International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 8, Issue 10, ISSN No. 2455-2143, Pages 15-24
Published Online February 2024 in IJEAST (http://www.ijeast.com)

ANALYSIS OF FLOOD DISASTERS IN SUB-SAHARAN AFRICA USING PYTHON VISUALIZATION TOOLS

ADIZUA, Okechukwu Frank, JACKRICH, Sophia Ibiteim, EYO, Alphonsus Joseph
Geophysics Research Group – GRG,
Department of Physics, Faculty of Science, University of Port Harcourt,
Port Harcourt, Rivers State, Nigeria.

Abstract— **Floods remain a threat especially in Sub-Saharan Africa affecting over 2.8 billion people the world over and causing over 200,000 deaths over the past few decades. Flood disasters in Africa have emerged as a multifaceted challenge with significant socio-economic and environmental implications. This work employs Python visualization tools to conduct a comprehensive analysis of flood occurrences across the African continent. It also focuses on exploring the spatial and temporal patterns of floods, examining potential climatic influences, assessing vulnerability, evaluating impacts, and proposing measures for forecasting and mitigating flood disasters. The combination of data analysis and Python visualization tools offers a promising path towards a more resilient and prepared future in addressing the pressing issue of flood disasters in Africa.**

Keywords — **Natural Disasters, Flooding, Socio-economic and Environmental Implications, Sub-Saharan Africa and Python Visualization tools**.

I. INTRODUCTION

Africa is one of the two continents in the world most affected by floods. In the past three to five years, flood events in Africa have had considerable impacts, with a peak of seven million people being affected in 2020 [1]. Floods have become more recurrent and a usual event in several countries. The upsurge in floods can be explained by various factors, including climate change which generates changes in precipitation regimes and intensity, and often manifests in torrential rains. Intense precipitation can cause flooding in small river basins and in rivers [2]. The population of Africa is growing twice as other parts of the world but management and planning remains a big problem throughout the continent and particularly in the sub-saharan region. The absence of management of disaster plans and the inadequate basic systems, infrastructures, and services has led to increase in vulnerability of urban areas [3]. A part of the population is affected by floods as a result of deficiency of the drainage systems. If no proper flood management is put in place, people that frequently settle in flood-prone areas while relocating from rural to urban areas will render them extremely susceptible [4]. Nigeria has had its fair share of flooding with an estimated 20% of the population in danger, causing more human displacement than any other natural disaster [5]. This frequently leads to fatalities and even displacement of populations. Records of these devastating flood impacts are bountiful throughout Africa, with a significant amount occurring in West and Central Africa.

Statement of the Problem

The catastrophes of flooding have caused fatalities, shifts in population, damage to property, disruption of important services, and financial difficulties. Floods have effects on both rural and urban areas; industries including agriculture, transportation, healthcare, and education are greatly impacted. In order to handle catastrophes effectively and plan for the future, it is important to understand or properly analyze the incidence of flood disasters with the view to identifying the underlying causes, effects, and mitigation activities associated with flood disasters. This therefore forms the fulcrum of this work.

Significance of the Study

It is crucial to analyze flood disasters that occur in Africa. The results of this study could guide in the creation of policies and the distribution of resources for successful risk reduction and disaster management plans [6]. It would also help local communities to take preventive action, participate in disaster preparedness, and support efforts to build resilience by having a better understanding of the causes and effects of floods. By providing information on the mechanics of flooding, its effects, and potential remedies, the study adds to the literature of flood disasters in Nigeria in particular and Africa in general.

Description of the Study Coverage Area

Africa is the second-largest continent bounded by the Mediterranean Sea, the Red Sea, the Indian Ocean and the Atlantic Ocean. It is divided in half almost equally by the Equator. The continent includes the islands of Cape Verde, Madagascar, Mauritius, Seychelles, and Comoros. The origin of the name “Africa” is greatly disputed by scholars. Most

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believe it stems from words used by the Phoenicians, Greeks, and Romans. Important words include the Egyptian word Afru-ika, meaning "Motherland"; the Greek word aphrike, meaning "without cold"; and the Latin word aprica, meaning "sunny". Today, Africa is home to more countries than any other continent in the world. These countries are Morocco, Algeria, Tunisia, Libya, Egypt, Sudan, South Sudan, Chad, Niger, Mali, Mauritania, Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Burkina Faso, Togo, Benin, Nigeria, Cameroon, Central Africa Republic, Equatorial Guinea, Gabon, Congo, the Democratic Republic of the Congo, Angola, Namibia, Botswana, South Africa, Lesotho, Eswatini, Mozambique, Zimbabwe, Zambia, Malawi, Tanzania, Rwanda, Burundi, Uganda, Kenya, Somalia, Ethiopia, Djibouti, Eritrea and the island countries of Cape Verde, Madagascar, Mauritius, Seychelles, and Comoros. Figure 1 shows the map of Africa showing the constituent countries.

Figure 1: Map of Africa showing the countries (Source: Pinterest)

Flood Events around the African Continent

Torrential rains and flooding affected 600,000 people in 16 West African nations in September 2009. The worst-hit countries were Burkina Faso, Senegal, Ghana and Niger [7]. This event closely followed the 2007 floods that displaced more than a million people in Uganda, Ethiopia, Sudan, Burkina Faso, Togo, Mali, and Niger, and claimed over 500 lives, and the 2008 flooding in Mozambique [8]. These events and the continually increasing number of people affected by flooding during the 2009-2010 rainy season, which numbered about 25,000 through April 20, are the most recent examples of the growing flood risks in Africa. The economic damages caused by floods as well as the number of people affected by them have substantially increased in recent decades [9]. The number of fatalities caused by floods in Africa during the period 1950-2009 [10], dramatically shows that deaths have increased by about one order of magnitude during the last 50 years. These numbers indicate a need for urgent actions, for the planning of which, we first need to understand the reasons why flood risk has strongly increased in Africa. Flood risk is

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determined by the probability that a flood may occur and the potential adverse consequences [11].

