International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at www.sciencesphere.org/ijispm

Megaproject complexity attributes and competences: lessons from IT and construction projects

Maxwell Nyarirangwe
University of the Witwatersrand, School of Construction Economics & Management
Private Bag 20, Johannesburg, 2050
South Africa
1304390@students.wits.ac.za

Oluwayomi. K. Babatunde
University of the Witwatersrand, School of Construction Economics & Management
Private Bag 20, Johannesburg, 2050
South Africa
oluwayomi.babatunde@wits.ac.za

Abstract:
Megaprojects have been associated with persistent underperformance technically, financially, socially and environmentally. This underperformance has been attributed to the inherent complexity attributes and the gaps in the form of the mismatch in the project management competences and processes used by the project management teams to deal with the complexity attributes. This study seeks to investigate the performance implications of these complexity attributes to recommend suitable management competences for the successful delivery of megaprojects. This conceptual study used an integrative literature review to analyze and synthesize findings from existing scientific articles related to the complexity constructs based on a comparative assessment of Information Technology (IT) and construction megaprojects. The Complex Adaptive Systems (CAS) Theory was also used to highlight some of the factors that influence megaproject performance towards identifying suitable management processes and competences, which are required to deal with megaprojects complexity. The key findings include a nomenclature of the main complexity attributes, their implications on the performance of IT and construction megaprojects, and, lastly, the management competences and processes that are required to deal with the complexity attributes for improved megaproject performance.

Keywords:
competences; complex adaptive systems; complexity attributes; megaprojects; management processes.

DOI: 10.12821/ijispm070404

Manuscript received: 25 September 2018
Manuscript accepted: 11 November 2019

1. Introduction

Megaprojects have been found to play an important role in the economic development of a nation directly and indirectly, through different multiplier effects [1-3]. Some of the most commonly cited socio-economic benefits of mega infrastructure investments include improved global connectivity, access to natural resources, competitive markets, and better job opportunities [4]. This is supported by studies in both the developing and the developed countries [5-7]. For instance, intensive capital investments in megaprojects in China have been associated with high rates of economic growth and, consequently, an upliftment of close to half a billion people above the poverty line between 1980 and 2000 [8]. While the importance of these developmental benefits cannot be overemphasized, megaprojects have also been found to have a tainted history of poor performance [9-11]. This poor performance has been espoused from technical, financial, socio-economic and environmental perspectives [12-13]. Additionally, the poor performance has been found to undermine the socio-economic, political and environmental benefits that could potentially be derived from megaproject investments [14]. The impacts of megaproject poor performance have been found to be, particularly, direr in the developing countries, where there are neither the necessary resources to absorb the associated shocks nor the required capacity to sustainably recover [8]. Consequently, it has become imperative to establish some of the failure factors involved, recommend suitable remedial measures that can contribute towards improving the performance of megaprojects and, ultimately, enhance their potential developmental impacts.

This study discussed these aspects based on experiences drawn from megaprojects that have been implemented in the Information Technology (IT) and construction sectors. The choice of these two sectors has been informed by considerations such as the amount of research that have been conducted to date and their contribution to the gross domestic products (GDP), particularly, the GDP of developing countries [12]. Research projects which have been conducted regarding the project management experiences during the planning and implementation of construction and IT megaprojects have revealed some gaps and important lessons which can be applied in other similar projects. For instance, with reference to the Brazil, Russia, India, China and South Africa (BRICS) economic group, the IT industry and construction industry have been found to, respectively, contribute about seven percent (7%) and six percent (6%) of the GDP [15]. This is an important value addition, which can be further enhanced through an improvement in the performance of the associated megaproject investments. This study aims to establish some of the factors that impact the performance of megaprojects and recommend suitable management processes and competences that can equip project teams to improve on the delivery of megaprojects. The three objectives include to: (1) establish the main factors causing poor performance of megaprojects; (2) recommend suitable management processes and competences for improving megaproject performance; and (3) determine the implications of improved megaproject performance for the developing countries. The findings from this study, therefore, contribute to the existing body of knowledge regarding project management and, particularly, megaproject delivery. The findings also provide important insights into megaproject attributes, their implications on performance, and the suitable project management processes and competences to address the challenges associated with the current project management approaches.

2. Background

For a proper contextualization of the preceding aim and objectives of this study, this section discusses the main constructs which have been addressed under this study. The first construct is megaprojects. This study discussed some of the current debates surrounding the conceptualisation of megaprojects, the current trends in global investments in megaprojects, and some of the key factors that have been found to impact the performance of megaprojects, particularly, the complexity attributes involved. The second construct is IT and construction megaprojects. The study undertook a comparative assessment of the findings from past research projects, which have been conducted across the IT and construction sectors to draw plausible generalisations for application in the delivery of similar-sized megaprojects. The third conjoined construct had to do with the management processes and competences required to deal with megaproject complexity to improve performance. Lastly, this study also incorporated a geographical distribution aspect to provide the necessary demographics of the different IT and construction megaprojects as an essential part of the analytical framework of this study.

2.1 Megaprojects as a developing phenomenon

The term “megaprojects” has been construed as an old phenomenon which dates back to the prehistoric times when ventures such as the Pyramids of Giza in Egypt, the Roman Colosseum in 80AD and the Great Wall of China were built [16]. The term “mega” originated from the Greek word “megas” which means "great, large, vast, big, high, tall, mighty or important" [17]. The term “mega” was found to have been initially used in relation to megacities in 1968 [10]. Subsequently, from around 1982, the term has been used loosely as a stand-alone adjective to refer to any large project [18]. Scientifically, the term refers to a measurement of worth that is expressed in millions. Using this scientific logic, it can be argued that megaprojects are endeavors worth millions of, notably, dollars, pounds, and euros [19]. Accordingly, this perspective has been used to define and delineate projects such as the Roman Colosseum, the Great Wall of China, and the Pyramids of Giza in Egypt, which were implemented in the past centuries [17]. The situation has since afterwards changed due to the evolutionary cycles associated with megaprojects [10]. Some important events which have been credited for transforming the megaproject landscape have been found to include the Second World War, the Cold War and the Space Race, which ushered megaprojects such as the Manhattan Project (1939 to 1946), and the Apollo Program (1961 to 1972), whose budgets have been estimated to be worth several billions and trillions of dollars [20]. Based on the scientific interpretation of the term “mega”, these important events-borne projects should ideally be termed “gigaprojects” and “teraprojects” based on the sizes of their budgets [5]. However, the terms “gigaproject” and “teraproject” have not been found as being used in the existing literature [19]. Instead the term “megaproject” has been used generally to refer to any massive project, without any attachment to a scientific meaning [12].

From the subtle dichotomy between the literal and scientific conceptualizations, megaprojects have been construed differently by different authors. The most commonly cited reason is the fact that megaprojects are large scale undertakings which require huge budgets and are delivered through complex multiple partnerships between the private and public sectors [21]. As a result, a broader definition of megaprojects has been provided by the United States’ Federal Highway Administration (FHA) as “… projects of a significant cost that attract a high level of public attention or political interest because of the substantial direct and indirect impacts on the community, environment, and state budgets” [22]. Additionally, the Major Projects Association (MPA) included the dimension of competence by defining megaprojects as “... projects which require knowledge, skills or resources that exceed what is readily or conventionally available to the key participants” [16].

