape Town, and Limbe and Douala in Cameroon (Kaitano et al., 2021; Robert, 2003, Mclean *et al*., 2001, Yande 2009 and Ouikotan *et al*., 2017). Table 4 presents an aggregate result of some selected coastal communities in Africa and impact of sea level rise.

Table 4: Impact of Sea Level Rise on some Selected Coastal Communities of Countries in Africa

Country	People affected		Capital value loss		Land at loss		Wetland at loss	Adaptation cost	
	# people (10000s)	% total	Mil US$	% GNP	Km2	% total	Km2	Mil US$	(GNP %)
Egypt	4700	9	59000	204	5800	1.0	-	13100	45
Senegal	110	>1	>500	>12	6100	31	6000	>10000	>0.21
Benin	1350		118		230		85		>0.41
Malysia	-	-	-	-	7000	2.1	6000	-	-
Nigeria	3200	4	17000	52	18600	2.0	16000	>1400	>0.04
Mauritus	3	<1	-	-	5	0.3	-	-	-

Nb: Assuming existing development and a 1m sea level. All impacts assumed no adaptation, while adaptation assumes protection, except in area of low population density cost are 1990 US$.
Source: Bijlsma et al. (1996) in Robert (2003).

Coastal towns are by far the most developed of Africa's urban areas and by implication, have a high concentration of residential, industrial, commercial, educational and military facilities (UN-Habitat, 2008). Urban residential development along the coast has, however, been indicated to be a large creator of risk for much of the urban population. Hazard (such as flooding) has been identified as one of the major factors that prevent Africa's growing population of coastal city dwellers from escaping poverty and stands in the way of achieving United Nations 2030 Sustainable Development Goal of significant improvement in the lives of coastal urban dwellers (Action Aids, 2006). This is because many coastal cities lack the infrastructure to withstand coastal hazards especially in Africa (Ouikotan *et al*., 2017).

It is unarguable that large concentration of assets and infrastructure in coastal regions in Africa has contributed substantially to higher direct losses from coastal hazards. Flood, erosion, ocean surge, salinity, air pollution and others periodically revisit the same geographical zones. The increased concentration of assets and infrastructure in coastal areas will lead to more damage caused by coastal hazards. According to the United Nations (1997), a growing number of extremely large cities are located in hazardous areas, which means that large amount of infrastructures may be affected. Community assets and infrastructure have been adversely affected by series of coastal hazards. Critical public infrastructure affected by coastal hazards include: market, road, school, worship Centre, electricity and others and pose varied risk levels to different segments of the population especially the poor and vulnerable.

Yande (2009) examined the impact of floods on the socio-economic status of livelihoods for the people of Sikaunzwe communities in Zambia using both qualitative and quantitative approaches. The study established that floods impacted on people's socio-economic livelihoods and critical aspect such as agriculture, health, education, housing, water and sanitation and property and assets. The impact of floods also includes; water borne diseases, cholera, dysentery, diarrhea (Theron 2017), homelessness (parker 2000), and destruction of infrastructure such as roads (Theron, 2007). Du Plessis (1988) also stated that farming communities in Southern Africa coastal communities had been particularly hit by the successive floods of 1983, 1984, 1985, 1986 and 1987 leading to shrinking incomes and built up of debt in certain farming communities. Farmers suffered losses in stock and irrigation land, houses were destroyed, bridges and roads destroyed as well as telephone and rail way lines. This led to severe economic stagnation as government had to divert funds to revamp the economy by dealing with the impact of floods (Yande, 2009). Flooding also threatens the very existence of humans in coastal communities in Mozambique (Parker, 2000). In Mozambique, at least twenty urban centers are at risk of flooding including major settlement along the Zambezi. Further, in Sudan in 1988, severe floods, like the recent ones in 2020, led to food shortages due to destruction of farmlands and livestock, warranting food aid after the floods (Parker, 2000).

Growing incidences of flooding is linked to the compounding impacts of sea level rise and intense rainfall caused by climate change in many locations. The Kenyan coastal city of Mombassa-Kenya has been particularly vulnerable to rising sea level which impact infrastructures; roads, building via flooding threats (Kabanda, 2020). Rail ways, parking lanes, power supply, communication infrastructures have been damaged in the area over the years. A similar situation has been experienced in Cape Town in South Africa due to flooding (Taylor and Davies, 2019; Engvist and Zurvigel 2019) leading to poverty and hardships (Jordhus-Lier *et al*., 2019; Dube,*et al*., 2020). Between 1990-2018, at least 334 major flood events occurred in Western Cape, South Africa with the highest recorded in 2008 with over 20 floods episodes (Kaitano, Godwel and David, 2021). These have led to serious economic loss over the years in Southern Africa (Dula *et al*., 2018 and Fitchette *et al*., 2016). Flooding equally leads to clogging of water system with either overgrown vegetation or wastes as is the case with Limbe and Douala in Cameroon (Ndula, 2018; Abass *et al*., 2020, Datu *et al*., 2015; and Mahmood *et al.,* 2017).

