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Identifying Infrastructure project uncertainties during project initiation using system thinking

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Abstract

This paper describes a system thinking conceptual framework which will be utilized in identifying uncertainties in infrastructure project during initiation stage deduced from literature review. It forms part of an ongoing PhD research project whose aim is to improve costing in infrastructure project to accommodate uncertainties. The paper concludes that system thinking approaches will enable key stakeholders in infrastructure project to identify and manage uncertainties that will impact on project goals adversely.

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***Keywords**:* Infrastructure project, System thinking, Uncertainty/Risk &Conceptual Framework Design*;*

1. Introduction

Traditionally, construction project professionals tend to focus more on risk and its impact neglecting the effective management of uncertainties. A lot of risks emerges from uncertainties which were not properly identified at the early stage of the project. Utilization of non-systemic (Traditional) approaches in risk management is widely practiced by construction project professionals which is a deterministic technique based on experience and laid down format[1](Atkinson, 1999). Due to the complexity and dynamic nature of infrastructure projects a holistic approach which integrates system thinking by gaining understanding of the functions, relations between them and environmental influences is needed for effective uncertainty management. System thinking approaches sees a construction project as a whole system by understanding and examining the relationship, interactions between the parts (stages and processes) that comprise the entirety.

Uncertainty management in the construction industry is now given an utmost attention for the effective construction project management. Sources of uncertainties within the infrastructure project emanates from various stages which was not adequately planned against during project conceptual stage. Traditional construction project management practices does not take cognizance of the fundamental sources of uncertainties. Holistic approach is quite needed to explore the sources of uncertainties within the infrastructure project so as to generate a robust uncertainty management for effective construction project management [2](Atkinson et al., 2006). The impact of ineffective uncertainty management can be very devastating in achieving the objectives of infrastructure project. It is advisable to detect or identify early the devastating uncertainties during the project initiation stage prior to progression. This will assist the key

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stakeholders within the construction project to make vital decision. A lots of risk emerges from uncertainties during the construction project lifecycle which wasn't properly identified or known about during the high level risk identification phase (Initiation stage).This risk can spread in an unpredictable manners sometimes lead to catastrophic ends. The dynamic and complex nature of infrastructure project makes it more susceptible to unforeseen events such as uncertainties. It has been discovered that overemphasis on operational control and lack of flexibility in the traditional project management is not sufficient enough for effective achievement of project objectives.The management of boundaries relations and operational change are the key success factors in effective delivery of project objectives which system thinking approach provides[3](Kapsali, 2011).Sources of uncertainties within the infrastructure projects are wide ranging and the traditional approach does not address it adequately. Flexibility and tolerance to vagueness are more paramount at the moment to manage the complex nature of infrastructure project. Extensive efforts are required which should inculcate effort such as organizational capability (Culture and learning approach [4](Atkinson et al., 2006).Infrastructure project is dynamic and complex thus involving significant amount of risks.The duration and scope which involve many parties in dynamic relationships with a multitude of interdependencies makes it more susceptible to risks which can propagate through numerous pathways in an unpredictable way[5](Loosemore, 2015).It is known that risk is embedded into any commercial organization's profit structure which is a basic feature of free enterprise system [6](Akintoye and MacLeod, 1997).Identifying and analyzing the relationship between the proposed infrastructure project and the embedded risk in the organization poses a great challenge for the key stakeholders. System thinking tends to give a closer analysis by understanding the interrelationships, interconnectedness between the process and stages within the projects in order to achieve or deliver the objectives. It has the ability to represent and assess dynamic complexity such as an infrastructure project [7](Sterman, 2000).It is advisable to identify early enough the potential uncertainties that might impact on the objectives of carrying out an infrastructure project during initiation stage. This paper intend to demonstrate that system thinking approach possess the adequate framework to identify infrastructure project uncertainties during initiation stage.

2.0 Literature Review

2.1 System thinking

The utilization is thought to facilitate complex decision making by various experts in the field [8](Lezak and Thibodeau, 2016).In infrastructure projects where activities are carried out in a sequential and dynamic order the utilization of system thinking will be quite useful. This will assist greatly in understanding the complexity posed in executing infrastructure projects. Complex systems such as Infrastructure project are marked by high level of uncertainty, ambiguity as well as emergence [9](Jaradat, 2016).It is paramount at this era to have a holistic thinking paradigm that creates new charter and opportunities to think differently on how complex system such as infrastructure project can be executed effectively [10] (Jaradat, 2016).

