

## CLIMATE CHANGE AND WATER RESOURCES IN LIBERIA: FLOOD RISK ASSESSMENT OF TWO SLUM COMMUNITIES (WEST POINT AND NEW KRU TOWN)

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Article Received on 23/01/2022

Article Revised on 13/02/2022

Article Accepted on 03/03/2022

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### ABSTRACT

The far-reaching impacts of climate change are gradually becoming a global emergency. The manifestations vary from region to region. Due mainly to higher precipitation and sea-level rise, flooding has emerged as one of the leading disasters exacerbated by the ongoing climate crisis. Liberia being one of the wettest countries in the world (World Bank Group, 2021), flooding is reasonably one of the most anticipated natural disasters, if not the most. Through Extensive Literature Review, ELR, and contacts with resourceful informants in the

environmental, disaster management, and water sectors of Liberia, this paper assessed the flood vulnerability levels of two of the flood-prone communities in Monrovia, West Point, and New Kru Town. Variables considered for ranking were dominant infrastructure type, frequency of flooding, time of flooding (months of the year), average income, and household size. Results indicate high population density, fragile infrastructure (mostly zinc shacks), flooding occurring mostly from July-September, and massive unemployment amongst residents of the two communities. Lack of proper urban planning resulting in poor drainage infrastructure sufficed as one of the major reasons for flooding in these two communities. Findings show a lack of preparedness from disaster management agencies like the EPA and LDMA. Most of the disaster management and environment management programs have been primarily reactive. Flooding events and victim reparation are emergencies only during flooding periods. Solutions will encompass adaptations strategies that build the resilience of

would-be victims to anticipated impacts through proper policy formulation and holistic implementation in addition to improved urban planning.

## INTRODUCTION

Climate change and the resulting negative consequences such as rising sea levels, desertification, land cover degradation, flooding, water scarcity, and water stress; and finding solutions to these are amongst the most significant challenges currently facing humanity. As the human population grows, resulting in more resources (food, fuel, shelter), the pressure on the natural environment intensifies, thus leading to extreme climatic events. As an essential element for life, water has suffered its most devastating attack due to climate change. The 70% mass of water covering the earth is a bubble. It constitutes over 95% is a saltwater deposit in the form of oceans. Less than 3% of global water is freshwater. Frustratingly, less than 15% of this is surface water, while the remaining freshwater available can be found underneath the earth as groundwater, ice caps, and glaciers. This finite amount of fresh water is under severe threat from rising pollution from industrial waste, human-induced scarcity, agriculture, and most notably, climate change. Projections hold that over two-thirds of humanity will face water challenges by 2050 (Boreti & Rosa, 2019; United Nations, 2018). Water security amid increasing scarcity is one of several current methods to combat water vulnerability. The term implies the capacity of a population to safeguard sustainable access to adequate quantities of water of acceptable quality (Boreti, A. & Rosa, L., 2019). Liberia is approaching two centuries of political independence. Little research has been conducted to document water data, consumptive and non-consumptive, assess potential threats, and instituted rigorous policy measures on safeguarding water resources in the country. This paper aims to contribute to this body of knowledge by dipping into the factors exacerbating climate change and the implications for water resources in Liberia. In the end, the research hopes to proffer policy recommendations based on experiences from other states on best practices in the water sector to curb the impact of climate change.

### 1.1 Problem statement

As the impacts of climate change become far-reaching, sea levels are rising unprecedentedly, leading to the destruction of coastal habitats. The slums of West Point and New Kru Town are amongst the most vulnerable places prone to coastal sea erosion. Inhabitants of these two coastal communities are considered some of the poorest groups in Liberia. In 2012, Monrovia

experienced its worst flooding event leaving over 10,000 residents of West Point and New Kru Town homeless (FPA, 2012).

These two communities are projected to be most affected by future climate change eruptions than any community in Liberia.

### **1.2 Significance of the study**

Overall, Africa is projected to be most affected by future climate events. This projection is precedent because Africans are poor and lack the institutional and structural framework to combat the growing impacts of climate change. Residents of slum communities like West Point and New Kru Town are even more susceptible to harsher has implications due to flooding-prone infrastructure and acute poverty. Assessing vulnerability informs adaptation and mitigation measures. This research hopes to inform national policymakers using data-driven recommendations on integrating flood-resilience adaptation measures to improve the capacity of these communities

### **1.3 Delimitation**

Several types of research have been conducted by academics, government agencies, and interested Non-government Organizations, NGOs on flooding impacts in the coastal city of Monrovia. However, none such research or survey has focused on the vulnerability assessment of the two most affected communities (West Point and New Kru Town). This research utilized the 'Key Informant' source approach to gather information on flooding sequence, affected livelihoods, dominant infrastructure type, and average income levels. One major limitation of the research is that residents of the affected communities could not take part in the study due to resource constraints both financially and materially.