IPCC, (1996) posited that climate change will exacerbate existing physical, ecological/biological, and socio-economic stresses on the African coastal zone. Most existing studies focus on the extent to which rising sea level could inundate and erode low-lying areas or increase flooding caused by storm surges and intense rainstorms. The coastal nations of west and central Africa (for example, Senegal, The Gambia, Sierra Leone, Nigeria, Cameroon, Gabon, Angola) have low-lying lagoon coasts that are susceptible to erosion and hence are threatened by sea-level rise, particularly because most of the countries in this area have major and rapidly expanding cities on the coast.

Tackling the Effects of Hazards in Coastal Communities in Africa

Knowing the origin or triggers of coastal hazards is vital to attempt managing these hazards (Ribot, 2014). Hazards of climatological origin such as floods and droughts faced by coastal cities emanate from a combination of factors such as uncontrolled urban development, climate change, urbanization, and sea level rise (Chan, 2018). There is the need to enhance understanding of coastal communities' vulnerability to these hazards in Africa (Kilhiia, 2011). Building resilience should be one of the primary focus of stakeholders in ensuring coastal communities are sustainable in the wake of climate change and its deleterious impacts such as floods, sea level rise and hurricanes (Handayani et al., 2019) and severe droughts (IPCC, 2019).

Flooding in the coastal communities in Africa is a growing issue due principally to the impact created by flood events and given that these coastal environments host a myriad of investments and growing population. There is therefore the need to augment flood hazard management strategies. Flood hazard management can be divided into two parts; flood hazard assessment and hazards reduction (Ouikotan et al., 2017). The objective of flood hazards assessment is to establish where the hazard is unacceptably high while hazard reduction is to select and implement measures in order to alleviate the flood hazard. Structural measures such as dams, dikes, coastal embankment and drainage network are insufficient and even the existing ones are not well maintained (Ouikotan *et al*., 2017). In cities like Lagos in Nigeria, structural measures are varied and comprise of storm water drainage channels, breakwater, dredging of river, channelization and revetment; these were constructed to protect the city from storm surges and coastal flooding (Ouikotan *et al*., 2017; Adelekam, 2015).

Adaptations which could be planned or autonomous are therefore necessary. In some communities, adaptation is widely seen as a public responsibility (Klein et al., 2000). This therefore means that all levels of government have a key role in developing planned adaptation measures which can be planned, accommodation and protection (Klein *et al*., 2001). However, a mixture of these operates in most cases and in certain circumstances the accommodation option remains largely unassessed (Robert, 2003). There is need to anticipate and plan for tomorrow rather than wait and react only when the capricious events have hit a community (Robert, 2003). Given that many decisions at the coast have long-term implications, the coastal zone is an area where anticipatory adaptation needs to be carefully considered such as upgraded flood defense and waste water discharges, construction of new bridges, and building setbacks to prevent development (Mclean *et al*., 2001 in Robert, 2003).

In Mozambique coastal areas, Yande (2009) recommended relocation with the provision of necessary social amenities such as hospitals, water, school and infrastructure, delineation of both the flood prone and non-flood prone areas with the latter serving as a temporal shelter for settlement during flood episodes. He also underscores the need for construction of canals into the Zambezi River and communities encouraged to use durable material for constructions as well as awareness made by stakeholders to local authorities and community based floods early warning system.

In some localities in Accra, Cotonou, Dakar, Nigeria, Limbe, Douala, and some Southern African coastal cities children are taken to the rooftop to preserve them from flooding; blocks or sand bags are used to create pathways for pedestrians, valuables goods are displaced to higher places such as top of the wardrobes, cupboards and tables (Action Aid 2006). Households in Accra fill and cement the compound of their houses; raise the building foundation or construct a retaining wall (Abeka 2014). In some coastal communities in Cameroon like Douala, during flood periods, people evacuate floodwater with the means of buckets, basins or they dig some trenches or place some PVC pipes to drain water from the houses (Ndula, 2018). In Lagos, moveable properties are relocated outside the flooded area, drains are constructed in front of houses, buildings are renovated, walls are built to prevent floodwater from entering houses, outlets are made at the backyard of houses to let floodwater flow from the houses (Ouikotan *et al*., 2017; Adelekan, 2010).

