Addressing the Challenges in the Construction Industry Using a Systems Thinking Approach; A Case Study in Ghana

Joe Frederick Cobbinah[1], Kwamina Ewur Banson[2(✉)], and Clinton Ohis Aigbavboa[1]

[1] Department of Engineering Management, University of Johannesburg, Johannesburg, South Africa

[2] Socio Economics and Commercialisation Center (SECC), Ghana Atomic Energy Commission (GAEC), Biotechnology and Nuclear Agriculture Research Institute (BNARI), Legon-Accra, Ghana

kwamina.banson@gaec.gov.gh

Abstract. Every construction project is exclusive and functions in a complex environs which needs its own sets of managerial procedures to complete the project in the predetermined duration, scope, cost, and quality desired. The construction process is viewed by many authors as a complex and risky business to undertake. Traditional project management view the construction process as linear, orderly and predictable which can be planned, organized, and managed top down like any other industry. The regular failures to finish construction projects timely and within estimated budgets assume thinking that the process may not be as orderly and predictable in the manner as perceived. The aim of this paper was to assess the possible application of systems thinking approach in the construction industry using causal loop diagram as an example. The application of systems thinking has the potential to alleviate several deficiencies that perhaps a more traditional project management approach has struggled to deal with. The result of the Bayesian Belief Network (BBN) model indicates that with systemic interventions of establishing funding source and reliable norms, chances of efficiency in the construction industry will increase from 42.6% to 67.6% high. It suggests a paradigm change from the traditional way of doing things by looking at a project from a holistic point of view.

Keywords: Challenges · Construction project · Project management · Systems thinking

1 Introduction

Each construction project is exclusive and functions in a complex environs which needs its own sets of managerial procedures. According to Wagner [1]. The challenges confronting the industry can be grouped under three main headings: Multiple – stages of design, procurement, and construction; Changing – frequent design changes, client requirements and performance priorities (time/cost issues); and Delays – in discovering

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rework. To address these challenges and inefficiencies confronting the industry, there is a need for project managers to move from traditional management approach and tools used in the past to a systemic method that deals with the original cause of the challenge. This new approach will provide a new tool for project managers to examine and understand the complex relationships of the project organization and the environment in which they operate [2]. The aim of this paper was to assess the possible application of systems thinking methods to address the challenges in the construction industry using some of it tools such as the causal loop diagrams and the Bayesian Belief Network Models.

1.1 The Traditional Project Management Concept

Traditional project management view the construction process as linear, orderly and predictable which can be planned, organized, and managed top down just like any other management discipline [3]. However, frequent failure of the industry to meet client requirement in terms of scope, time, quality and cost clearly show that the process is not ordered and predictable in its nature as perceived by players in the field. Clearly, the use of linear schedules tools by project managers to effectively planned and manages construction activities have contributed significantly to the poor performance and success of the industry. To deal with these challenges requires a paradigm shift.

1.2 Performance of the Construction Industry

The construction industry just like any other industry requires modern management techniques and tools to increase productivity and function effectively. The industry lacks behind other industry in terms of achieving its objectives on time, within budget and quality desired. Despite the improvement in project management methodologies to correct this unwanted situation over the years, many projects continue to fail. The emergence of tools including value engineering, value management, quality assurance, and wireless communication technologies in production management besides the well-known project management tool: critical path method (CPM) and numerous cost management interventions have only added marginal improvements [4]. The Critical Path Method which is the last and probably the best innovation of project management tools evolved during the early 1950s.

The Problems militating against performance and efficiency in the construction industry are numerous as outlined by the following professionals and research bodies. These bodies view the problems from different angles. Leśniak et al. [5] attribute the problem to lack of understanding of the effect of running projects in a multidimensional and multidisciplinary project environment. According to Shoar and Banaitis [6], the problem was placed on the lack of committed leadership, client's satisfaction and commitment to the workforce executing the project. Furthermore, Sanni-Anibire et al. [7], attribute the lack of performance to the nature and type of project to be executed. Many scholars and authors posit that there is the need to refine the existing project management practices which are deeply rooted in the scientific theory to design, execution, and control which forms a theoretical framework underpinning project management. However, the opinions of scholars and practitioners does not support the view that improvement lies in refining existing tools and methods. Scholars such as Brunet [8], among others,

in their assessment of the current project management practices, tend to question the conceptual framework on which project management was built. These authors critically examined the state of conventional project management tools and approaches, only to highlight the weakness and its lack of relevant and comprehensive theoretical capability to bring improvement to project management practices, thus suggesting a paradigm shift to cope with project complexity especially in the contemporary world.

