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Coming to Terms with Reality: the Impact of the Emerging Climate Change Risks (IECCR) on Sustainable Urban Growth in Damaturu

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Abstract—*This paper aims to assess the Impact of the Emerging Climate Change Risks (IECCR) on Urban Infrastructure (housing stock, road transport, energy and water systems), economic and social well-being, applicable to Damaturu (Yobe State, Nigeria). It also seeks to develop a viable adaptation strategy (AIECCR) that could lead to resilient and sustainable urban growth of the town. The paper made use of the criteria developed by the Climate Change Risks Observatory (CCRO) to extract the IECCR applicable to the study area. The IECCR & AIECCR strategies were transformed into a Self-Administered Questionnaire (SAQ) and administered to the built environment professionals to weight the likelihood of the impacts, effectiveness of the strategies, and their willingness to implement them. Subsequently, data analysis was carried out using the SPSS. The research has generated a comprehensive list of IECCR & AIECCR strategies for the study area, revealed disparity among the professionals, and identified variables with statistical difference such as; IECCR on Energy Systems (PI3j), Water Systems (PI4e, PI4f), Social Well-Being (SWIa), Some of the variables were rejected and some retained. 'Climate Change' as a topic itself is still an alien phenomenon, and is often mystifying and even blasphemous in the study area. For that reason, an in-depth reconnaissance survey of the study area was limited. Identifying the IECCR & AIECCR strategies and integrating them into policies can eventually affect the way towns and cities are designed, planned, and constructed. It can also save considerable time, lives, and resources if implemented in every plan and development. This is the first research carried out for the study area that has identified a comprehensive list of IECCR & AIECCR strategies, which when implemented could lead to resilient and sustainable growth of Damaturu.*

1. INTRODUCTION

Most of the built environment professionals such as Architects, Engineers, Surveyors, Planners, and 'Others' that are acquainted with the impact of climate change in the North-Eastern part of Nigeria mention drought & desertification, and receding of Lake Chad as the major examples. This phenomenon had been studied profusely for decades, and; several studies have shown that the hydrological cycle of the Sahel region which forms almost half of the Lake Chad region has changed over the last half of the last century [1]. Prominent among the recent studies are the ones carried out by Batterbury and Warren, and Hulme [2] [3].

These well quoted publications are still highly appreciated, and have drawn attention to a number of problems that has afflicted a lot of people in the study area. Drought and desertification, receding of Lake Chad has left a lasting impression on the academics and the built environment professionals at the study area in such a way that; most of the responses they give always relate to - or - refer to these well-known impacts. However, the Impact of the Emerging Climate Change Risks (IECCR) is not only restricted to those known impacts, but has Impact on urban infrastructure (UI) such as; housing stock, road transport systems, energy systems, and water systems; economic impact (associated with housing stock), and impact on social well-being (impact on human health) as well.

2. METHODOLOGY

The research made use of the criteria developed by the Climate Change Risks Observatory (CCRO) [4] for extracting the IECCR applicable to the study area. The IECCR & AIECCR strategies were transformed into a Self-Administered Questionnaire (SAQ) and administered to one hundred and five built environment professionals from the field of Architecture, Engineering & Surveying, Planning and several other professions categorised as 'Others' to weight the likelihood of the impacts, effectiveness of the strategies, and their willingness to implement them in their plans, designs or future policies. See Table 1. Subsequently, data analysis was carried out using the SPSS statistical tool. Ranking of the data was carried out using the Kendall's Coefficient of Concordance (*W*), and the Reliability analysis of the data was carried out using Analysis of Variance (ANOVA).

3. RESEARCH FINDINGS

The research has compiled a comprehensive list of IECCR & AIECCR strategies for the study area that was not put together prior to this, several statistical tools were used to carry out the analysis of the data obtained and has revealed a disparity among the built environment professionals. Ranking of the data obtained has shown clearly how their views differ on certain subject. One-way ANOVA has also revealed 10 out of 100 variables of the study has statistical difference such as; IECCR on Energy Systems (PI3j), IECCR on Water Systems (PI4e, PI4f), IECCR on Social Well-Being (SWIa), AIECCR on Housing Stock (API1a), AIECCR on Energy Systems (API3f), AIECCR on the Economy (AEIb, AEIc), and AIECCR on Social Well-Being (ASWIe). Some of the variables were rejected and some retained.