Based on these different definitions, what constitutes megaprojects has been concluded as being, largely, elusive and constantly developing phenomena [23-24]. Additionally, the several debates around the key properties of megaprojects have influenced their conceptualization [21]. For instance, on the one hand, some authors have argued that most views regarding megaprojects have been influenced by the contexts within which either the projects are located or the environments under which the associated studies are conducted [25]. On the other hand, it has also been posited that the current conceptualization of megaprojects has been heavily influenced by the disproportionate number of studies which have been conducted in the developed countries as compared to those in both the emerging markets and the developing countries [20, 26]. Additionally, other researchers have cautioned against drawing broad generalizations of the term megaproject for application in the emerging markets and the developing countries contexts [21]. As a result, it has been accentuated that the generally applied USD 1 billion budget threshold is rather arbitrary and, hence, not universally applicable across different socio-economic and spatial settings [23].

By following up on this logic, it has been advanced that the average budget sizes of megaprojects such as the International Space Station, the Joint Strike Fighter and the United Kingdom high speed rail system, surpass the GDP of countries such as Kenya, Guatemala, and so on [21, 23]. In order to have a realistic perspective across both developing and developed countries, it has been posed that contextual aspects such as the ratio between the megaproject budget and the host nation’s GDP must be taken into account [20, 23]. Consequently, it has been suggested that any project with a cost-GDP ratio of about 0.02% in the contexts of both the developed and the developing countries should qualify to be categorized as a megaproject [27]. By applying this approach, infrastructure projects in Eastern Europe with average budgets of between EURO 100 and 250 million have been categorized as megaprojects [28]. This cost-GDP ratio approach has also been proffered as a way of evaluating the risk exposure levels associated with megaproject investments, particularly in the developing countries with low GDPs. This study supports such an approach as a useful way of informing governments in the developing countries regarding possible exposure in the event of megaproject failure. This is, particularly, important given the proliferation of megaproject investments in countries such as South Africa, Nigeria, Ethiopia, Kenya, Tanzania, and Morocco, among the other developing countries [29-31].

Another related debate has focused on the key factors behind the underperformance of megaprojects [5, 32]. Among the many factors that have been put forward in the literature, project size and complexity levels have emerged as two of the most common and impactful factors [33-37]. It then follows that by using project size and the degree of complexity involved, megaprojects (large and complex) have been categorized into small projects (small and non-complex), large projects (large and non-complex), and complex projects (small and complex) [26] (Figure 1).

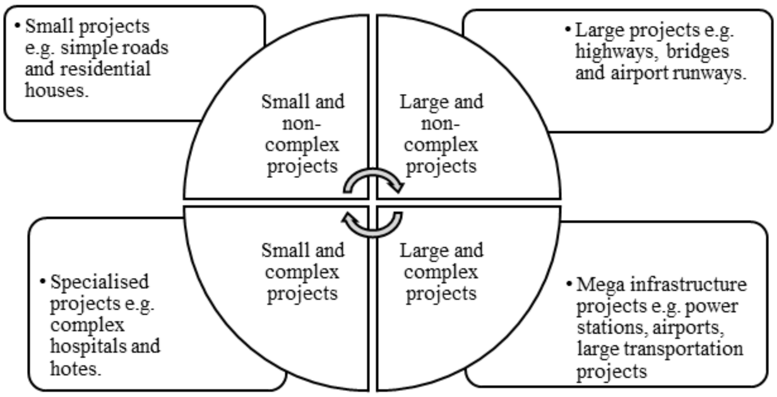

Figure 1. Project Typology based on Size and Complexity (Adapted from [27]).

In an attempt to further simplify the conceptualization, megaprojects have been defined broadly under the investment, operations and economic perspectives [20, 27] as discussed subsequently. Firstly, the investment perspective delineates mega infrastructure projects based on issues such as the size of budget, technological components and the levels of innovation involved. Secondly, the operations perspective covers aspects such as the implementation timeframes involved and the environmental impacts. Lastly, the economic perspective focuses on the contextual issues which affect or are affected by the project [22]. Based on these views, this study upholds the inclusion of contextual aspects in megaproject delineation, regardless of the attributes used.

2.1.1 Trends in megaprojects investment

Megaprojects have been viewed as a preferred business model for delivering goods and services, a strategy for fostering economic growth, and a platform for advancing global connectivity [1-2, 29, 38]. This has been underscored by the increasing investment in megaprojects globally. From a construction sector perspective, series of megaprojects have been implemented across the world (Table 1).

Table 1: Some of the World's Largest Megaprojects

Megaproject	Country	Description	Cost Estimate
International Space Station.	USA, Russia, Japan, Canada and Europe.	Considered as the most expensive single item ever built.	$150 billion (as of 2010)
Al Maktoum International Airport.	United Arab Emirates.	Considered to be world's largest in terms of size and passenger volume with capacity to land four jets simultaneously.	$82 billion
South-to-North Water Transfer Project.	China.	Built to divert water from the Yangtze River using three huge canals to bring it to the north of the country Considered to be three times more expensive than the Three Gorges Dam.	$78 billion (as of 2014)
California High-Speed Rail	USA.	Designed to link San Francisco to Los Angeles over a distance of about 1,300 km.	$70 billion
Dubailand.	United Arab Emirates.	Mega theme park with the world's largest hotel (6,500 rooms), sports venues, eco-tourism, science attractions, and a giant mall to open in project will open in 2025 in Dubai.	$64 billion
London Cross-rail Project.	United Kingdom.	Part of London's expanding underground system, with 42 km (26 mi) of new tunnels to connect 40 stations. To be complete by 2020.	$23 billion
Beijing Daxing International Airport.	China.	This airport megaproject will have seven runways and the largest terminal in the world. Designed to help ease the load on nearby Beijing Capital International Airport and will open in 2025.	$13 billion

(Source [10, 12, 28])

From the IT sector's perspective, some of the megaprojects that have been rolled out includes deep ocean marine fibre optic networks whose footprint has been found to be continuously growing [39-41]. It has been reported that in 2016, a total of 354 submarine cable systems were active, under construction, or expected to be fully-funded with the aim of linking and increasing communication efficiency across Africa, North and South America, Asia, Australia and Europe [39, 42-43]. The network has been projected to continue growing, particularly, in the light of the strong investment drive by companies such as Google, Huawei Marine, and Microsoft [43], with a number of projects being rolled out over the past few years (Table 2).

Table 2: Some of the Recently Constructed Submarine Cable Network Projects

Project	Description	Length (kilometers)
Sea-Me-We 5.	Links Asia and Europe.	20,000
Hawaiki Submarine Cable.	Links Australia, New Zealand and the USA.	14,000
Monet	Links the USA and Brazil.	10,600
Australia West Express.	Links Australia and Djibouti.	10,100
South Atlantic Cable System.	Links Brazil and Angola.	6,200
SemanticNet Fiber Atlantic.	Links the USA and France.	6,675
MAREA.	Links USA and Spain.	6,600
CamTel and China Unicom.	Links Brazil and Cameroon.	6,000
Indonesia Global Gateway.	Links Indonesian and Singapore.	5,300

(Source [11])

In the African context, other megaproject investments in the information and communication technology (ICT) sector have been construed in terms of innovation hubs such as the Kigali Innovation City (Rwanda) [38], Konza Technology City (Kenya) [5, 48], Yabacon Valley (Nigeria) [49], and the proposed Sheba Valley (Ethiopia) [50]. These innovation hub megaprojects have been planned to serve purposes including acting as research centres and information hubs. Although some of these megaprojects such as the Konza Technology City have encountered major implementation challenges and slow progress [5], others such as the Kigali Innovation City have progressed well [38].

