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IMPACTS OF CLIMATE CHANGE ON AGRARIAN INFRASTRUCTURE AND CASCADING EFFECTS ON HUMAN AND ECONOMIC SUSTAINABILITY IN NIGERIA

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Nigeria, one of the fastest growing economies in Africa has agriculture as a critical sector of the economy contributing significantly to the country's GDP, supporting livelihoods of agrarian communities and employing over 70% of active population. Infrastructures in the form of physical facilities and service systems play important roles in human and economic development but are in deficit and the few available are in poor conditions. Climate change and its resultant impacts are on the rise having implications not only on agricultural production but also infrastructures supporting any form of development. The interdependencies among infrastructure systems within communities can lead to a chain of negative events. This paper critically assess the cascading effects of climate change on human and economic sustainability by focusing on how climate change impacts on infrastructure can trigger a chain of negative events leading to loss livelihoods, affecting economic sustainability and increasing poverty levels. An integrated approach using secondary data from existing literature and key informant interviews to explore the interplay between institutional processes and biophysical processes within the environment reveals that first, power relations at levels of authority has strong influence on exacerbating impacts at community levels. Secondly, climate change impact assessment should be viewed beyond the boundaries of a community. Finally, the study suggests measures for enhancing community's capacity for adaptation to current climate variability and future climate change.

Keywords: Agriculture, Climate Change, Cascading Effects, Infrastructure, Sustainability.

1 INTRODUCTION

Climate change is a challenge driving natural hazards global and a threat to human and economic development. Climate change is characterized by variations in average weather conditions alongside irregular and unpredictable patterns. Rising temperature and high evaporation rates alter rainfall patterns, resulting to heavy rains and floods on one end and insufficient rains and droughts on the other end of an extreme. Persistent alteration of the climate system will likely be prolonged as future projections suggest increasing variations in average weather conditions as well as increasing occurrences of climate related events such as floods and droughts (Dai & Zhao, 2016). This will have huge impacts (either directly or indirectly) on almost all sectors of global economies and on infrastructure. Previous studies have documented climate change impacts on various sectors including the transport sector (Nemry & Demirel, 2012; Neumann et al., 2015), power sector (Panteli & Mancarella, 2015; Van Vliet, Wiberg, Leduc, & Riahi, 2016), water sector (Olmstead, 2014; Olmstead, Fisher-Vanden, & Rimsaite, 2016; Van Vliet, Vögele, & Rübbelke, 2013) as well as the agricultural sector (Ghile, Taner, Brown, Grijsen, & Talbi, 2014; Kurukulasuriya & Rosenthal, 2013).

Agriculture a critical sector of the economy plays the fundamental role of providing food for the growing population, a source of raw materials for industries and supports livelihoods. It contributes to the growth of a country's GDP, sustains economic development and reduces poverty levels (Binswanger & Landell-Mills, 2016; Godoy & Dewbre, 2016). With population growth and continuous need for economic support, the sector will have to raise its production to meet the increasing demand. There is therefore the need for a robust agricultural sector in order to achieve this. However, infrastructures in the form of physical facilities and service systems needed to improve agricultural production are unfortunately in deficit and the few available in poor conditions and thereby vulnerable to adverse conditions such as climate change (Ayinde, Falola, Babarinde, & Ajewole, 2016; Ebele & Emodi, 2016). Climate change and its resultant impacts will have implications for the agricultural sector but particularly on infrastructure systems facilitating agricultural production. This will not only undermine the performance of the sector but can unleash future risks and uncertainties on how infrastructure systems will function.

Furthermore, infrastructure systems mutually depend on each other for their functioning so that damage on an individual infrastructure can precipitate disruptions in other infrastructure facilities and services (Chappin & van der Lei, 2014). Depending on the nature of dependencies among infrastructures, a chain of negative events also referred to as cascading effects can be initiated. The loss or damage of an infrastructure will not only have implications on that individual piece but can on a wider scale affect efforts towards human and economic sustainability. This paper therefore aims to critically assess the cascading effects of climate change on human and economic sustainability by focusing on how climate change impacts on agricultural infrastructure can trigger a chain of negative events leading to loss of livelihoods and consequently increasing poverty levels. The focus is on how institutional processes at levels of authority significantly influence the status of infrastructure systems at community levels thereby increasing risk and impacts. This paper will help towards developing best practice guidelines for risk reduction. It will also help decision makers to formulate strategies to improve the resilience of infrastructure systems.