## **2. LITERATURE REVIEW**

### **2.1 Overview**

Several studies project that climate change's direct and indirect effects will undoubtedly negatively impact water infrastructure, food, and human systems (Goyal & Surampalli, 2018). Africa has been pointed out as one of the world's most vulnerable regions, most vulnerable to climate change impacts due to almost all 54 states (Kusangaya et al., 2014). As a result of greenhouse gas emissions, primarily from the unrestricted use of fossil fuels, the human-induced crisis of climate change and its adverse impacts on water resources has led to a warming planet threatening lives and livelihoods, particularly for poor people in Africa and

other developing countries. Between 1980 and 2009, floods were projected to have killed 539,000 people and negatively impacted the lives of 2.8 billion people globally (Eccles et al., 2019; Doocy et al., 2013). Although studies on the possible effects of climate change on flood danger have advanced significantly over the last decade, attempts to transform this knowledge into practical guidelines for flood estimates are still in their immaturity (Wasko et al., 2021). This research seeks to assess the effects of climate change on water resources in Liberia, precisely the issue of flooding in two slum communities, West Point and New Kru Town.

As climate change's impact creates more strain for the current water crisis, fixing this rise in water vulnerability will require a thorough understanding of not only timing but location and magnitude of change impact on water availability (Boehlert, B. et al.

In addition to availability and access to fresh water, the geographical and temporal distribution of resources, competition among its uses, ecosystem protection, climate-related disasters and dangers, and various other factors are also important considerations. To analyze the effects of climate change on water resources in New Zealand, Zemansky et al. (2012) employed two methods: (1) trend analysis of historical climate and hydrology data from routine monitoring systems using the Mann-Kendall method, and (2) modeling of anticipated effects as a result of conventional greenhouse gas emission scenarios and concluded that water use increased, but higher stream recharge made compensated for the loss in groundwater recharge from rainfall. As a result, streamflow was significantly affected, although groundwater levels were only slightly affected. Persad et al. (2020) argued that California risks wasting water investments, failing to meet sustainability goals, and experiencing significant water supply deficits if water planning does not account for the whole range of expected climate consequences. Most water resource planning decisions continue to downplay the immediate impacts of climate change on water.

## **2.2 Climate change and Urban Flooding**

There are compelling pieces of evidence already pointing to the impact of climate change on natural and artificial water structures. A warmer climate can transmit many adversities to our planet. Irregular rainfall or precipitation patterns leave wet areas wetter and dry regions drier. In addition to being of the projected hotspots for future Climate disasters, Liberia is mainly situated along the coast. Higher precipitation rate accompanied by rising sea levels and the low elevation of Monrovia makes the capital flood-prone. Cities are being most affected by

climate-induced flooding. In July 2021, Europe experienced one of humanity's worst-ever flooding events. This catastrophe destroyed lives and offset urban infrastructure in the affected areas.

### **2.3 Flooding in Germany, Belgium, and Luxemburg**

Germany is located in Western Europe. Ranked the seventh-largest nation in Europe, Germany is home to approximately 84 million people. In July 2021, Germany experienced one of its deadliest flooding events when flash flood took residents of many communities by storm in mainly the country's Western region, leaving hundreds dead and much more homeless (Cornwall, 2021). The flooding was a result of a heavy downpour of rain. Unprecedented precipitation of about 15 centimeters left nearly 165 people dead, and mass housing washed within just 24hrs. Germany experienced its worst flooding event; another wealthy European nation, Belgium, was hit with a massive landslide due to high precipitation. Approximately 50 lives were lost, and a quantum proportion of property and infrastructure lie in ruin. Luxemburg, another European giant, was hit by floods and landslides during the same period. Scientists have warned for years that climate change would result in more floods in Europe and worldwide. Hotter air contains more moisture, which may result in more significant precipitation. Flood damage on the continent may cost up to €48 billion per year by 2100 — up from €7.8 billion currently (Cornwall, 2021). These compounding environmental issues leave one wondering if such impacts can be felt by some of the wealthiest nations globally; what would the case be for a fifth-ranked poorest country in the world like Liberia. Climate change impact assessments are mired by uncertainties scientists are struggling to overcome.