Among the other socio-economic objectives, investments in megaprojects in the developing countries have generally been conceptualized as a deliberate strategy to foster economic growth [2, 18, 29, 31]. For instance, infrastructure-led development policies have accounted for China's high rates of economic growth between 1980 and 2000 [31]. Apart from the direct socio-economic benefits such as job creation and poverty alleviation, intense mega infrastructure investments has also been contributed towards the achievement of the United Nations' Millennium Development Goals

(UN MDGs) across the BRICS nations [52]. From a business perspective, the annual global mega infrastructure project market has been estimated to be worth between USD 6 and 9 trillion, which is approximately 8% of the global GDP [53]. Consequently, the need to tap into this lucrative business has also been advanced as one of the key drivers of the global spread of megaproject investment by multi-national construction and funding institutions [54]. This trend is one of the factors that has transformed the perspective of megaprojects from being the preserve of a few rich countries into a global phenomenon with a rapidly expanding footprint even in the developing countries [55]. Additionally, the growth in megaproject investments has been underpinned by the projected economic returns of between 5% and 25% of the infrastructure investments [40]. This estimated return on investment (ROI) has been found to resonate well with governments in the emerging markets and the developing countries in Africa, Asia and South America, where infrastructure-led development models have increased over the years to bridge the infrastructure deficits associated with increasing population and rapid urbanization [55].

Little wonder, then, that the prioritization of megaproject investments nurtures global competitive platforms for attracting and allocating foreign direct investments (FDI), including the underlying ideas and philosophies [56]. Under the logic of FDI and on the one hand, developing countries have leveraged on the natural resource endowments to position themselves as potential growth engines that are attractive to global megaproject investors [51]. On the other hand, developed nations have been found to extend their ideological influence through certain qualifying conditions which they often tie to infrastructure funding such as the Overseas Development Assistance (ODA) and Structural Adjustment Programs (SAP) [57, 8]. It then follows that the rise of powerful emerging economies such as BRICS and the increasing role of institutions such as the BRICS Development Bank in the global megaproject market is radically transforming the ideological landscape, particularly in the developing countries [51-52]. Most notably, China has been investing in several megaprojects in Africa through initiatives such as the Belt and Road Initiative and the China-Africa Forum for Cooperation [8, 31, 58] (Table 3).

Table 3: Chinese-funded Megaprojects in Africa

Country	**Megaproject**	**Project Cost**	**Project Status (as at date)**
Kenya.	Mombasa-Nairobi Railway.	USD3.2 billion	Completed
Nigeria.	Coastal Railway.	USD11.17 billion	Completed
Ethiopia.	Addis Ababa to Djibouti Railway.	USD4 billion	Completed
Tanzania.	Bagamoyo Megaport.	USD11 billion	Planned
Algeria.	The Great Mosque of Algiers.	USD5 billion	Planned
Egypt.	New Cairo.	USD35 billion	Planned
Congo-Brazzaville.	Pointe-Noire Special Economic Zone.	USD4.5 billion	Planned
Angola.	Lobito-Luau Railway Link.	USD1.8 billion	Completed
South Africa.	Modderfontein New City.	USD8 billion	Planned
Kenya, Uganda, Burundi, Rwanda.	East African Railway.	USD15.5 billion	Under construction
Zimbabwe.	New Parliament Building.	USD0.46 billion	Under construction

(Source [2, 30, 58])

The trends in global megaproject investments, accompanying the influx of FDI, have been used to categorize emerging economies into four groups based on their levels of institutional, infrastructure and factor market maturity [59]. The first group, which is central to this study consists of economies such as those from the Sub-Saharan Africa, which have been found to be characterized by poor institutional structures and low infrastructure and factor market development [22, 60]. These countries have been found to struggle with high infrastructure backlogs due to stunted economic growth, failure to attract alternative forms of infrastructure project funding, and the resultant overreliance on insufficient central and local government budgets [6, 60]. Many of these countries, especially those with vast natural resource endowments have been found to be the prime destinations of Chinese megaproject investments [4, 30, 58].

The second group consists of emerging economies in Asia and Latin America, which are relatively well-endowed with infrastructure and factor markets but suffer from inadequately developed institutions [7]. The third group includes mid-range emerging economies such as India, where well-advanced institutions have not been complemented with adequately developed infrastructure and factor markets and, hence, local companies have been stifled growth-wise and forced to migrate globally [61]. The last category includes highly successful countries such as South Korea and China, which have been found as having advanced institutions, modern infrastructure, and mature factor markets that enable their competitiveness to lie in the continuous improvements of their value chain [7]. These countries, particularly China, have been found to leverage on the opportunities of megaproject investments in developing countries to hone their business model skills to enter and operate in the global market [4, 8, 31, 62].

2.1.2 Perspectives of megaprojects in developing and developed countries

The perspectives of megaproject investments differ between developed and developing countries [63]. While the single most important driver of mega infrastructure projects in the developing countries has been found to be the need to foster economic growth and development, the situation is different in the developed countries [29, 64-65]. The importance of concentrating megaproject investments in the developing countries is the potential to grow, for example, Africa's GDP by an additional two percent (2%) and improve productivity by about forty percent (40%) [63]. This is contrary to the situation in the developed world where such investments have been found to have a much broader focus [69].

The main motivation for megaproject investments in the developed world has been construed in terms of technological, political, economic and aesthetic motivations [10, 66]. Under the technological motivation, megaproject investment has been influenced by the excitement and satisfaction that engineers, designers and architects derive from delivering iconic and innovative projects such as the Burj Khalifa Tower in Dubai, the Channel Tunnel which links the United Kingdom to France, and the Boston's Big Dig projects [67]. The political motivation is premised on the satisfaction, attention, exposure, and visibility that politicians derive from building huge and complex monuments [54]. Although this exposure has been viewed positively, it has also been found that when the megaprojects failed, the consequences have often been catastrophic to the detriment of the reputations of the actors involved [66]. The economic motivation has been supported as the delight that business actors and trade unions derive from generating lumpy economic and financial benefits as well as job creation opportunities from mega infrastructure projects [60]. This is a reason that due to their enormous sizes, megaprojects have sufficient scope and budgets to meet the diverse aspirations of the different actors involved [49, 68]. Lastly, the aesthetic motivation has to do with the pleasure that designers and users derive from the beauty associated with iconic buildings and structures such as the Sydney Opera House and the San Francisco's Golden Gate Bridge, which are both considered as aesthetically breath-taking ventures [69]. In addition to these different motivations, some other world megaproject investments, such as Tokyo's Metropolitan Expressway, Hong Kong Airport, the Milau Viaduct in France and the Oresund Link between Sweden and Denmark, have been designed to meet other spatial and aesthetic objectives such as contributing towards urban renewal and macroeconomic efficiency [70]. Other megaproject investments serve as a direct public sector intervention to counter macro-economic depressions, as was the case in USA where projects such as highways and stadia have formed part of the government's interventions to ameliorate the impacts of the Great Depression in the 1950s and 1960s [67].

