Climate change risk on infrastructure and policy implications of appropriate mitigation measures in the Nigerian agricultural sector

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CLIMATE CHANGE RISK ON INFRASTRCTURE AND POLICY IMPLICATIONS OF APPROPRIATE MITIGATION MEASURES IN THE NIGERIAN AGRICULTURAL SECTOR

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Abstract: Agriculture a critical sector of the Nigerian economy contributes 26% to the country's GDP, and supports livelihoods by employing over 70% of the active population. The importance of the sector for food security, poverty reduction and economic development has been recognized. While population growth places increasing food demand and raw materials, the sector will have to double its productivity to meet demand and this is highly dependent on the availability of infrastructure. Infrastructure to support agricultural production and other economic purposes are found to be inadequate and the few available are in poor conditions due to inappropriate policy processes amongst others. The frequency and severity of climate related events occurring as rapid onset and slow onset events are on the rise posing threats to the few available infrastructures. This paper aims to analyse climate change risks on infrastructure in the Nigerian agricultural sector through a review of existing of literature. Findings reveal that policy and institutional processes at levels of authority significantly influences the status of infrastructures at community levels which in turn contributes to increased risks and impacts of climate change. Suggestions for infrastructure appropriation for continuous capacity building can reduce risks from climate change, and improve resilience of infrastructures in agrarian communities.

Keywords: Climate change, Impacts, Infrastructure, Risk, Policy

1. INTRODUCTION

Climate change, a change in the average climate patterns is a challenge experienced globally with adverse impacts on almost all sectors of world economies. Climate change driven by both natural and anthropogenic activities contributes to global warming with consequences of rising temperatures, increased evaporation, heavy rains and storms, leading to extreme weather events such as floods on one end and droughts on the other end of an extreme. Climate change also increases the frequency and intensity of these extreme weather events with adverse impacts globally. These are expected to have more impacts on developing regions due to their limited capacity to adapt to adverse conditions (Sherman et al., 2016).

Nigeria, a tropical African country bounded by the Sahara desert to the north and the Atlantic Ocean to the south experiences contrasting adverse climate related events ranging from floods to droughts due to its location. Alongside, seasonal changes in weather patterns influences the climate related events experienced as floods are experienced mostly during rainy seasons and droughts in the dry season. These changes in weather and climate has resulted to more frequent and severe floods mostly along coastal/ riverine areas, droughts around the northern arid regions, prolonged dry spells, irregular precipitations, and water scarcity (Elusoji, 2016; Olayide, 2016). This has led not only to personal and large economic losses but huge impacts on critical infrastructure systems supporting everyday living thereby a threat to economic development (Ebele & Emodi, 2016).

Infrastructures, referring to core services in the form of hard physical facilities and organisational structures needed for the effective functioning of an economy, are at risk of adverse effects of climate change. However particular emphasis are placed on infrastructures in the agricultural sector; a critical sector which when affected will lead to high food insecurity, and poverty (Boko et al., 2007; Ebele & Emodi, 2016). Agrarian communities also known as rural communities that host agricultural activities are dependent on the availability of infrastructure systems such as roads, electricity, and water for optimal productivity. However these are grossly inadequate and the few available ones in poor conditions leading to economic underdevelopment and decay (Ayinde, Falola, Babarinde, & Ajewole, 2016). Infrastructures in rural communities are generally characterized by a state of low quality and/or long periods of usage without maintenance (Sam, 2014). Growing populations and the continuous use of the few available infrastructure systems reduces the resilience of such systems thereby exposing them to multiple risks such as climate change. Infrastructure risk is therefore the potential for losses due to the failure of infrastructure systems supporting agricultural production.

The increasing incidences of climate change driven events and the inadequacy in terms of quality and quantity of infrastructure systems to support agricultural production are major challenges that can lead to a failure in the agricultural sector with resultant impacts on the general economy. While little can be done to influence the changing weather and climate conditions, policies and processes can be tailored towards safeguarding infrastructures from loss/damage. Hence, infrastructure appropriation: the act of ensuring the adequacy of infrastructures in terms of quality and quantity is critical for climate change risk and impact reduction as well as improved resilience of infrastructures.

