

CLIMATE CHANGE ADAPTATION AND VULNERABILITY ASSESSMENT OF WATER RESOURCES, AGRICULTURE AND FOOD SYSTEM IN LIBERIA

Prof. Huseyin Gokcekus (Lecturer) and N. Robert Kerkulah Geninyan*

Yakin Dogu Bulvari, Lefkosa, Mersin 10.

Article Received on 05/02/2022

Article Revised on 26/02/2022

Article Accepted on 18/03/2022

***Corresponding Author**

**N. Robert Kerkulah
Geninyan**

Yakin Dogu Bulvari,
Lefkosa, Mersin 10.

ABSTRACT

Climate change and fluctuation are having a negative impact on world events, including temperature patterns, irregular showers, windy storms, and prolonged dry periods with increasing frequency and severity. The effects of these climate change stimuli vary from lower production to complete crop failure, animal mortality, and an increase in agricultural pathogens, water-borne illnesses, and crop insect outbreaks. Climate change events are expected to increase temperature, rainfall, and sea level rise in Liberia, which is particularly vulnerable. Catastrophic floods, heavy, erratic rain, and wind storms are becoming more common and intense in more parts of the country. People living in rural regions, particularly those who are already susceptible to climate change due to marginalization and neglect, are expected to bear the brunt of the effects of climate change. Rainfall and temperature totals in Liberia are referred to as "weather characteristics" on both a short and long-time frame. The two most significant seasons in Liberia are the rainy and dry seasons. The climate of Liberia is tropical, with minimal variation between day and night and season. Water resources in Liberia and how they are utilized are critical to the problem of enhancing food security across the country. Liberia has an abundance of water resources, but efficient management and planning of these resources is critical to attaining national objectives and goals in decreasing conflicts between competing users. This difficulty is exacerbated by a variety of administrative, technological, and political issues, including the dismal status of the Liberian economy after 14 years of civil conflict. For 89 percent of the Liberian population, agriculture is the primary source of income. The industry is critical to Liberia's economic and

social growth since it contributes considerably to job creation, food security, and family income. Despite the significance of agriculture, poverty is continuously greater among farming families in Liberia than in non-farming households. Future agricultural output in Liberia will have to expand faster than population growth in order for nutrition to improve and food insecurity and undernourishment to decrease, particularly in rural Liberia. This will have to take place mostly on current agricultural land. Improvements will therefore have to come from sustainable intensification that makes good use of land and water resources while without harming them. An integrated and sustainable strategy to the use and management of the natural wealth is required.

INTRODUCTION

Climate change is rapidly altering global events since temperature patterns have a negative impact on plant and human activity. Agriculture consumes by far the most of the Earth's available freshwater: 70% of "blue water" withdrawals from watercourses and groundwater are for agricultural use, which is three times more than 50 years ago. Agriculture's worldwide water consumption is expected to rise by 19 percent by 2050 owing to irrigation demands. Currently, around 40% of the world's food is grown in artificially irrigated regions. Liberia, like any other Sub-Saharan African country, Over the last decades, Africa has faced and continues to face major hurdles in its economic development performance, notably widespread poverty, high inequality, unemployment, and inadequate access to water, sanitation, and electricity. Agriculture, fisheries, and forestry all play important roles in food and nutrition security, socioeconomic development, and poverty alleviation. The country is very susceptible to high-level climate change events, including increasing temperatures, excessive rain, and rising sea levels. The 2018 flood disaster report from the Liberia National Disaster Management Agency (NDMA) stated that several sections of the nation continue to endure large floods, irregular rainfall, windy storms, and prolonged dry spells with increasing frequency and severity. Agricultural output and productivity continue to deteriorate as a result of human and natural factors. The effects of these climate change stimuli range from less production to crop failure, animal deaths, and more agricultural pathogens, water-borne illnesses, and crop insect outbreaks, among other things.

As a result, income diversification of households and small farm holders, crop and animal disasters occur. Agriculture, forestry, and other land use all play an important role in ensuring food security and long-term development. Afforestation, sustainable forest management, and

reducing deforestation are the most cost-effective mitigation methods in forestry, but their importance varies a lot from place to place.

Cropland management, grazing land management, and organic soil restoration are the most cost-effective mitigation measures in agriculture. In light of this, the government should concentrate on adaptation techniques to alleviate the developing scenario through enhanced diversity, which would minimize the susceptibility of the various agricultural systems to severe weather and boost resilience. To have a reasonable chance of limiting global warming to less than 2 degrees Celsius above pre-industrial levels in the twenty-first century, global human greenhouse gas emissions must be reduced by 40 to 70 percent between 2010 and 2050, and then to zero or less in 2100.

Liberia as a State

Liberia is situated on Africa's west coast (between longitudes 7° 30' and 11° 30' west, and latitudes 4° 8' and 8° 30' north). Sierra Leone borders it on the west, Guinea on the north, Côte d'Ivoire on the east, and the Atlantic Ocean on the south (Figures 1a and b). It is Africa's first republic, having gained independence in 1874 under a constitution modeled after that of the United States of America. From 1990 to 2003, two civil conflicts displaced hundreds of thousands of people and damaged the economy and infrastructure. In 2005, a democratic government was elected.

Problems

One of the most essential aspects of climate change in Liberia is human activity and technical advice. Farmers in Liberia have contributed to the aggressions of climate change by engaging in activities such as deforestation (cutting down trees), indiscriminate use of agro pesticides, poor agricultural techniques among farmers, uncontrolled bush burning, and coal burning. The combination of the aforementioned activities has resulted in unfavorable environmental effects such as greenhouse gas accumulation in the atmosphere, which is now accelerating global warming, decreased precipitation, soil erosion, loss of soil fertility, and unnecessary or extreme weather conditions such as droughts and flooding. Most river catchment regions have been damaged, impacting agricultural output and leading to famine, starvation, and mortality of humans and other non-human ecosystem components. The Republic of Liberia has a long history of climate change patterns, as recorded by the National Disaster Management Agency (NDMA) in the past (2015–2018).

