Bolstering Infrastructures' Resilience to Disasters in Sierra Leone Through Climate-proofing

- *A POLICY APPROACH*

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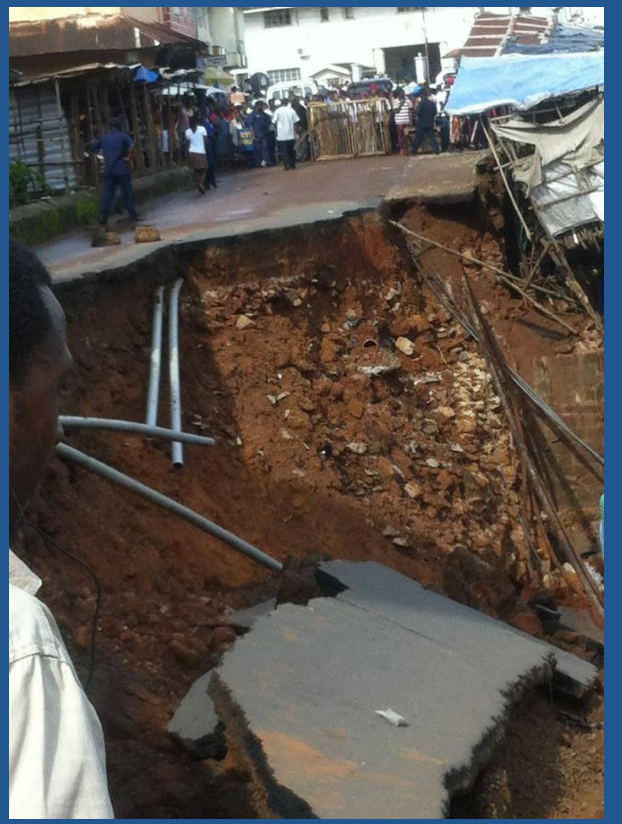

OBJECTIVES

- **Briefly assess** the **soundness of existing infrastructures** in Sierra Leone to **withstand** related disasters.
- **Highlight the importance and opportunities** for ***climate-proofing*** in infrastructure planning design, construction, operation and maintenance in Sierra Leone
- **Explore the prospect for mainstreaming *Climate-proofing*** in infrastructural development, hence disaster risk management.
- Raise awareness on the importance of ***Climate-proofing*** and bring its consideration to the fore. And
- Highlight the need for the Engineers to identify an **entry point** and play an active role in ensuring climate-proofed infrastructures are developed and regulated accordingly.

SCOPE

- Policy Approach
- Review few Disaster related Projects and pick out **gaps**

. Desk Studies on climate change and resilience

Constraints and Limitations

- The Author was **not able to adequately delve into more detailed**, in-depth research work to proffer more possible practical solutions on ***climate-proofing***. The list of disasters and **solution is not exhaustive**. It would have been prudent enough to be engaged in a more robust and detailed institutional assessment and **adequately triangulate** the data obtained. Existing coping mechanisms where not researched.
- It was also impossible to **conduct field visits** to monitor and study the performance of existing infrastructure exposed to various disaster risks. However, some existing infrastructure designs were reviewed during the desk study.

METHODOLOGY

- In planning, designing and maintaining infrastructural projects the AIIB (Asian Infrastructure Investment Bank), (a 21st century Infrastructure Investment based bank) considers the "***lean*", clean" and "*green*"** concept for resilience. The Author adopted this concept to assess and analyze the status of infrastructure in Sierra Leone in withstanding disasters.

- According to the bank, **"*lean*"** represents**, efficient size** of management team and **highly skilled staffs** to ensure resilient infrastructures are built. **"*Clean*"** stands for **zero tolerance for corruption**. Flouting existing procurement practices in implementing infrastructure project can potentially undermine the integrity of infrastructure to withstand disaster to some extent. **"Green"**, institutions dealing with infrastructural development should consider the **environment** from the planning to operation and maintenance phase which has much to do with ***climate-proofing***. The basic fact is that Infrastructures are normally established on an existing environment and can either impact the environment positively or negatively.

