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Infrastructure development in the West African extractive industry: a system thinking approach.

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INFRASTRUCTURE DEVELOPMENT IN THE WEST AFRICAN EXTRACTIVE INDUSTRY: A SYSTEM THINKING APPROACH

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The extractive industry in the West African region contributes significantly to the socio-economic development of the host communities and the wider economies of resource-rich countries. However, the spill-over effects to the domestic suppliers and the wider economy are hampered by several factors key among is infrastructure development (ID). This study employs multi-strategy approach comprising system thinking tool of causal loop diagram (CLD) to identify key variables and high leverage points underpinning and affecting ID to enhance insight and understanding and interrelationships in the phenomenon under consideration. The literature on the case countries, Ghana and Nigeria, is used to map CLD for infrastructure validated via semi-structured interviews. The CLD demonstrates that strategic investment in infrastructure will boost economic growth, mitigate the negative secondary impacts of the extractive industry and quell social upheaval in host communities. Policy options are recommended for improving infrastructure development.

Keywords: causal loop diagram, extractive industry, infrastructure, system thinking

INTRODUCTION

The West Africa region is endowed with enormous natural resources ranging from hydrocarbons to minerals that significantly contribute to the socio-economic development of the region. In Nigeria, for instance, the oil and gas sector accounts for about 10 per cent of gross domestic product, and petroleum exports revenue accounts about 86 per cent of total exports revenue (OPEC, 2019). It has 40 billion barrels of proven oil reserve and regarded as the 13th largest oil-producing country in the world (ibid). Similarly, Ghana's extractive sector comprises oil, gas, mining including quarrying contributed 13.6 per cent of the country's GDP. In terms of employment, the Ghana Labour Force Survey 2015 estimated that about 74,663 people were employed in the mining and the oil and gas sector (EITI, 2020). Despite the region's immense wealth, the socio-economic impact of the extractive industry on local communities and the national economy has been less transformational due to myriad of factors. To stimulate economic diversification and avoid resource curse in these countries, studies have recommended creating enabling environment for

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transformation, proper utilisation of resource revenue, improving weak institutions and governance system (Sigma and Garcia 2012, Gary *et al.,* 2009; Kuzu and Nantoggmah, 2010; Robinson, 2006; Ross, 2001; Hodler, 2006; Collier and Hoeffler, 2005; Jensen and Wantchekon, 2004). In more recent times, studies have focussed on developing and passing local content policy (LPC) and regulations ostensibly to compelled extractive companies to increase the usage of local goods and services in their activities (Heum, 2008; Korienk and Ramdoo, 2017; Heum *et al.,* 2011; Tordo and Anouti, 2013; Acheampong *et al.,* 2015; Amoako-Tuffour *et al.,* 2015; Obiri *et al.,* 2019; Obiri and Bassam, 2019).

On-going academic studies and discussion on engineering resource-based development in resource-rich countries exclude one critical area; the role of infrastructure development in the extractive industry. Broadly, infrastructure can be grouped into physical and institutional infrastructure. Public utilities such as electricity, transport infrastructure, and telecommunications etc. are critical business development infrastructure that creates a conducive environment for business development and productivity. Africa's largest infrastructure deficit exists in terms of electricity generation capacity and security of supply (ADB, 2015). In terms of transport infrastructure, it is estimated that African transport cost is four times higher than developed countries thereby complicating imports of equipment and materials (McKinsey and Company, 2010). The quality of the above plays a significant role in influencing profitability considerations for investors (INTSOK, 2003). Apart from the above, public institutions play a key role in churning industrial policies to support local industry via establishing company registries, enforcing contracts, laws and strategies (Kazzazi and Nouri, 2012). These policies and laws will increase the reliability of institutions and the legal system, create the enabling infrastructure for business development, and also provide the incentive to enhance sound business practices (INTSOK, 2003). For this study, infrastructure development is deemed as a system defined as a group of interrelated elements forming a complex whole (Alasad *et al.,* 2013).