This paper aims to analyse climate change risk on infrastructure in the Nigerian agricultural sector in order to highlight the importance of resilient infrastructures for impact and risk reduction in agrarian communities. While extensive studies have been conducted on the importance of infrastructure to agricultural and economic development (Ikeji, 2013; T. Lawal, 2014), and limited research on the impacts of climate change on infrastructures such as roads, buildings and irrigation facilities (Adewole, Agbola, & Kasim, 2015; Ede & Oshiga, 2014) research on how the condition of infrastructure can exacerbate climate change risks and impacts are lacking. The main focus of this paper is on how institutional processes at levels of authority influences the status of infrastructures which in turn increases infrastructure risk to damage or loss by climate change so as to propose best practices for improved resilience of infrastructure systems. Following a critical review of existing literature, major climate related events experienced in Nigeria were identified and categorized into rapid and slow onset events according to DWF's (Development Workshop France) classification of disasters. We examined the current and future impacts of these events on infrastructure (transport systems, irrigation systems and agricultural services). We then considered how institutional processes influence the status of infrastructures thereby exposing them to further threats. The following sections of the paper are outlined thus. First is a general overview of climate change and its related events in Nigeria. The second section focusses on the impacts of climate change on critical infrastructure systems, particularly transportation systems, irrigation systems and agricultural services. Thirdly, is critical infrastructure status and factors influencing the status of infrastructure. Finally, the conclusion and recommendations.

2. CLIMATE CHANGE & RELATED EVENTS IN NIGERIA

Climate is the general weather conditions of a place over a period of time. Climate change is a shift in the average climate patterns as a result of increasing concentrations of greenhouse gasses (GHG) due to natural or human activities GHGs such as carbon dioxide (CO_2), chlorofluorocarbon (CFCs), methane (CH_4), and Nitrous oxide (N_2O) contributes to global warming resulting to high temperatures, higher rates of evaporation, drying of water bodies, higher concentration/ condensation of atmospheric pressure, consequently falling back as heavy rains. The concern about these alteration of weather patterns is that resultant climate related events such as floods and droughts attributes to the frequency and intensity of natural disaster globally (Holling, 1973; Pelling, 2010). Not only is there an increase in the occurrence of these events but also its increasing impacts on the built environment and socioeconomic activities.

Generally, temperature and rainfall projection in Nigeria reveals hotter and drier conditions. Annual mean temperature increase of between 1-4oC is expected. Lower rainfalls are expected towards the north however due to high evaporation and ocean currents, higher rainfalls are expected towards the coast (B. J. Abiodun, Lawal, Salami, & Abatan, 2013). Rainfall in particular is a major determinant to the occurrence of either floods or droughts across the country (Fuwape, Ogunjo, Oluyamo, & Rabiu, 2016).Climate related events commonly recorded in Nigeria include drought, epidemic, extreme temperature, flooding, and storm (refer to Table 2).

Table 2: Climate Related Events in Nigeria 1900-2016 (EM-DAT IDD, 2017)

Event type	Events count	Total deaths	Total affected
Drought	1	0	3,000,000
Epidemic	42	23,978	304,436
Extreme temperature	2	78	0
Flood	44	1493	10,478,919
Storm	6	254	17,012

Nigeria a tropical African country is particularly vulnerable to climate related events ranging from droughts on one end and floods on the other end of the extreme driven by climate change. Floods record the highest frequency as well as the highest impact. Droughts on the other hand have the least frequency of occurrence yet a very high impact in terms of the number of people affected. Flooding is recorded almost annually in recent years due to the continuous rise in sea levels threatening coastal towns as well as infrastructures located in those regions (Davis, 2013). Droughts formerly linked to only the north-eastern region of the country is gradually experienced in other parts of the country as prolonged periods of precipitation deficiency leads to water shortages (Gwamzhi, Dongurum, Dabi, & Goyol, 2013). Warmer temperatures are increasingly experienced and new temperature records are set (Eludoyin, Adelekan, Webster, & Eludoyin, 2014). Changing rainfall patterns: late onset of rains, irregular and erratic rains often accompanied by storms are continuously recorded (Lawal et al., 2016).