4. RESEARCH LIMITATION

'Climate Change' as a topic itself is still an alien phenomenon, and is often mystifying and even blasphemous in the study area, an in-depth reconnaissance survey of the study area were limited and raise suspicion, accessibility to acquiring a more diverse data had also been restricted due to the on-going insurgencies.

5. VULNERABILITY OF DAMATURU TO IECCR

Yobe State has hot and dry climatic condition in the northern part of the State for most part of the year, and the southern part of the State, has a hotter and cooler condition for most part of the year. March, April and May, are the hottest months of the year ranges from 39 – 42°C [5]. Damaturu, the administrative capital of Yobe State is located between latitude 11° 44' N to 11° 45'N and longitude 11° 56' E to 11° 58' E [6]. The West African Sahel-Savannah region has become synonymous with crisis and catastrophe, with images of dying trees, moving sand dunes, drying up of wetlands, and expanding swathes of unproductive land, have become conventional in both popular and political discourse [7]. Recent statistics has also shown an increase of IECCR threatening the entire region. Nigeria, together with South Sudan occupies the 3rd position on the verisk Maplecroft 2015 vulnerability index. Note: Nigeria was the 6th most vulnerable country in 2014 (now in 3rd) A stark reality that the situation is getting more severe [8]

Table 1: the impact of the emerging climate change risks (IECCR)

The Impact of the Emerging Climate Change Risks (IECCR) on Urban Infrastructure (UI) such as; Housing Stock, Road Transport Systems, Energy Systems and Water Systems; Economic Impact (associated with Housing Stock) and Social Well-being Impact (Impact on Human Health) applicable to Damaturu (Yobe State, Nigeria).
*Emerging Climate Change Risks (increase in severe temperature, intense precipitation & extreme weather occurrence) ECCR
IECCR on UI (housing stock, road transport systems, energy systems and water systems)

Research Area	Effects
Climate Change Impacts on Housing and Human Settlements	An increase in the ECCR on UI (Housing Stock) causes: Deterioration of housing units and loss of habitable land for development [9]
Climate Change Risks in Building – An Introduction	Delay to construction process Poor internal environment leads to the growth of mould in houses Damaging of building fabric and structural damage as a result of wind related events [10]
Coming to terms with reality: the Impact of the Emerging Climate Change Risks (IECCR) on Sustainable Urban Growth in Damaturu	Dust storm induced by drought causes the destruction of roofs, stalls and buildings [11]
Climate Change and Innovation in House Building - Designing Out Risk	Increased soil drying will affect water tables and could affect foundations in clay soils [12]
Preparing For Change - A Climate Change Adaptation Framework for the Built Environment	Causes damage to other properties from flying debris [13]
A Changing Climate for Property Investment: A Trustee's Guide	Decreased durability and performance of materials [14]
Assessment of Defects at Construction and Occupancy Stages	Increase of latent defect problems [15]
Effect of Lightning on Building and Its Protection Measures	Lightning strike damage to buildings during storms [16]
GRaBS Summary and Policy Guidelines adapting transport systems to climate change	An increase in the ECCR on UI (Road Transport Systems) causes: The rapid dilapidation of sub-grade material beneath the roads, thus leading to the loss of strength and bearing capacity Dirt roads and other roads with inadequate foundation and drainage have a high tendency of being washed away or battered The damaging of street lighting, sign post and filling stations [17]