Unpredictable and variable rainfall patterns are impeding agricultural activity, especially crop and animal husbandry. The climate in which plants live is changing quicker than anybody could have predicted.

These changes, particularly in temperature patterns, are having a significant influence on crop viability and output potential. Crop productivity studies under global warming also indicate that the productivity of the country's staple rice and other tropical crops may decline as global temperatures rise. These changes are being accelerated by humidity and wind speed. Variations in climatic patterns, such as increased drought, severe heat and floods, and rising levels of salt stress, are projected to exacerbate these restrictions, hurting output and productivity. Furthermore, there is a substantial increase in the frequency and unpredictability of extreme rainfall events, as well as rising sea levels along the country's coastal belts. According to projections, yearly temperatures will rise by 0.9–2.6 degrees Celsius by the 2060s (USAID, 2017), with the northern inland area seeing the fastest rate of warming. Furthermore, there has been a significant rise in the frequency of hot days and nights in all sections of Liberia. There are no consistent rainfall projections available, although patterns indicate an overall rise in average annual rainfall with increases in both wet and dry seasons. Furthermore, increasing sea levels are a severe climatic event throughout the country's coastal zones and areas. Due to harsh weather events and high temperatures in the Republic, there is increased animal loss and crop loss and failure, as well as increased pest and disease incidence. Water quality is deteriorating, and there is a lack of essential health facilities, particularly sanitary infrastructure. There have also been reports of coastal floods and erosion, as well as damage to homes and infrastructure and salinization of land and aquifers. There is a rise in the danger of vector-borne, air-borne, and water-borne illnesses and pests, as well as increasing food insecurity.

Justification of Study

Climate change has been a reality in Liberia and throughout the world; the consequences are unavoidable and seem to be lethal as global warming continues to worsen on a daily basis. Liberia's agricultural industry is critical to the country's economic growth, job generation, and accomplishment of development goals.

Food and nutrition security, poverty reduction, and general social cohesiveness are all priorities. The contribution of the sector to More than 70 percent of Liberia's population provides sustenance for an estimated 35 percent of families^[6], who are involved in rice,

cassava, rubber, oil palm, cocoa, and sugarcane cultivation. However, because of poor agricultural output, Liberia imports more than 80% of its basic foods, rendering the nation subject to global food price instability.

Rice and cassava are the key staple food crops in the nation, with rice serving as the primary staple. Rice producers get their livelihood/employment, either directly or indirectly, from agro-related operations and activities, notably throughout crop value chains. Studies on rice production under global warming also indicate that rice and other tropical crop productivity would decline as global temperatures rise.

These changes are being accelerated by humidity and wind speed. Adverse weather conditions continue to jeopardize rice production throughout Africa, notably in Liberia. The unfavorable weather circumstances have a direct influence on yield augmentation. Drought, severe heat, floods, and rising levels of salt stress are likely to impede production. Overarching goals.

- I. To assist government initiatives aimed at improving climate resilience and adaptation a specific goal.
- II. To provide an enabling environment for an integrated approach to risk management in climate change.
- III. Determine the distribution of risk reduction techniques and mitigating measures Adopted Hypothesis.

The study's goal is to look into the impact of climate change on agriculture and the food chain in the United States. As a result, Liberia.

- I. Creating an enabling environment for an integrated approach to risk management in climate change has little impact on Liberia's agricultural or food system;
- II. That the spread of risk reduction methods and mitigation measures has no influence on Liberia's agricultural and food system.



Figure xxx: Map of Liberia Describing the Study Area.

Liberia, which is located between Sierra Leone and Cote d'Ivoire, has a population of 5.12 million people as of January 2021.

Liberia has a female population of 49.7 percent and a male population of 50.3 percent. 52.3 percent of Liberians reside in urban regions, while 47.7 percent live in rural areas. Rice is grown by more than 75 percent of the inland population as the major staple meal. In Liberia, around 46 percent of the land is categorized as arable.