Sterman (1992) postulated, that a system must be complex with multiple interdependent components, highly dynamic involving multiple feedback process and have non-linear relationships. Infrastructure development, therefore, can be said to be a complex system with multiple feedback process, multiple stakeholders and relationships, involves a large number of resources, public entities and public spending (Capka, 2004; Frick, 2008; Williams *et al.,* 2009; Sewell, 1987). Consequently, system thinking will be adopted in investigating the subject as the method is premised on investigating interrelationships in a system. The paper contributes to the literature on resource-based development by emphasising the central role infrastructure can play in propelling socio-economic development in resource-rich countries. As highlighted above, previous studies on the subject focussed on revenue management, transparency and accountability, and legislation framework etc. neglecting the subject of infrastructure development which this study intends to fill the gap by using system thinking to demonstrate the importance of it. Accordingly, the study will identify high leverage points for infrastructure development and recommends policy options to that effect. To that end, causal loop diagram (CLD - system thinking tool) will assist in analysing the repercussion of infrastructure development in the extractive industry, and therefore, brings to the fore the importance of infrastructure development. The paper is structured into five sections: section one introduces the topic; section two explains system thinking and CLD;

section three covers research methods, section four, results and discussion of the study; and the last section covers conclusion.

SYSTEM THINKING

The theory underpinning system thinking (ST) sees the world as a complex system and consequently supports the understanding of its interconnectedness and interrelationship (Sterman, 2010). System thinking aids holistically in understanding the potential factors influencing an issue and its interrelationships. Furthermore, ST view "problems" as fragments of a complete system thereby addressing the root causes of the problem (Banson, 2015). Today's challenges can be overcome by shifting from a "traditional" way of thinking to a "systems" viewpoint point that sees inter-connectedness relationships and patterns rather than events (Banson, 2015). Hence, the adoption of ST allows both the researcher and respondents to understand the phenomenon from multiple and diverse points of view that ultimately aids in better policymaking. Causal loop diagram (CLD) as one of the tools of ST is defined as the "diagrammatical representation of the interrelationships in a system based on a cause and effect scenario" (Obiri *et al.,* 2020). ST and CLD are based on the concept of feedback that sees the world as an interconnected set of circular relationship, i.e., 'A' causes 'B' causes 'C' causes 'A' and 'D' causes 'B' as illustrated in figure 1. This concept is markedly different from the linear cause-and-effect ('A' causes 'B' causes 'C') way of viewing the world.

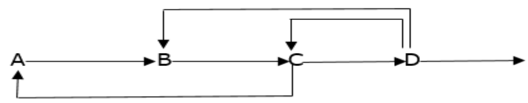

Figure 1: Feedback loop perspective

The above circular relationships give a clearer explanation of the all the factors likely to affect an issue, and therefore you are in a better position to address the problem compared to the linear cause-and-effect perspective (Kim, 2014). Also, the feedback loop provides a better perspective into how and why things happened thereby helping the research participants to gain a better understanding and thereby proffer better solutions. The above definitions of system thinking and CLD bring two critical themes: the notions of interrelationships and interdependencies which form the basis for the adoption of this methodology to explain the relationships and the interdependencies. Additionally, this methodology allows the researcher and the research participants to understand the factors, relationships and feedback in the infrastructure model. The model, in turn, provides deeper insights and challenge research participants to holistically consider the cause and effect of any policy recommendations thereof. As argued by Boateng *et al. (*2016) the use of feedback diagrams (CLD) provide a basis for policy discussion, need to persuade stakeholders of new insights and challenge policymakers to be wary of overconfidence in taking decisions, and lastly, helps policymakers appreciate the essence of endogenous view to policymaking. Accordingly, the above underpinning theories formed the basis for employing system thinking and CLD to assist in formulating infrastructure policy for the extractive industry and in the process breakdown the various factors that will influence the policy thereof.