The uniqueness, complexity and uncertainty involved in executing activities in infrastructure projects make control more cumbersome thus deviation from plans becomes more probable [11](Sydow and Staber, 2002).This prompt the need for change management which is generally linear in approach following some predetermined formalized communication model. In this type of reductionist approach lacks flexibility thus creating obstacle in producing an explanatory and predictive framework for managing infrastructure project [12] (Müller, 2003).During executing a project, task becomes uncertain resulting to change unpredictability and this requires creativity. The project control and management team of infrastructure project needs creativity to tackle this non-linear and evolutionary phases [13](Smyth and Morris, 2007).According to [14] John (2007) system thinking can be utilized to gain an understanding of individual, collective behaviour, human as well as technical alike which cannot be derived from standalone analysis. This will be achieved through synthetic and integrative thinking approaches. It has been researched that system thinking can complement the conventional management strategy utilized in managing infrastructure project by suggesting different levels of analysis and synthesis for problems [15](John, 2007).Infrastructure project is quite susceptible to unforeseen complex changes which tend to make the initial plan move inordinately to a catastrophic level if adequate remedial measures is not put in place. In order to manage and plan against this

issue, it requires flexibility in approach which system thinking provides.It can provide a conceptualize framework which utilizes different tools, theories and strategies to build a holistic, contingent outlook and practices [16](Carmen, 2009).It is pertinent during Infrastructure Project initiation to identify uncertainties that might impact adversely on the project objectives before a decision is made by the key stakeholder. It is generally faced with limited information about the project to be carried out and crucial decision is necessary before final initiation. This stage is carried out with highest level of uncertainties on the project with lowest level of precise information as well.

2.2 Uncertainty

It can be simply explained as lack of certainty involving variability or ambiguity. The management of uncertainty deals with managing perceived threats and opportunities as well as the risks implications. It also involve the managing of various sources which lead to risk, threat and opportunity[17](Chapman, 2003).This paper will solely deal with the identification of main sources and factors that generate uncertainties in an infrastructure project early enough during project initiation stage using system thinking approaches. In order to clearly illustrate the approaches utilized in this paper a clear distinction needs to be made between uncertainty and risk in infrastructure project.Risk can be described or explained as the exposure to uncertainties that will have adverse effects on project objectives. A reliable strategy known as risk management is utilized in reducing and controlling risks [18](Tam, 2012).The traditional construction project management team focuses too much in managing, reducing and controlling risk already identified previously with similar project without paying more attention on uncertainties within the organization itself which might impact adversely on the project objectives. The general practice involved, is having a generic risk management template for managing and controlling risk without critiquing the interconnectivity and interconnectedness of activities within the project and how it impact on the organization(operating environment) strategic objectives. Construction projects are confronted with strategic issues which may have impact on the performance in the long run. It is paramount to balance the key stakeholders' objectives with adequate risk management strategies [19](Abednego and Ogunlana, 2006).System thinking approach will employ mainly the soft system strategy in bridging the operating environment(organization) and project objectives together so as to achieve a meaningful and purposeful deliverables. This approach will ensure a conceptual framework that equal social to technical, uncertainty and complexity as integral part of the management of tasks, planning and control [20](Saad et al., 2002).In conventional project management a hard system approach is utilized which tends toward process management [21](Phelan, 1999). It utilizes mainly hard system which focuses on process standardization in terms of constrained triangular metrics(Cost, Time and Scope) [22](Atkinson, 1999).Soft system approach will not replace the conventional method of infrastructure project management but complement it.

2.3 Infrastructure project

It is often utilized as a way of achieving organization's strategic plans directly or indirectly. This is always triggered or authorized as a result of some strategic consideration such as market demand, strategic opportunity/business need, social need, environmental consideration, customer request,techmological advancement & legal requirement [23](PMI, 2013).In infrastructure project initiation phase is where the key stakeholders expectations are aligned with project's purpose so as to give them visibility about scope and strategic objectives. Also set's the project vision and what's required by the project to accomplish. Initial scope is defined, initial financial resources commitment made as well, both internal and external stakeholder who will influence the project outcome is identified[24](PMI, 2013).At this stage,overral plans made are from expert judgments and contains lot of biases due to limited information about the project. This makes the infrastructure project prone to a lot of uncertainties which is a potential source of risks. Traditional techniques involved in achieving the initiation phase of an infrastructure project are mostly reductionist approaches and doesn't pave way for surrounding uncertainties to be adequately examined. A strategy which involves holistic, interconnectivity and interdependence approach is required to fully understand complex project like infrastructure type [25] (Stewart and Fortune, 1995).Holistic problem overview is required where situation is perceived in reality as a systems, also components relationships between system and