There is much that decision-makers can do to protect the well-being of the city's population and lessen the potential harms of natural disasters and climate change to the economy. In a bid to respond to hazards, urban planning has been implemented such as in the North African Coastal Cities of Alexandria which is exposed to risks. The Master Plan is prepared to direct future urban growth, define city limits, and establish a land-use program with rules for densities, building heights and open space ratios taking into account future climate scenarios. This is therefore a good way to tackle hazards in coastal Africa.

Also, infrastructure investments are a non-negotiable. Investments in making existing structures more resilient would benefit coastal marine defenses. Some key urban infrastructures and buildings, along with water supply and drainage systems, could be made more robust and better able to withstand the damages that can occur in storms such as the one that affects most African countries. Some of these cities can lower flood-related risks by taking steps to improve control of runoff and discharge sources, and routine maintenance of the sewage system. These would lower risks during floods and storms. In addition, areas slated for development can be sited and prepared to minimize the vulnerability.

There is equally need for institutional preparedness in areas where same is lacking. Upgrading early warning systems covering all types of disasters emerges as a particularly sound investment. Improved management of coastal areas also emerges as critical. For example, a system of "smart buoys" along the coastline could help generate timely data that could help protect people and property from coastal storm surges. Improved communication among agencies involved in disaster prevention and response could strengthen timeliness and coordination, leading to more robust responses.

Breakwaters are offshore structures designed to intercept and reduce wave impact arriving at the coastal areas in communities mostly hit by coastal hazards in Africa. In West Africa, breakwaters are mostly implemented at the harbours for the purpose of reducing wave actions on ships. For instance, the deep water port of Lomé opened in 1967 and the distant Akosombo Dam in Ghana have played a great role in disrupting the sediment dynamic along the western coast in the Bight of Benin (Anthony and Blivi 1999). Togo faced several coastal management challenges that involved shoreline dynamics, pollution, flooding, and the possible effects of rising sea levels. The Lomé beach eroded at an average rate of nearly 7 m/year (Blivi 1993). To control this, the coastline was protected by building breakwaters along 12 km of the coast from Kpeme Gumukope to Aneho (Blivi 1993). Furthermore, as part of the Benin Sea Defence Project to protect 7 km of coastline that was eroded to 762 m in 40 years, a 300 m long breakwater was constructed. Other breakwater projects implemented in Africa include the Abidjan Port Expansion Project. The construction includes the demolition and reconstruction of the east and west breakwaters at the entrance to the canal. The project aimed to improve the status of the port of Abidjan as a central port on the Atlantic coast and to promote socio-economic development of Côte d'Ivoire and West Africa as a whole.

Another important way of managing coastal hazards in communities of Africa can be through the use of groynes. It is the process to mitigate, or displace, coastal erosion facing urban or punctual important (important enough to be protected) areas. Amongst the most popular is the method practiced is in the West African sub-region, from Senegal to Nigeria. The Keta coastal area which is located east of the Volta River estuary started experiencing erosion between 1870 and 1880 after about 200 m to 300 m of land was removed from the central Keta area (UNESCO-IOC 2012). The recession at the mouth of the Volta grew annually at between 4 m and 10 m after the Akosombo Dam was constructed on the Volta River (Angnuureng *et al.*, 2013). This dam prevented about 99.5% of sediment discharged by the river from getting to the beach (Ly, 1980).

Jetties and revetment ensure reliable stabilization of tidal inlets or river mouths, regulating the development of undesirable features, like channel siltation. These structures are usually constructed to intercept sediment that is transported alongshore, so that they can prevent sediment accretion in inlets or estuaries. Large quantities of sediment are trapped in the updrift of the jetty. But such a process also results in a narrowing of the coastline downdrift of the jetty. Since jetties are relatively longer than groynes, greater sediment loss to deep water is much more experienced during storm events (Masselink and Hughes 2003). Jetties are, for example, located at the eroding tidal inlets of the Elmina Benya lagoon in Ghana, in the port of Takoradi, in the port of Cotonou as well as in other areas along the Gulf of Benin (Anthony et al. 2019; Abessolo Ondoa *et al*., 2020). Revetments are structures to protect a soft feature such as a dune or coastal slope or provide supplementary protection to existing defenses such as a dike or seawall (Bayle et al. 2020). Between 1959 and 1960, a 100 m long revetment was built on the coastline of Jamestown, Accra (UNESCO-IOC 2012).