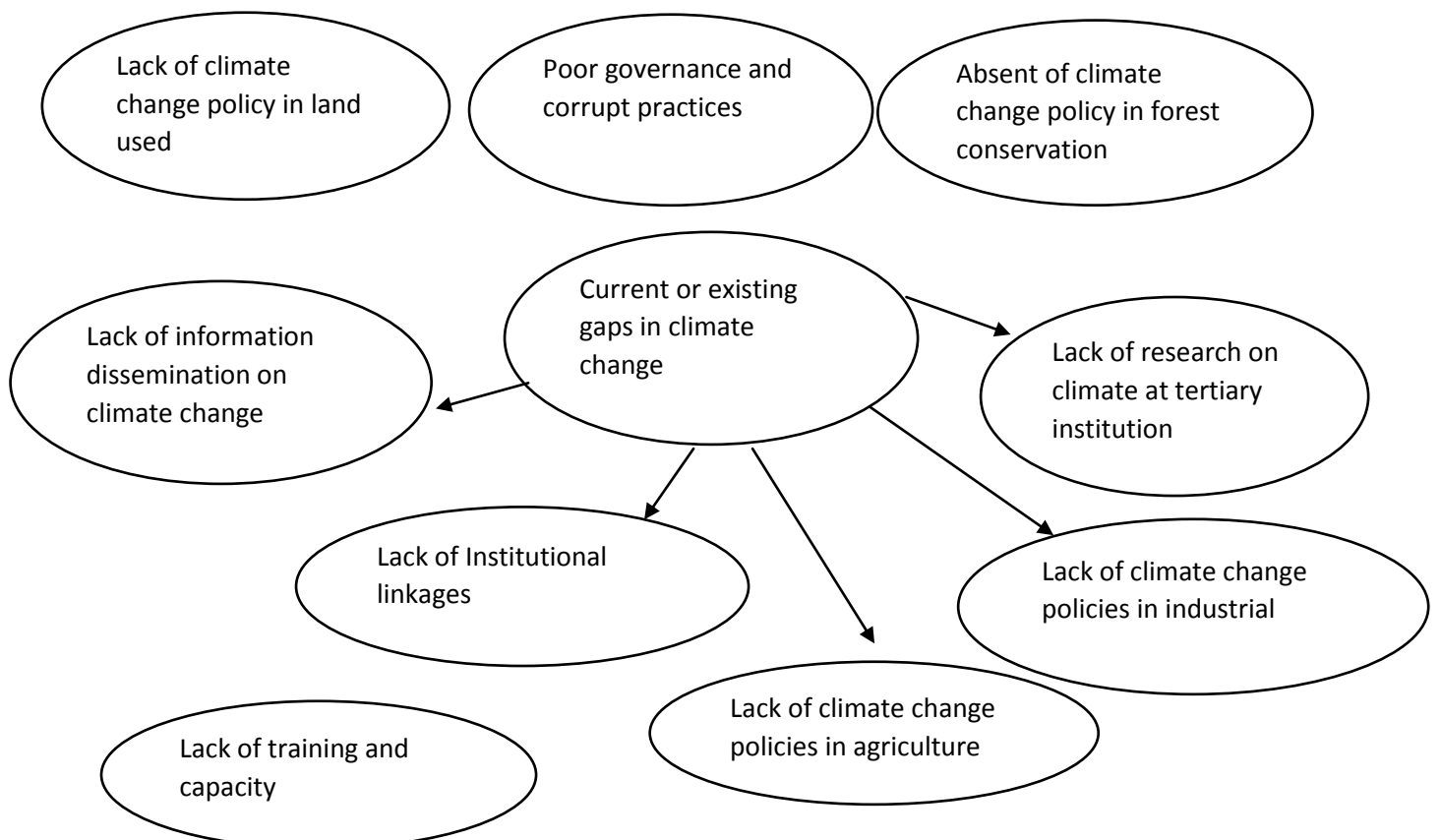
Liberia is organized into three agro-ecological zones, each represented by one county in this research. First, the Coastal Plains zone, which is mostly composed of mangroves and scattered 8 bush and savannah forests, has the greatest potential for grazing crop production.

This natural zone is represented by the homes in Grand Bassa County. Second, the Forest Zone was separated into two sections: "closed" forests and "transitional" forests. Lowland and upland rice, as well as yams, coco yams, potatoes, and other vegetables, are regularly grown in this zone's farming methods. This zone is ideal for growing coffee and cocoa, as well as cash crops including citrus, rubber, and oil palm.

Households in Nimba County, which borders Côte d'Ivoire to the east, are typical of this zone. Finally, the Northern Savannah zone is characterized by extensive grasslands with scattered trees and bushes. Although coffee and cocoa are the most important commercial crops for smallholders, the majority of them also produce rice and cassava for sustenance. Households in Lofa County, which borders both Sierra Leone and Guinea, reflect the Northern Savannah zone.

Current Gaps in climate change model

Climate change has had a major detrimental influence on all aspects of life in Liberia, including agriculture, fisheries, forests, natural ecosystems, and widespread human health concerns. Climate change variability and events are intense as a consequence of the gaps shown in the table below.



In land use, there is a lack of climate change policy.

Policymakers have not formed a climate change policy on sustainable land use. As we are all aware, the effect of anthropogenesis has resulted in the global climate change phenomenon.

In Liberia, people utilize the land in an indiscriminate and unsustainable manner. Unsustainable land uses, such as mining, have resulted in serious environmental problems in the nation. Policymakers should use climate change-friendly policies to protect our land from environmental deterioration and depletion, so they should do this.

Climate change knowledge is not widely disseminated.

Climate change issues are not readily communicated to the grassroots, who are severely impacted, especially those in neglected rural regions. As a consequence of the country's inconsistent and irregular rainfall pattern, farmers and rural inhabitants are perplexed about when and how to plant their crops during the rainy season. Furthermore, the occasional outbreak of insect-pest and illness in humans and animals is gravely harming people in many aspects of their existence.

Training and capacity development are lacking.

This is one of the most potent weapons for eradicating poverty and sickness among the public, especially in the country's neglected rural regions. Farmers, charcoal burners, miners, and other private and public sector members get no training or capacity development. People are recklessly chopping down trees and young shrubs that safeguard the ecosystem.

Poor governance and unethical behavior

In this nation, corruption has been the norm. As a result, laws and policymakers are often interested in achieving their personal interests rather than the public interest. Legislators are uninterested in defending their country. They proceed to implement faulty policies that serve their own interests and inadequately rule their subordinates, subjects, and people. They are concerned with today's generations while ignoring future generations, even their own.