Background

- Disasters are **inevitable** and **fatal.** They cause widespread destruction, damage to property and loss of life. The **world as a whole is prone** to Disasters. Most of the disasters occurring in the world are related to or exacerbated by climate change impacts. The impact of disasters seems to vary with vulnerability, ie. **The higher the vulnerable, the more the impact**. **The poor** are the most vulnerable, and as rule Sierra Leone falls in that category, according to the World's GDP rankings, with relatively minimal structures in place for effective resilience. Sierra Leone, like other nations, is prepared for disasters, but the question is**, "*how prepared*"?**

Background Cnt.

- In 2015, it was reported that over **150 major disasters** affect millions of **people worldwide**. The only difference is that disasters varies in magnitude and impact from country to country. **Floods remains to be the most frequently** occurring disaster in almost every part of the world. Examples of disasters in the World are: flooding, earthquake, heatwave, typhoon/hurricane, landslide, drought, diseases outbreak, etc.

BACKGROUND Cnt.

- In **West Africa, starting June 2009**, over **600,000 people** have been affected by **flooding** as a result of heavy rains, with a death toll of about 159 persons (**Relief web**).

Background Sierra Leone

- In Sierra Leone, the largest national disaster we've faced is the **Ebola** epidemic, which took about **4000 lives**, although this is regarded as a health and not climate or geologically related disaster. In September 2015, most parts of the country suffered from flooding due to heavy downpour. Some media houses **reported 4 fatalities**, however, **over 567 families (2630 persons)** were affected, leaving most people homeless and devastated. (Reliefweb.com).

DANGER AHEAD

- The Situation update by FAO revealed that, "***2015 and 2016*** *are predicted as an* ***El Nino*** *year and Sierra Leone is one of the countries that will be affected by this weather phenomenon making the country much wetter than it already is*". This prediction serves as a **wakeup call** to prepare the nation for extreme weather events. **considering our state of preparedness** and disaster response capacity, the question is, "how prepared is Sierra Leone for this?"
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BOLSTERING INFRASTRUCTURE'S RESILIENCE IS PART OF PREPAREDNESS

- It is perceived that infrastructure plays a key role in the delivery of services and in the overall development of a nation**. In Sierra Leone, infrastructure, such as roads, bridges, drainage systems, power supply, water systems are also prone** to disasters and yet capital intensive, losing them to disaster is a mire waste of resources and in turn undermines the country's development drive. When disasters strike, their function is undermined and as a result, intensifies the impact of the disaster, making the recovery path more challenging. On the other hand, with resilient infrastructure, we might not completely eliminate related disasters, but there is as opportunity to somehow alleviate their impacts and save lives and property. **Therefore, bolstering the resilience of critical infrastructure can serve as part of the preparedness measures to tackle possible disasters in Sierra Leone.**