According to Derakhshan et al. [9], the method to construction management practices as embedded in project management literature and courses is of less value in the advent of rapidly technological change and modern construction projects complexity. This situation highlights the need to look for an alternative approach to project management theories that are closer to contemporary reality so as to address the weaknesses in the traditional project management practices. Furthermore, Bjorvatn and Wald [10] during their assessment of project management theory, stated: "the fundamental theory for management of project is obsolete and cannot solve the problem of complexity in a modern project". The industry is in search of new models that can depict contemporary reality; project management should also reconsider the theoretical framework that underpins project management practices to accommodate new challenges.

2 The Need for Systems Thinking Approach

The construction industry in Africa and Ghana, in particular, significantly contributes to the prosperity and development of the economy as in other parts of the world [11]. However, the performance of the industry in developing countries is abysmal in terms of meeting the expectations of clients and society as a whole and Ghana is not an exception [12]. The contribution of major construction activities in developing countries account for about 10% of their GDP, 50% of wealth invested in fixed assets and 80% of the total capital assets [13]. Furthermore, the industry is second to agriculture in terms of employment [14]. Notwithstanding the crucial role construction plays in developing countries development, the industry is characterized by cost and time overruns. Most projects do not realize their projected benefits and some are even terminate before their accomplishment. Undoubtedly, the building industry lags behind other industries in developing countries and in particularly their developed nation's counterparts. The sustainability of the construction industry in developing countries requires a new approach of doing things, to enhance capacity building, evolve, improve and raise the effectiveness of the industry in a more holistic way of thinking from reductionism way of thing. The traditional project management approach is based on the reductionist approach to deal with complex situations by breaking the entire system into its interactive parts. The concept is based on logical thinking that a complex system is the sum of its component parts, and therefore can be reduced to individual constituents for analysis. However, this approach according to Banson et al. [15], does not take the system as a whole into consideration, and could lead to consequences not accounted for. In addition, reducing complex systems to its constituent's part for analysis is a fundamental mistake. As opined by Banson et al. [16], the outcome from this approach is often far from contemporary realities and when adopted by management and decision makers in their analysis could result in unintentional consequences that will require expensive alleviation.

In contrast, systems' thinking is an approach which focuses on modeling features found in actual systems. The key concept of systems thinking in management is the emphasis on *holism*, which means that the parts cannot be fully understood without the examination of the entire system. It uses a set of tools and the art of interrelated thinking to deal with ambiguity in complex systems and the incorporation of mental models into systems structures. Systems thinking approach focus on procedures, feedback loops or mechanisms and interdisciplinary perspective to address multi-dimensional and multi-disciplinary project environments. It suggests a paradigm shift from the traditional way of thinking by looking at a project from a holistic point of view. This helps to reveal the fundamental causes and challenges in projects during the design and implementation stages. Systems' thinking offers comprehensions into the behavioural patterns and structure of organizations and the environment in which they operate. According to Highsmith [17] managing an operation with systems thinking can help improve performance, reduce uncertainty, anticipate delays and prevent unintended consequences. Even though, systems thinking approach according to Kim [18], has been criticized by critics as representing the view of technocratic to solving business problems, too fundamental and depends on models which threaten its validity in management training. However, its significant advantages were established by Sherwood [19] when they use systems thinking models to highlight and addressed problems in integrated project. It clearly demonstrates how to transform tough ideas into beneficial management tools for change. This has highlighted the weakness in traditional methodologies to dealing with today's complex management difficulties which only treat the symptoms.

3 Research Methods

The framework of the Evolutional Learning Laboratory (ELLab) of systems thinking was used to analyse the current events or symptoms, patterns of behaviour and the structure influencing the construction industry in Ghana to develop stakeholders' mental model using causal loop diagram (CLD). The first step involved a comprehensive review of literature and data collection through the question to find key drivers disturbing construction projects. Step two integrated the various key variables identified during the survey into a structure models using a software called Vensim [20]. Exploring and interpreting the archetypal models for patterns, interrelatedness is step three. It also involve analyzing feedback, and existing reinforcing and balancing loops. The aims of this step is to develop an understanding of selected variables, their interdependency and roles, and levels of impact in the whole system. Step three was done by interpreting and exploring the model for patterns, interconnected components, and analyzed feedback, reinforcing and balancing existing loops. Leverage points are identify as a result of interpreting the identified models for systemic intervention. Leverage points identified in the CLD are points of power, where a minor alteration can produce a major alteration in the whole system [21]. The identified leverage points are then selected as the main objectives for systemic interventions using the BBN. The BBNs are constructed to include the opinions and suggested mediations by the stakeholders.