Climate change and its related events can exhibit as rapid onset events or slow onset events (refer to Figure 27). Rapid onset events include floods, epidemics, and storms; while slow onset events include extreme temperatures, and droughts.

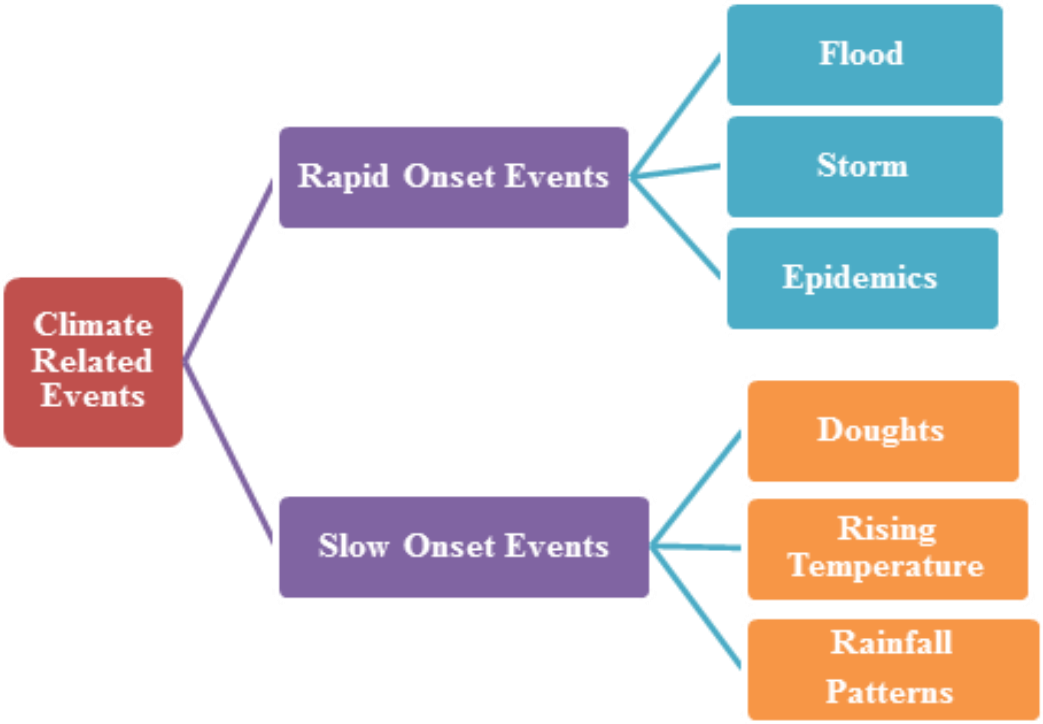

Figure 27: Classification of Climate Related Events

Whether rapid onset events such as floods or slow onset events such as droughts, both are on the increase and have impacts not only on individuals, communities and livelihoods, but also on infrastructures (Imo, 2014). As such, while studying the frequency and occurrence of climate related event is important, likewise the impacts of these events on critical infrastructures.

3. CLIMATE CHANGE IMPACTS ON CRITICAL INFRASTRUCTURE

Climate change and its associated events either occurring as rapid onset events such as floods or slow onset events such as droughts are on the increase and projections reveals that more will be experienced in the coming years. They have impacts on both human and socioeconomic activities thereby affecting the general economic development of a nation. These have negative implications for critical infrastructures such as roads, and bridges, irrigation systems, as well as agricultural services resulting in negative effects on water sources, disruption of services, the spread of epidemics from plant pests and diseases and lower rates of food production. This section focuses on the impacts of different climate related events namely: floods, drought, storms, extreme temperature and changing rainfall patterns on transportation systems, irrigation systems and agricultural services.