Vulnerability of Infrastructure

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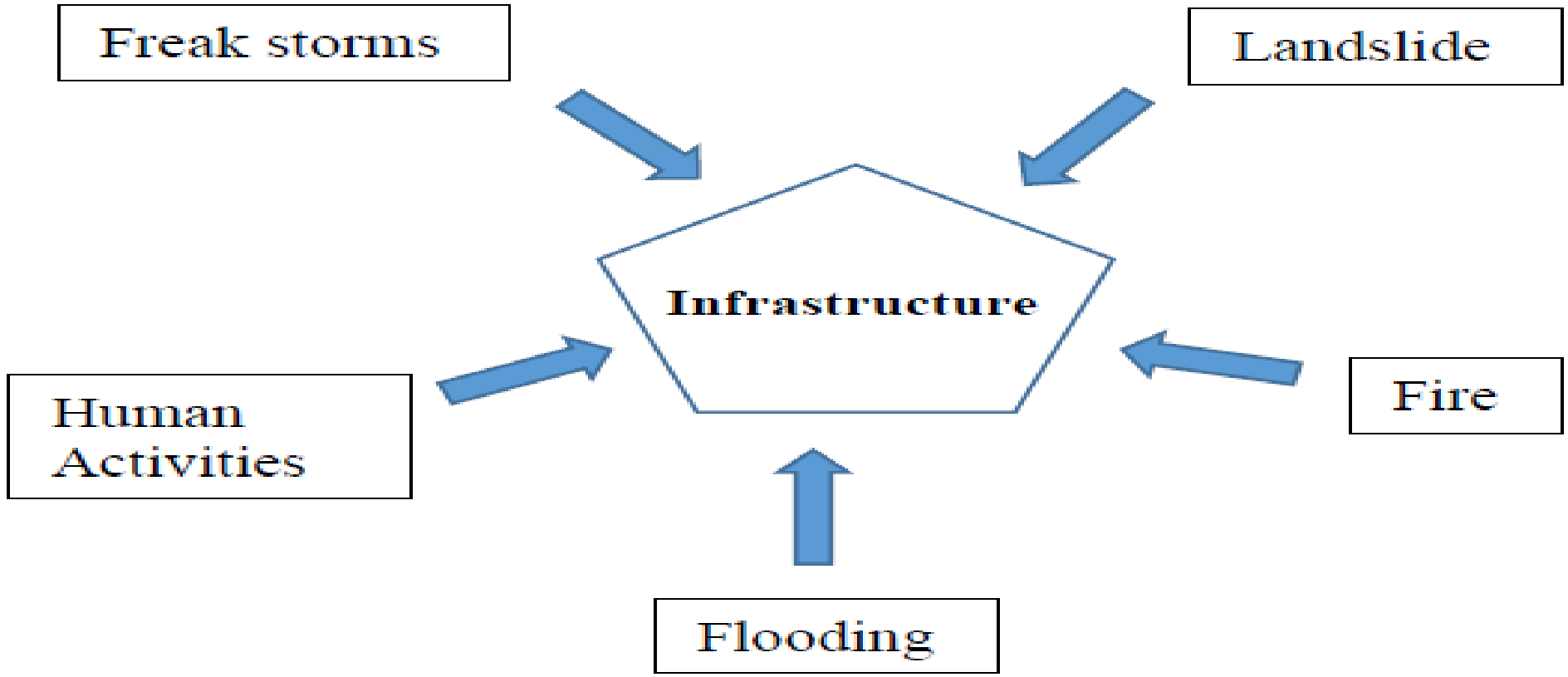

Fig 1. Vulnerability of Infrastructure in Sierra Leone

Example Infrastructure Disaster: Collapsed King Jimmy Bridge

Hmmmm

Climate Change and Climate Variability and their impact on Infrastructure

- Historical evidence has proven that the impact of climate change can either completely destroy essential Infrastructure or at best, rendered them unfit to withstand the overburden caused by disasters and potentially undermining their function or purpose.

CLIMATE

- *Climate in a narrow sense is usually defined as the "**average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities **over a period of time ranging from months to thousands or millions of years.***
- *The **classical period is 30 years**, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as **temperature**, **precipitation, and wind**. Climate in a wider sense is the state, including a statistical description, of the climate system.*

Weather

- the **day-to-day state of the atmosphere** and its short-term (from hours to a few weeks) variations such as temperature, humidity, precipitation, cloudiness, visibility or wind etc.

Climate change

- refers to any **change in climate over time**, whether due to natural variability or anthropogenic forces.

Climate variability,

The problem

- **refers** to variations in the mean state and other climate statistics (standard deviations, the occurrence of extremes, etc.) on all temporal and spatial scales beyond those of individual weather events**. Variability** may result **from natural internal processes** within the climate system (internal variability) or from variations in natural or **anthropogenic external forces** (external variability).
- **Engineering Designs** should cater for this variability

Relationship Between Climate Change and Variability

- **Therefore, variability on time scales longer than a few decades (longer than a standard climatic averaging period) is usually referred to as** climatic change.