Given the increasing complexity, changes and unpredictability of the construction projects, economic actors, and businesses should take into considerations all factors that

might impact its relationships in the industry [22]. The theory of stakeholders in business ethics and organisational management that addresses values and morals in dealing with an organisations is detailed by Bosch and Nguyen [23] was adopted.

3.1 The Causal Loop Diagram

To integrate and interpret the mental models of stakeholders, the *Causal loop diagram (CLD)* is used as a tool. To develop an understanding of a system likeness, mental models are use. Mental models explains and shows how the behaviour of a system variables are interrelated. It consists of variables connected by causal arrows with Nodes and edges which take signs ('positive and 'negative and delays') to describe the causal linkages. The rest of the nodes are the causal linkages creating the problem. From a systems viewpoint, these signs are used to show the behaviour of a cause and effect. *CLDs* transform the complex features into a simple and easy to comprehend format by means of Vensim software tool. A CLD is formed by identifying and determining the variables relating with other variables within the whole system.

4 Results and Discussions

4.1 The Mental Model of the Construction Industry

Figure 1 presents the CLD of the complex construction industry and its impact on sustainable construction among the stakeholders in Ghana. This model provides an explanation of both direct and indirect feedback loops between the design and construction management activities and its impacts on timely and successful completion of projects. This will allow contractors and stakeholders to identify business prospects that improve efficiency and back the growth of sustainable construction activities. The models can be used as development toolkits in the construction industry by decision and policy makers.

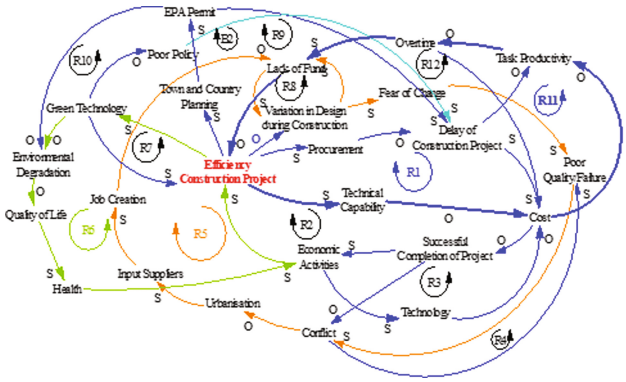

Fig. 1. CLD of the construction industry

Describing the causal linkages of Fig. 1, variables linked by causative arrows with signs such as "S" (same) and "O" (opposite) are used. The circles of cause and effect

as described by the Feedback loops takes on life of their own. Figure 1 demonstrates feedback loops within the management of construction projects revealing the pros and cons of project sustainability. The feedback loops in Fig. 1 signifies that a particular change kicks off a set of changes that cascade through other elements that will either intensify ("reinforce" (R)) or step down against ("damp", "balance" (B)) the initial variation.

The illustration shows that, the possibility for constructors to achieve sustainable construction project outcome is dependent on timely procurements of materials and equipment from nominated suppliers/suppliers. The good of timely procurement is therefore in opposite direction to delays in construction which enhances task productivity, which reduces overtime and cost leading to successful completion of the project as shown in Fig. 1. Abandonment or failures of projects are not without cost, they are costly in two ways, and the first is the cost of fixing the cause of failure and the price of solving conflicts. This leads to overtime which depletes funds and finally pushes back against the efficiency of construction projects as shown by 'R11' in Fig. 1.

To ensure efficiently in the construction industry, the town and country planning agents in collaboration with the EPA ensure that design and environments meet standardization. This mostly leads to delay and clients and some contractors begin work without a permit. This agent, therefore, tries to enforce regulations by trying to stop the work that has commenced and hence creates delays and cost within the system as shown in Fig. 1, 'B2' leading to unsuccessful completion of the project which hinders economic activities and affects efficiency.

Efficiency in the construction industry is also affected by variation in the design during construction which sometimes leads to poor acceptances by clients as a result of fear (high cost). Conversely, this leads to poor or failure of project arousing conflicts which affects urbanization and economic activities (input supply). If the capacity to supply input is eroded, several things go bad and leads to unemployment which affects cash flow and funds availability as shown in Fig. 1, 'R5'.