3.1 Impacts on Transportation Systems

Transportation systems to include but not restricted to roads, culverts, drainages and bridges are vulnerable to the impacts of climate change. Roads transportation occupies over 75% of total movements in Nigeria (FRSC, 2015). The development of new roads or an improvement of existing ones have a strong correlation on improved agricultural production (Laurance et al., 2014). Roads contributes to the increase in agricultural production by easing the movement of inputs and workers to farms and the transportation of produce from farms to markets (Binswanger-Mkhize & Savastano, 2017). The lack of good road network or a disruption in the system affects production rates and commuters wellbeing.

Rapid onset events such as floods of all kinds either coastal or flash floods have impacts on transportation systems. Coastal floods and storm surges can affect roads and bridges as salinity can speed up the rate of deterioration in road surfaces as well as concrete reinforcements. The 2012 floods in Nigeria brought to prominence the vulnerability of transportation system to impact of climate change. In parts of Plateau state, heavy rains resulting to flooding washed out the top soil, weakened drainages and culverts. Roads and bridges were destroyed cutting off communities and hindering recovery efforts to affected places (Umweni, 2014). This led to the loss of lives, properties and livelihoods as well as the disruption of services. Commuters were forcing to take longer routes at a higher cost or journey on canoes with uncertainty of getting to their destinations in safety (Plateau News update, 2012). This had huge impacts on agricultural production as low yields were recorded due to farmer's inability to access and move farm inputs such as fertilizers. The transportation of farm produce from farms to markets was also affected leading to large quantities of food waste. Though road transportation was crippled, new opportunities to a new source of income emerged for canoe operators (Times, 2012).

Droughts on the other end, either hydrological, meteorological or socioeconomic, can change the morphology of the land. Drought as a result of heat and rainfall changes can alter moisture balance consequently influencing the deterioration of road pavements. Cracks on road surfaces as a result of heat and subsequent water percolation into cracks causes potholes. The implication of droughts on road and bridges is that high heat and lack of moisture can leads to the gradual caving in of the land area thereby affecting designs and constructions under the initial land conditions. Extreme heat softens asphalts and expands bridge joints; heavy freight under these conditions damages road surfaces, and bridges respectively. Its nature reveals their vulnerability and makes them liable to destruction by adverse conditions.

3.2 Impacts on Irrigation Systems

Irrigation is an agricultural practice to augment for water supply for crop growth during periods of insufficient rainfall. Water for irrigation purposes are sourced from dams, tube wells, wash bores and boreholes: collectively referred to irrigation infrastructures. Sourcing water for agricultural purposes from these systems is increasingly difficult as both slow and rapid onset climate events affect their functioning (Binswanger-Mkhize & Savastano, 2017).

Heavy rains and floods accompanied by surface run-off deposits sand, silt and mud blocking irrigation systems. Wash bores drilled on shallow alluvial aquifers along river beds to source for underground water and wells can completely be blocked leaving farmers with no option but to recover by drilling new wash bores for the next planting season and re-dig the wells

(Umara, 2010). This affects the farmer's income levels. Small earth dams are commonly constructed by impoundment of river basins to collect water for agricultural purposes. The increasing demand for water resources has led to the construction of both concrete and earth dams which are used for either irrigation, water supply, hydropower generation or a combination.

Increase in temperature, evaporation and consequent droughts results in water shortages and lower water levels affecting the availability of water for irrigation. According to Olagunju (2015) droughts depletes not only surface and ground water but also affects land and environmental conditions. Rasul and Sharma (2016) opined that water shortages due to climate change among others, affects water levels of dams for irrigation and hydro-energy generation. The interdependencies between these two sectors is that the hydro-energy generated is in turn used to power irrigation facilities and run small scale food processing industries. For instance the six (6) dam sites used by Nigerian Electricity Supply Corporation (NESCO) for electricity generation in Plateau state is at risk of water shortages due to climate change (FMPS, 2006) . Communities where these dams are located also use these water sources for irrigation and other purposes. This will trigger competition for water resources between the energy sector and the agricultural sector. Other critical sectors interdepending on the water sector can also be affected by water shortages.