Simple ,
believe it or not

- **as the weather is changing, which we all experience, the Climate is also changing with it**.
- The Author further stated that Scientists view climate change as the way **climate fluctuates yearly above or below a long-term average value**.
- Studying the **frequency and magnitude of extremes** is very important, as it affects people in different regions in various ways.

HOW QUICKLY CHANGES HAPPEN ?

- The current concern stems from the rate of change is – "how quickly changes are happening?".
- We use these averages and ranges to make important **societal decisions**. For example, climatological normals of precipitation and historical records of storm events are used to calculate probabilities of future rain events. **Engineers can then use these data to design community storm water drainage systems** and other related infrastructures. These Changes should inherently reflect on our design, therefore we need to ensure that the changes are monitored locally as regional averages can be deceptive.

- WE DON'T KNOW.

Variability and Engineering Design

- I can conclude that, Climate change and variability is real, the entire World is suffering from its impact.

- **Therefore, Infrastructural design should reflect climate change and variability**.

Resilient Infrastructures

Infrastructure should be:

- technically,
- policy and legally,
- financially, and
- institutionally.

RESILIANT

RESILIENCE DEFINED

- According to the Oxford Dictionary, ***resilience*** is (Of a person or animal) able to withstand or recover quickly from difficult conditions.

INFRASTRUCTURE RESILIENCE

- *New infrastructure can be climate resilient by ensuring that an asset is located, designed, built and operated with the current and future climate in mind. Existing infrastructure can be climate resilient by ensuring that maintenance regimes incorporate resilience to the impacts of climate change over an asset's lifetime*". AU (2015)

Practical ways to achieve resilience for infrastructure

To achieve Resilience, Some possible adaptation measures include:

- Ensuring infrastructure is resilient to potential increases in extreme weather events such as storms, floods and heat waves as well as extreme cold weather.
- Ensuring investment decisions take account of changing patterns of consumer demand as a result of climate change.
- Built-in-flexibility, so that infrastructure assets can be modified in the future without incurring excessive cost.
- Ensuring that infrastructure organisations and professionals have the right skills and capacity to implement adaptation measures".