### **2.4 Recent flooding events in Monrovia**

In Monrovia, Liberia's capital city, flooding remains unabated due to the heavy downpour of rain, poor drainages, and the construction of buildings in waterways (Charles et al., 2020). In 2016, Monrovia experienced its worst flooding incident in centuries. As a result of flash floods in Monrovia, the primary route connecting the Roberts International Airport in Liberia's capital city of Monrovia was closed, displacing thousands of citizens and forcing many to abandon their homes (Oduor, 2016). As the urban population skyrockets, the likelihood is even higher for the incidence of these environmental disasters. Measures instituted to tackle the recurrence of these climate-induced environmental calamities remain primarily reactive.

Another flooding event in July 2018 left approximately 35,000 people affected, according to a National Disaster Risk Management Report in 2018. The distribution of victims by location showed that West and New Kru had the most affected. About 60% of this number (17,466), according to the NDRM's datasheet, were women and children. In the last decade, floods have wreaked havoc on Monrovia. For a city with a significant homeless population and many informal settlements, there are growing concerns over the likelihood of sanitary problems and the spread of sickness.



**Figure 1: Parts of Monrovia submerged in water as flood rages havoc on residents in 2016 & 2018.**

## **MATERIALS AND METHODS**

### **Study Area**

Liberia is a small nation located on the west coast of Africa with an estimated population of about 5 million people spread across a landmass of approximately 96,320 km<sup>2</sup>. Liberia is one of the wettest nations on the planet, with rivers, jungles, mangroves, and marshes aplenty (UNICEF, 2017). Several significant river systems drain a great portion of the nation in Liberia. These rivers originate in neighboring countries and travel mostly from northeast to northwest. In addition, several small rivers run directly into the sea in the coastal zone ("Hydrogeology of Liberia," 2021). Liberia has six major rivers and a vast stretch of the Atlantic Ocean along the coast. Major rivers in Liberia include St. Paul, Cavalla, St. John, Cestos, Mano, and Lofa River.





Figure 2: Hydrological map of Liberia showing the major rivers.

Monthly Climatology of Min-Temperature, Mean-Temperature, Max-Temperature & Precipitation 1991-2020 Liberia