2.2 Megaproject performance

Despite the importance of megaprojects in economic development, a major concern remains the persistent poor performance of megaprojects [9, 27]. Studies across different sectors have highlighted that up to 82% of megaprojects fail to perform in accordance with the established performance evaluation criteria [9, 14, 32, 71). This higher percentage of underperforming megaprojects overshadows the few that have performed well but unacknowledged. For instance, from the construction sector perspective, the Beneluxlijn metro rail project (Netherlands) has been viewed as a successfully implemented construction megaproject [11, 72]. Its construction was completed within budget and a few months after the target completion date [72]. As for the IT sector, the case of Kroger Co's successful migration from the traditional waterfall model to the agile methodology including has also been described as a successful megaproject [73]. Despite these notable cases of successful megaprojects, most similar-sized projects have performed poorly in terms of budget overruns, scope creep, schedule overruns, costly environmental impacts as well as in terms of the overall failure to achieve the original project, business and community goals [9, 32].

By and large, megaproject underperformance has occurred across different sectors and geographic spaces [39, 71, 74]. Under the construction sector, cost and schedule overruns are the most common challenges facing mega infrastructure projects [32, 75-76]. This view has been supported by findings from a study involving 52 multi-sectoral megaprojects located across the developed world, where between 73% and 77% of the projects underperformed against original cost and schedule baselines [71]. Another cross-sectoral comparative study revealed that hydroelectric and nuclear power mega infrastructure projects do experience the worst schedule and cost overruns, mainly due to the novelty of technology, perceived risks and safety issues involved [12]. A number of underperforming construction-based megaprojects have been found across Europe, the USA, Asia and Africa (Table 4).

Table 4: Examples of Megaprojects that Underperformed

Country of Location	**Project Name**	**Performance Measurement**	**Literature Consulted**
United Kingdom and France.	Channel Tunnel project.	▪ 80% overall cost overruns. ▪ 140% financing cost escalation of original estimates.	▪ [12, 71]. ▪ [9, 50, 54].
USA.	New Denver International Airport.	▪ 200% in overall cost overruns. ▪ Passenger traffic- 50% of projected.	▪ [9, 39, 50]. ▪ [9].
South Africa.	Gauteng Freeway Improvement Project.	▪ Perceived negative impact of cost of living triggered community unrest and payment boycots.	▪ [77].
South Africa.	Gautrain Rapid Rail Link.	▪ 870% in overall cost overruns between 2000 and 2011.	▪ [9, 50].
Denmark and Sweden.	Scandinavian Great Belt Rail Tunnel.	▪ 110% in overall cost overruns. ▪ Negative environmental impacts triggered community unrests.	▪ [9, 39].
Hong Kong.	Chek Lab Kok Airport.	▪ Cost overruns negatively impacted on the country's economy by about US$20 million.	▪ [39].
Kenya.	Mombasa-Nairobi Railway.	▪ 400% budget overrun to 6% of GDP.	▪ [30].

In terms of the IT sector, one of the most extensive studies has been conducted by The Standish Group [74] in the form of periodic analysis of the performance of megaprojects from across the world since 1994. The study uses a global database of more than 50,000 projects which are categorized as "successful", "challenged" and "impaired" [75]. Successful projects are the projects that have been delivered within budget, on time, and within the performance requirements and, as a result, are able to save at least USD40 billion per annum globally [74]. Challenged projects have been completed and operationalized but exceeded the budgets, overshot the time estimates and do offer fewer features than originally specified. These projects experience additional costs of about USD132 billion annually globally [75; 48]. Lastly, impaired projects were cancelled during their development cycle but nonetheless still incur about USD77.5 billion in additional costs annually [74]. The performance trends across the three categories of projects has been studied between 1994 and 2015 (Figure 2).

Based on the results in Figure 2, the majority of projects analysed between 1994 and 2015 have been challenged. When combined, an average of 71% of the IT projects were either challenged or impaired. Similar trends have been established in a study of ICT projects which were implemented by the Dutch government, where 13% were considered successful, 58% were challenged and 29% were failed projects [74]. Additionally, when measured against financial, schedule and expected benefit baselines, about 30% of the IT megaprojects drawn from across the world have suffered cost overruns of up to 100%, while 35% have experienced schedule slippages of up to 200% [75]. More concerning about the result, close to 40% of the projects have completely deviated from the originally specified content. In another assessment conducted by The Standish Group [74] in 2016 focusing on IT projects drawn from across the world, almost similar trends were established (Figure 3).

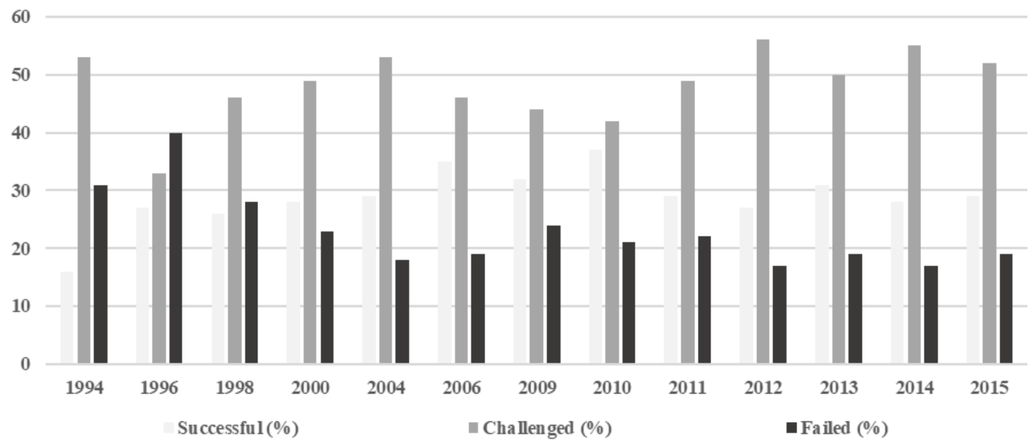

Figure 2. IT Megaproject Performance (Source [74])

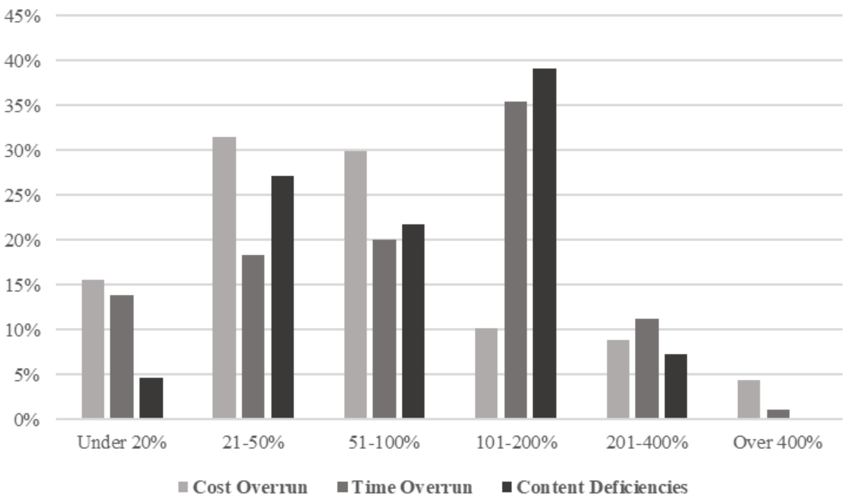

Figure 3. IT Megaprojects Underperformance (Source [74])

3. Research method

It is worth recalling that the aim of this study was to establish some of the factors that impact the performance of megaprojects and recommend suitable management processes and competences that can equip project teams to improve on the delivery of megaprojects. This study sought to achieve this aim by addressing the following objectives:

- Establishing the main factors causing the poor performance of megaprojects, based on the lessons from IT and construction megaprojects;
- Recommending suitable management processes and competences for improving megaproject performance; and
- Determining the implications of improved megaproject performance particularly for developing countries.