Causes of Flooding and some Fatality Statistics in Africa

Flooding in Africa could be caused by both natural and artificial (man-made) means. Natural causes include climate change, heavy or torrential rains or rainstorms; oceans storms and tidal waves usually along the coast or human causes which include urbanization, burst water main pipes and dam spills [12]. In Ivory Coast, at least 19 people died and several were injured in July due to the flooding which also killed around 20 people recently in Uganda. There were 88 deaths in 2020 in Niger due to floods, while 77 people died in 2021. In 2022, 24 deaths were recorded for the same reasons [13]. Figure 2 provides a useful approach for identifying and analyzing the causes of flooding and for proffering solutions.

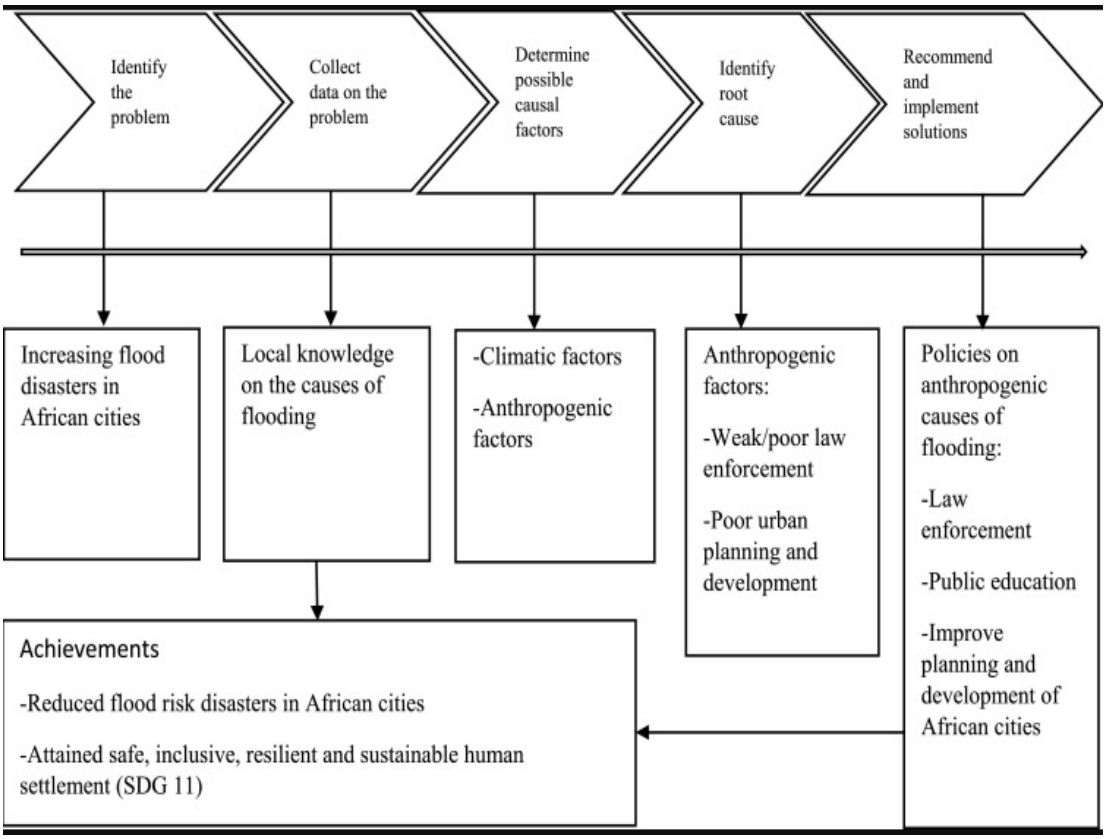

Figure 2: A useful approach (analytical framework) for identifying and analyzing the causes of flooding and for proffering solutions. (Adapted from the work of [21] to flooding in Harper City, Liberia)

Devastating Effects of Flooding

The effects of flooding have significantly increased in the last three decades resulting in loss of lives and properties. Irreparable damages have been sustained by the inhabitants of Africa as a result of what has become perennial natural disaster in African town and cities. Apart from houses that collapse by flooding, schools buildings and bridges also collapse causing severe economic losses. Markets places and farmlands are submerged for weeks and sometimes are washed away. Many farmlands both arable and agro-forestry are swept away while schools are also submerged for weeks. Some animals lose their lives to flooding while many bridges collapsed and electric poles destroyed [14]. These effects could finally result in the degradation of agricultural land, fatalities to humans and animals. The environment is also degraded, infestations spread, buildings, bridges, dams, embankments, drains, roads, railways, etc. are destroyed and soil and water polluted by chemicals [15].

II. Materials and Methods

The data that provided much of the evidence regarding the prevalence of flooding in Africa was sourced from the EM-DAT database and previous studies. This work was successfully carried out to analyze and extract meaningful information from the database, which was achieved by harnessing the power of data analytics technological tools on an immense volume of data. The data analysis tool used was Python for easier manipulation of the database; Python is a high-level, general-purpose programming language; it is dynamically typed and garbage-collected. It supports multiple programming paradigms, including structured, object-oriented, and functional programming. Pandas is an open-source Python

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library, it is a flexible and easy-to-use data analysis and manipulation tool built on Python. NumPy is an essential tool for exploratory analysis of a dataset it can return descriptive statistics like the average of a set of values or provide a statistical overview of the dataset under analysis.