Two fundamental building blocks are considered in the construction of CLD: reinforcing loop with a function of increasing or decreasing indefinitely and balancing loop which stabilizes over time. In building the CLD, an arrow is used to depict a causal relationship between two variables, i.e., "a" and "b". The relationship between the said variables can be termed positive if an increase in "a" causes an increase in "b", and negative if an increase in "a" causes a decrease in "b". The other critical step in mapping the CLD is the extent of CLD boundary. The following guidelines were employed in identifying the variables:

1. Factors identification - model building begins with listing those factors that have a major influence on the output (Alasad *et al.,* 2013). Observation, discussion, interviews and existing data are some of the approaches recognized in identifying the influences (Forrester, 1992). Stakeholder databases and written database are significant sources of data for identifying a problem (Sterman, 2000; Forrester, 1992).

2. This question can be addressed by ignoring variables which are not critical to the problem under consideration (Kim, 2002). The researcher should be asking questions like "If I were to double or halve this variable, would it have a significant effect on the issue I am mapping?" and "how detailed should the diagram be?" (Kim, 2002).

Accordingly, for the model in question, the above guidelines were used in analyzing data extracted from academic publications, government policies and regulations on the case countries (Tordo *et al.,* 2013; Tordo and Anouti, 2013; Kalyuzhnova, *et al.,* 2016; Ovadia, 2014; Ovadia, 2016; Klueh *et al.,* 2009; Kazzazi and Nouri, 2012; Neum *et al.,* 2011; Sigma and Garcia 2012; Obiri *et al.,* 2020; Acheampong *et al.,* 2015; Obiri and Bassam, 2019; Obiri *et al.,* 2019; Kuzu and Nantoggmah, 2010). The system boundary constitutes the variables used in the modelling as indicated in table 1.

Table 1: System boundary for the infrastructure development model

Challenge Code	Challenge Type
Infrastructure (I)	**Type 1: Endogenous Variables**
I_1	Infrastructure capacity
I_2	Social Environment
I_3	Employment
I_4	Disputes
I_5	Theft
I_6	Business Environment
I_7	Reputation
I_8	Legal action
I_9	Delay
I_{10}	Economic growth
I_{11}	Legal cost
I_{12}	Local Content Development
	Types 2: Exogenous Variables
I_{13}	Institutional infrastructure
I_{14}	Social infrastructure
I_{15}	Educational infrastructure
I_{16}	Business development infrastructure

RESEARCH METHODS

The study employs a multi-strategy approach comprising system thinking (ST) methodology and qualitative data. The ST was adopted as its underpinning feedback loop perspective aids in conceptualising the various factors influencing the phenomenon under consideration, and thereby, provides research respondents with wholistic perspective to the issue before respondents' proffer solutions. Likewise, focus group allowed the researcher to receive a wide range of responses in one meeting making it less expensive, and the participants had the opportunity to engage other participants and ask questions making the method appropriate for generating ideas. Dawson (2015) argued that focus group has the advantage of helping participants to remember issues they might otherwise have forgotten, and even group effect and participant interaction serve as a useful resource in data analysis (Dawson, 2015). In nutshell, the method was adopted to stimulate detailed discussion on the subject and offer the opportunity to seek clarification or counterproposals. The study is divided into two stages: stage one involves identification of the variables from literature, and the second stage involves the validation of the CLD which serves as a basis for policy recommendation. Identification of the variable is predicated on having a small and manageable model size, only variables with direct impact or major influence on the output are considered in the addition the guidelines outlined in section two (Obiri *et al.,* 2020; Alasad *et al.,* 2013). This facilitates easy appreciation and understanding of the model. After the identification (shown in table 1) VENSIM software is used to map CLD for infrastructure development as described in section 2. VENSIM software is primarily used for modelling, analysing and simulating for improved performance of real systems. At stage two, the focus group and interview are used to validate the model. The explicit purpose of the model was to disaggregate the central theme of the study and provide deeper insights and challenge research participants to holistically consider the cause and effect of any policy recommendations thereof. Purposive and snowball samplings were used to select industry players based on their knowledge and understanding of the research area and the ability to answer the research questions. After a brief introduction on the research topic, participants were asked to discuss the model and validate its causal linkages. Based on the validated model, participants discussed and recommended policy for enhancing infrastructure development. The on-line interview was used as a back-up method for researchers unable to attend the group discussion.