2 OVERVIEW OF NIGERIAN, THE AGRICULTURAL SECTOR AND AGRICULTURAL INFRASTRUCTURE

Nigeria, a sub-Saharan country located in the humid tropics is bounded by the Sahara desert to the north and the Atlantic Ocean to the south often characterized by a hot tropical climate. The country has two seasons (rainy and dry seasons). Rainy periods range from between 2-3 months in the extreme north of the country and between 9-12 months in the coastal region. These seasons largely determine temperature as mean maximum and minimum temperatures of 41-13^{o}C and 32-21^{o}C are experienced in the north and south respectively (Adakayi & Ishaya, 2016; Eludoyin, Adelekan, Webster, & Eludoyin, 2014). Jos Plateau, located along the central part of the country experiences a cool semi-temperate weather with temperature of 18-25^{o}C (Odunuga & Badru, 2015). The northern Sahelian region records an annual rainfall of less than 600mm, while the coastal south receives more than 3,500m (Akinsanola & Ogunjobi, 2014). Rainfall is considered the most vital climate element as it recharges water sources for power generation, industrial use, irrigation and other agricultural related activities, however there is a high variation in its distribution. These high variations often results in climate related hazards such as floods and droughts affecting climate dependent activities such as agriculture.

Agriculture includes the cultivation of land for crop production and rearing of livestock to provide food for man, raw materials for industries, as well as job opportunities. Researches such as Garnett et al. (2013) and Diao (2016) has shown high correlation between agricultural development and economic growth. As such the viability of the agricultural sector will have a significant influence towards human and economic sustainability. Townsend (2015) asserts agriculture can reduce 65% of rural poverty, improve food security and raise income levels. In a study, he found that growth in the agricultural sector can raise rural income levels two to four times more than other sectors of the economy.

In relation to Townsends assertion, Sertoglu, Ugural, and Bekun (2017) opined that Nigerian agricultural sector plays a vital role in the economic development by contributing about 30% to GDP and 80% of total employment. Agriculture in Nigeria is highly dependent on rainfall, and dominated by smallholder farmers operating at subsistence level, engaging in local farming methods (Adegoke, Ibe, & Araba, 2014)(Ozor, Enete, & Amaechina, 2016). The poor state of infrastructures in the form of hard physical infrastructures and soft service systems to support agricultural production is currently a threat to the performance of the sector (Obadiah, Enejoh, Kojah, & Dadah, 2016). This alongside shocks from climate change has caused major setbacks on the sector. Future climate change will raise the frequency of climate related hazards not only affecting agricultural production but particularly damaging infrastructures supporting agriculture (Elliott et al., 2014; Sun et al., 2013). If this occurs, it will hinder efforts towards sustainability.

Infrastructure generally refers to basic physical facilities and organizational structures required for the effective operation of a society or economy. Infrastructure is the bedrock of economic development and particularly a major determinant to the growth of the agricultural sector. Agricultural Infrastructures are hard physical facilities and soft infrastructure services needed for effective agricultural production and overall rural development. Gajigo and Lukoma (2011) buttressed the importance of agricultural infrastructure to improving outputs, reducing transaction costs, and connecting global markets; these all boost agricultural productions and the general economy. Scholars such as Wharton (1967) and Patel (2014) attempted various classification of agricultural infrastructure (refer to

Table **1**). Wharton's classification includes: capital intensive, capital extensive and institutional infrastructure, while Patel classified into: input based, resource based, physical and institutional infrastructures.

Table 1: Agricultural Infrastructure

Wharton	Patel

• Capital Intensive: Irrigation, Roads, Bridges	• Physical Infrastructure: Road connectivity, Transport, Storage, Processing, Preservation, etc • Resource based: Water/Irrigation, Farm power/Energy
• Capital Extensive: Extension services	• Input based: Seed, Fertilizer, Pesticides, Farm equipment, Machinery, etc
• Institutional: Formal & Informal institutions	• Institutional Infrastructure: Agric research, Extension & Education technology, Information & communication services, Financial services, marketing, etc

In the context of this paper, agriculture focuses solely on crop production therefore agricultural infrastructure is limited to facilities and services fundamentally improving production rates. These are broadly categorized into on-farm and off-farm infrastructure and will include:

- Off-Farm infrastructure: Transport systems (roads and bridges)

  Institutional service systems (Agric research & extension)

- On-Farm infrastructure: Irrigation systems (Dams, tube wells, wash bores, boreholes)

  Inputs (Fertilizer, seeds, farm equipment, etc)

Infrastructure facilities in the form of physical assets such as roads, bridges, dams, irrigation facilities are critical to agricultural production as they determine the extent and quantity of agricultural outputs (Patel, 2014). So also service system such as agricultural research and extension services significantly influences crop yields through enhanced application of scientific knowledge (Qamar, 2016). A damage/loss of a physical facility or disruption of service systems will affect the availability of food to support the growing population and raw materials for industries. This can have impacts on income levels to support households as more than 80% of the rural populace depend on agriculture for their livelihoods (Wossen, Berger, Haile, & Troost, 2017). A free flowing agriculture builds supply chains, supports other non-farm activities thereby developing the economy of the rural areas and the general economy.