III. PRESENTATION OF RESULTS

Figure 3 shows the summary of flood events around sub-saharan Africa.

	Country	Magnitude	OFDA Response	Total Deaths	Duration	No. Homeless	No. Affected	No. Injured
27	South Sudan	0.000000	1	0.000000	9 days 00:00:00	0.000000	2.900000e+05	0.000000
7	Central African Republic	8350.000000	1	1.000000	17 days 00:00:00	23798.000000	0.000000e+00	7.000000
3	Botswana	0.000000	1	3.000000	9 days 00:00:00	32000.000000	1.067760e+05	0.000000
6	Cabo Verde	0.000000	1	3.000000	39 days 00:00:00	0.000000	1.500000e+02	0.000000
9	Comoros	0.000000	2	3.000000	6 days 00:00:00	0.000000	3.374350e+04	75.000000
17	Mali	2.666667	3	4.333333	50 days 08:00:00	1525.333333	2.289367e+04	5.666667
13	Gambia	0.000000	1	6.000000	9 days 00:00:00	0.000000	2.000000e+04	0.000000
10	Congo	1300.000000	1	6.000000	14 days 00:00:00	5000.000000	0.000000e+00	0.000000
18	Mauritania	29420.000000	5	8.600000	13 days 14:24:00	4661.000000	9.845000e+03	0.000000
32	Zambia	2180.000000	1	10.000000	59 days 00:00:00	0.000000	3.476600e+04	0.000000
25	Senegal	37615.750000	4	13.500000	11 days 12:00:00	0.000000	1.309000e+05	0.000000
31	United Republic of Tanzania	167300.000000	1	18.000000	16 days 00:00:00	0.000000	5.000000e+04	0.000000
8	Chad	0.000000	1	20.000000	71 days 00:00:00	0.000000	5.948310e+05	0.000000
29	Togo	33480.000000	2	23.500000	39 days 00:00:00	6687.000000	8.630750e+04	78.000000
14	Ghana	16811.800000	5	24.800000	22 days 00:00:00	1000.000000	1.405050e+05	7.400000
2	Benin	0.000000	2	25.000000	96 days 00:00:00	75000.000000	3.675000e+05	500.000000
4	Burkina Faso	54411.666667	3	25.666667	42 days 08:00:00	9333.333333	1.254440e+05	357.666667
30	Uganda	37846.000000	1	27.000000	19 days 00:00:00	0.000000	6.307500e+04	0.000000
28	Sudan	176312.445000	4	29.750000	23 days 00:00:00	0.000000	2.583638e+05	47.250000
19	Morocco	0.000000	1	35.000000	1 days 00:00:00	0.000000	1.000000e+04	0.000000
1	Angola	8260.000000	3	38.333333	28 days 08:00:00	0.000000	1.137760e+05	0.000000
15	Kenya	100.000000	1	40.000000	39 days 00:00:00	0.000000	6.000000e+04	0.000000
26	South Africa	41545.333333	3	41.000000	31 days 16:00:00	66.666667	8.078533e+04	107.000000
22	Niger	36887.466000	5	43.800000	40 days 00:00:00	0.000000	1.908568e+05	12.000000
5	Burundi	6097.980000	2	48.000000	11 days 00:00:00	6250.000000	1.150000e+04	91.000000
11	Djibouti	370.000000	1	51.000000	4 days 00:00:00	1500.000000	9.850000e+04	0.000000
24	Rwanda	0.000000	1	69.000000	32 days 00:00:00	0.000000	2.000000e+04	0.000000
33	Zimbabwe	295.000000	1	70.000000	61 days 00:00:00	66000.000000	2.000000e+05	0.000000
21	Namibia	34291.333333	3	80.666667	31 days 00:00:00	0.000000	3.050000e+05	0.000000
16	Malawi	141345.562500	4	99.250000	29 days 18:00:00	0.000000	5.733115e+05	329.250000
12	Ethiopia	26495.000000	2	99.500000	37 days 00:00:00	0.000000	2.358000e+05	0.000000
23	Nigeria	14300.000000	1	200.000000	8 days 00:00:00	0.000000	8.406500e+04	0.000000

Figure 3: Summary of flood events around Africa

Figure 4 shows the severity of floods in African countries. A larger number of total deaths were recorded in the Democratic Republic of Congo and Nigeria.