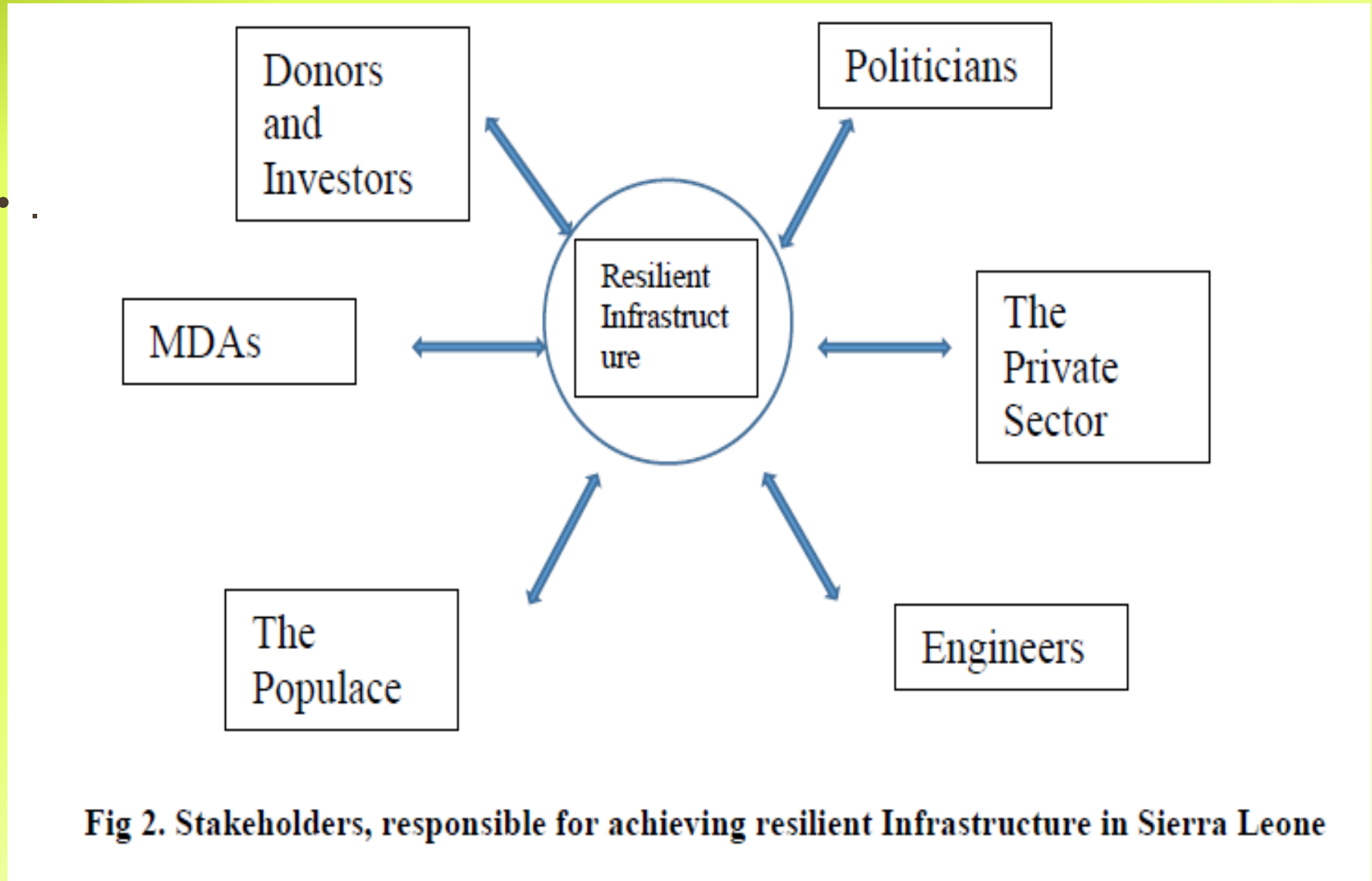

Fig 2. Stakeholders, responsible for achieving resilient Infrastructure in Sierra Leone

Climate-proofing proper

•IT'S A buzz word

- Interestingly, ***Climate-proofing*** is not a new concept.
- Lunwig (2009), indicated that the phrase "***Climate-proofing***" appeared in Australian and American Policy documents decades ago.
- In Scientific literatures, it was probably first described by Glantz (2003).
- It is also important to note that the concept of climate proofing started in the 1970s.

Definition

- However***, Climate-proofing*** *is the process of planning, designing, constructing and maintaining Infrastructures to cape with climate variability. Moreover, assessing and dealing with future uncertainties, risk to disasters is central to all interpretations of* ***climate-proofing****.*

How can we interpret this concept of climate-proofing

- A **policy objective** or additional standard, set of risk threshold for management of infrastructure,
- **A decision support system** for interventions in 21st century's infrastructural developmental projects, with focus on climate change and climate variability, taking into account the uncertainties that comes with a changing climate, or
- **A new planning paradigm** for Infrastructural management, natural resources management and spatial planning, taking into account the risk and opportunities and associated uncertainties.

CLIMATE PROOFING CONCEPTS

- In Asia AND OTHER PLACES, there are numerous climate resilient or ***climate-proofing*** projects implemented through reputable institutions, such as, UNDP, World Bank, Asian Infrastructural Investment bank, etc. All with the primary aim of ensuring infrastructures are adequately PROTECTED AGAINST DISASTERS, hence reducing the **Vulnerability** of Infrastructures.

Practical example of ***Climate-proofing*** procedures in Engineering:

- ***Drought-proofing*** measures which includes changes in land-use practices and other social and livelihood related consideration.
- Fundamental water resources management paradigm or **Integrated water resources management.**
- **Adaptive management,** which includes some form of mitigation and preparedness practices.
- **Formulation and revision of design rules** and management criteria, based on statistical evidences from analysis of monitoring data.
- In order to take unknown flood risk into account, **safety margins are added to design** rules for infrastructural development

- Also bear in mind that there should always be **room for increasing safety margins** as variability continues to become more substantial.