3 CLIMATE CHANGE AND ITS IMPACTS ON AGRICULTURAL INFRASTRUCTURE IN NIGERIA

Climate change, an evident change in the average weather conditions is a challenge experienced globally. Global warming driven by natural and anthropogenic activities is responsible for changes in mean temperatures, evaporation rates, and rainfall pattern. IPCC observed that though uncertainties exist in predicting how future climate change will be, the likelihood of warmer climates, higher evaporation rates and longer periods of dry spells are expected (Solomon, 2007). By 2013 it was predicted that for every degree centigrade rise in temperature there will be 7% increase in evaporation and between 1-2% increase of precipitation (Guardian, 2013). Subsequently predictions made are now reality as recent records reveal irregular rainfall patterns characterized by sporadic rains, shifts in the onset and cessation dates of rains, and extended periods of dry spells around the tropics (Allen, 2015; Eruola, Bello, Ufeogbune, & Makinde, 2013; Salack, Giannini, Diakhaté, Gaye, & Muller, 2014).

Nigeria is not left out in this record as hotter and drier conditions are becoming common. Abiodun, Lawal, Salami, and Abatan (2013) observed rising temperatures across the country, less rainfall towards the extreme north and higher rainfalls along the coast due to high evaporation and ocean currents. These changes in the climate system drives changes in rainfall patterns and subsequently determines the occurrence of climate related hazards such as floods or droughts (Fuwape, Ogunjo, Oluyamo, & Rabiu, 2016). A summary of major climate related hazards experienced in Nigeria shows that floods and droughts are particularly the most devastating in terms of costs and total number of people affected across the country (refer to Table 2).

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

Event type	Events count	Total deaths	Total affected	Total damage ('000 US$)
Drought	1	0	3,000,000	71103
Epidemic	42	23,978	304,436	-
Extreme temperature	2	78	-	-
Flood	44	1493	10,478,919	644522
Storm	6	254	17,012	2900

Floods are common during the rainy season for example, in 2012, continuous heavy tropical rains during the rainy season caused flooding in Nigeria affecting about seven million people and causing huge damages. About 200 hectares of farmlands were destroyed, leading to a loss of livelihoods for farming households as well as physical damage to agricultural infrastructures such as transport and irrigation systems. Frequent floods from sea level rise is threatening human and economic activities along coastal towns (Adeagbo, Daramola, Carim-Sanni, Akujobi, & Ukpong, 2016; Davis, 2013). The presence of water bodies naturally attracts economic activities like irrigation, power generation, and water supply schemes as well as the growth of human settlements. Transportation systems are interconnected to the aforementioned sectors as they depend on it for the effective flow of goods and services (Gajigo & Lukoma, 2011). As such poor transportation system raises costs of inputs for production, and reduces accessibility of produce to points of demand.

Road transportation is the main form of agricultural freight in Nigeria, moving food crops from agrarian communities to markets, processing points and urban centers. Porter (2014) observed that unfortunately only about 30% of rural roads are all season roads thereby affecting the flow of both agricultural inputs and outputs. Roads in agrarian communities are mostly unpaved feeder roads, characterized by laterite surfaces and poor drainages. Such poor condition makes it less resilient nature to adverse climate change. Patel (2014), Storeygard (2016), Fungo and Krygsman (2017) asserts that roads in good conditions minimizes transportation costs, improves accessibility and boost economic development.

Climate change affects water demand and supply of irrigation systems. Rising temperatures and high evaporation rates will demand more water for agricultural and other agrarian purposes. Climate change will affect the yield of water sources thereby an inability to meet water demand. Agriculture is currently the largest consumer of the water sector and with future climate variability water demand for irrigation will likely be higher than what it is now (Ashofteh, Bozorg-Haddad, & Loáiciga, 2016). Agriculture in Nigeria is rainfall dependent. Climate change will make rainfall patterns highly unpredictable and will cause stresses on agricultural production. Consequently, irrigation has the potential to reduce the risks of agricultural shocks from water shortages. The inadequacy of structured dams to store water for irrigation purposes is a factor of vulnerability in times of water shortages.