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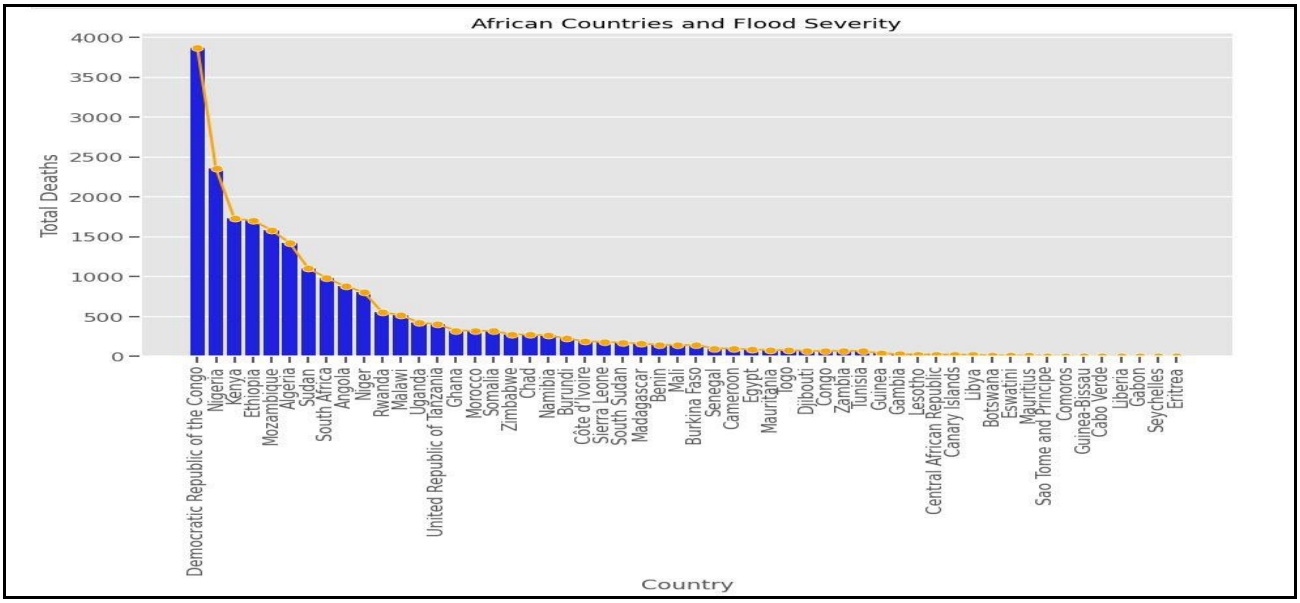

Figure 4: African Countries and flood severity.

Figure 5 shows the features associated with flood events around Africa (adapted from the work of [16].

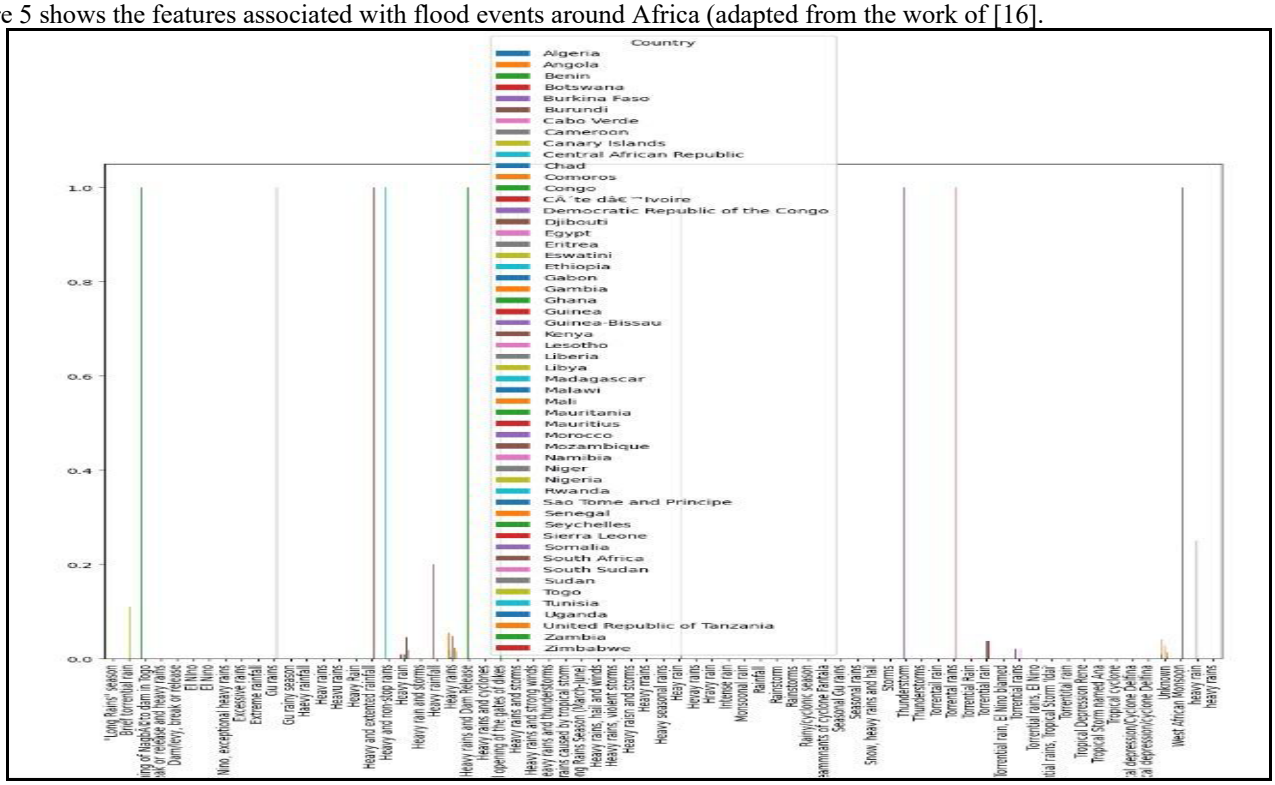

Figure 5: Features associated with flood events around Africa [16]

Figure 6 shows the countries with the highest and lowest number of people affected by floods. Nigeria had the highest number of affected persons. Things affected may be business, shelter, and means of livelihood. Most countries had a lesser impact.