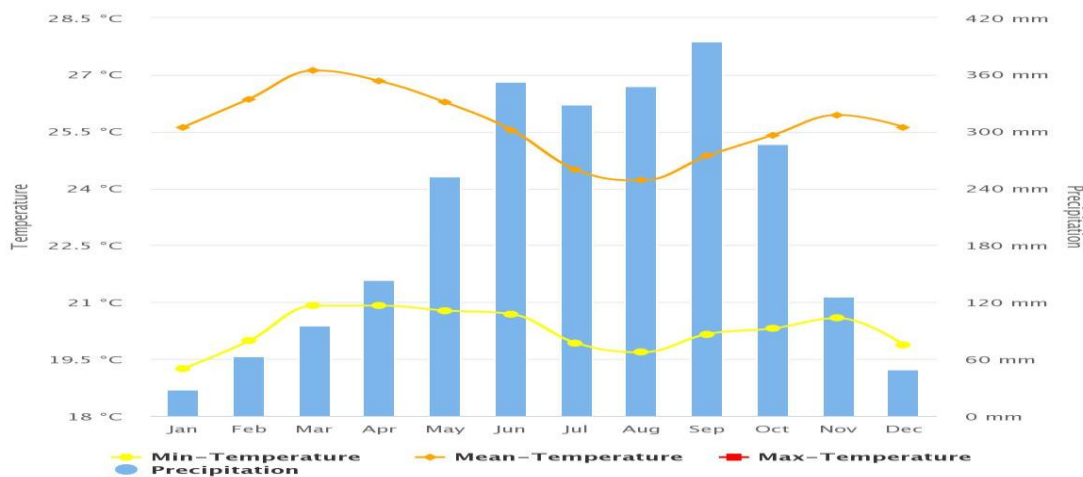
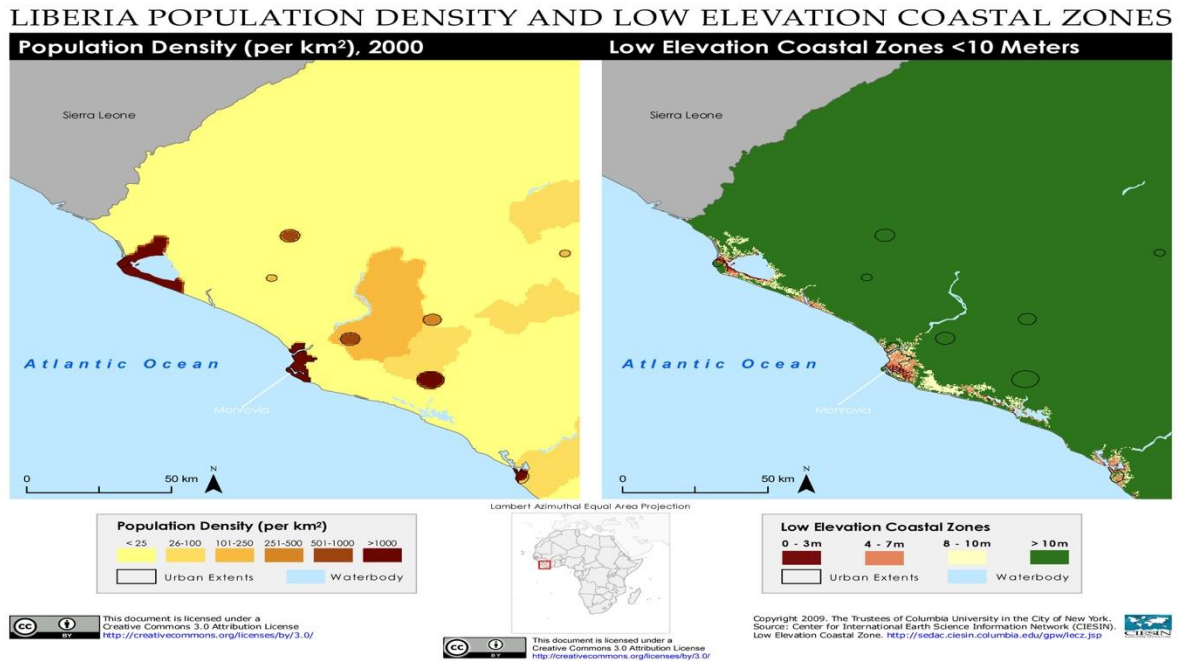


Figure 3: Data for min, max, mean temperature and precipitation trend in Liberia from 1991-2020. Copyright (World Bank Group, 2021).

### 2.5 Monrovia

Monrovia is situated along the coast, on the peninsula of Mesurado, between the Atlantic Ocean and the Mesurado River, the mouth of which provides a vast natural port. Monrovia has a tropical monsoon climate, according to the Köppen climate classification (Am). It is the wettest capital city globally, with an average annual rainfall of 4,624 millimeters (182.0 in). The yearly temperature of Monrovia averages relatively around 26.5 degrees Celsius. The elevation is low due to the coastal situation of the area. The height is less than 10m above sea level, making it the most vulnerable to extreme climate events like flooding. Two of Liberia’s

major rivers (Cestos and St. Paul rivers) flow across the capital city of Monrovia, constantly flooding wetland areas. Socioeconomic issues like high rates of severe poverty, joblessness (56.6 percent in Greater Monrovia), dense population, and underdeveloped infrastructure exacerbate the susceptibility of broad segments of the people to climatic effects (Climate Resilience- Liberia, World Bank, 2019).



**Figure 4: Map of Monrovia showing population density and elevation sourced from Google Copyright 2020.**

## 2.6 West Point and New Kru Town

Considered two of the largest slums in the capital of Liberia, West Point, and New Kru Town have been the primary destination of internal migrants since the 14yrs of war (Draper, 2018). This mass movement of people to these locations results from cheaper housing and a low cost of living. West Point and New Kru Town are regarded as the two largest slums in Monrovia, with a combined estimated population of 130,000 with a population density of about 22,000/km<sup>2</sup> (LDHS, 2014). The Freeport of Monrovia is located less than 1km from these two communities on both sides. This port location creates multiple disturbances regularly as ships duck and exit. The Du or Monserado river experiences regular ocean intrusion due to this ship ducking and exiting.