RESULTS

Validated Causal Loop Diagram (CLD) and Analysis

The proposed CLD was validated by industry experts who were asked to review the diagram to (1) add or drop variables (cause, effect), (2) verify the existence of relationships or otherwise in the model, (3) identify any missing relationship (Alasad *et al.,* 2013). During the validation of the CLD, participants agreed that there is an "interplay between these key factors whichever way you look at it…for instance the factors infrastructure capacity and economic growth". However, they postulated that "the rate of impact of some factors on others vary considerably". Research participants suggested the addition of technology infrastructure and financial incentive to the model which are captured under the variable of business development infrastructure. The validated infrastructure model contains the reinforcing loop from R1 to R8 as depicted in figure 2. From figure 2 as infrastructure capacity increases (as a result of investment in business, educational, social and educational infrastructure) in the extractive industry it will impact economic growth, and economic growth, in turn, impacts infrastructure capacity positively forming a reinforcing loop, R2. Likewise, as local content development (LCD - the building of local capacity and capability in the extractive industry) increases in the extractive, it impacts economic growth positively and economic growth, in turn, impacts LCD positively forming reinforcing loop R1. Again, increased LCD will impact economic growth, and economic growth will in turn impact infrastructure capacity positively forming loop R3. Reinforcing Loop, R4 suggests an increase in the business environment will impact economic growth positively, and economic growth, in turn, will impact the business environment positively. Similarly, R5 suggests that an increase in infrastructure capacity as a result of investments will impact the social environment positively and social environment, in turn, will impact the business environment positively, and the business environment will impact the social environment. Similarly, reinforcing loop, R6 suggests that improvement in the social environment as a result of an increase in infrastructure capacity will affect the business environment positively, and business environment, in turn, impacts economic growth and in turn impact infrastructure capacity positively. Also, R7 suggests that an increase in delay will increase legal action and an increase in legal action will, in turn, increase delay. And finally, the last reinforcing loop R8 suggests, as the business environment increases, it will reduce disputes (especially in host communities), and disputes will affect reputation, and reputation will affect the business environment. These loops demonstrate two things: investments in infrastructure capacity can boost the host country's local capability in terms of skills and technical expertise, education and research and development, and support local manufacturing and industrial capabilities and ultimately propel economic growth, and conversely, lack thereof can lead to social upheaval and disorder especially in host communities. The latter scenario happens as a result of negative secondary impacts of the extractive industry which serves a magnet for migration with resultant pressure on existing infrastructure and agriculture lands. Decisions on infrastructure investments, therefore, should involve all stakeholders; central government, local authority, extractive companies, civil society and community leaders.

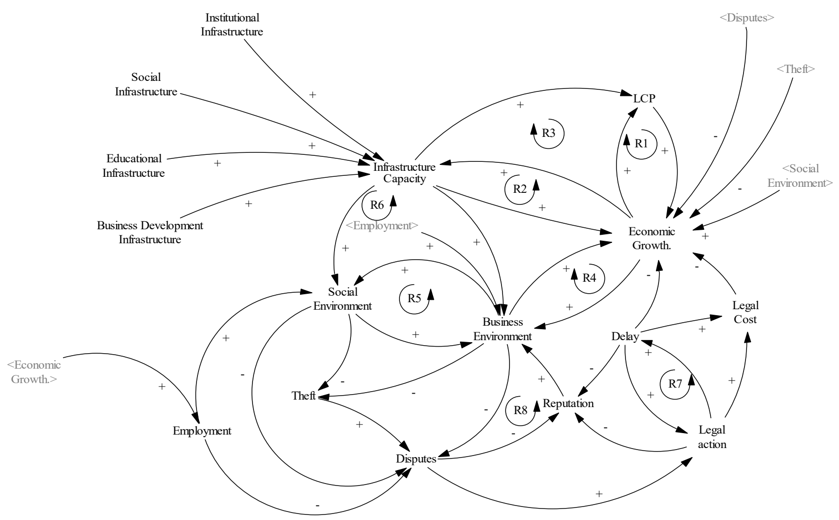

Figure 2: Causal loop diagram for Infrastructure Development

Figure 3 constitutes the high leverage points or key policy areas for government capital investment. The causes tree depicts that infrastructure capacity is influenced by business development, educational, institutional, social infrastructures, and economic growth.