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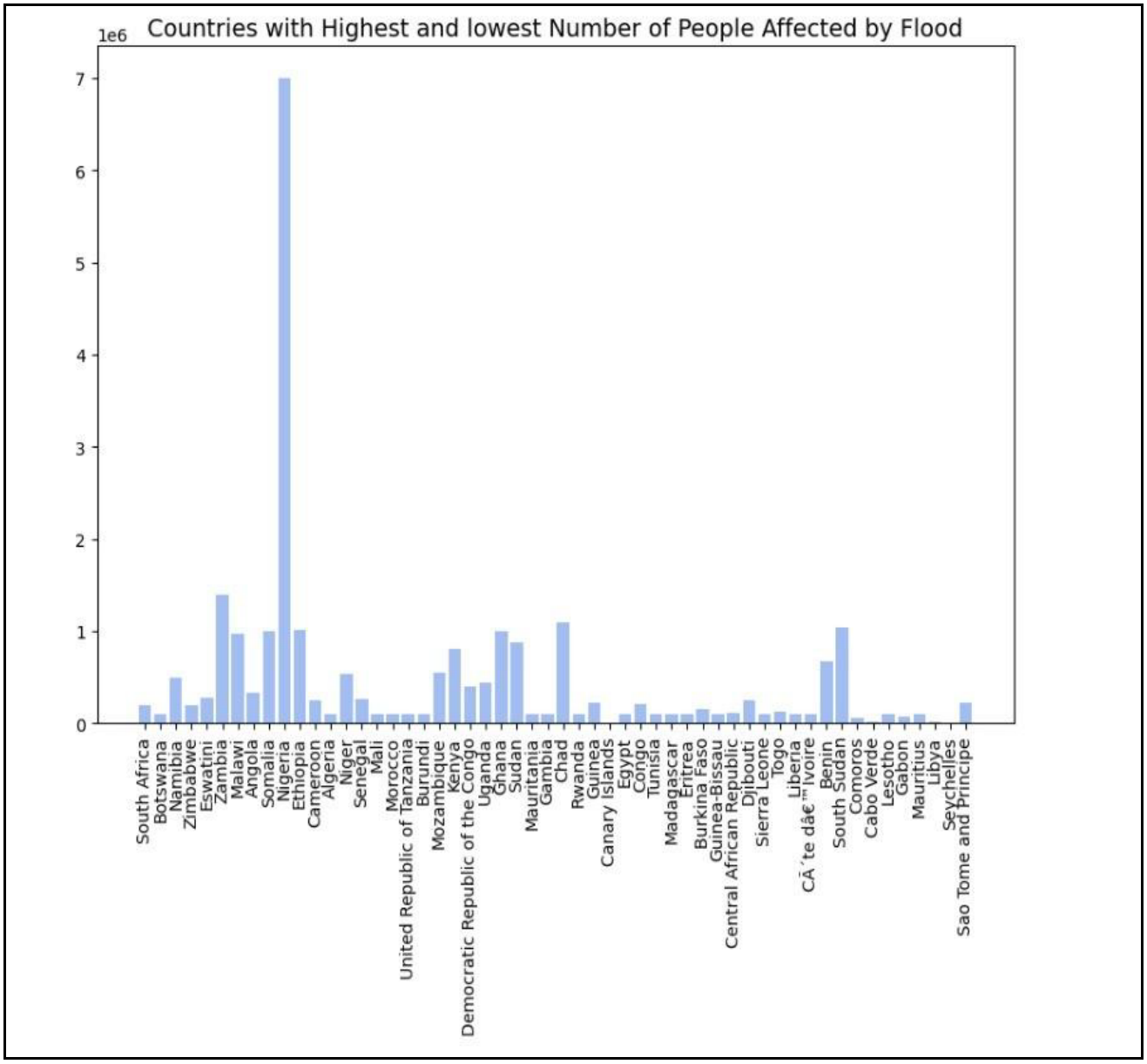

Figure 6: Countries with highest and lowest number of people affected by flood.

Figure 7 shows countries with the highest number of people displaced by floods. From the visualization, it is estimated that Niger had the highest number of displaced persons exceeding the 600,000 mark. Uganda, Somalia, and Sudan reached 200,000 persons displaced. Most countries had a lower number of people displaced which is below 100,000.