This investigative phase of the study forms part of the literature review stage of an ongoing research program. Consequently, the research method used is the review of existing literature on the subject matter as no primary data had been collected at this stage. This section, therefore, discusses the literature review method which has been utilized to achieve the preceding objectives. The first part of the methodology employed identified the different literature review options, which have been accentuated by different authors which include critical review, narrative review, mapping review, meta-analysis, mixed methods review, overview description, qualitative evidence analysis, rapid review, scoping review, state-of-the-art review, systematic search and review, systematized review and umbrella review [78-79]. These different methods were then assessed based on their suitability for achieving this study's objectives. The methods retained include critical review, narrative review, integrative review and systematic review. This process was then followed by a detailed assessment of each method's objectives, advantages and disadvantages (Table 5).

Table 5: Objectives, Advantages and Disadvantages of Literature Review Methods

Review Methods	Objectives	Advantages	Disadvantages
Critical review.	Aims to demonstrate that the writer has extensively researched the literature and critically evaluated its quality.	A critical review provides an opportunity to 'take stock' and evaluate what is of value from the previous body of work.	Critical reviews do not typically demonstrate the systematicity of other more structured approaches to the literature.
Narrative review.	Provides a systematic process for identifying and selecting materials, synthesizing them in textual, tabular or graphical form, and for making some analysis of their contribution or value.	Identifies what has been accomplished previously to allow for consolidation, summation, avoiding duplication and identifying omissions or gaps.	Lacks an explicit intent to maximize scope or analyse collected data and hence its conclusions may be open to bias from potential omissions of literature sections or not questioning the validity of statements made.
Integrative review.	Focuses on reviewing, critiquing, and synthesizing representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated.	Ability to deal with dynamic complex topics with potential to generate contradictions. Provides review and critique to resolve inconsistencies in the literature.	Potential challenges for researchers to fail to maintain scientific integrity and associated threats to validity due to too narrow definition of constructs.
Systematic review.	Considered as the best-known type of review, which seeks to systematically search for, appraise and synthesis research evidence in a way that is transparent and replicable by other researchers.	Upheld for ability to draw together all known knowledge on a topic area.	Restricting studies for inclusion to a single study design such as randomized controlled trials can limit the application of this methodology to providing insights about effectiveness rather than seeking answers to more complex search questions.

This analytical process resulted in the selection of the integrative literature review as the most suitable research method for addressing the objectives of this study. The decision was also informed by the method's comprehensiveness in reviewing, critiquing and synthesizing literature pertaining to the study constructs [79-81]. The integrative literature review method has been advanced as a suitable method for reviewing dynamic topics which are perceived as experiencing rapid growth but have not benefited from a wide and comprehensive review and update over an extended period [82]. Integrative literature reviews have also been recommended when dealing with new and emerging topics whose complexity have the potential to generate a contradiction or discrepancy between what is found in literature and what is observed about the issue [79]. It was on the basis of these different attributes, that the integrative review method has been adopted under this study and used to analyse existing literature on IT and construction megaprojects towards addressing the research objectives in the discussions preceding this section on the research method.

The approach involved the critiquing, synthesizing and reconceptualizing of findings drawn from existing literature on megaproject attributes and their performance implications as well as suitable project management processes and competences for improving megaproject delivery. Special attention was given to literature that focused on IT and construction megaprojects.

The integrative literature review process involved four key stages. Firstly, the relevant journal articles that dealt with megaprojects in general were selected using the Social Science Citation Index as well as the Web of Science [81]. Secondly, journal articles which focused on IT and construction megaproject attributes including their performance implications and suitable project management processes and competences were selected, regardless of their year of publication. Thirdly, out of these journal publications, the articles published between the years 2012 and 2019 were prioritized, although a few older ones were also reviewed for trend analysis of the megaproject attributes and their performance implications as well as suitable project management processes and competences (Table 6). Lastly, the trend analysis provided the opportunity of establishing the critical gaps and in drawing specific conclusions relevant to the study's objectives. The research's objectives and the theoretical framework were the lenses through which the various articles were selected and reviewed.

Table 6: Summary of Literature Review Methodology Flow

Theoretical Framework	**Relevant Literature Selection**	**Core Constructs**	**Integrative Literature Review Processes**	**Key Outputs**
Complex Adaptive Systems Theory.	Journal Articles published between 2012 and 2018. Limited number of journal articles older than 2012. Limited number of other non-journal articles and books.	Megaprojects attributes and performance implications. Required management processes and competences. Implications of improved megaproject performance in developing countries.	Critical Analysis. Synthesizing. Reconceptualization.	Trends across constructs. Key conclusions.

4. Study findings

This section discusses the findings of the study objectives. Firstly, the key attributes of megaprojects and the factors that influence their performance are explored. This was followed by a comparative assessment of these characteristics and performance factors within the context of IT and construction megaprojects. The purpose of this comparative assessment was to create the necessary distinction and draw important lessons required to guide the subsequent discussions. Based on the outcome of this assessment, the study recommended some of the suitable project management competences and processes that can better equip project management teams to deal with megaproject complexity attributes and improve performance. Lastly, the implications of these performance improvement mechanisms on project management in general, and developing countries, in particular, are then analysed.

4.1 Characteristics of megaprojects

Mega infrastructure projects exude certain characteristics which distinguish them from the other conventional projects [20, 24]. Some authors have attributed the difficulties associated with delivering mega infrastructure projects and, ultimately, their poor performance, to these properties [9, 20, 83]. Consequently, it has been cautioned that mega infrastructure projects should not be perceived as magnified versions of smaller projects, but rather, as completely different ventures in terms of scale, objectives, structural and institutional complexity [33]. This view has been justified, particularly, by the extent and nature of the complexity attributes involved in delivering these gigantic ventures [16, 84]. Some of these unique distinguishing characteristics have been found common across IT and construction megaprojects (Table 7). These findings act as an important basis for drawing important lessons which can be applied to other similar projects in order to contribute towards improving performance.