external environment are well established [26](Stewart and Fortune, 1995).System thinking approaches utilizes different tools for achieving the sole objectives.
This paper will describe a conceptual framework for utilizing soft system analysis a system thinking method. It is a holistic approach applied to an infrastructure project which is viewed as a broader system with various subsystems underneath. It deals with both hard tangible information and soft complexity (People's involvement and Conflicting interest)[27](Stewart and Fortune, 1995).The findings of this paper are solely based on and derived from various existing literature reviewed for ongoing doctoral research studies. In order to fully understand this conceptual framework a system diagramming technique will be utilized to depict holistic, interdependence and interconnectivity amongst the system and subsystems involved.Rich picture concept mapping and causal diagram will be utilized for the system diagramming technique.

2.4 Rich picture

It is a graphical representation technique of soft system methodology which represents a complex situation[28] (Pain, 2012).This will be quite useful during infrastructure project initiation stage precisely during conceptual estimation phase.The conceptual and preliminary estimating phase normally takes place prior to engineering and design completion. This is when there is limited information about the infrastructure project to make a robust estimate. It is done in the schematic and budgetary section of the project initiation stage. It is generally susceptible to high level of uncertainties due to vague information available. It can be readily utilized to organize complex situations and identify underlying issues and stakeholders of a system[29] (Pain, 2012).Any tools can be used to represent a rich picture as long as it encourages discussion, interaction as well as attaining holistic understanding overview of a system by key stakeholders [30] (Pain, 2012). Infrastructure project can be well represented holistically using rich pictures during the initiation stage so as to identify potential uncertainties that might impact on project objectives. Some of the inputs for this technique will be related history and lesson learned files of similar project. This technique gives a preliminary overview of the operating environment of infrastructure project with external influences and doesn't really dig deep into the dynamics that might impact on the project objectives.Another soft system methodology is required for further analysis.

2.5 Concept Mapping

It can be simply described as the integration of qualitative and quantitative methods designed to enable a group of people to articulate and depict graphically a coherent conceptual framework or model of any issue or task of interest [31] (Trochim and McLinden, 2016).This will be quite resourceful during infrastructure project uncertainties identification. It enables multiple stakeholders within the infrastructure project to produce interpretable pictorial view of their various ideas, concepts, including how they are interrelated as well. The interrelationship between the elements within the system can be adequately depicted using concept mapping. The input directly from the rich picture can be studied to some extent using this soft system methodology. During infrastructure project initiation when high level risks, assumptions, issues and constraints etc. are being identified concept mapping approach will be effective. It can assist in providing information where potential constraints, uncertainties might spring-up from having analysed the operating environment and external influence on the project via rich picture. In order to depict the entire interconnectedness and a robust feedback loop amongst the system elements a further soft system analysis is required namely causal diagram.

2.6 Causal Diagram

A causal diagram is utilized by identifying key variables (Elements) within a complex system and indicating the causal relationships between them via a feedback loop. This constructed loop is then used to create a concise framework about a particular issue or task [32] (Lannon, 2018).Causal diagrams assist complex systems to understand the behaviour of elements within them thus creating more insight into how the subsystem behaves. The input from both the rich picture and concept map can really assist in generating a robust causal diagram of an infrastructure project. Understanding how the infrastructure project phase's works, most especially the activities within the initiation stage where limited information is available will

assist greatly in generating potential uncertainty sources and factors as well. Crucial relationship between the system and the external environment is quite essential. For instance depicting the causal effect of finances, geological conditions and political atmosphere on the project will be quite helpful in planning for proactive strategies. It can also be utilized for stakeholder analysis and their influences on the project as well. It will assist the project management team to plan accurately the communication channels.