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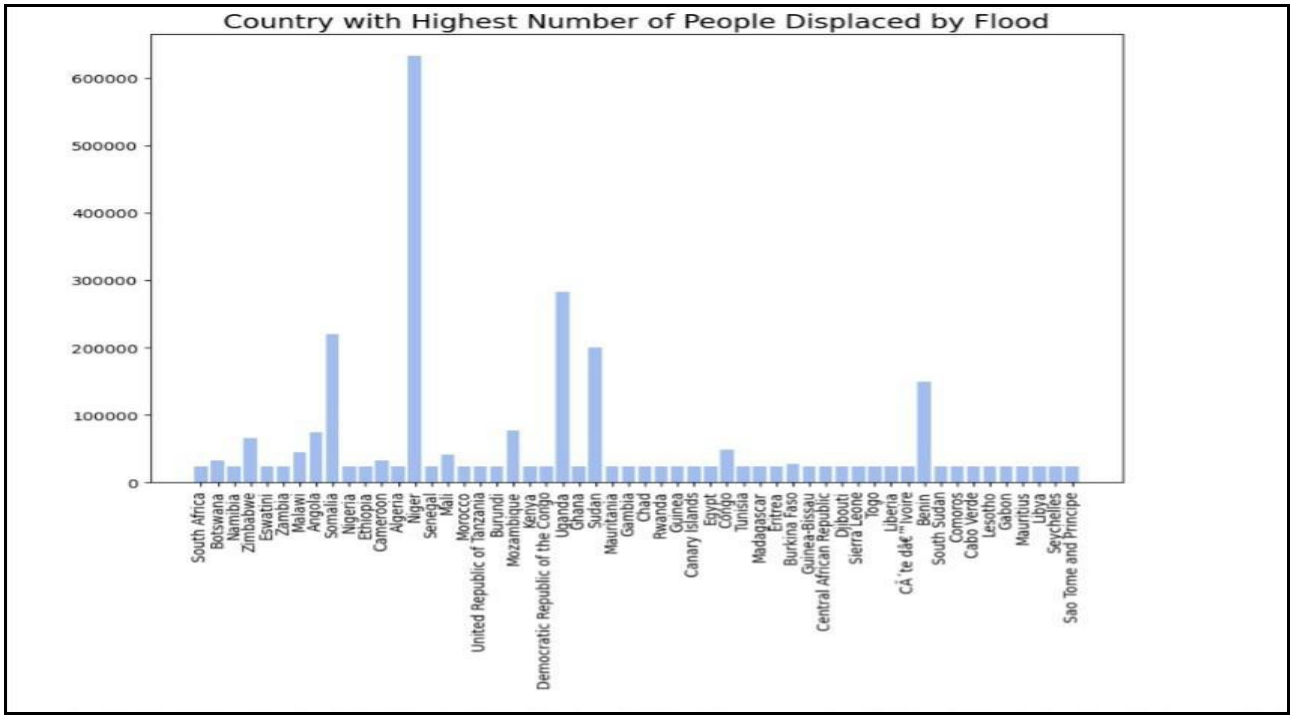

Figure 7: Countries with highest number of people displaced by flood.

Figure 8 shows the number of people injured by floods. Nigeria had the highest number of people injured.

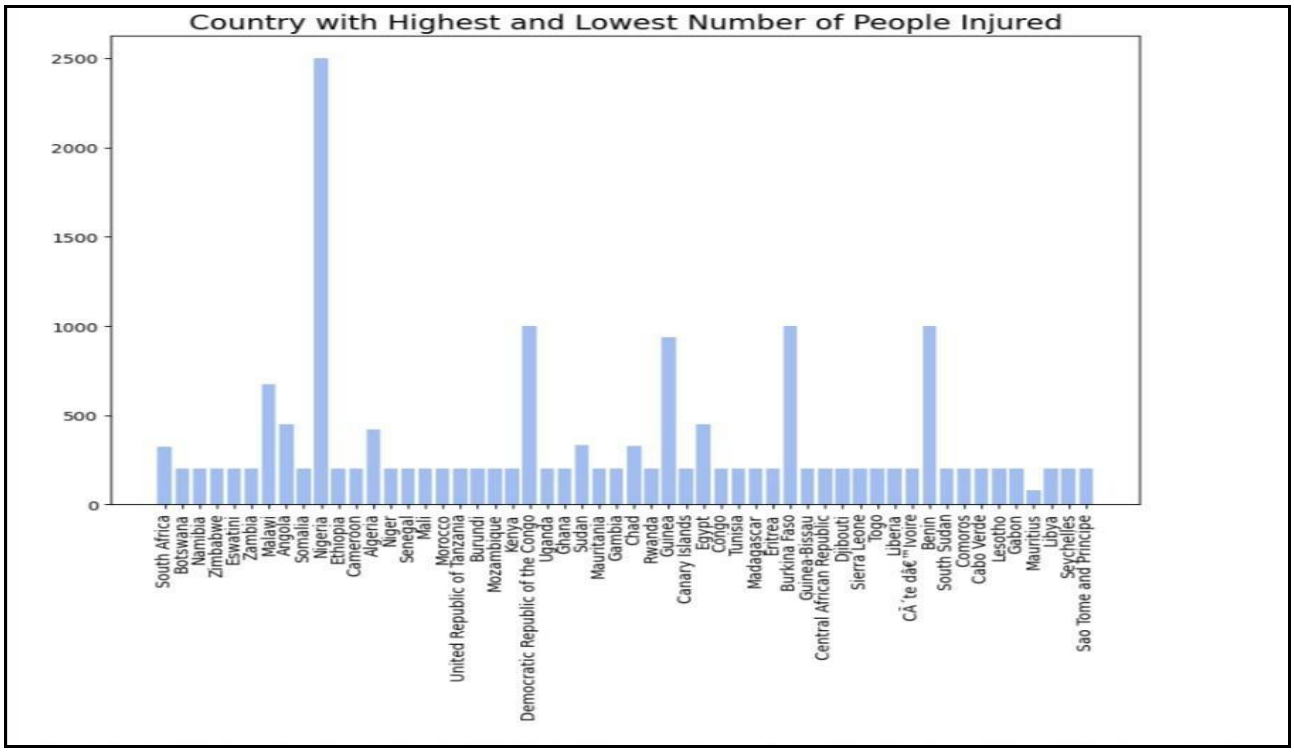

Figure 8: Countries with highest and lowest number of people injured.