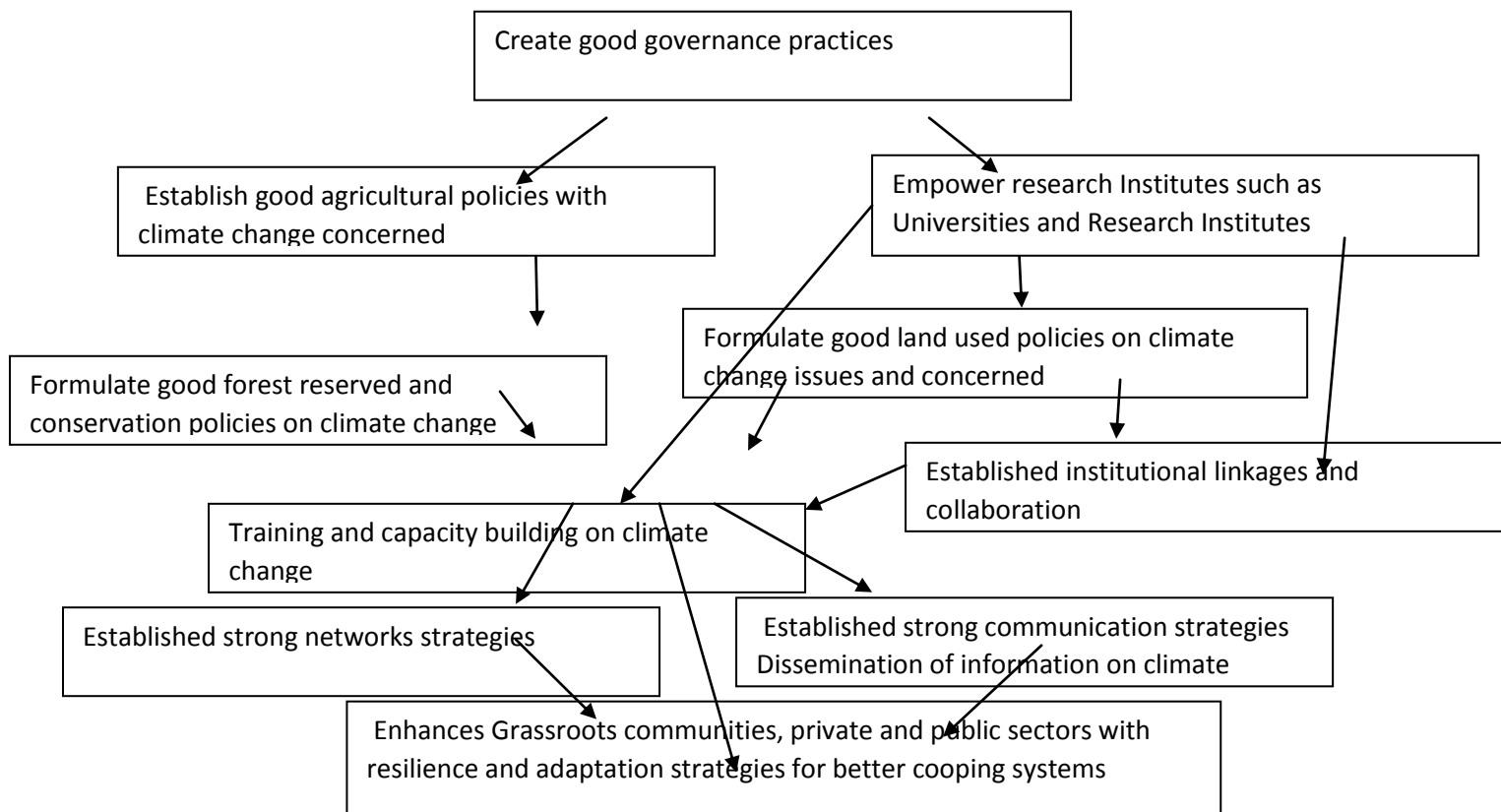
There is no climate change policy in place for forest protection.

There is no policy on forest protection and just a few mentions of climate change. Foresters do not advocate climate change to community forest owners or private wood industry owners. All across the country, people are indiscriminately cutting down trees from forests, which is

harming both current and future ecosystems and leaving the environment at risk of being completely wiped out.

In agricultural policy, there is a lack of climate change policies.

Climate change problems are generally required to be explicitly expressed in agricultural policies, although all agricultural policies do not address any climate change concerns. Because legislators are unconcerned about climate change problems while developing agricultural regulations, certain agricultural methods are fully anti-climate change. Even though food production is critical to human survival, production techniques must be in conformity with climate change concerns.



The gap model for addressing climate change in Liberia shown above clearly displays mitigation measures to climate change variability and occurrences. If, on the other hand, these difficulties are addressed.

Liberian weather characteristics (rainfall and temperature)

Weather is a short-term (day-to-day) atmospheric state at a specific location, while temperature is the average of the whole daily weather condition as measured over a considerably shorter time span. The weather in Liberia is often influenced by elements such

as pressure, temperature, precipitation, humidity, wind, cloudiness, floods, rain, ice storms, and so on, but temperature is primarily determined by altitude, latitude, distance from the sea, ocean currents, and so on. Weather changes are noted regularly, although temperature changes occur considerably more quickly.

The complete circumstances of the rainfall and temperature in Liberia over a shorter and longer period of time are referred to as the weather characteristics in Liberia. In Liberia, there are two distinct seasons: the rainy season and the dry season. Liberia's weather is tropical, with very minor differences between day and night and across seasons. Temperatures are never higher than 37 degrees Celsius. There are two seasons: the rainy season, which lasts from May to October, and the dry season, which lasts from November to April.

Inland, the yearly rainfall averages 4,320 mm. During the rainy season, the average humidity in the coastal area is 78%. When the Harmattan winds come from the Sahara, the humidity can drop to 30%.