**Figure 5: Merged images of Near Sea West Point and Infrastructure in New Kru Town.**

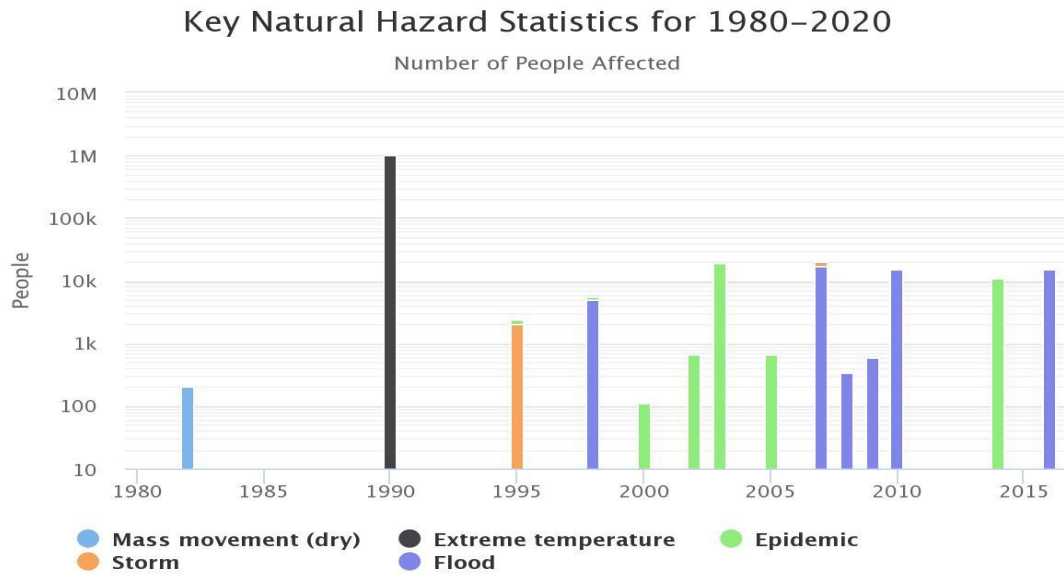
The images in **Figure 5** of housing infrastructure in the slums of West Point and New Kru Town are only not deplorable but unfit to resist uneasy climate ravaging- in short, they are not flood-resistant infrastructures.

## **2.7 METHODOLOGY**

The research used a Systematic Literature Review (SLR) to examine expert published materials on the subject. This research utilized sources like Google Scholar, ScienceDirect, JSTOR, and SpringerLink to gather and review these publications. The IPCC recommended variables in measuring climate change impact on water resources (precipitation, temperature, and sea-level rise) were studied thoroughly using available data on rainfall patterns and temperature changes from 2006-2018 to measure flood impact on residents and assess vulnerability levels. The ArcGIS software 10.0 was used to source satellite images of the two communities and erosion impacts on infrastructure. Key informants in the environmental sector like EPA, the National Disaster Risk Management, and the water sector were contacted for information on flooding sequence in the last 15yrs, affected livelihood, and income matrix of inhabitants.

## **RESULTS AND DISCUSSION**

Climate change impacts are being felt already in Liberia. Drastic changes in precipitation pattern over the years has left Monrovia even wetter. The low elevation (<10m) makes the city susceptible to increased flash flooding.



**Figure 6: Data summary of the incidence of Natural Disaster from 1980-2015; sourced from World Bank Climate data for Liberia. Copyright World Bank Group 2021.**

A World Bank climate data suggests that flooding has been the most disrupting disaster in urban Liberia in the last four decades. More residents have been affected by flooding than any other natural disaster in the previous 40yrs as it accounted for about 30% of disaster management issues.

Changing precipitation is likely to result in high-risk flooding scenarios because of Liberia's large number of rivers, drainage basins, and aquifers, as well as its low-lying coastline zone. Because of its location on the coast, Liberia is vulnerable to rising seas and urban flooding (World Bank, 2021).