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IV. DATA ANALYSIS

Data analysis, often interchanged with the term "data mining", constitutes the intricate process of plunging into extensive datasets to unearth concealed gems of knowledge. In the context of managing flood disasters in Africa, data analysis assumes an indispensable role, acting as the catalyst for the extraction of vital information that spans a wide spectrum of applications [11]. Data analysis is about harnessing the full spectrum of information past and the process is powered by advanced techniques and tools that go beyond the surface layer of data, revealing valuable insights that remain hidden from the unaided eye. By transforming raw data into actionable insights and informed decisions, data analysis equips us with a powerful toolset for navigating the multifaceted challenges presented by flood disasters. Data analysis and data mining are the key instruments that enable us to delve deeper into the layers of big data, unlocking the treasures of concealed knowledge that can significantly enhance our ability to anticipate, respond to, and mitigate the devastating consequences of flood disasters in Africa to build a comprehensive understanding of flood risk factors, assess the impact on affected regions, and predict the potential extent of damage. The codes below are the libraries used in the analyses, and the dataset loaded. The codes focus on two plots, which are 'total deaths' and 'country' & line plot of the entire data against both 'end date and 'magnitude'.

```
import seaborn as sns

import matplotlib.pyplot as plt

plt.figure(figsize=(12,6))

sns.line plot(data=africa_df, x='Start Date', y='Magnitude')


africa_df = pd.read_csv('clean_2.csv')

africa_df
```

```
plt.figure(figsize=(12,6))
sns.lineplot(data=africa_df, x='End Date', y='Magnitude')

fig, ax = plt.subplots(1, figsize=(10,7))
X_total=africa_df['Country']
y_total=africa_df['Total Deaths']
plt.bar(X_total, y_total, color='#A2BDF2')
plt.title('Total Death on Countries of case study', size=16)
ax.tick_params(axis='x', rotation=90)
```

```
fig, ax = plt.subplots(1, figsize=(10,7))
X_total=africa_df['Country']
y_total=africa_df['No. Injured']
plt.bar(X_total, y_total, color='#A2BDF2')
plt.title('Country with Highest and Lowest Number of People Injured',
size=16)ax.tick_params(axis='x', rotation=90)

fig, ax = plt.subplots(1, figsize=(10,7))
X_total=africa_df['Country']
y_total=africa_df['No. Affected']
plt.bar(X_total, y_total, color='#A2BDF2')
plt.title('Countries with Highest and lowest Number of People Affected by Flood',
size=16)
```

The codes below focus on three plots which are 'No. injured' and 'country', 'No. affected' and 'country' & 'No. homeless' and 'country'.