Table 7: Megaproject Characteristics

Megaproject Characteristics	**References for Prevalence under Construction Megaprojects**				**References for Prevalence under IT Megaprojects**			
	[9]	[27]	[39]	[54]	[2]	[23]	[50]	[72]
Extensive physical size.	✓	✓	✓	✓	✓		✓	✓
Huge budgets.	✓	✓	✓	✓		✓	✓	✓
Long planning and implementation timeframes.	✓	✓	✓	✓	✓	✓		
High media attention.		✓						
High social and political significance.		✓	✓					
Involvement of multi-disciplinary and often virtual professional teams.	✓	✓	✓	✓	✓	✓	✓	✓
Complex activity interdependences.	✓	✓	✓	✓	✓	✓	✓	✓
High pace and require innovative approaches.	✓		✓	✓			✓	✓
Complex iterative decision-making processes.	✓	✓	✓	✓	✓	✓	✓	✓
Diverse stakeholders.	✓	✓	✓	✓	✓	✓	✓	✓
High risk and uncertainty from technological novelty.	✓	✓	✓	✓	✓	✓	✓	✓
Complex contractual frameworks and procurement processes.	✓	✓	✓	✓	✓	✓		

4.2 Megaproject performance

This section discusses the attributes that influence megaproject performance. It started off with the debates around the different criteria used to assess megaproject performance. The debates were then followed by a comparative assessment of the performance factors to determine their applicability to IT and construction megaprojects. The eventual findings were then used to highlight some of the gaps in the current project management approaches as the bases for identifying and recommending the suitable management processes and competences that can be applied to improve megaproject performance.

4.2.1 Megaproject performance measurement criteria

While project performance has been studied for a long time, there has been no universally accepted measurement criteria or what constitutes project success [84]. Different studies have come up with an inexhaustible list of measurement metrics, which has resulted in some inconsistencies in the conclusions that have been drawn [77, 85]. Different models have also been proffered in an attempt to delineate suitable performance measurements criteria [87, 86]. For instance, some authors have suggested the need to distinguish between project management success and project success as a way of minimizing the ambiguities involved [53, 84, 86]. Consequently, project management success has been construed as covering the tripartite project management elements of time, cost and quality while project success focuses on the broader aspects of a project beyond the tripartite constraints or golden triangle [84].

Under project success, some authors suggested that other important factors such as the priorities of different stakeholders, contextual factors, the projects' financial and non-financial impacts on the organisational value, and the associated time dimensions must form part of the performance evaluation criterion [85]. These broader evaluation criteria have been advanced as a way of ameliorating against some of the gaps associated with the traditional performance assessment methods centred only around the triple constraint factors of time, cost and quality [86]. This view has been underpinned by findings from cases where, despite having exceeded the planned time and budgets, some projects were still considered to have been very successful, while in other cases those that would have been completed on time and within budgets still failed to satisfy the needs of investors [53]. Consequently, the need to incorporate more attributes beyond time, cost and quality resulted in a further differentiation of project performance into project and product success [84, 86]. While on the one hand, product success is a measure of the extent to which the project would have met the customer's organizational or business goals, project success, on the other hand, is an absolute measure of how the project would have achieved the traditional triple constraint success criteria [84-85]. As discussed earlier, an example which has been used to demonstrate product success is the migration by The Kroger Co from traditional waterfall to agile processes, where the associated benefits were accentuated in the form of achievement of the company's financial and non-financial goals as well as client satisfaction metrics [73]. Based on these performance measurement dynamics, this study proposed an evaluation model which incorporates financial and non-financial measures including the broader customer, community, environmental and political aspects (Figure 4).

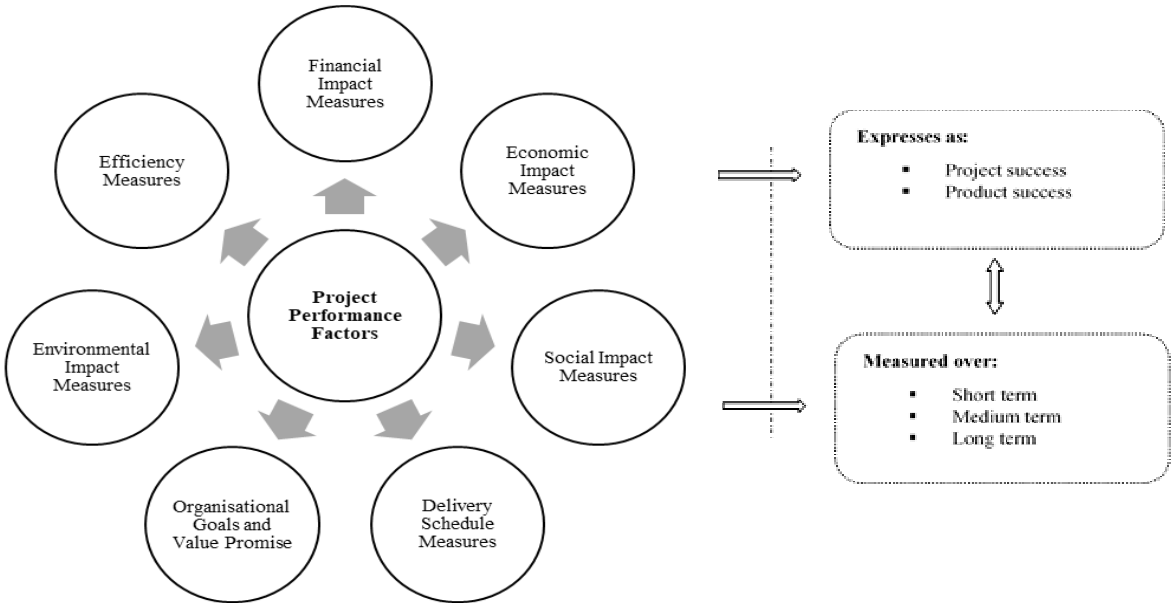

Figure 4: Proposed Performance Measurement Model

4.2.2 Megaproject performance factors

The poor performance of megaprojects has been attributed to a variety of factors which, most notably, include inaccurate forecasting and cost estimations, wrong planning and implementation strategies, underestimation of potential delays, inadequate risk management, unanticipated scope creep, unforeseen geological and environmental challenges, technological factors, poor project governance and stakeholder management, and human resource problems [87]. Some authors have also posited that these factors should be further delineated in accordance with the megaproject delivery stages in order to trace where, in the project cycle, failure would have taken place and, consequently, inform the designing and targeting of suitable intervention measures and improvement processes [37, 88]. Megaproject performance can also be explored from the technical (economic and technological) and human (psychological and political) perspectives [26, 89-90]. Lastly, another comprehensive categorization of performance factors has been based on location and technology, team organization and communication, planning and execution processes, governance and stakeholders, and the delivery strategy [91-92]. Due to the comprehensiveness of this preceding categorization, it has been adopted in the comparative assessment of IT and construction megaproject (Table 8).

What becomes clearer in the list of performance factors is the disproportionate share of human attributes. As a result, based on the Pareto principles, some authors have posed that human factors account for over eighty percent (80%) of megaproject failures [77, 90]. For instance, in a study of about 214 IT projects which were drawn from across the world, it was found that about twenty four percent (24%) were cancelled. Out of these cancelled projects it was found that fifty three percent (53%) of the cases had to do with management-related issues, twenty seven percent (27%) were due to technology-related issues, while twenty percent (20%) were a result of business/organization-related issues [9]. It then follows that the predominance of human factors in influencing megaproject performance has been used as a point of reference in highlighting some of the gaps associated with traditional project management approaches and methods

[72, 80]. This point of reference is further justified by the debates around subjects such as megaproject performance measurement criteria [84-86].