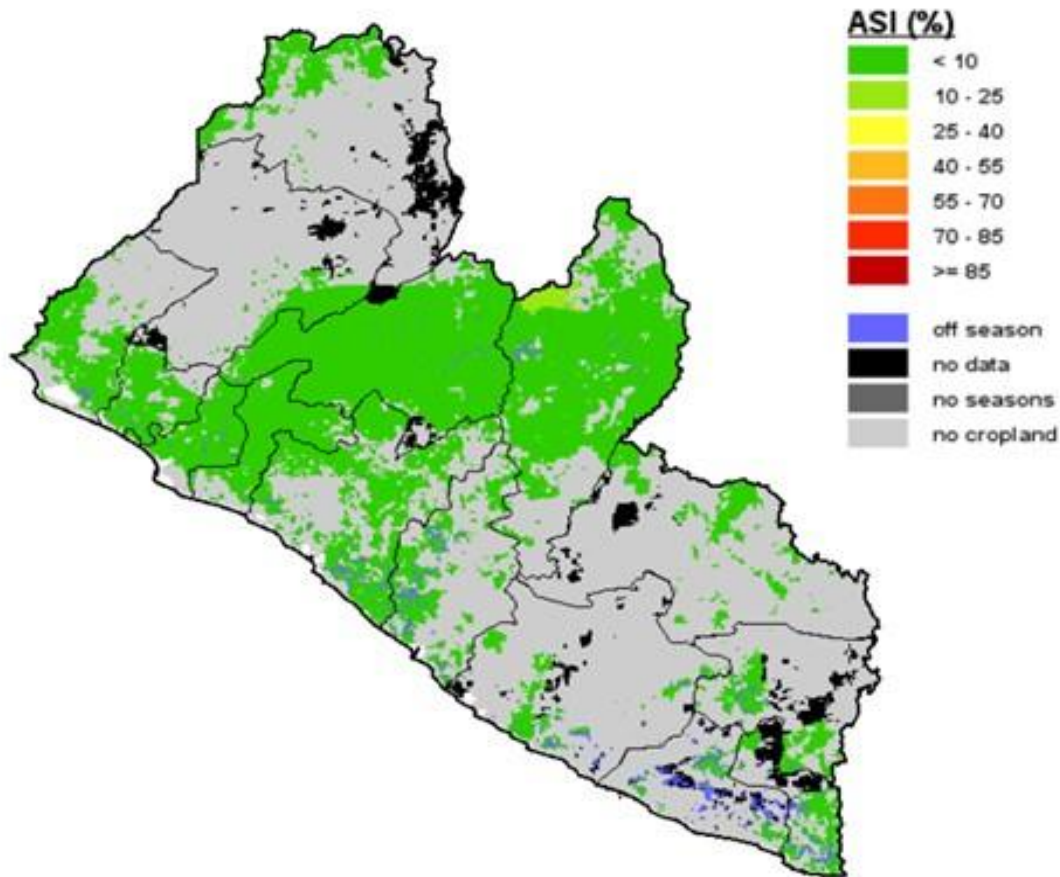
Liberia has one of the greatest precipitation rates in the world (4,000 to 5000 mm/year), and its capital supply of water is 71,000 km³/year, with the remainder renewable. The volume of water is 232 km³/year.

Total water extraction in 2000 was expected to be 106.8 million M³, with agriculture accounting for 57%, the household sector accounting for 28%, and industrial accounting for 15%. During the dry season (December to February), the average temperature in Monrovia (capital city) is 23.3 °C with a high of 30.5 °C. While the lowest and highest Fahrenheit (°F) temperatures in the colder months range from 76°F to 90°F, temperatures rise rapidly in March and April.

Monrovia has a lot of rainfall throughout the rainy season, up to 5 meters (200 inches) every year. When it comes to rain, Monrovia gets the most in June and July, with a total of 1970 millimeters falling over 42 days.

Liberia - Agricultural Stress Index (ASI)

from start of season 1 to dekad 2, April 2021



Source: FAO/GIEWS Earth Observation System.

Urban Liberia now has safe and upgraded water sources that can be used to grow crops like rice and corn. Why is this the case when statistics show that 6560 (43.5 percent) of all fully operational water sites in Liberia provide water all year, boosting food security throughout the country? Liberia has an abundance of water resources, but efficient management and planning of these resources is critical to attaining national objectives and goals and decreasing conflicts between competing users. This is made even more difficult by a number of administrative, technological, and political issues, including the poor state of the Liberian economy after 14 years of civil war.

Rural areas account for 73.4 percent of Liberia's poverty and present unique challenges to service delivery and poverty reduction, necessitating simple and long-term solutions. Liberia is located on Africa's West Coast in the southwestern part. It covers an area of approximately

111,400 square kilometers, 14 percent of which is covered by water. Liberia is bounded to the west by Sierra Leone, to the north by Guinea, to the east by Côte d'Ivoire, and to the south by the Atlantic Ocean. Liberia's temperatures seldom get over 37 degrees Celsius.

Inland, the yearly rainfall averages 4,320 mm. During the rainy season, the average humidity in the coastal region is 78 percent, although it may plummet to 30 percent when the Harmattan winds blow from the Sahara. Liberia has a number of significant river sources. The longest water source is the Cavalla River, which runs between Liberia and Cote d'Ivoire, while the Mano River runs between Liberia and Sierra Leone. The St. Paul River is the second longest river in Liberia, feeding the Mt. Coffee hydroelectric facility (the country's sole large power plant) and supplying the majority of raw water to Monrovia. However, the nation continues to suffer with the availability of safe drinking water. As a result, Liberia has just two significant lakes: Lake Shepherd in Maryland County and Lake Piso in Grand Cape Mount County, with Piso being the largest of the two. They are both located in the Atlantic Ocean. Groundwater is generally accessible and can be used in most regions of the nation in sufficient quantities for rural water supply, which is based on dug wells and, to a lesser degree, drilled boreholes. Boreholes may be drilled at depths of up to 100 meters. However, reliable data on boreholes and yields is lacking. There is a scarcity of data on water quality from both surface and groundwater sources.