3.3 Impacts on Agricultural Services

Climate change has impacts not only on hard physical infrastructures such as transportation and irrigation systems but also on soft infrastructure services that support agricultural production. Here agricultural services includes but not limited to research and development (R&D) and extension services. Agricultural services provide support to meet the increasing demand from growing populations, through educational methodologies, technology transfer and advisory services. However climate change can challenge agricultural research and services.

Floods, excess rains and moisture supports the germination of fungi and bacteria as they thrive under damp conditions (Delcour, Spanoghe, & Uyttendaele, 2015). Rising temperature, high evaporation rates and changing rainfall patterns leading to warmer conditions causes genetic changes in pathogens making them develop resistance and contributing to the emergence of new or the spread of existing diseases (Delcour et al., 2015; Elad & Pertot, 2014; Sable & Rana, 2016).

Multiple and interconnected infrastructure systems ranging from telecommunications, transportation, and electricity can affect agricultural services in one way or the other. For instance, chemical agents such as pesticides, insecticides and herbicides acquired from input and extension services require optimal storage condition in order to get to the farmer in good quality. These conditions range from cool room temperature, dry environment and away from sunlight. The movement of these chemicals from the point of supply to the point of demand is critical in guaranteeing its quality. The storage conditions in most cases are not adhered to and the local farmer does not have the means to check the effectiveness of the agents before being administered. The poor quality of roads and vehicles are likely to make the journey longer and transportation will have an impact on the conditions of the chemical agents.

In another scenario, the administration of chemical agents is suitable non-rain days. The lack of early warning weather systems and weather information mechanisms greatly affects the functionality of chemical doses administered. Local farmers often rely on local knowledge to predict rainy and non-rain days (Kijazi, Chang'a, Liwenga, Kanemba, & Nindi, 2013). Uncertainties from climate change will challenge rainfall predictions from local knowledge (van Wilgen, Goodall, Holness, Chown, & McGeoch, 2016). Other times chemicals applied based on predictions from local knowledge are washed off leaving the farmer with no option than to re-administer the doses at a later date. Low-income farmers might not be able to afford another round of chemical agents. Farmers who have successfully curtailed the infestation on their farms are at risk of re-infestation from farms that have not been able to complete the treatment of such diseases.

Both rapid onset and slow onset events have impacts on transportation and irrigation infrastructures systems and disrupt agricultural services. The increasing frequency and resultant impacts of these events can reduce infrastructures life span. In assessing the impacts of climate change, though the frequency, intensity and severity of these events are a threat to infrastructures, the conditions or design of such infrastructures are important factors driving impacts. The next section focuses on the status of infrastructures and factors affecting the status of infrastructures at community levels.

4. CRITICAL INFRASTRUCTURE STATUS IN NIGERIA

Nigeria is increasingly becoming a society with multiple infrastructural challenges ranging from power blackouts due to power failure, transportation gridlock due to poor transportation network (Steven, O'Brien, & Jones, 2014; Yapicioglu, Mogbo, & Yitmen, 2017). These were ones seen as unfamiliar situations but in recent years are becoming common circumstances. Nigerian economy has experienced very little growth in the recent years due to poor productivity, this is however, strongly linked to the lack of infrastructural needs to support optimal productivity. The lack of or poor state of infrastructure for improved agricultural production increases the risk propensity of infrastructures to adverse climate change. Appropriate infrastructure particularly to the rural areas is critical for sustainable agricultural development and the economic advancement of a country. Infrastructures such as roads, bridges and irrigation systems play a vital role in the physical and socioeconomic development of not only individuals and but communities as a whole. (Ibem 2009) regards such infrastructures as essential assets that enable, sustain and enhance societal living conditions. As such they facilitate the production of goods and services, the distribution of finished products to markets, and the provision of basic social services.

The provision and maintenance of critical infrastructures which includes transportation and irrigation systems has solely been the responsibility of the three (3) tiers of government (federal, state, and local government) until in recent years when public private partnership has become common due to policy changes in national economy (Udoka, 2013). More than 80% of infrastructures are provided by the government through ministries, agencies, and government parastatals saddled with the responsibility of providing public services to the teaming population. However, the conditions of infrastructures such as roads are in deplorable states, characterized by large potholes, gullies, and reduced road width due to eroded road shoulders.