Training courses, data collection, budgetary preparations are a good way to revert the impact of climate related hazards in coastal communities in Africa. Most African coastal hazards countries are today organizing training courses to help build the capacity levels of their engineers or officials in order to equip them properly. Also, these officials are trained on how to take and prepare data collection and forecast prior and after a coastal hazard occur. Furthermore, most of these coastal hazards communities in Africa sometimes make available a budgetary package for any eventuality of such coastal hazards like flooding, earthquakes, tsunamis etc.

Hazards Management Challenges in African Coastal Communities

Despite the observed increases in the trend of hazard events and huge magnitude of damage, the management methods implemented to solve them are inadequate and inefficient. Ouikotan et al., (2017) point out the gaps and the challenges that need to be tackled for a proper flood risk management in West African coastal cities. First, structural measures are a means to revert the impact of hazards on coastal communities in Africa. However, these measures fall short yielding the desired outcomes. In Senegal, Nigeria, Ghana and Cotonou coastal cities, the simple way of determining floods risk as at 2017 was by flood prone areas mapping, done by simple observations and interviews, recording and mapping of flooded areas (Ouikotan et al., 2017). Flood damages estimate is done roughly after a flood event mainly to know the number of affected people and organize the relief services. There is equally the problem of little or no publication of figures of damage cost but for Lagos-Nigeria whereby sometimes figures of damage cost are published by Lagos Insurance Companies (Ouikotan *et al*., 2017).

There is equally the challenge of using obsolete master plans in most coastal environment. For instance, structural measures such as dams, dikes, coastal embankment and drainage network are used which sometimes are insufficient and lack maintenance. For instance, in Dakar their master plans were not reviewed until 2013 (Diongue, 2014) due principally to the lack of political will, so drainage works were designed without any scientific basis. Another challenge is that of insufficient and not well maintained drainage networks (Diop 2006, Gnele 2010, and Africa Development Bank Group, 2006).

Aside the structural measures, the non-structural measures such as land use control and catchment management via legislations or use of institutional approaches are vital in mitigating the impact of the effect menacing the coastal communities in Africa. Based on land-use control and catchment management, myriad of the literature points out the fact that in most coastal communities in Africa, laws and guidelines for land planning and management are diverse, uncoordinated with a lot of centres of decision making (Ouikotan et al., 2017, Abilabi, 2018, Alemagui, 2006 and GFDRR, 2010). Urban planning policies, until now, have been weak and not capable of reducing or prohibiting settlements in low areas, flood plain and swampy areas and also to regulate the population movement towards the city; so that a lot of population are living in flood prone areas (Balgah and Fombe, 2012, Fogwe, 2007, Kemengsi, 2018). According to Rain *et al*., (2011) 172,000 residents are estimated to be at risk in Accra of a 10-year flood and 33,000 residents are located in slums. The General census made by the Municipality of Cotonou showed that in 2010, 9% of the parcels were in flood prone areas (Ouikotan *et al*., 2017). In Dakar, the irregular constructions cover more than 25% of the urbanized zones (Ouikotan *et al*., 2017). Just as in Douala and Limbe coastal towns of Cameroon, Western Cape, South Africa, Mozambique, Zambezi coastal areas. In Lagos-Nigeria, it is estimated that 70 per cent of the city's population lives in slums. Since 2011, Lagos state government has embarked on the demolition of buildings located on drainage paths (Adelekan, 2015 in Ouikotan *et al*., 2017).

Preparedness and planning disaster relief are another measure of adapting to the deleterious impacts of floods in coastal communities in Africa. Many coastal communities in Africa have developed flood disaster relief and implemented an emergency plan in case of disaster (Ouikotan *et al*., 2017). In Ghana, the National Disaster Management Organization (NADMO) was established in 1996 to manage disasters and similar emergencies in Ghana. It is responsible for the preparing plans against flooding, coordinating resources of government institutions and non-governmental institutions, mobilization of help for affected communities and relocation of people and providing food aid in a post disaster scenario (NADMO, 2016). However, the level of preparedness, recovery and response in post disaster phase is very low and this increases the chances of further damage (Bhattacharya-Mis and Lamond, 2011 in Ouikotan *et al*., 2017).