Table 8: Megaproject Performance Factors

Megaproject Performance Factors	**Applicability to Construction Megaprojects**		**Applicability to IT Megaprojects**	
	[12]	[92]	[75]	[77]
Location and technology	-Unavailability of qualified craft workers. -Logistical challenges e.g. non-existing infrastructure, logistics and transportation needs. -Complicated political and regulatory environment and local content requirements.			Shortage of skills/ competences.
Team organization and communication	-Inappropriate project organizational structure. -Lack of coherent teams, high turnover of experienced and skilled staff, and frequent changes in project leadership. -Lack of team and cultural cohesion regarding language, beliefs and working styles due to geographically dispersed who are unfamiliar and working together for the first time.	Management and leadership factors. Team skills and competences.	-Lack of executive management support. -Unrealistic expectations.	-Team members lack skills and competences. -Overambitious plans. - Poor leadership in project delivery. -Critical skill shortages -Insufficient management support.
Planning and execution processes	-Optimism bias and strategic misrepresentation. -Inadequate and non-comprehensive risk assessment, mitigation and management. -Lack of execution plan alignment and insufficiently integrated schedule. -Regulatory and environmental delays. -Baseline schedule acceleration and compromised schedule quality. -Ineffective change management. -Unfit documents, procedures and processes.	Overambitious project size. Complexity attributes.	-Unmanageable project size. -Unmanageable complexity levels. -Unclear statement of requirements. -Poor planning.	-Project oversizing, long delivery schedules and poor estimation methods. -Project volatility, complexity and black swan effects. -Poorly defined technical requirements, inappropriate technical designs and poor risk management. -Inappropriate user documentation and development tools.
Governance and stakeholder management processes	-Involvement of joint ventures among project owners, funders, consultants and contractors. -Convoluted governance processes with poorly defined roles and responsibilities. -Complexity contractual framework. -Multiple stakeholders and coordination challenges and cross functional group interfaces.		Poor user involvement.	-Poor stakeholder communication. -Poor stakeholder management.
Delivery strategy	-Poorly designed project contracting and delivery strategies. -Unclear and ambiguous contracts. -Difficult collaboration among owners, funders, consultants, contractors and suppliers. -Complex local content requirements regarding the procurement of material suppliers and contractors.			

One of the main gaps has been ascribed to the limitations associated with the traditional project management methods in addressing the complexities emanating from the interaction of the different megaproject characteristics [36, 93]. Consequently, complexity has been highlighted as the single most impactful megaproject performance factor [5, 36]. It has been posited that megaproject complexity tends to increase in proportion to the size of the project [3,16]. Moreover, it has also been proven that the size, duration and complexity of mega infrastructure projects makes them unmanageable in terms of accurately predicting critical interdependencies and relationships, emergent and unpredictable human behaviours as well as the constantly evolving internal and external environments [3]. Based on the output of a size-complexity matrix [74], the other related models such as the Contextual IT Project Framework [36], and the

Complexity-Leadership Model [34], this study encourages project management teams to carefully plan and appropriately scale the size of their projects in order to contain the magnitude of complexity involved and, ultimately, improve their chances of success. In order to illuminate the complexity attributes associated with megaprojects, Complexity Theory has, generally, been adopted as a suitable lense due to its universal application across multiple disciplines such as biology, physics, chemistry, mathematics, science, meteorology, and social sciences [62]. However, it has also been countered that there is no unified theory of complexity, but rather, related concepts and theories such as catastrophe, chaos, dissipative structures, multi-agent systems, and systems theory [9, 33, 35].

One branch of Complexity Theory, whose application in megaprojects has been reasonably researched is the Complex Adaptive Systems (CAS) Theory [33, 62, 93]. By drawing insights from the findings of such CAS-based research, this study has also adopted the CAS Theory as a suitable lense in assessing the complexity attributes involved in megaproject delivery. By definition, CAS has been construed as a system that is adaptive, based on the emergent properties that arise from the system's interaction with its internal and external environments [16]. The main properties of CAS include co-evolution, emergence, self-organization, fitness landscape, edge of chaos, dynamism, non-linearity, and adaptation [33, 62, 93]. Within the context of construction megaprojects, the CAS Theory has been found applicable at the levels of the industry, project management office, project site, and project management team [51, 95]. The different CAS attributes have also been found to have been applicable in megaprojects (Table 9).

Table 9: Applicability of CAS Attributes to Megaprojects

CAS Attribute	**Mega Infrastructure Project Characteristics**	**Consulted Literature Sources**
Multiple agents.	Multiple stakeholders including owners or sponsors, funders, regulatory entities, project management consultants, specialist consultants, contractors, subcontractors, material suppliers, unions, watch dogs and user groups.	[12, 33, 35, 62, 93].
Hierarchical structure.	Organizational and decision-making structures consisting of the owner or sponsor, funders, managers, consultants, contractors and material suppliers.	[12, 16, 26, 33, 42, 62].
Modular structure.	Mega infrastructure projects modules consist of sub-projects as well as planning (concept design, prefeasibility study, feasibility study), financing (financing and detail design) and implementation (tendering, construction and operation) stages.	[42, 93, 70, 72, 90].
Adaptive capacity.	Use of innovative contracting methods and various forms of partnerships to expedite decision making and conflict resolution.	[89, 90].
Co-evolution and Self-organization.	Evolution in response to stakeholder requirements, financial need, limited capacity, etc. Uniqueness due to factors such as quality of front-end planning, specifications, clarity of goals, completeness of implementation programs, etc.	[86].
Emergence.	Formation of alliances, partnerships, coalitions, policies, protocols locally, regionally and internationally.	[26, 34].
Dynamism and non-linearity.	Multiple sub-projects which are delivered by separate but inter-dependent specialist teams and exhibit processes and cultures which are different from those of the global project.	[77, 96].

The findings from these studies have been used as the basis for the selection of the CAS Theory as the most suitable framework under this study. Ultimately, this study uses the CAS Theory principles to delineate the most suitable complexity management competences and processes.

4.3 Complexity management processes and competences

The application of the CAS Theory to megaproject characteristics and delivery has been used to highlight some of the gaps associated with traditional project management processes and approaches [5, 34, 76]. For instance, it has been established that traditional project management competences do not adequately equip project management teams to deal with the complexity attributes involved in delivering megaprojects [92, 96]. This view has been corroborated by equating the competences and processes required to deliver megaprojects to a jumbo jet pilot's license [10]. By implication, trying to deliver a megaproject using traditional management competences and processes can be likened to attempting to fly a jumbo jet using a motor vehicle driver's license and, hence, the widely reported failures.

Consequently, a new set of unique management processes and competences has been propounded to further equip project management teams to effectively deal with the complexity attributes involved in delivering megaprojects and improve their performance [68, 92, 96]. These unique management processes and competences have been informed by, and structured around, the different CAS properties associated with megaproject delivery such as leadership, positive behaviour and success mentality, flexibility and adaptability, and organizational structure (Table 10).