The limited design of infrastructures including roads, bridges and irrigation systems exposes of such infrastructures to impacts from extreme weather. For instance, Roads in agrarian communities are mostly unpaved feeder roads, characterized by laterite surfaces, heavy rains coupled with poor drainage, therefore the top soil is washed off. Water logging is experienced mostly at the peak of the rainy season though not necessarily as a result of heavy rains but consistent rains for days the soil becomes saturated with water thereby making roads un-motorable. Also traditional earth dams commonly constructed for agricultural purposes are more or less temporary structures which can easily be destroyed leading to dam breaks due to the material and nature of construction (Stephens, 2010). They are liable to dam leaks and water seepage which will lead to higher rates of water loss as compared to a properly constructed dam. Ebele and Emodi (2016) observed that weak infrastructure systems which are already at risk to adverse conditions are liable to damage or loss and disruption in services.

5. FACTORS INFLUENCING INFRASTRUCTURE STATUS IN NIGERIA

In recent year, government policies adjusted to involve private partnership in infrastructure provision in the country. Though PPP (public private partnership) provides about 15% of infrastructure provision which is yet to be fully been implemented (Adeyinka & Olugbamila, 2015), government still remains the main provider. Despite these efforts, the state of infrastructure has continuously been a thing of concern for sustainable development in Nigeria. Existing Literature such as Nchuchuwe and Adejuwon (2012), Agber, Iortima, and Imbur (2013), Agber et al. (2013), Abiodun, Akintoye, Liyanage, and Goulding (2013), Gbadebo and Olalusi (2015) have identified a number of factors that influence the status of infrastructures in Nigeria (refer to Figure 28).