4.2 Bayesian Belief Network (BBN) Modelling

Deliberations with some key stakeholders were involved in the identification of leverage points from Fig. 1 and also participated in the creation of the BBN models. Increasing efficiency in the construction industry was suggested as a leverage point. Together with some key experts and literature review, the BBNs were built to include the opinions and proposed solutions of the construction industry. Unescapably and admissible, the use of public funds are seriously scrutinized and moneys and interventions must demonstrate value both afore and after project inception, therefore the creation of BBN models are to aid in investment decisions.

4.3 Bayesian Belief Network (BBN) Modelling for Increasing Efficiency for Construction Projects

It is obvious from the arguments above that improving construction productivity is one of the key leverage points to overcome the challenges in the construction industry.

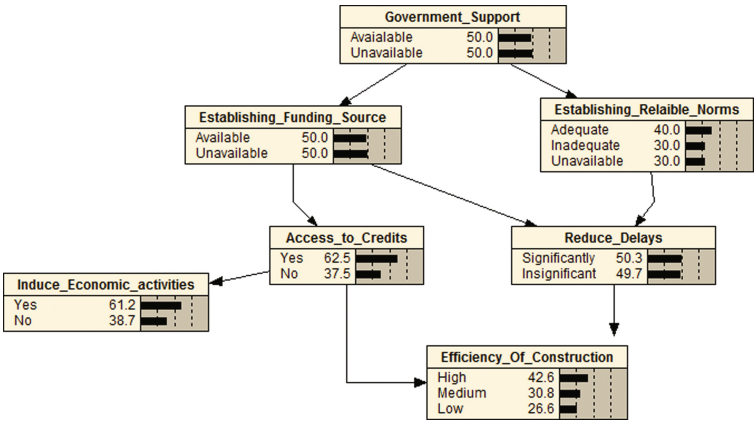

Fig. 2. BBN for increasing efficiency of construction service (without intervention)

Subsequently, several Bayesian Belief Network (BBN) models as (Figs. 2 and 3) were established to determine the interventions for enhancing efficiency in the build industry in Ghana.

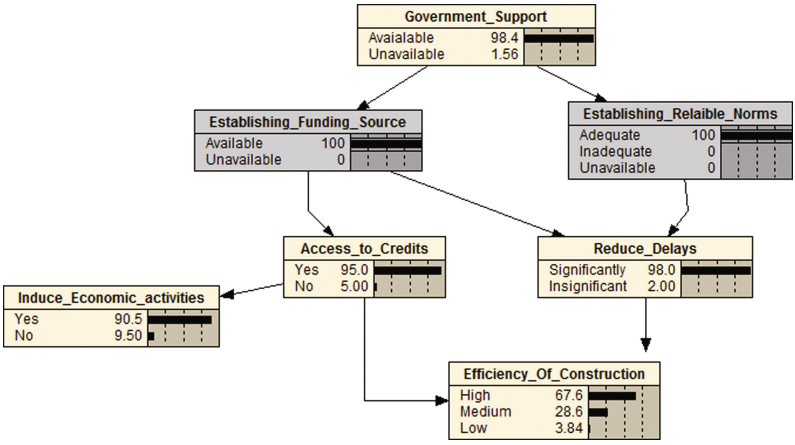

Fig. 3. BBN for increasing efficiency of construction service (with intervention: establishing funding source and reliable norms)

The BBN model of Fig. 2 shows that the present state of efficiency in the construction industry as 42.6% probability high with the probability of significant delays of 50.3%. Also, the chances that economic activities will be induced are 61.2% with 62.5% chances of getting access to credits. The systems BBN model of Fig. 2 was used as a decision support tool to observe the likely consequences of alternative interventions by studying what will occur to the system when a specific policy or combination of tactics is applied. They included establishing funding source and reliable norms for construction. Figure 3 shows increased levels of efficiency with spiral positive effects on other components of

the systems. The BBN model (Fig. 3) indicates that with the systemic interventions of establishing funding source and reliable norms will increase the chances of efficiency in the construction industry from 42.6% to 67.6% high. With the probability of reducing delays significant from 50.3% to 98%. Also, the chances that economic activities will be induced is improved from 61.2% to 90.5% with 95% chances of increasing access to credits from 62.5%.

4.4 Implication of the Findings

To identify the fundamental causes or sources of management challenges in the construction industry, systems thinking is the approach to adopt. It highlights the possible consequences of policy decisions that may affect successful outcome of construction projects.