## 2.8 Vulnerability Level Assessment

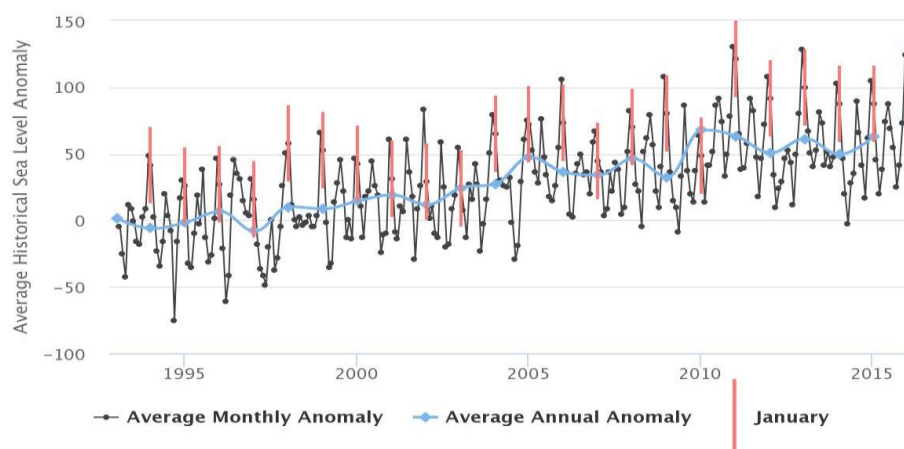
The World Bank's climatic projection for Liberia indicates that Monrovia is highly vulnerable to climate change due to its low elevation and high precipitation. Rising ocean levels may also put coastal regions at greater risk of flooding during periods of severe rainfall (USAID, 2017). According to the United Nations Environment Program, Metropolitan Monrovia region alone, a forecasted sea-level rise of 16 cm by 2030 will put 675,000 people and 9,500 hectares of land in danger.

These extreme weather events will most affect West Point and New Kru Town. The two communities are densely populated, with a combined population of approximately 130,000 people and a density of 22,000/km<sup>2</sup>. The housing infrastructure for the two communities is

similar, predominantly zinc shacks. The income level, on average, is extremely low. While Liberia is prone to floods but not drought, future challenges may include population dislocation in neighboring nations. Rainstorms, storm surges, rise in sea levels, and increasing erosion exacerbate the vulnerability of urban and rural infrastructure (World Bank, 2021). Comparatively, West Point seems far more vulnerable than New Kru Town. This is due to 1) the difference in elevation and 2) the population density. The income levels are the same for the two slums.

Historical Sea Level for coastal Liberia (1993–2015)

*observed anomalies relative to mean of 1993–2012*



**Figure 7: Observed sea level rise along Monrovia's coast from 1993-2015; Copyright, World Bank Group, 2021.**

### Current efforts by Government

Through specialized agencies like the Environmental Protection Agency and Disaster Risk Management, the government of Liberia has been making efforts to mitigate the impacts of coastal flooding. Liberia's commitment to almost all international treaties on ecosystem environmental sustainability speaks volumes to her urge for a cleaner, greener, and safer planet. When nations assembled in Paris, 2015 to booster efforts to the SDGs, Liberia was present and after that committed herself to work with partners to ensure a safer planet for future generations. The aftermath of the 2016 flooding in Monrovia left stakeholders pondering effective ways of preparing and tackling disaster.

### The National Disaster Management Act of 2014

The NDMA is a legal tool that ensures that appropriate authorities are given the power to identify, analyze, and monitor early warning catastrophe risks across the nation. Above all, it

will help develop these institutions to respond to emergencies quickly, effectively, and efficiently. This will have a significant impact on poverty reduction.

### **National Disaster Risk Management Policy 2012**

The NDRMP has five priority focus: i) Create a legal, institutional, and good governance framework for disaster risk management (DRM)

ii) To provide general direction for incorporating disaster risk reduction into development, recovery, and humanitarian response policy and plans;

iii) To provide overall direction for integrating disaster risk reduction into development, recovery, and humanitarian response policy and plans; iv) Contribute to national risk management applications for sustainable national development; and v) Strengthen disaster preparedness for effective emergency and recovery responses.

### **The National Action Plan for Disaster Risk Education- Liberia 2016-2021**

The NDRM team devised “National Action Plan for Disaster Risk education - Liberia 2016 to 2021” in response to the growing dangers of rapid coastal flooding and other forms of natural disaster. This action plan has five thematic areas: 1) devise governance for disaster risk reduction, 2) enhance preparedness for emergency response, 3) increase alert for risk identification, 4) education, and 5) risk management application.

### **The Monrovia Metropolitan Climate Resilience Project (EPA’s FP160 Project)**

The FP160 is an ongoing adaptation program being implemented by the Environmental Protection Agency of Liberia to build coastal resilience to predicted impacts of climate change. This project is being financed by the Green Climate Fund and hopes to build coastal defense infrastructure, produce a flood mitigation plan, and help coastal populations diversify their livelihoods. Climate change negatively impacts the Liberian capital, Monrovia, which is especially susceptible to sea-level rise and an increased frequency of high-intensity storms. In turn, this has culminated in coastal erosion and coastline retreat, which endangers the long-term viability of ecosystem services and directly affects the fisheries-based livelihoods of the people of Monrovia (EPA Liberia, 2021).