Domestic sewage, on the other hand, poses a slew of issues since the sole traditional sewerage system, which was already in disrepair before the civil war, is no longer operational. Some of the sewage water is collected and thrown away in lagoons and other bodies of water by trucks that use vacuums to pick it up.

Water quality is getting worse in some places because of mining, logging, farming, and other activities.

Agriculture is the primary source of income for 89 percent of the Liberian population.

The industry is critical to Liberia's economic and social growth since it contributes considerably to job creation, food security, and family income. In 2016, the industry contributed roughly 26 percent of the actual Gross Domestic Product (GDP), with China accounting for nearly one-third of that. Livestock subsegments Such an expansion would

mean that agriculture would continue to be a growth engine, important for economic development, environmental services, and reducing rural poverty in the long run.

Despite the significance of agriculture, poverty is continuously greater among farming families in Liberia than in non-farming households. In Liberia, 77.2 percent of agricultural families are impoverished, more than 60 percent are food insecure, and more than one-third are severely impoverished.

To understand why, we must first recognize that the national absolute poverty rate in Liberia is 54.1 percent; the food poverty rate is 45.0 percent, and the severe poverty rate is 18.5 percent. In addition, the Liberian agricultural farming industry makes minimal use of contemporary technologies.

Approximately 4% of the planted area is irrigated, while the remaining 5% and 2% are fertilized and pesticide-treated. Meanwhile, 43 percent of agricultural families bought seeds for agriculture, accounting for 26 percent of total revenue. However, just 4 percent of those purchased seeds were certified enhanced varieties, indicating that the majority of purchased seeds are traditional types.^[19] Rice and cassava are the primary two food crops farmed, while a large proportion of agricultural family's plant fruits and vegetables. Sixty percent of families grow vegetables, twenty-seven percent grow fruits, and thirty-three percent grow a permanent income crop. Liberia's top five cash crops are cocoa, sugar cane, rubber, coffee, and oil palm. Dr. Grace Flamogayan's unpublished research from 2005 listed three primary reasons why there is a lack of food supply in the Liberian market and why the agriculture industry is not thriving. Inadequate utilization of modern agricultural farming technology and equipment for large-scale commercial agricultural cash crop production, such as rice and cassava. Incentives from the government to develop and finance agricultural cultivation and animal husbandry in Liberia are lacking. Local marketplaces have little or no supply of agricultural farming goods. These factors have resulted in a high percentage of poverty among local farmers.

Liberia has a poor population of 50.9 percent (2.2 million Liberians). Rural poverty outnumbers urban poverty (71.6 percent vs. 31.5 percent). Rural Liberia, on the other hand, is home to 49.5 percent of the country's farmers.

Food insecurity affects approximately 39.1% of the population. While food poverty is greater in rural regions (50.9%) than in urban areas (28.1%), the difference is narrower than in absolute poverty, demonstrating the influence of subsistence farmers' contributions to food requirements. Extreme poverty affects 16.5 percent of the population on a national scale. Extreme poverty is greater in rural regions, accounting for 26.5 percent, whereas it is as low as 7.2 percent in urban areas. Montserrado has the lowest rate of severe poverty (2.7%) among regions, while the South-Eastern region has the highest (40.8%).-headed families are poorer than female-headed households, with absolute poverty rates of 52.3 percent and 46.3 percent, respectively. In the 12 months preceding the survey, 51.2 percent of families reported food shortages. Rural areas have a higher rate of food insecurity (58.8 percent) than urban areas (44.2 percent of families). On average, farming families plant three distinct kinds of crops. Cassava is grown by 74% of homes, rice is grown by the same percentage, and vegetables are grown by 60% of households. 40% (40.6%) of households with animals were noted to be present in agricultural households. Nonetheless, there remains a lot of poverty among agricultural families.