5 Conclusion

As confirmed in the above CLD, systemic methodologies will undoubtedly help construction industry to evolve from traditional to systemic approaches and provide systemic solutions and interventions which will ensure efficiency in the industry. To solve today's problems, decision or policy makers must overcome the erroneous perceptions of systems and interconnected thinking that created the current predicament of "keep on doing what we did in the past". Governments, managers, policymakers, scientist and contractors can benefit from this approach which will help them to foresee the consequences of the actions and decisions they make, as well as help to avoid any unpredicted consequences of policies as a result of "silo mentality" and "organizational myopia".

References

1. Wagner, D.N.: Breakin' the Project Wave: understanding and avoiding failure in project management. PM World J. **1**, 1–21 (2016)
2. Banson, K.E., et al.: Strategic management for systems archetypes in the piggery industry of Ghana—a systems thinking perspective. Systems **6**, 35 (2018)
3. Tonchia, S., Tonchia, M.: Industrial Project Management. Springer (2018)
4. Koke, B., Moehler, R.C.: Earned Green Value management for project management: a systematic review. J. Clean. Prod. **230**, 180–197 (2019)
5. Leśniak, A., Górka, M., Skrzypczak, I.: Barriers to BIM implementation in architecture, construction, and engineering projects—the Polish study. Energies **14**, 2090 (2021)
6. Shoar, S., Banaitis, A.: Application of fuzzy fault tree analysis to identify factors influencing construction labor productivity: a high-rise building case study. J. Civ. Eng. Manag. **25**, 41–52 (2019)
7. Sanni-Anibire, M.O., Mohamad Zin, R., Olatunji, S.O.: Causes of delay in the global construction industry: a meta analytical review. Int. J. Constr. Manag. 1–13 (2020)
8. Brunet, M.: Governance-as-practice for major public infrastructure projects: a case of multilevel project governing. Int. J. Project Manag. **37**, 283–297 (2019)
9. Derakhshan, R., Turner, R., Mancini, M.: Project governance and stakeholders: a literature review. Int. J. Project Manag. **37**, 98–116 (2019)

10. Bjorvatn, T., Wald, A.: Project complexity and team-level absorptive capacity as drivers of project management performance. Int. J. Project Manag. **36**, 876–888 (2018)
11. Boadu, E.F., Wang, C.C., Sunindijo, R.Y.: Characteristics of the construction industry in developing countries and its implications for health and safety: an exploratory study in Ghana. Int. J. Environ. Res. Public Health **17**, 4110 (2020)
12. Abankwah, B.D.: Project Failure in the Road Construction Industry of Ghana. University of Cape Coast (2020)
13. Aganbegyan, A.: On immediate actions to reinvigorate social and economic growth. Stud. Russ. Econ. Dev. **30**, 1–9 (2019)
14. Anaman, K.A., Osei-Amponsah, C.: Analysis of the causality links between the growth of the construction industry and the growth of the macro-economy in Ghana. Constr. Manag. Econ. **25**, 951–961 (2007)
15. Banson, K.E., Nguyen, N.C., Bosch, O.J.: A systems thinking approach to the structure, conduct and performance of the agricultural sector in Ghana. Syst. Res. Behav. Sci. **35**, 39–57 (2018)
16. Banson, K.E., Nguyen, N.C., Bosch, O.J.: A systems thinking approach: "the greater push model" for growth and sustainability in Africa-evidence from Ghana. Int. J. Mark. Bus. Syst. **1**, 289–313 (2015)
17. Highsmith, J.: Adaptive Software Development: A Collaborative Approach to Managing Complex Systems. Addison-Wesley (2013)
18. Kim, S.: Can systems thinking actually solve sustainability challenges? Part 2, the diagnosis. Creating Sustainable World Through the Power of Business, vol. 2012. University of Michigan, Michigan (2012)
19. Sherwood, D.: Seeing the Forest for the Trees: A Manager's Guide to Applying Systems Thinking. Nicholas Brealey Publishing (2002)
20. http://www.ventanasystems.co.uk/
21. Banson, K.E., Nguyen, N.C., Bosch, O.J.: Systemic management to address the challenges facing the performance of agriculture in Africa: case study in Ghana. Syst. Res. Behav. Sci. **33**, 544–574 (2016)
22. Bosch, O., Nguyen, N.C., Ha, T.M., Banson, K.E.: Using a systemic approach to improve the quality of life for women in small-scale agriculture: empirical evidence from Southeast Asia and Sub-Saharan Africa. Adv. Bus. Manag. Towards Syst. Approach **273** (2014)
23. Bosch, O., Nguyen, N.: A new approach for cross sectoral and organizational collaboration and communication to deal with increasing complexity and promote effective change. In: IUAES/AAS/ASAANZ Conference