STATEMENT OF THE PROBLEM (SALONE CONTEXT)

- **Apart from flooding, the country has also suffered from other disasters such as; fire outbreak, water shortage, rock fall and landslides. Most of these disasters are coursed by climate change and climate variability impacts.** The obvious variations in weather pattern makes it very difficult to predict with utmost certainty of the frequency and magnitude of disasters related to climate change, therefore, **maximum preparedness is very vital** to minimize the damage caused by disasters

- Additionally, there is extremely **weak regulatory** system to **enforce resilient standards** in almost all sector dealing with infrastructure.

THE APPROACH IN THIS PAPER

- In comparing the state of the current infrastructures exposed to disasters, the author considers ideal design and best practice in the planning, design, construction and maintenance of infrastructure. The emphasis thereon is **not to apply principles and design parameters** to design and maintain various infrastructure in a climate-proofed manner**, but to rather highlight the importance** of its consideration since this is more of **a policy approach to the problem**.

Data Collection and analysis

- The main data collection techniques used was; **interviews, Document review, Direct observation and from experience**.

KEY FINDINGS AND ANALYSIS

To better understand the situation and bring out useful findings, the author divides the findings under some prominent disasters Experienced in Sierra Leone and **adopt the lean, clean and green principle form the Asian Infrastructure Investment Bank(AIIB) for analysis and discussions.**

For this review, the author considers the most frequent and most prominent disasters in Sierra Leone such as**; flooding, transportation accidents, fire and the Water shortage crises.**

Flooding Disaster

- FLOOD VICTIMS AT NATIONAL STADIUM September 2015

DANGEROUS PREDICTION

- Since **2016 and 2015** are predicted as ***El nino* years**, we are expecting wetter periods than usual. Even with rainfall of relatively lesser intensity, our drainage infrastructure seems to be overwhelmed by the **resulting runoff**.

  This is an indication of **looming** **danger**.

- **FLOODING** **RESULTS**

CAUSE

- **Drainage network**: the existing drainage networks and carriageways are not hydraulically sound to convey runoff safely from settlements,

- they are **not of appropriate sizes** or not designed with due consideration of current trends,
- **unplanned settlements** and urban sprawl
- people are in the habit of **dumping rubbish** in drainages


DRAINAGE CLOGGED WITH WASTES

Climate-proofing our drainages to withstand flooding

- The Government should ensure that all **drainage network** is **redesigned** with due consideration of climate variation. To ensure this, design standards should be developed and enforced. Drainages should be designed appropriately by **skilled engineers**, with the Ministry of works responsible to check all design for compliance. This calls for **institutional reform and training**.
- The **procurement process** for installation of drainages should be done in a transparent manner with **zero tolerance for corruption**. Responsive and sound construction companies should be selected and they should be supervised to ensure all design considerations are reflected during construction.
- The Drainages should be **designed as a system and not in isolation**.
- With good Institutional framework a robust operation and maintenance practice should be enforced.
- **Bioengineering** would be helpful.

Another Cause of flooding

- **Precarious settlements:** The Impact of flooding can be intensified by poor urban planning. Most people are constructing houses along river banks and across drainages**, obstructing the flow of water**.
- The legal instrument (**Freetown Improvement Act of 1960**) available for planning the capital Freetown, is already obsolete. Most part of the capital city is not planned.

Mainstreaming *Climate-proofing* in planning and regulatory system

- With the frequency of flooding in the country, Authorities responsible for planning the cities should develop an appropriate **master plan for cities** considering all possible climate resilient elements such as; drainage networks, **removing settlements from risk areas such as Kroo bay, Aberdeen creek etc.**
- The **legal instrument** for planning Cities should be revised and appropriate **regulations and codes** should be developed to control the planning in the country.