Water shortages and consequent droughts commonly experienced during dry seasons does not only extend the fight against hunger but is triggering conflicts among agrarian communities (Nyong, Dabi, Adepetu, Berthe, & Ihemegbulem, 2008; Rindap, 2015). Crop production and livestock rearing require water for their survival, often procured from the same source. Rising temperatures and high evaporation rates places higher water demands for both user groups. Hotter and drier conditions driven by climate change is lowering water levels and shrinking water bodies (Klein et al., 2014). Overcrowding and competition for available water sources is leading to unprecedented circumstances.

4 STUDY AREA

Plateau state located in central Nigeria is known as the country's hydrological centre (refer to Figure 1). Jos, the state capital known as Tin City, is a confluence town linking the Northern and southern part of the country (Dung-Gwom, et al, 2009). It is one of the fastest growing cities in the sub-Saharan Africa with a population of about 1.8 million people (NPC, 2011), and a beehive of economic activities. Plateau is endowed with both natural and man-made resources: natural scenery with beautiful rock out crops supporting tourism as well as good weather conducive for agricultural production (Wapwera, 2014). Plateau state as the name implies is a table land with Jos Plateau at the upland and surrounding environs at the lowlands. Plateau is known for agricultural production of a variety of exotic fruits, vegetables and grain in the upland and mostly tubers and rice in the lowland, most of which are grown all year round thereby contributing to the economic upliftment of the country (Chuktu, 2002). These diverse and unique characteristics alongside potentials for more economic growth are found mostly in agrarian communities. In recent years, climate change (both mean changes and extreme events) and its resultant impacts have negative implications on livelihoods and economic activities (Audu, Audu, Binbol, & Gana, 2013; Bako, 2015; Davou, 2012). Floods and droughts are the two main climate related extremes experienced in the state prevalent in the southern lowlands and of uplands of the state respectively. The area has also experienced the physical dereliction of basic infrastructure among others (Dung-Gwom, Hirse, & Pwat, 2008; Wapwera, 2014) and future climate trends are expected to further result in changes in the structure of the environment with impacts on already weak agricultural infrastructure.