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```
fig, ax = plt.subplots(1, figsize=(10,7))
X_total=africa_df['Country']
y_total=africa_df['No. Homeless']
plt.bar(X_total, y_total, color='#A2BDF2')
plt.title('Country with Highest Number of People Displaced by Flood', size=16)
ax.tick_params(axis='x', rotation=90)
```

It was the implementation of these codes that gave rise to all the earlier presented figures 2 – 8.

V. DISCUSSIONS

The impacts of flooding are felt by the affected individuals and the society at large, through loss of property and infrastructure, damage to farmland, displaced water-living wildlife posing threats, contamination of drinking water, spread of waterborne diseases, fatalities, and loss of well-being, loss of livelihoods, economic depression, and hindrances in achieving social development goals such as safety and eradication of poverty [17]. Due to Africa's diverse climatic conditions, the natural disasters and associated hazards common in the continent include droughts, erosion, landslides and flooding. Recent studies have shown that flooding has been the most frequent and worst natural hazard in Africa within the last decade. Nevertheless, 94% of states in Africa fail to remit 1% of their gross domestic product (GDP) for research and development, a figure set by the African Union (AU) to promote flood risk management. Many of the studies reviewed have identified key or main causes of flooding as anthropogenic factors. Building beside rivers leaves settlements vulnerable to flooding and town planning could limit further expansion of settlements on vulnerable land. Blockage of waterways, by indiscriminate dumping of refuse, for example, diverts the flow of water. Inadequate drainage and broken water pipes also poses a huge problem, as well as dam overflows. Resourcing suitable maintenance programs could help to prevent these causes of flooding [18]. Trees growing on moderate slopes help to prevent erosion, landslides, water runoff, and flooding, through take-up of water and land stabilization by tree root systems. Forestry management could mitigate the loss of trees. The impacts of flooding from waterborne diseases must be met with well-resourced health programs. Therefore, given the political will and prioritizing of resources, flood occurrence, and impacts could both be reduced [19].

VI. CONCLUSION

Although flooding is practically an annual challenge/issue in Africa, the negative effects associated with it can be lessened with wise and proactive management practices. Thus, research that might help better manage the hazards related to flooding is of great significance. Understanding the information found in the data that is now available and making predictions about extreme events are necessary for this. Several methods, including distribution fitting, hydrological modeling, and the application of GIS and geospatial methodologies, have been used to simulate flooding in Nigeria and other parts of sub-Saharan Africa. Due to the shortcomings identified in these methods, alternative strategies that have proven effective in other nations must be taken into account. Specifically, there is potential to leverage the data-driven and Bayesian methods that are commonly employed in modeling water-level discharge, extreme precipitation, or river flow gauge data in nations like the UK, Australia, China, and Vietnam. This study has therefore analyzed the flood disaster menace in sub-Saharan Africa within the past few decades. The work revealed the summary of flood events around Africa, the flood severity which has shown that Congo DRC and Nigeria are the two countries with the most severity of flood, while countries like Eritrea, Seychelles and Gabon were the least affected in terms of flood severity. The work has also shown countries with the highest and lowest numbers of affected persons by the flooding problem and how the flood induced displacement of person's trends looks like. The study revealed that Niger had the highest statistics of displaced persons, followed by Uganda and Somalia with Sudan and Benin Republic maintaining the fourth and fifth positions respectively on displaced people's statistics, other countries showed minimal relative displacement of affected persons. This work equally revealed the injuries statistics with Nigeria leading the pack in the sub-Saharan region. This work has therefore leveraged on data analytics and Python tools to analyze flood disasters in the sub-Saharan Africa within the past few decades.

VII. RECOMMENDATIONS

The locals living in and within sub-Saharan Africa need a positive attitudinal change to the activities and roles they play in exacerbating the flood situation in the sub-region [20]. It is recommended that the member states need to vigorously develop a clear continent-wide Flood Risk Management framework that incorporates relevant aspects of local

knowledge on the root causes, mitigation and coping mechanisms. Finally, we recommend for local community-based studies on participatory mapping and monitoring of flood risk disaster areas in African cities. Future research is encouraged, particularly in terms of creating a database that will house different historical flood data, regardless of the sizes and recurrence intervals of the events.

VIII. REFERENCE

[1] Tomara, W. (2021). Increasing Droughts and Floods on the African Continent in Global Economy and Development.

[2] Fenosoa, R., and Jacques T. (2021). Urbanization and Floods in Sub-saharan Africa: Spatiotemporal Study and Analysis of Vulnerability Factors- Case of Antananarivo Agglomeration (Madagascar). Local Environment Management and Analysis (LEMA). Belgium

[3] Jha, A. A., Bloch, R., and Lamond, J. (2012). Cities and Flooding: A Guide to Integrated Urban Flood Management for the 21st Century; The World Bank. Washington D.C

[4] Lin, B.B.; Philpott, S.M.; Jha, S. (2015). The Future of Urban Agriculture and Biodiversity- Ecosystem Services: Challenges and Next Steps. Basic Applied. Ecology. 16, (pp.189–201).

[5] Etuonovbe, A. (2011). The Devastating Effect of Flooding in Nigeria; UNOCHA - United Nations Office for the Coordination of Humanitarian Affairs publication.

[6] Onuigbo, I.C., Ibrahim, P.O., Agada, D.U., Nwose, I.A. and Abimbola, I.I. (2017). Flood Vulnerability Mapping of Lokoja Metropolis Using Geographical Information System Techniques. Journal of Geoscience and Geomatics. 5,(pp. 229–242).

[7] Komolafe, A. A., Adegboyega, S. A., and Akinluyi, F. O., (2015). A Review of Flood Risk Analysis in Nigeria. American Journal of Environmental Sciences 11(3), (pp.157–166). doi: 10.3844/ ajessp.2015.157.166

[8] United Nations (2009). Water in a Changing World, 318 pages, UNESCO publishing, ISBN: 978-1-84407-840-0.

[9] Jonkman, S.N. (2005). Global Perspectives of Loss of Human Life Caused by Floods, Natural Hazards, 34, (pp.151–175).

[10] European Parliament Council (2007). Directive 2007/60/ of the European Parliament and of the Council of 23 October 2007 on the Assessment and Management of Flood Risks.

[11] EM-DAT (Emergency Events Database) (2004). OFDA/CRED International Disaster Database, from http://www.cred.be/ emdat, Universite Catholique de Louvain, Brussels.

[12] Peduzzi, P., Dao, H., Herold, C., and Mouton, F., (2009). Assessing Global Exposure and Vulnerability Towards Natural Hazards: The Disaster Risk Index. Natural Hazards and Earth System Sciences **9**(4), (pp.1149–1159). doi: 10.5194/nhess-9-1149-2009

[13] Aurore, B., (2022). Climate Change, Urbanization Increases Flooding in Africa. African Environment

[14] Adelekan, I. O. (2016). Flood Risk Management in the Coastal City of Lagos, Nigeria. Journal of Flood Risk Management, 9, (pp.255–264).

[15] Oyegbile, O., 2008. Battling a Global Threat, Tell Magazine, Lagos: Tell Communications Limited, Ikeja. Publication of 11 August, 2008, (pp.20–25)

[16] Conway, D., Persechino, A., Ardoin-Bardin, S., Hamandawana, H., Dieulin, C., and Mahé, G. (2009). Rainfall and River Flow Variability in Sub-Saharan Africa during the Twentieth Century. Journal of Hydrometeorology, 10, (pp.41–59).

[17] Brown, E., Lumbroso, D. and Wade, S. (2014). Science for Humanitarian Emergencies and Resilience (SHEAR) Scoping Study: Annex 1 – Results of a Stakeholder Questionnaire. Retrieved from https://www.gov.uk/dfid-research-outputs/final-reportsciencefor-humanitarian-emergencies-and-resilience-shear-scopingstudy

[18] Egbinola, C. N., Olaniran, H. D. and Amanambu, A. C. (2017). Flood Management in Cities of Developing Countries: The Example of Ibadan, Nigeria. Journal of Flood Risk Management, 10, (pp.546–554).

[19] UNOCHA. (2018). Nigeria: Humanitarian Response Plan; United Nations Office for the Coordination of Humanitarian Affairs: Abuja, Nigeria.

[20] United Nations (2019). Make Cities and Human Settlements Inclusive, Safe, Resilient, and Sustainable. Retrieved from https://unstats.un.org/sdgs/report/2019/goal-11/

[21] Issah, B. 2023. We all share the Blame: Analyzing the Root Cause of Flooding in African Cities with Specific Reference to Harper City, Liberia. Environmental Challenges. Vol.13. 100790. Elsevier.