### **Limitation of current efforts**

Disaster emergency planning seemed to be of little interest among practically all of the national development operations that have been taking place in Liberia since the country's independence a century ago, especially for most previous national political governments

(Koffa, 2018). Traditionally, public policies in Liberia have been reactive. Currently, disaster management programs have primarily been implemented in response to crises. Like most development initiatives for the third world, flood mitigation has been primarily funded by donor countries on a relief basis. This culture of foreign-sponsor dependency subjects these initiatives to terms that are not sustainable. Programs such as “The EPA’s coastal relief initiative” have all been reactive and failed at preparing victims adequately to avert future danger. There seems to be no policy framework that is/is homegrown to build the resilience of potentially affected communities to the impacts of climate-induced flooding. There has been a series of fiasco programs to relocate the residents of flood-prone West Point by succeeding regimes. Most of these relocation plans have failed miserably because they targeted donor sponsorship. Disaster management programs by the LNDRMA have been in response to flooding events. Compounding this problem is the fact that Monrovia is poorly planned. The city’s population has grown tenfold since the civil war. More than any other event in the country's history, the 14-year civil war exacerbated the country's environmental circumstances. Due to the civil conflict, residents and communities were exposed to significant degrees of vulnerability (Koffa, 2018).

## **CONCLUSIONS AND RECOMMENDATION**

### **Conclusion**

Science has at least proven beyond reasonable comprehension that our climate is changing and that the ripple effects are far-reaching and daring for humanity. As the human population grows, resulting in more resources (food, fuel, shelter), the pressure on the natural environment intensifies, thus leading to extreme climatic events. A warmer climate can transmit many adversities to our planet. Irregular rainfall or precipitation patterns leave wet areas wetter and dry regions drier. While Liberia is prone to floods but not drought, future challenges may include population dislocation in neighboring nations. Rainstorms, storm surges, rise in sea levels, and increasing erosion exacerbate the vulnerability of urban and rural infrastructure (World Bank, 2021). According to the United Nations Environment Program, Metropolitan Monrovia region alone, a forecasted sea-level rise of 16 cm by 2030 will put 675,000 people and 9,500 hectares of land in danger. In Liberia, most researches have focused on maintaining the system- seeking donor support as an intervention after flood events.



This paper, through extensive document review and engagements with resourceful informants in the environmental, disaster management, and water sectors of Liberia, conducted a vulnerability assessment of two slums communities routinely affected by climate-induced disasters; West Point and New Kru Town, using variables and indicators such as infrastructure type, income level, household size and incidence of flooding to rank vulnerability. The vulnerability of the two communities remains unaddressed as the average infrastructure type remains flood-prone, with zinc shacks dominating. The population density is high, with an average of more than eight persons per household. The majority are unemployed, with most youth involved in street selling. This research concludes that disaster management in Liberia is still in the reactive stage instead of being proactive. Disaster emergency planning seemed to be of little interest among practically all of the national development operations that have been taking place in Liberia since the country's independence a century ago, especially for most previous national political governments (Koffa, 2018). Flood reduction strategies have been donor-driven. They have never proven effective at building local resilience to avert the impacts of climate change adequately.

### **Recommendations**

Tackling challenges posed by climate change will have to be innovative and flexible. A stakeholders engagement approach that ingrates multidimensional solutions will be a great start at building resilience to lower vulnerability for locals. Numerous implications have resulted from Liberia's lack of a robust political intent toward catastrophe emergency management and environmental stewardship (Koffa, 2018). This paper recommends the following:

1. Disaster management efforts go beyond mitigations and begin formulating routine programs that build resilience to future climate-induced flooding.
2. Government and partners invest more in homegrown adaptation methods that are both proactive and reactive
3. Conduct regular inter and cross-sectorial vulnerability assessments to beef-up resilience
4. Institute bottom-top policy formulation mechanisms that consider the views of potentially affected communities
5. Set up a national task force on sustainable use of wetlands and drainage monitoring
6. Investment in flood-resistant infrastructure for potentially affected neighborhoods
7. Invest in environmental management education to create awareness

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