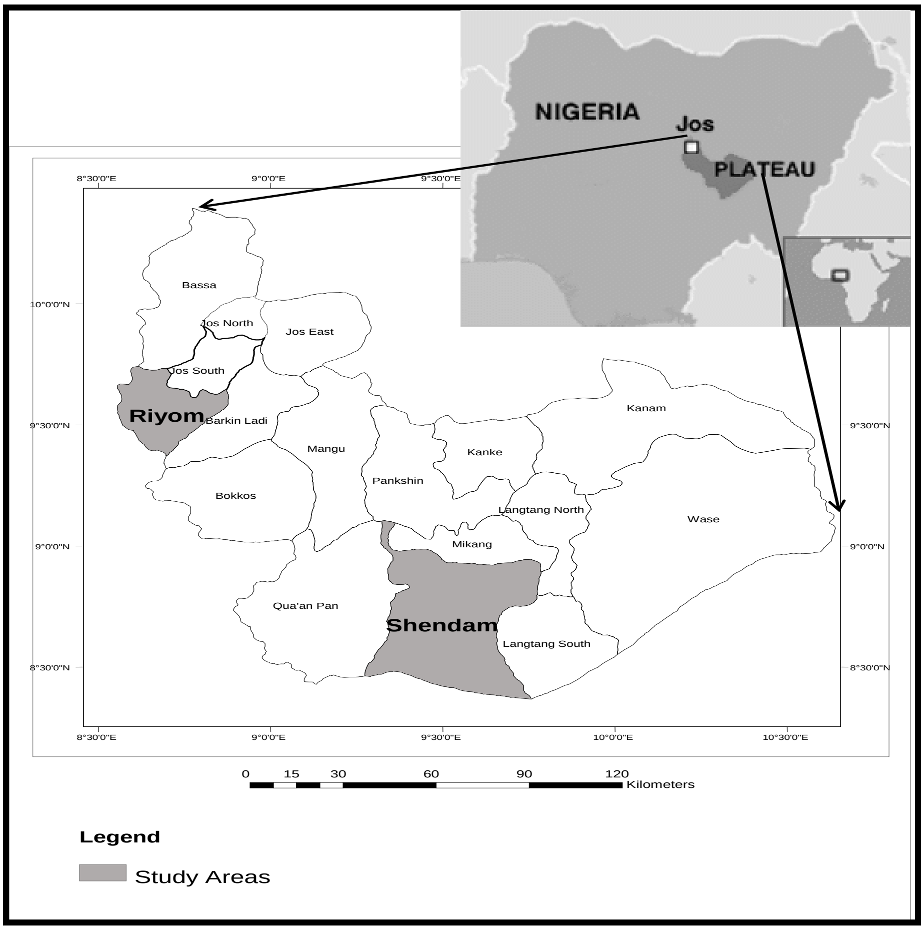

Figure 1: Case study communities, Plateau State, Nigeria (Source: GIS lab, UniJos)

3 METHODOLOGY

Floods and droughts are the two main climate related hazards experienced in Nigeria (refer to Table 2) as such the study is designed to address these events. Secondary data from existing literature: journal articles, official documents, and news publications were used to identify LGAs affected by climate change. Using purposive sampling, Shendam (Case study 1) is selected from ten (10) LGAs most affected by floods. So also, out of the three (3) LGA most affected by water shortages Riyom LGA (Case study 2) is selected. Case study 2 qualifies for the selection not on the basis of the most affected LGA but due to access to information (refer to Table 3).

Table 3: Case Study Selection

RANK	EVENT COUNTS	TOTAL DEATHS	TOTAL AFFECTED	TOTAL DAMAGE	SELECTED LGA
1ST	Floods	Epidemics	Floods	Floods	Shendam
2ND	Epidemics	Floods	Drought	Drought	B/Ladi OR Riyom
3RD	Storm	Extreme temperature	Epidemics		
4TH	Extreme temperature	Storm	Storm		
5TH	Drought	Drought	Extreme temperature		

In-depth interviews were conducted with two (2) representative officers of selected case study local government areas. Information from transcribed interviews was used alongside official documents (Reports on floods and agricultural projects in Plateau State) to ascertain the level of damage, cause of damage, and secondary impacts as a result of infrastructure damage. It was then found out that the cause of infrastructure damage and disruption of services was beyond the occurrence of a climate event within a location. In order to understand further possible external factors, Nine (9) key informant interviews were carried out through snowballing with heads of units of two relevant government ministries, and three agencies who are responsible for the provision and maintenance of infrastructure. Through this, information on the existing institutional framework as well as institutional processes for the provision and maintenance of infrastructure was assessed. The findings are presented in the next section.

4 RESULTS AND DISCUSSION

4.1 IMPACTS OF FLOODS

Plateau state is experiencing more floods in recent years than in times past. Participants identified flooding as the major climate related hazard experienced almost annually in the study area. Floods of different magnitudes are experienced however the 2012 is prominent as the most devastating having impacts of roads, bridges, culverts, irrigation facilities and other infrastructures. A summary of the impacts of floods on agricultural infrastructure and its cascading effects is presented in Table 4.

Table 4: Impacts of Floods in Shendam (Case Study 1)

DIRECT IMPACTS ON INFRASTRUCTURE	CASCADING EFECTS
Transportation System (Off-Farm)	**Agriculture**
• Washout of bridges and culverts • Washout of bridge and road embankments • Damage to road surface	• Waste of food crops • High cost of transportation • High cost of inputs e.g fertilizer, seeds • Loss of production due to infrastructure damage
Irrigation system (On-Farm)	**Economic Impacts**
• Blockage of tube wells • Pollution of water sources	• Market instability and Price hike of goods • Low patronage of small scale industries e.g rice mills • Less profit • Disruption of commercial activities due to supply chain disruption • Constraints economic development
Others	**Human Impacts**
• Damage to buildings • Damage to electric poles and cables • Damage to processing equipment • Damage to farmlands and crops	• Loss of human lives • Loss of livelihoods • Human displacement • Diseases/ Epidemics • Increased poverty levels • Food Insecurity • Disruption of social activities

The Shendam town bridge was totally washed away, and two (2) other bridges in surrounding villages collapsed cutting off agrarian communities from the town. The Shendam-Yelwa-Ibi road and three (3) other roads linking the LGA were badly affected by various levels of impacts ranging from damage to surfaces, embankments and culverts. In describing the impact, a participant explains thus: "*We had a case of one of our box culverts that was under construction but got washed away during the flood so we had to start all over again.*" This caused disruption of services and hindered relief efforts. Affected communities were inaccessible and commuters were left with no option than to take longer routes at higher prices or use canoe cross the river.