Policy Discussion

This section presents a discussion of the respondents' policy proposal based on the validated model and interview schedule sent to participants before the interview. Study participants argued that "one of the main challenges with infrastructural development in the extractive industry has to do with lack of proper planning at the institutional level, wastage of scarce resources on non-essential projects to fulfil political party's manifesto depriving government's agencies of the requisite money for infrastructure projects and maintenance".

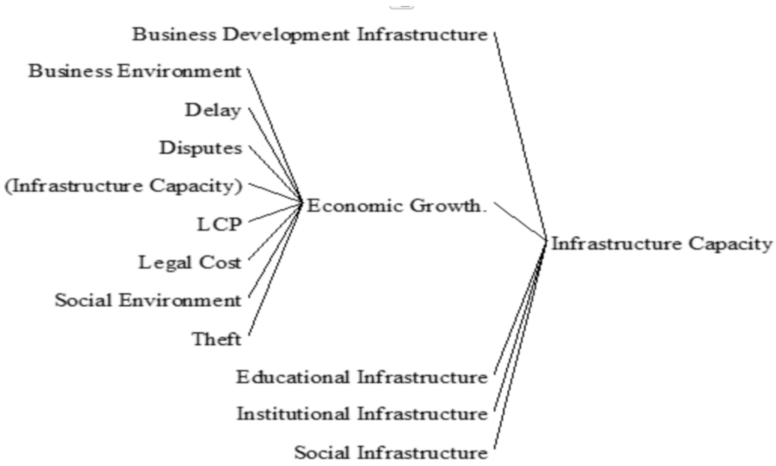

Figure 3: Causes tree for Infrastructure Development model

This, therefore, will require optimal utilisation of scarce resources in the identified high leverage areas, a broad consensus on national development policy, and special attention to the host communities to reduce negative secondary impacts of the extractive industry. Others postulated that overpricing of projects happens because "most public institutions employ procurement processes and selection matrices which are not transparent". By abusing the use of a procurement process such as "sole-sourcing" which is not value for money-oriented, the state tends to lose huge sums for money. In certain instances, "projects are awarded to contractors who are not well-resourced; this often results in projects suffering delays and cost overruns". It is worthy to note that state institutions supposedly have performance monitoring and evaluation outfits who are tasked to audit ongoing infrastructural projects. Conversely, however, such "auditors are easily influenced by contractors, and they eventually compromise on expected standards".

Accordingly, this demand strengthening of institutional infrastructure to curtail political interference. Furthermore, there is an urgent need for strong political will to stamp out corruption and redefine the conditions for sole sourcing and procurement process. State institutions must be empowered to conduct a value for money analysis to curtailed mostly inflated government projects. Since there are limited financial resources of the state, there should be a government strategy to encourage private finance and public-private partnership (PPP) to bridge the infrastructure gap in resource-rich countries. This requires standardisation or clarification of laws concerning P Besides, a special purpose vehicle should be established with voluntary contribution from oil and mining companies (in exchange for reduced taxes), international development partners, a percentage of government extractive revenue and an infrastructure levy to support infrastructure development in the high leverage areas. Key to the success of the above-mentioned policies will be stakeholder consultation in the extractive industry. The above-suggested policies should be used in improving the high leverage points of business development, educational, social and institutional infrastructure.

CONCLUSION

The paper underscores the critical role infrastructure development plays in engineering resource-based development in resource-rich countries which previous studies have neglected. To that end, system thinking and causal loop diagram (CLD) were employed to identify the key variables influencing infrastructure development and its relationships and in turn, identify the high leverage points for improvement in ID. The CLD demonstrated strategic investments in infrastructure in the high leverage points can propel economic growth and on the other hand, lack thereof could increase negative secondary impact in host communities. Availability of this infrastructure will accelerate more volumes of in-country manufacturing and supply to the extractive industry. The study recommends strengthening of state institutions to clamp down on abuse of procurement practices, standardisation of PPP laws to attract foreign investment, channelling more state investment into the high leverage points and stakeholder engagement in the industry.

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