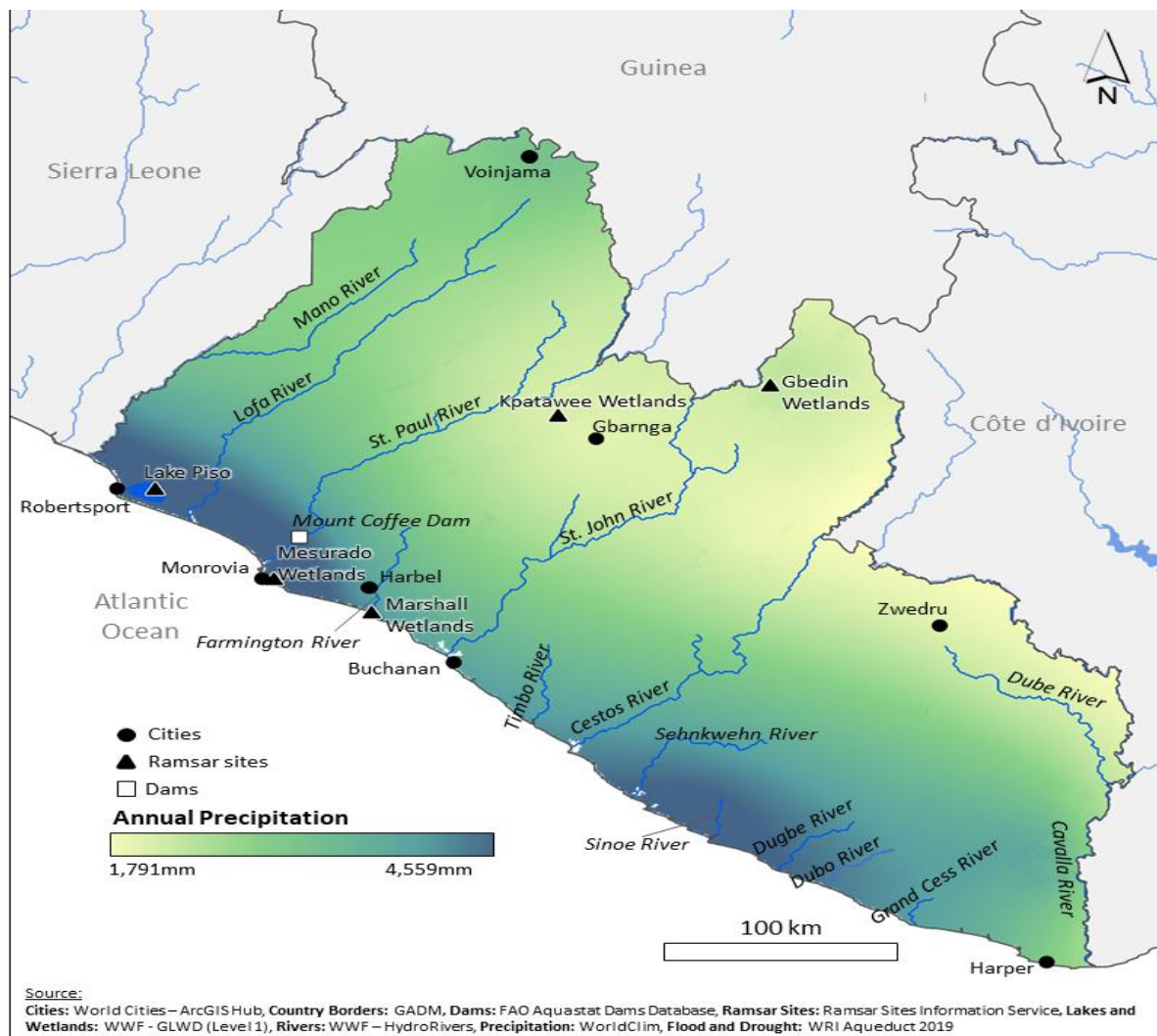
Smallholders with low land endowment dominate farming, and they employ workers to compensate for family labor shortages. Farming families cultivate an average of 1.6 hectares of land, with 3% cultivating more than five hectares. To make up for a lack of family labor, 86 percent of agricultural families hire or exchange labor.

Future agricultural output in Liberia will have to expand faster than population growth in order for nutrition to improve and food insecurity and undernutrition to decrease, particularly in rural Liberia.

This will have to take place mostly on current agricultural land. Improvements will therefore have to come from sustainable intensification that makes good use of land and water resources without harming them. Cash Rice, cassava, eddoes, potatoes, and other crops need an optimal quantity of water to thrive. Higher rainfall in rural regions such as Bong County, Nimba County, Maryland County, and the south-east part of Liberia, which causes flooding and washing away of the top soil, may contribute to the soil's inability to sustain farming in such locations. Furthermore, irrigation pipes, canals, and sprinklers transfer water from the appropriate sources. Irrigation improves crop growth and quality while ensuring an ample agricultural supply in desert and semi-arid areas. Irrigation methods of various types are commonly employed in Liberia. The channel and drainage irrigation systems are the most

commonly employed irrigation techniques. Aside from agricultural development, the channel and drainage irrigation system are also used for animal cooling, mining, and sewage disposal. As a result, it has a variety of direct and indirect effects on the traditional ecology of Liberia's hinterland. Water is distributed from a central point in channel and drainage irrigation systems, either from a manually dug well, pump, or river source; hills, mountains, large trees, or boreholes. Water is channeled through trenches and lines. This provides water routes to the crops, enabling water to move through the trench lines to the crops or vegetables. This is a traditional approach that is mostly used in rural Liberia. These pipes, which run at high pressure, act as a water gateway. As a consequence, the flow of water is frequently quite high.

Map of water resource in Liberia indicating major river routes, supply system and distribution throughout Liberia.



Characteristics of Water Resources in Liberia

Liberia has 23 minor coastal drainage regions and 15 major basins that drain into the Atlantic Ocean from the northeast to the southwest. The six major rivers (Mano, Lofa, St. Paul, St. John, Cestos, and Cavalla) have their sources in Guinea's Fouta Djallon Mountains. These rivers drain 56% of Liberia's water resources, while 11 medium-sized tributary rivers and several short coastal rivers drain the remainder. Over 600,000 hectares of freshwater wetlands, 55,000 hectares of coastal mangroves, and three of Liberia's five Ramsar sites have been established in the country's coastal plains. Lake Piso and Lake Shepherd are the two biggest brackish lakes. Lake Piso is the country's biggest Ramsar site.

Mount Coffee Dam, Liberia's sole noteworthy reservoir, holds 239 million cubic meters (MCM) of water from the St. Paul River. The dam generates municipal electricity and serves as a major source of drinking water for Monrovia. Liberia has an abundance of water resources all around the nation. Liberia has the third greatest water availability per capita in Sub-Saharan Africa, with 49,028 m³, and is much higher than the Fallen mark for water stress. The proportion of water withdrawals to renewable supply is less than 1%. Surface water is abundant, although dry season flows might be minimal.

Low St. Paul River flows restrict hydropower output at the Mount Coffee Dam, which is the city's primary source of municipal power and a key supply of energy. In both rural and urban settings, groundwater is the major supply of drinking water. Although the hazards of over-exploitation are modest, data on groundwater usage and availability are sparse. Groundwater quality is rarely extensively monitored, despite the fact that pathogenic contamination is common in urban aquifers due to inadequate sanitation systems. Shallow groundwater, a critical source of drinking water, is especially vulnerable to pollution. The effects of climate change on total rainfall are unknown, while more heavy rainfall would increase the danger of floods and epidemics of waterborne illnesses, particularly in coastal areas. As demonstrated in the case of the new Kru, sea level rise would exacerbate the effects of devastating storm surges, submerge coastal wetlands and mangroves, and endanger coastal towns.