Apart from the physical destruction of farmlands and crops, the loss of transport services lead to large amounts of food waste due to farmers inability to transport food crops from interior villages to market. The time of the disaster event coincided with the peak of the rainy season when farmers often move food crops from barns to markets in order to take advantage of the peak price periods as more profits are made at such times. Farmers had difficulties transporting crops to the markets and this affected their income levels.

It is also noted that due to the loss of crops and low income levels, the following farming sessions was affected. Farmers reported that they lacked the capacity for intense cultivation as the years before the floods because of the loss suffered the previous year. Though relief in the form of seedlings and fertilizers were given to them, it was not enough to recover from the loss.

Participants noted a general increase in the prices of goods, both food crops and none food items, around the study area after the event. This was attributed to the flood however it was difficult to separate goods of sources genuinely affected from those making use of the opportunity to raise the prices of goods. Also, commercial activities at markets such as the popular Yelwa Shendam market was affected as revenues generated from traders and motorists on market days was low thereby affecting the economy of the LGA.

In case study 1 the initial cause of infrastructure damage and services disruption was the intense flood driven by heavy rainfall, however the condition of the infrastructure at the time of the event is identified as a major cause of the disaster. Roads with poor surfaces, weak embankment and aged were the most affected. So also poorly constructed, poorly maintained and aged bridges were those found to have collapsed or completely washed off during the event.

4.2 IMPACTS OF DROUGHT

Water shortages a relative form of drought, is a climate related hazard experienced in case study 2. Farmers here engage in both dry and rainy season farming for year round production relying on irrigation facilities such as local dams, boreholes and tube wells to irrigate their crops. In recent years, there have been experiences of less water in the surrounding water bodies as perennial streams are now seasonal stream. And seasonal streams now experience less months of flow. A participant stated that the erratic rainfall experienced in the area in recent years could be the reason for this decline.

This gradual loss of water is affecting the potential for sustained dry season irrigation farming in the area. A summary of direct impacts of droughts on irrigation infrastructure and cascading effects is presented in Table 5

Table 5: Impacts of Droughts in Riyom (Case Study 2)

DIRECT IMPACTS ON INFRASTRUCTURE	CASCADING EFECTS
Irrigation System (On-Farm)	**Agriculture**
• Low water levels • Low water quality • Low yields of dams, boreholes and tube wells	• Low crop yields • Wastage of inputs e.g seeds, pesticides, • Loss of production due to low water levels affecting irrigation infrastructure
Transport system (Off-Farm)	**Economic Impacts**
• Bad and dusty roads	• High cost of sourcing water • Cost of constructing irrigation facilities • Less profit • Disruption of commercial activities due to inability to meet demand • Constraints economic development
Others	**Human Impacts**
• Spread of plant pests and diseases • Loss of crops and livestock	• Overcrowding and competition on water sources • Strife and conflicts • Loss of human lives • Loss of livelihoods • Human displacement • Increase in poverty levels • Food Insecurity • Loss of trust • Pressure on authorities and security agencies

An observed increase in general temperature and high loss of moisture is placing higher demands for farmers to irrigate their crops in the study area. Participants noted changes in the size of water bodies, and lower water levels affecting the availability of water for irrigation and in turn production rates. In recounting an experience, a participant explains how surface water is affected thus: *"Normally the water around that place lasts up to January- February, but I don't know what happened last year… **by early December the water dried up**."*

Another participant further notes how the provision of an alternative facility to augment for water shortages could not solve the problem as the water levels had gone down. Thus:

"It was a very serious problem and of course there was no magic we could do. We tried all we could, in fact we sank ***two boreholes*** *just to augment but eventually we lost a large chunk of the farm because there was really no water. But who do you blame because we already did our survey and found out the water stays longer but somehow* ***it dried up*** *before …"*

Climate change and its impacts are having a negative turn on water sources for irrigation and other related agricultural related activities, leading to a chain of events affecting communities and the economy in general. In the study area, conflicts arising from competition for use of water sources between farmers and herdsmen have led to the loss of food crops, livestock and trust. This is in line with Pathirage, Ingirige, & Al-Khaili (2015) assertion that impacts on infrastructure systems can have either direct or indirect effects on the environment.

Case study 2 (Riyom) is one of the least ranked LGAs in terms of infrastructural development as such lacks adequate irrigation facilities such as dams is to harness its dry season potentials. Low yield from boreholes and its ephemeral nature suggests improper construction as most are short lived. The condition/status of infrastructure at the time of a climate related events either lessen or worsen risks and impacts. The next section assesses factors influencing infrastructure status.