Furthermore, early warning systems in African coastal communities are equally an issue of concern. As opined by Ouikotan *et al*., (2017) early warning schemes have not yet worked properly as the case with flood damage reduction measures especially in West African coastal cities. For instance, in Cotonou and Dakar, they are not yet implemented and in Accra and Lagos where they are implemented, they are not working properly. Even when implemented with the aid of bilateral cooperation, the lifetime of projects is short-lived, due to lack of maintenance.

Research Limitations/Implications

Even though committed to fighting climate change by ratifying relevant global and regional instruments, a lot is needed from many African governments in addressing SDG 13 of the UN Agenda 2030 on Taking Climate Action. Importantly, it is necessary to adopt adequate measures and mobilize resources in developing coastal stabilization programmes necessary to reduce coastal exposures to these hazards. Indeed, there is limited application of the Sendia Framework on Disaster Risk Reduction as coastal communities still experience loss of human lives, human injury and destruction of livelihoods and critical infrasture as a result of climate change-related hazards.

Originality/Value of the Paper

This paper highlights and discusses the trends and impacts of climate change-induced hazards on African coastal communities. The paper sheds light on the growing trend as well economic impacts of such hazards. In terms of the various existing adaptions, the paper indicates that major gaps still exist especially as these hazards to continue to kill, injure and destroy the livelihoods of mostly the vulnerable coastal populations. Given the limited investments in infrastructure to help adaptation efforts in these communities, the paper indicates that most of the economic costs linked to climate change relate to livelihood destructions.

Even though committed to fighting climate change by ratifying relevant global and regional instruments, a lot more is needed from many African governments in addressing SDG 11 of the UN Agenda 2030 on Taking Climate Action. In ensuring the effective implementation of 2015 Sendai Framework on Disaster Risk Reduction (DRR), it is necessary to adopt adequate measures and mobilize resources in developing coastal stabilization programmes necessary to reduce coastal exposures to these hazards. This is critical in saving lives and livelihoods. The success of this will largely depend on creating and emphasising partnerships at all levels. The

2015 Paris Agreement in this light offers glimpse of hope in the global commitment to address climate change. However, without effective political commitment and partnerships with local, national and regional institutions and stakeholders, the expectations of the agreement especially in contribution to attaining SDG 13 could remain utopic.

One of the key ways of addressing these risks therefore lie in developing robust early warning mechanisms based on consistent data records and improved monitoring technologies of weather and climatic phenomena, while ensuring sustainable land use practices. The success of this is anchored on synergies between development stakeholder involving national, regional institutions, and global institutions. While national governments should live up to their commitment to the Nationally Determined Contributions (NDCs) including reviving the National Adaptation Plans (NAPs) in addressing climate change in line with UNFCCC, activities of regional organisations such as the Africa Development Bank Climate Change Financing projects are critical in helping communities adapt sustainably to the adversities of climate change especially on businesses in coastal communities of Africa.

Conclusion

Climate change is indeed an existential threat to African coastal communities. The geographical diversities of Africa’s coasts serve as precursors to many anthropogenic climate change-related hazards such as floods, droughts, storms, landslides and wildfires amidst others. This paper e-rays the trends and balance sheet of these hazards on coast communities in Africa especially in terms of casualties, loss of livelihoods and infrastructural damages. This clearly indicates that the implementation of the Sendai Framework of DRR in Africa needs to be expedited in order to make Africa safe in the face of climate change adversities. Key amongst other areas of intervention are improving disaster monitoring and early warning systems as well as investing and supporting local, regional and national governments on building robust coastal stabilisation programmes that will enable them sustainably adapt to these adversities while efforts to decarbonise the global economy continue as a sure step towards climate change mitigation.

Furthermore, in order to ensure effective hazard management in coastal communities in Africa, there is the need to adopt proper hazard assessment not emergency management after due diligence has been taken to collect the necessary data pertaining to the pre, during and post hazards events. Most importantly are data on climate, hydrology, hydraulic, land and soil conditions. Adequate tools like hydrological and hydraulic models and potential damage evaluation tools are needed for flood hazard assessment and they cannot be applied effectively mainly due to lack of data and lack of skilled personnel (Ouikotan *et al*., 2017). Even when the data exist, the legal instruments to ensure the implementation of policies are lingering with lapses and there is limited application of modern day tool such as GIS and satellite images or models for hazard assessment and management in most coastal environments in countries such as Nigeria, Cameroon, and Ghana amongst others.

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