Water Crisis

- Recent experience **of extreme weather events** in Sierra Leone helps pinpoint impacts of climate change on water supply in the capital city. The immediate impacts of **droughts** are observed at Guma Valley water company's (water utility) **reservoirs,** where the level of water reduced considerably during the dry season, it was also reported that the water level was 5 feet lower than that of previous year (2015). Consequently, the significant drop of water level **spiked the demand** for water in Freetown, which far exceeds the capacity of the utility to meet, resulting in extreme shortage of water from March to June this year. On one hand, people were blaming the utility for poor management of the utility, on the other, the utility was casting the **blame** on people that have encroached on the catchment areas around the reservoirs and dams.


THE HUNT FOR WATER IN FREETOWN

Climate proofing the water supply systems

- **prompt and diligent** steps are taken to minimize disaster impacts.
- **Political interferences should be avoided** to ensure the that the operation of the entire water system is not compromised.
- **Implementation of integrated water resource management** and developing basin plans
- Introducing disaster **and climate risk assessment,** and improving general framework for risk assessment and management in Sierra Leone.
- Major recommendation would be**, massive tree planting exercises of fast growing trees** and creating a green belt around catchment areas.

Accidents in the Transportation Sector

- The dominant means of transportation in Sierra Leone is land and water. On land, most of the road are poorly designed with inappropriate curves and levels. These roads do not quickly dissipate rainwater during and after a downpour, making it very difficult to distinguish the road from the drainage. Consequently, roads are rendered impassable during extreme weather events. Often than not roads are not build to resist erosion, making the roads unsafe for pedestrians and motorists. Even though there are other reasons for road fatalities in Sierra Leone, one of the reasons for fatalities on roads are is poor construction and design**. Maneuvering around potholes** had been recognized as one of the reasons for collision and hence fatality on the roads. The fatality level in relation to motor vehicle stock corresponds to a fatality rate **of 35-45 fatalities per 10,000 vehicles (SWEROAD (2011).**
- Sierra Leone has a history of high road deterioration, MAINLY due to intense rainfall and intense heat.

- On **water transportation**, in **2009**, it was reported that over **250** people perished in **the Shenge boat accident.** As we look at road accidents, we should also consider the potential hazard on water transportation as most of the safety standards to be observed are not enforced.

10 people and some cows


AGED TENGBEH TOWN BRIDGE


FLOODING IMPEDES TRAFFIC IN FREETOWN

Spate of fires in Sierra Leone

- **Poor town planning**, where settlements are clustered in an area without adequate allowance between houses.
- **Use of substandard material for construction**, typical example is the fire at Siaka stevens street in February 2016, where fire gutted down a two storey building. Purported reasons were, poor electrical installations and wooden floors.
- **Poor structural design** and construction, for instance, where concrete covers are not adequate to withstand the heat and protect the structural integrity of the building and allow trapped victims to come out alive.
- Lack of **adherence** to any set **building code and standards**.
- Unavailability of **adequate fire engines** and equipment to attend

Steps to be taken to address Fire accidents in Sierra Leone.

- Effective and **participatory town planning**
- Development and **enforcement of building codes**
- **Bolstering the Fire response department** in the Country
- **Regulate the standards of electrical equipment and electrification practice**

DISCUSSIONS

- The findings generally indicate that **other countries in the world shares the same concern** about disaster risk management and infrastructure resilience. It was also noted that, in 2015, the African Union summoned all Ministers of African Government in charge of infrastructure related sector to the first Africa Climate Resilient Infrastructure Summit, which took place in Addis Ababa. Although it was not proven whether Sierra Leone was represented in that Summit, but this shows the importance of the topic being discussed in this paper.
- In Sierra Leone, on the Disaster Management front, the **Office of National Security is effectively coordinating all disaster** related response and preparedness activities. It is believed that **ensuring infrastructure resilience is part of preparedness measures**, but much is yet to be done in bolstering infrastructure for disasters as a preparedness measure. With requisite political will, the Sierra Leone **Institution of Engineers should consider this as an entry point** to identify and collaborate with the relevant stakeholders to ensure effective ***Climate-proofing*** is actualized.