4.3 INFRASTRUCTURE STATUS IN CASE STUDYCOMMUNITIES

In terms of transport infrastructure, a respondent explained that over 90% of roads in the state are government (3-tiers) owned but only about 30% are all season roads. They are mostly unpaved feeder roads, characterized by laterite surfaces and poor drainages.

In terms of irrigation facilities, farmers impound waterways to collect flowing water for irrigation as such dams for irrigation are more often locally designed and constructed earth dams. This reveals the less resilient nature of infrastructures in the areas attributing it to government who are responsible for the provision and maintenance of such infrastructures. In explaining how processes at decision making level affect infrastructure status, four (4) main factors were identified to influence the conditions of infrastructure. A summary of findings of is presented in Figure 2.

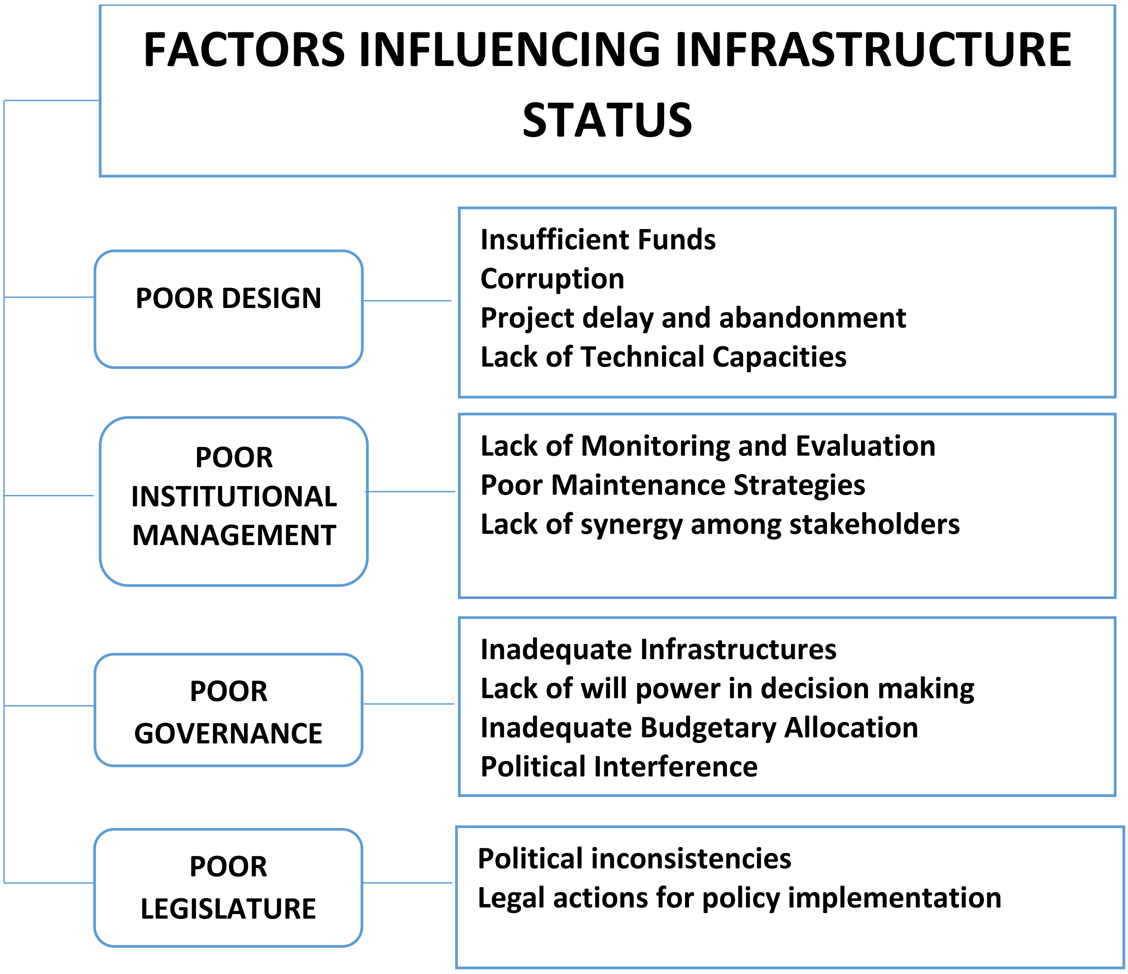

Figure 2: Factors Influencing Infrastructure Status

POOR DESIGN

This deals with both poor infrastructure design and project design as a result of insufficient funds, corruption, project delay and abandonment, and lack of technical capacities. Findings reveal that irrigation facilities and transport systems provided were poorly designed and such projects were short term measures. Poor infrastructure design thus:

*"... **wash bores because they are shallow** and as the name implies it's a small tube drilled into the sand. So when there was a flood it totally destroyed it because it covered the pipes such that they could not be found so it had to be reconstructed. So also tube wells, wash bores, even our dams."*

In certain project designs, state and local government institutions are constrained on the level of operation and type of infrastructure they provide. Participant explains thus:

"…so we were not allowed to construct big infrastructures, we were only allowed to provide assets and inputs."

In explaining how insufficient funds determine the type of infrastructure provided, a participant says thus:

"…we provide culverts and small bridges ***because the project envelope could not take care of big bridges*** *…*

Another participant explains further:

POOR INSTITUTIONAL MANAGEMENT

Poor institutional management ranging from lack of monitoring and evaluation, poor maintenance culture and lack of synergy among stakeholders influence the conditions of infrastructure. Participants agree that most bridge collapse could have been prevented but lack of monitoring and poor maintenance routine compound to other environmental reasons lead to destruction of infrastructures. A Participant explains thus:

We were training farmers on how to maintain the roads. It was basically ***manual road maintenance because you know it is cost intensive to carry out mechanical maintenance****. So we train the farmers to carry out* ***manual Road maintenance*** *and the supply then were* ***simple maintenance tools*** *for them to be able to maintain the roads themselves* ***until the government is able to come back to carryout mechanical maintenance.***

In terms of location, bridges are naturally located on or along riverbeds. This makes the pillars prone to erosion due to the river flow but due to poor institutional management resulting in poor maintenance culture and the use of crude methods of maintenance infrastructures are often left in vulnerable states.

POOR GOVERNANCE

The inadequacy of infrastructures is attributed to poor governance. Findings reveal that government's priority for the provision of adequate infrastructures is misplaced. Budgetary allocations and decisions towards the provision of infrastructures such as roads, dams, etc tend to favour urban areas above the rural area.

Years after the occurrence of an event, communities have not bounced back as livelihoods and economic activities are yet to recover. Corrupt practices amongst government officials and infrastructure providers are hindering recovery efforts to affected communities. Corruption leading to delays, embezzlement, misappropriation and lack of funds are barriers to pursuing specific policy/program to an expected end. This is also affecting the recovery efforts as projects awarded for the reconstruction of affected bridges Due to corruption, the cost of a project at the point of execution is mostly not commiserating with the funds approved at the points of decision. 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

LACK OF LEGISLATURE

Political instability a consequence of change in government results in delays in the enactment of laws and regulations. As a result, the frequent change in the judicial system limits the ability of the system to follow a proceeding to its conclusion. A participant explains that: *"The country has laws to govern the people but, it lacks the will to implement them".*

Political office holders are noted to award huge contracts to friends and relatives who are not skilled to execute projects. Such corrupt practices are often than not prosecuted and no one is held accountable for poor projects. Climate change and its resultant impacts bring to limelight how corrupt processes at levels of authority have weakened the infrastructure sector leading to a collapse of the nation's economy.

5 CONCLUSION

Climate change, changes in mean weather conditions and associated climate related events are on the rise having impacts on agricultural infrastructure. This in turn affects agricultural production, livelihoods and income levels, triggering a chain of events i.e cascading effects on human and economic sustainability. Future climate change will have further implications on infrastructure as they are increasingly becoming vulnerable to loss and damage due to their currents state as most are found to be in poor conditions thereby less resilient to adverse conditions. Though infrastructure facilities are located in communities, processes at levels of authority and weak institutional policies affect the status of infrastructure at community levels thereby playing a part in exacerbating impacts.

Through an integrated approach, an attempt to assess the impacts of climate change on infrastructure facilities and services, has demonstrated that infrastructure risk to damage can be prevented or minimized through structural and non-structural measures. It is therefore recommended that both structural and institutional measures be employed as a means for climate risk reduction and for improved resilience of agricultural infrastructure. There should be a synergy among organisations saddled with the responsibility of infrastructure provision to incorporate standards into the plan, design, operation and maintenance of infrastructures. Strong legislation should be put in place to implement laws and regulations to prosecute offenders and put in check corrupt practices.

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