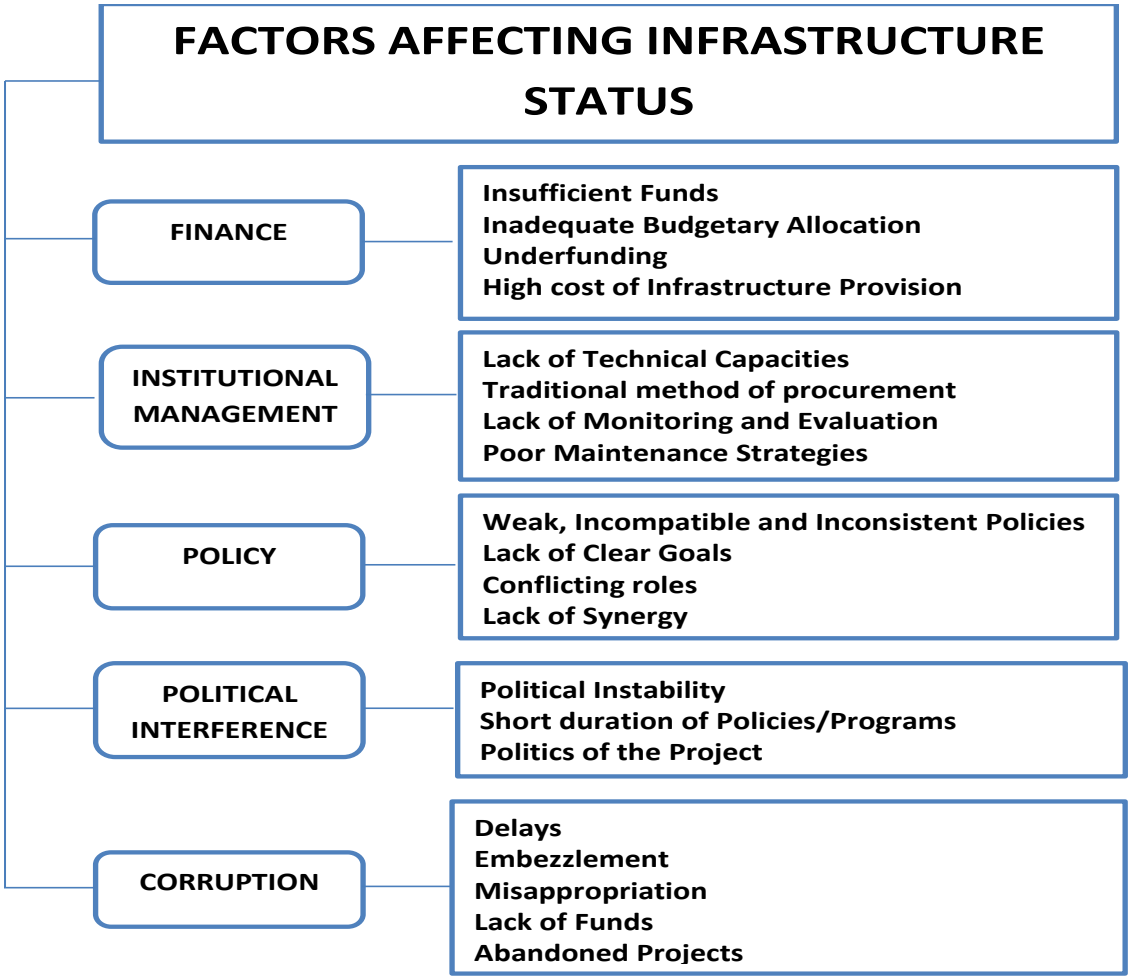

Figure 28: Factors Influencing Infrastructure Status

First, the poor state of infrastructure in Nigeria is as a result of financial constraints. Underfunding and inadequate budgetary allocation by the government as well as the high cost of infrastructure provisioning has led to inadequate number of infrastructures in Nigeria. Nchuchuwe and Adejuwon (2012) observed that government' activities reveal that priority in policy formulation and resource allocation is accorded to urban areas at the expense of the rural agrarian areas. For instance, more than 70% of good paved roads are located in urban areas in Nigeria. As resources are meagre, the number of projects awarded will be less thereby affecting the available quantity of infrastructures most of which are not in favour of agrarian communities.

Secondly, weak institutional management as a result of lack of technical capacities, continuous employment of the traditional method of infrastructure procurement, lack of monitoring and evaluation alongside poor maintenance strategies.

Thirdly, weak, inconsistent and incompatible policies/programs influence the status of infrastructures at community levels. This leads to conflicting roles and a lack of synergy between different programs/projects of the 3 tiers of government. The relationship between existing institutions and the local community is important for the realization of the set roles for programs and projects.

Fourthly, is undue political interference. Political instability resulting to change in government has led to short duration of policies and programs as well as uncompleted

projects without full accountability. Political office holders award infrastructure contracts to friends and associates who are not trained to execute projects. This affects the final outcome such projects.

Finally, Corruption leads to delays, embezzlement, misappropriation and lack of funds to pursue specific policy/program to an expected end. Due to corruption, the quantified cost of a project at the point of execution is mostly not commiserating with the funds approved at the points of decision (Egharevba & Chiazor, 2013). This affects the designs of infrastructures as standards are not adhered to. Corruption is a major factor that foils almost all the factors influencing the state of infrastructure in Nigeria.

6. CONCLUSION AND RECOMMENDATION

Infrastructures (transport, irrigation and agricultural services) supporting agricultural production is in deficit and the few available ones are in poor condition. Climate change and its related events (droughts, floods, storms, extreme temperature, changing rainfall patterns and epidemics) will have future implications on the current state of infrastructures which will further weaken efforts towards improving agricultural production. Evidence reveals human influence through complicated institutional processes contributes to climate change risks and impacts as such the availability of appropriate infrastructures can reduce risk and impacts. Though infrastructures are located and function within communities, planning decisions for its provision are made by the government at levels of authority. It is recommended that infrastructure providers which are the 3 tiers of government (federal, state and local) as well private providers incorporate standards into the plan, design, operation and maintenance of infrastructures. Legal systems should be put in place to check corruption and undue political interference. Government budgetary allocation should accord priority to the infrastructure sector as well as rural agrarian communities. For improved resilience of infrastructures, periodic maintenance of roads and irrigation systems, reinforcement of bridges, renewal of stressed systems and redundant systems to ease stress on overused systems.

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