Assessing the Capacity of infrastructure in Sierra Leone to withstand disaster.

- **Legal framework is very weak** as almost all of our legal tools are outdated, and probably constituted with minimal consideration for climate change
- Visual demonstration can justify the fact that our **aged infrastructures** cannot withstand occurring disasters such as flooding, transportation accidents, etc.
- Most of our **Infrastructures** in Sierra Leone are **poorly maintained**
- **Standards and not enforced** in infrastructural project implementations.
- There **is no known regulatory body** or system particularly responsible to ensure that infrastructures are climate resilient.
- **Institutional capacity** assessment was not within the scope, however, capacity improvement programmes for the application of effective ***climate-proofing*** should not be overruled.
- **There is prospect for mainstreaming *Climate-proofing* in infrastructural development, hence disaster risk management.**
- Much more is yet to be done to **raise the awareness** on the importance of ***Climate-proofing*** and bring its consideration as a preparedness measure.

General recommendations for implementing *Climate-proofing* to infrastructural developments and possible challenges.

- Often than not, in Sierra Leone, infrastructure projects have been undertaken without considering ***climate-proofing*** in the entire project life cycle. However, for effective resilience, ***climate-proofing*** **solutions should be applied in the entire life-cycle** of an infrastructure project with due involvement of engineers in all stages

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OPPORTUNITIES FOR ENGINEERS IN CLIMATE PROOFING

LIFE CYCLE PHASE	CLIMATE RESILIENT DECISSION POINTS
Policy and Planning	Location of Asset
	Capacity of asset
	Design of Asset
	Funding Mechanism and risk sharing
	Design Codes and construction standards
Conceptual Design	Conceptual Design Parameter
	Conceptual modelling
	Investment Plans
Detailed Design	Detailed Design Parameters
	Modelling
	Environmental Impact assessment
	Financial Evaluation
	Cost-benefit analysis
Construction and establishment	Construction methods and materials
Asset Management	Operation and Maintenance considerations
Monitoring and Adaptation	Retrofitting

able 1 Infrastructure life cycle and ***climate-proofing***.

Possible Challenges to *climate-proofing in Sierra Leone* are:

- Political Interference
- Cost factor
- Corruption
- Lack of adequate technical Capacity
- No local or nationwide Engineering codes.
- Weakness in risk analysis, knowledge management and planning at local level

RECOMMENDATIONS

- Note that, the solutions to address ***climate-proofing*** highlighted in this paper are not exhaustive, but there is an **opportunity for further research to be done**.

- To ensure ***effective Climate proofing***, we **should involve all key-stakeholders** and it should be **applied in all stages** in the life cycle of infrastructural projects.

- climate change should be **considered in strategic planning, finance, program design, and project implementation across a wide range of sectors including health, education, energy, tourism, infrastructure, agriculture, transportation**, etc.

- Practical actions should be taken by **the institution of engineers to ensure infrastructures in Sierra Leone and adequately *climate-proofed***.

RECOMMENDATIONS

- **A strong political will** is needed to reinforce the ***climate-proofing*** drive.
-
- There opportunity **to establish Related Engineering codes in Sierra Leone**, to incorporate disaster risk amongst other considerations.
-
- **Advocacy in key** to ensure infrastructure across the country are adequately ***climate-proofed***.
-
- The **capacity of all stakeholders** involved in planning, designing, constructing and maintenance of infrastructure projects should be developed.

- ***Climate-proofing*** **requirements should be mainstreamed into all stages in the life cycle of infrastructural development.**

RECOMMENDATIONS

- The **legal framework** and related policies for effective ***climate-proofing*** should be drafted and implemented.

- ***Climate-proofing*** should be included in our **local development plans.**

- **Upgrade (retrofitting) of existing infrastructure** and ensure that ***climate-proofing*** measures should be considered in new infrastructure project development.
- ***Climate-proofing*** should be adopted in our **regular infrastructure related practice** and **not be considered as a one-off measure.**

•END

- Thank you