Over the previous ten years, from 2010 to 2020, the interiors of Liberia have seen a total of 61 percent of water shortage supply, whereas counties in central Liberia, such as Montserrado county, Margibi county, and others, have had a 23 percent drop in low water supply. This is mostly owing to the fact that Liberia lacks a hydroelectric energy supply system, whether

small or large, to provide the nation with safe pipe-borne water and power. It contains one significant hydro dam, the Mount Coffee Dam, which was damaged during the 14-year civil war and was rehabilitated in May of 2012, although not to full capacity. The nation has three small hydros, including the firestone hydro in Hardel Margibi county, which is directly for the firestone firm and supplies energy and water to its employees and rubber factories.

Liberia has recently established two mini-hydro projects in the interiors of Nimba and Lofa counties. If fully operational, the Gbedin micro hydro would provide 33 kilovolts of electricity and water to both public and private businesses in Nimba county, as well as the Lofa county Yandohun, Kolahun district, hydro. Although Liberia has made little headway in addressing the challenges caused by a shortage of energy and water in rural and urban Liberia, much more has to be done in order to provide power and water to 56 percent of Liberia's 4.5 million people.

There has recently been a large need for a supply of fresh fruits from rural Liberia, yet rural Liberia has failed to meet 35% of the demand for these agricultural goods.

CONCLUSION

The country is very susceptible to high-level climate change events, including increasing temperatures, excessive rain, and rising sea levels. According to unpolished data, several regions of the nation have seen catastrophic floods, strong unpredictable rainfall, windy storms, and prolonged dry periods with increasing frequency and intensity. Furthermore, agricultural productivity and output, more so than any other industry, are being harmed by human and natural factors. Climate change variability, as reported, and related vulnerabilities are projected to adversely harm the marginalized and ignored rural poor, according to World Population Data 2013.

The complete circumstances of the rainfall and temperature in Liberia over a shorter and longer period of time are referred to as the weather characteristics in Liberia. In Liberia, there are two distinct seasons: the rainy season and the dry season. Liberia's weather is tropical, with very minor differences between day and night and across seasons. Temperatures are never higher than 37 degrees Celsius. There are two seasons: the rainy season, which lasts from May to October, and the dry season, which lasts from November to April. Inland, the yearly rainfall averages 4,320 mm. During the rainy season, the average humidity in the

coastal area is 78%. When the Harmattan winds come from the Sahara, the humidity can drop to 30%.

REFERENCES

1. Frank, Daniel N., et al. "Disease phenotype and genotype are associated with shifts in intestinal-associated microbiota in inflammatory bowel diseases." *Inflammatory bowel diseases*, 2011; 17.1: 179-184.
2. Mandel, Lauren Heather, Bradley Wade Bishop, and Ashley Marie Orehek. "A new decade of uses for geographic information systems (GIS) as a tool to research, measure and analyze library services." *Library Hi Tech*, 2020.
3. Rahman, Md Saifur, and Lukas Giessen. "Formal and informal interests of donors to allocate aid: Spending patterns of USAID, GIZ, and EU forest development policy in Bangladesh." *World Development*, 2017; 94: 250-267.
4. Sebahia, Mohammed, et al. "The multidrug-resistant human pathogen *Clostridium difficile* has a highly mobile, mosaic genome." *Nature genetics*, 2006; 38.7: 779-786.
5. Tarway- Twalla, Alfred K. "The contribution of grassroots businesses to post- conflict development in Liberia." *Journal of Enterprising Communities: People and Places in the Global Economy*, 2011.
6. Mookherjee, D. and Shorrocks, A. (1982). 'A decomposition analysis of the trend in UK income inequality', *Economic Journal*, 92: 886–902.
7. Gini, C. (1921). *Measurement of Inequality of Incomes*. *Economic Journal*, (31): 124-126.
8. Foster, J., J. Greer, and E. Thorbecke (1984): "A Class of Decomposable Poverty Measures," *Econometrica*, 52: 761-766.
9. Ravallion M (1998) *Poverty Lines in Theory and Practice*. Living Standards Measurement Study Working Paper No. 133. Washington, DC: World Bank.
10. Liberian Hydrological Service. *Liberia River Basins 2016: Drainage Divisions and River Basin Boundaries*; Monrovia, 2016.
11. Liberia Environmental Protection Agency(EPA). *Liberia National Drought Plan*; Monrovia, 2019.
12. Balarin, J. *National Reviews for Aquaculture Development in Africa*; FAO: Rome, 1984.
13. Liberian Hydrological Service. *Rivers*. Gatter, W. *The Coastal Wetlands of Liberia: Their Importance for Wintering Water Birds*. International Council for Bird Preservation; UCBP: Cambridge, 1988.

14. Pingali P, Khwaja Y and Meijer M. (2005). Commercializing small farmers: Reducing transaction costs. FAO/ESA Working Paper No. 05-08. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.
15. Rao, N.P., Geleta, D., & Suryanarayana, N.(2015). An economic inquiry into commercialization of small holder agriculture: the case umbullo watershed. International journal of multidisciplinary educational research, 4, 4(1).
16. Slavchevska, V. (2015). Gender differences in agricultural productivity: the case of Tanzania. Agricultural Economics, 46: 335–355.
17. Straberg P.J, Jayne T.S, Yamano T., Nyoro J., Karanja D. and Strauss (1999). Effect of agriculture commercialization on Food crop input use and productivity in Kenya. MSU international Development Working paper No, 71.
18. USAID. Liberia- Environmental Threats and Opportunities; Washington, D.C., 2014.