3.0 Conceptual Framework for Infrastructure project uncertainties identification.

The conceptual framework will be depicted descriptively from the sourced literature review. It will be compared in tandem with hard system and Soft system methodology.This framework will be tested and proved when appropriate data are sourced from case study firm (Construction industry) during the PhD thesis progression. The conventional approach is of the reductionist type and does not address adequately the change and dynamics within the infrastructure project activities. Employing this conceptual framework will assist to understand the dynamics, interrelationship and interconnectedness amongst the activities as well as phases within the infrastructure project enabling the stakeholders to identify uncertainties that may impact on objectives. Employing Soft system analysis (System diagramming technique) in identification of infrastructure project uncertainties is a nascent approach which will contribute immensely to the body of knowledge. The proposed conceptual framework is depicted below in figure 1

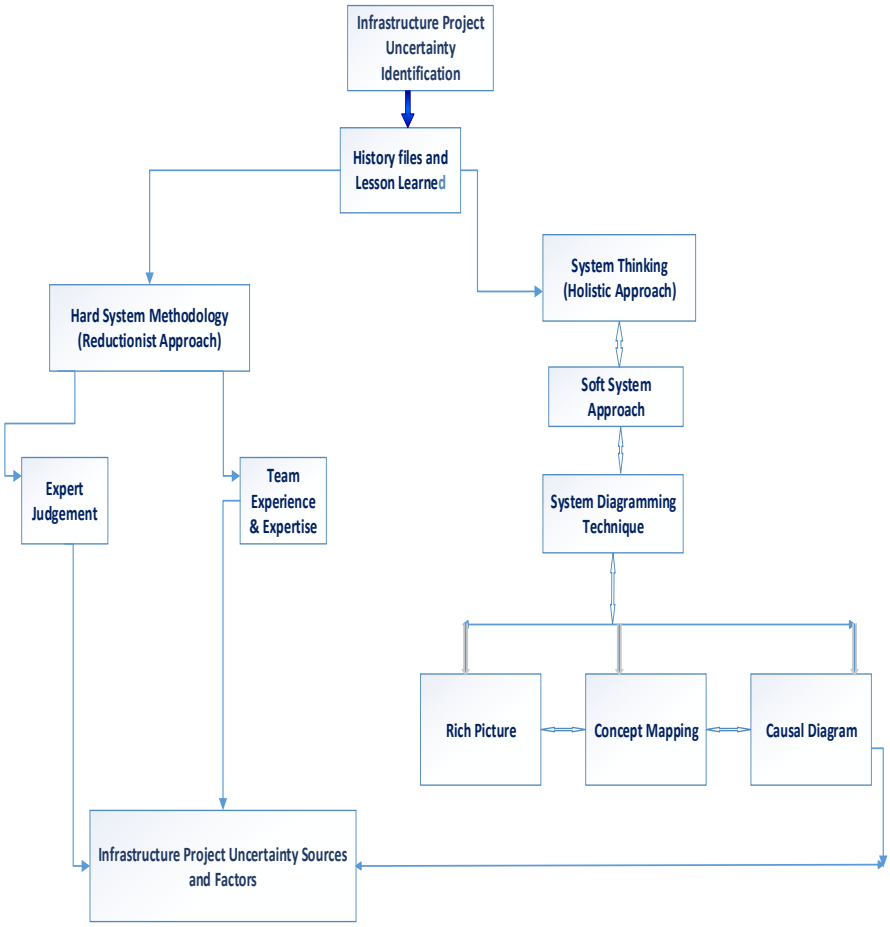

Fig.1 Conceptual framework design

4. Findings

Organizations embarking on an infrastructure project faces high risk due to the complexity involved. In order to mitigate the impacts of any uncertainties that might hinder the effective execution of the project

activities a proactive and holistic approach is quite essential. This conceptual framework design utilizing system thinking described above will enable key stakeholders to identify early enough uncertainties that may impact on project objectives. These uncertainties are mainly major sources of risks which may have adverse effects on project delivery. This conceptual framework will also enable the project management team during initiation stage to be proactive enough to these major sources of risk and proffer contingency plans so as to mitigate the impact to an acceptable level prior to actual execution. This systemic approach will serve as a supplementary technique to the existing approaches.

5. Conclusion

The Infrastructure project uncertainties varies considerably depending on the nature and type of project operating environment. The above conceptual framework is applicable to mostly project executed in Europe and North America. In order to design a robust framework, statistically significant data are needed to be analysed appropriately. Due to the stage of the ongoing PhD thesis work, data are yet to be sourced so as to produce a robust work. This framework is to serve as a supplement to the traditional management approach of uncertainties and risk.

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