Addressing Climate Change Adaptation in Regional Transportation Plans: A Guide for California MPOs and RTPAs	The Rutting of Asphalt The Buckling of Asphalt [18]
Climate Change Impacts In Urban Areas of Mozambique - A Pilot Initiative in Maputo City	Increased road surface and bridges damage Increased maintenance requirements for roadside [19]
Decision and Information Sciences - Climate Change Impacts on the Electric Power System in the Western United States	An increase in the ECCR on UI (Energy Systems) causes: Thermal expansion of transmission and distribution power lines causes line sag, decreasing the amount of power that can be securely transported through lines Reduced transmission line capability increases congestion problems thereby increasing the use of more expensive generating power sources High demand for electricity to run air conditioners and refrigerators [20]
Climate Change Adaptation Report	Damaging of equipment due to high operating temperatures Localised drying of subsoil increases ground resistivity and the ability of cables to dissipate heat into the ground, leading to rapid degradation and failure [21]
Extreme Weather Effects on the Energy Infrastructure	Distribution transformers which typically cool off at night, are unable to cool down sufficiently during warm nights Seasonal and daily temperatures and precipitation changes affect the timing of peak electricity demands and the size of these peaks [22]
Climate Impacts on Energy Systems - Key Issues for Energy Sector Adaptation	Reduced solar cell efficiency Reduced energy generated by Solar Power Energy transmission and distribution is affected by erosion Increased vulnerability of existing assets [23]
Water scarcity and climate change - Growing risks for business and investors	An increase in the ECCR on UI (Water Systems) causes: Increased water temperatures leads to more algal and bacterial blooms that further contaminate water supplies Increased higher costs for water [24]
Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change	Increased fluvial flooding Increased sewer (pluvial) flooding [25]
Cities and Climate Change: Policy Directions	Water shortages for households, industries and services [26]
Climate Change Risk Assessment for the Water Sector	Supply-Demand Deficit [27]
Economic Impacts (associated with Housing Stock)	
Impact of Climate Change on Infrastructure and CGE model inputs	An increase in the ECCR on the Economy (associated with Housing Stock) causes: Increased residential and community property damage Increased commercial property damage Increased maintenance, repair and replacement of residential and commercial buildings Increased maintenance, repair and replacement of utility infrastructure (e.g. septic tanks/soak-away) Increased maintenance costs associated with damage to drainage infrastructure (e.g. culvert) [28]
Adapting to Climate Change - Cities and the Urban Poor	The value of local infrastructure is at risk The value of regional or national assets is at risk The value of human settlements is at risk [29]
The Economics of Global Climate Change	Increased costs of air conditioning [30]
Whole Life-Cycle Costing: Risk And Risk Responses	Reduced asset life Potential need for retrofitting mechanical ventilation Increase in the cost of materials supply Risk of water restriction Higher costs of repair Increased downtime [31]
Social Well-being Impacts (Impact on Human Health)	
Climate in Peril - A popular guide to the latest IPCC reports	An increase in the ECCR on Social Well-being Impacts (Impact on Human Health) causes: Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated [32]
Health Effects of Climate Change in the UK	Thermal stress, chemical and biological contamination in the indoor environment [33]

Climate Change and Human Health - Risks and Responses	Increased vector-borne and rodent-borne diseases Increased water-borne diseases Mental, nutritional, infectious and other health effects [34]
The Anatomy of a Silent Crisis	Voluntary and involuntary displacement [35]
Climate Change Impacts on Livelihoods, Climate Change Impacts on Vulnerable Groups	Distress to livelihoods Distress to vulnerable groups (women and children) [9]

Kendall's Coefficient of Concordance (*W*), and Reliability analysis of the data carried out using Analysis of Variance (ANOVA) have both shown disparities of perception among the respondents. The differences in Cronbach's alpha and the severity index of ranking have also justified how perception of the respondents differs. Subsequently, One-way ANOVA was used then to test their significant difference.

Variables with significant difference

Energy transmission and distribution is affected by erosion (PI3j) - One-Way ANOVA has indicated that there was a significant difference between the perceptions of the built environment professionals on IECCR on Energy Systems (PI3j) applicable to Damaturu. The null hypothesis ($H_{0:\ 1=0}$) - ($p < 0.05$) was retained.

Increased fluvial flooding (PI4c) - One-Way ANOVA has indicated that there was a significant difference between the perceptions of the built environment professionals on IECCR on Water Systems (PI4c) applicable to Damaturu. The null hypothesis ($H_{0:\ 1=0}$) - ($p < 0.05$) was rejected.

Water shortages for households, industries and services (PI4e) - One-Way ANOVA has indicated that there was a significant difference between the perceptions of the built environment professionals on IECCR on Water Systems (PI4e) applicable to Damaturu. The null hypothesis ($H_{0:\ 1=0}$) - ($p < 0.05$) was retained.

Supply-Demand Deficit (PI4f) - One-Way ANOVA has indicated that there was a significant difference between the perceptions of the built environment professionals on IECCR on Water Systems (PI4f) applicable to Damaturu. The null hypothesis ($H_{0:\ 1=0}$) - ($p < 0.05$) was rejected.

Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated (SWIa) - One-Way ANOVA has indicated that there was a significant difference between the perceptions of the built environment professionals on IECCR on Social Well-Being (SWIa) applicable to Damaturu. The null hypothesis ($H_{0:\ 1=0}$) - ($p < 0.05$) was retained.

Despite the fact that an abundance of adaptation strategies, plans, and programmes have been established, advancement in turning these into action has been sluggish. The improvement of a sound knowledge base to support adaptation globally is recommended to accelerate progress, but has trailed behind. The prominence in both current and newly proposed programmes is very much on practice-oriented research with strong stakeholder involvement [36]. The repercussions of climate change for the environment and society, will not only depend on the response of the Earth system to changes in radiative forcings, but also on how people react through changes in technology, economies, lifestyle and policies [37].

Land use planning is vital for managing issues associated to climatic variation in urban settings. Nonetheless, Master Plans do not usually include climatic aspects, and only limited studies have addressed climate change at the urban scale, more especially in developing countries [38]. Developing and implementing climate change adaptation measures is not a hitch free process, but quite a continuous struggle of stumbling upon and overcoming challenges [39].

6. DISCUSSION AND CONCLUSION

The study has clarified the likely Impact of the Emerging Climate Change Risks (IECCR) on Urban Infrastructure (UI) such as; Housing Stock, Road Transport Systems, Energy Systems, and Water Systems; Economic and Social Well-being Impact, and their adaptation strategies applicable to Damaturu (Yobe State, Nigeria). It has also received a positive recommendation by the built environment professionals of their willingness to consider and integrate the IECCR & AIECCR strategies into their plans, designs, policies and programmes. This was achieved by the confirmation of the research hypotheses.

Acknowledgement of the IECCR & AIECCR strategies and its integration in the way town and cities are planned, designed or constructed will go a long way in helping the study area to adapt to IECCR. The lackluster attitude of waiting for the federal government or the state government to solve all our problems will not help in adapting to the IECCR. Despite the fact that quite a majority of the population in Nigeria live below the poverty line, Nigeria is not a poor country. The built environment professionals are competent enough to assess and develop strategies for climate change adaption. However, developing solutions is one thing, implementing them is another. Problem identification is the first step and one of the most important in the Planning Process. The built environment professionals in Lagos State Nigeria, for example, did not wait for the long awaited Climate Change Bill that was passed since 2010 and has still not become a Law at the time of writing this journal before springing into action to employ the latest technology for reclaiming and protecting their shorelines, in order to tackle the effects of sea level rise they are threatened with. Lagos State in the opinion of the researcher will always be a step ahead of other states in

Nigeria due to the fact that; they have successfully hosted their 6th Climate Change Summit in 2014. There is a clear indication that the outcome of their policies is not just left on paper, but implemented as well. Of course comparing Lagos State with other States might seem unfair, but each and every State in the country is capable of planning and implementing its Climate Change policies with or without the intervention of Federal Government or Aid from elsewhere. The built environment professionals, policy makers and residents in the study area need to be enlightened with other IECCR and its effects that equally threaten a resilient and sustainable urban growth, other than the ones they are already familiar with such as the ones mentioned earlier on. Time, lives, and a lot of resources could be saved if these IECCR are identified and acknowledged early in the wider society, and taken into consideration in every kind of development to ensure a resilient and sustainable urban growth.

Criticising the heads of government, parliamentarians, ministers, state commissioners and heads of local government when things go wrong is like a pastime to many people at the study area (and other towns and cities around the world as well by people not happy with their government's policies). However, these set of policy makers do not bend down on drawing boards to sketch, or use the computer mouse to design how our cities ought to grow. The design, supervision and monitoring of construction works are ordinarily carried out, or ought to be carried out by the built environment professionals (and should continue to be so). Contracts are advertised, construction companies/firms bid, successful bidders win and are awarded with the contract. Subsequently, it is left to the built environment professionals to do their jobs professionally.

There is a room for further research to find out which is more important? Adhering to 'standards' regardless of how it affects professional practice and urban growth or the need to study the vulnerability of town and cities to climate change, assessment of its impact and the provision of its adaptation strategies before carrying out any future plans or designs? This is the first research carried out for the study area that has identified a comprehensive list of IECCR & AIECCR strategies, which when implemented could lead to a resilient and sustainable growth of Damaturu.

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