Table 10: Competences and Processes for Managing Megaprojects as CAS

Management Processes	Consulted Literature	Management Competences	Consulted Literature
Processes that emphasize leadership approaches more than techniques of control and power.	[92].	Ability to create an engaging ecosystem for stakeholder engagement, adaptive concept scoping and human engineering.	[9, 86].
Processes that propagate positive behaviour and success mentality e.g. unique incentives and inhibitions.	[53].	Creating an enabling environment for innovation through space for creativity, engagement, debate and co-creation.	[5, 6, 96].
Processes that emphasize the assessment of the value of outcomes rather than efficiency optimization.	[97-98].	Architecting complex change through diffused leadership, agile project processes, etc.	[90].
Processes that leverage and encourage adaptive and learning attributes than enforcing of optimization-focused systems, contracts and processes.	[11].	Building a performance culture by e.g. structuring of contracts around shared accountability, mutual achievement and collaborative partnerships.	[6, 89].
Processes that emphasize incentives and encourage personal commitments e.g. transparent organizational practices, policies and outcomes.	[13, 62, 89].	Aligning business models through deliberate migration from strict compliance to contracts towards using human collaboration.	[23, 89].
Models that shift decision making from centralized command and control to points of interface in the mega infrastructure project structure.	[5, 68, 77, 89].	Changing leaders through distributed leadership models which shifts focus from managing complicated technological projects to leading complex social interactions.	[5, 92, 95-96].
Organizational structure and processes which are flexible enough to adapt as more knowledge is gained in the system.	[68, 23].	Learning agility through moving away from risk averse governance to embedded learning models.	[96].

4.4 Implications of complexity management processes and competences

The comparative assessment of the characteristics and performance attributes of IT and construction megaprojects revealed some similarities which can be generalized across other similar projects. For instance, the disproportionate role played by human factors in influencing the success of megaproject delivery posed questions regarding the adequacy of the project management approaches currently used in delivering these projects. As such, given the similarities that have been found across the IT and construction megaprojects, it can be advanced that the management competences and processes are applicable to megaprojects across different sectors. This has implications for the project management field as now discussed next. Most of these management processes are outside the traditional project management philosophy as they have been largely informed from a megaproject complexity perspective. Consequently, these competences and processes can complement the skills, approaches, and processes of the current traditional project management discipline and, by extension, enhance the project management teams' capabilities in delivering megaprojects.

Furthermore, the inclusion of these competences and processes in the project management curriculum can contribute towards equipping future project managers to effectively deal with megaproject complexity attributes and to achieve better performance. This is, particularly, important in the developing countries where there has been a general dearth in the capacity of project teams to effectively deliver megaprojects. A case in point has been the infamous Kusile and Medupi Power Stations in South Africa, in both of which an overreliance on foreign experts has not augured well both in the delivery and performance of the power station [6, 8]. Additionally, the rapid proliferation of megaprojects in developing countries and the potentially disastrous consequences of their failure further underscore the importance of these competences and processes in contributing towards performance improvements. Given the huge cost of megaprojects relative to the developing countries' GDP, any mechanisms that can result in performance improvements will have substantial positive socio-economic impacts. Based on these implications, this paper has managed to achieve its stated objectives.

5. Conclusion

This paper aimed to illuminate some of the main factors behind the poor performance of megaprojects to establish the required improvement mechanisms. This has been achieved by analysing some of the main characteristics which make megaprojects complex to manage and highlighting some of the key factors that influence their performance. This was achieved through a comparative review of findings from literature on IT and construction megaprojects. The main megaproject characteristics from the two sectors and the associated factors that influence their performance were analysed and found to be relatively similar. The paper then crystallized how some of the gaps associated with the traditional project management practice limit the capabilities of the project management teams to effectively deal with the complexities involved in megaproject delivery. By applying of the CAS Theory, the important management processes and competences for megaprojects were then identified as some of the mechanisms that can be used to equip project management teams to deliver megaprojects more effectively. Justifications were given on how the proposed processes and competences can improve the performance of megaprojects and positively impact the economies, particularly of developing countries. Most importantly, the in-depth review and comparative analysis of megaprojects in the IT and construction sectors has brought to the fore the inherent complexities associated with megaprojects. A limitation of this paper has to do with the unavailability of empirical data to back and test some of the propositions; thus, setting the background for further investigation in the future. Having said, the findings from this study contribute to the project management body of knowledge by setting the stage for discussions on linking the proposed management processes and competences to specific megaproject complexity attributes. This is a knowledge gap that has been identified and which serves as one of the focus areas under an ongoing broader research program.

References

[1] A. Carr, "Community Economic Development Strategies in the New Millennium: Key Advantages of Community Benefits Agreements in Urban Mega-Projects," Hastings Race and Poverty Law Journal, vol. 16, no. 2, p. 263-311, 2019.

[2] M. Girma and M. Singh, "Empirical Analysis of Mega Projects Effects on Destination Ethiopia," American Journal of Marketing Research, vol. 5, no. 1, pp. 1-9, 2019.

[3] E. K. M. Rad, "Development of a Project Complexity Assessment Method for Energy Megaprojects," PhD Thesis, School of Energy, Geoscience, Infrastructures and Society, Heriot-Watt University, United Kingdom, 2016.

[4] S. Shan, Z. Lin, Y. Li and Y. Zeng, "Attracting Chinese FDI in Africa: The role of natural resources, market size and institutional quality," Critical Perspectives on International Business, vol. 14, no. 2, pp. 139-153, 2018.

[5] A. B. Omonyo, "Moderating Role of Project Leadership on the Influence of Complexity on Success of Public Infrastructural Megaprojects in Kenya," Doctoral dissertation, Jomo Kenyatta University of Agriculture and Technology, Kenya, 2019.

[6] A. Othman, "A Conceptual Model for Overcoming the Challenges of Mega Construction Projects in Developing Countries," African Journal of Engineering Research, vol. 2, no. 4, pp. 73-84, 2014.

[7] M. W. Peng, S. Lebedev, C. O. Vlas, J. C Wang and J. S. Shay, "The Growth of The Firm in (and out of) Emerging Economies," Asia Pacific Journal of Management, vol. 35, no. 4, pp. 829-857, 2018.

[8] C. Sears, "What Counts as Foreign Aid: Dilemmas and Ways Forward in Measuring China's Overseas Development Flows," The Professional Geographer, vol. 71, no. 1, pp.135-144, 2019.

[9] H. T. Dimitriou, "What Constitutes a Successful Mega Transport Project?" Planning Theory and Practice, vol. 15, no. 3, pp. 389-430, 2014.

[10] B. Flyvbjerg, "What You Should Know about Megaprojects and Why: An Overview," Project Management Journal, vol. 45, no. 2, pp. 6-19, 2014.

[11] A. Gupta, "Successful delivery of mega-projects," PhD. dissertation, Civil, Architectural, and Environmental Engineering, University of Texas, United States, 2015.

[12] Construction Industry Institute. (2015. 10.01). Successful Delivery of Mega-Projects. Research Summary 315-1. CII Annual Conference Edition [Online]. Available: https://www.construction-institute.org.

[13] N. Gil and J. K. Pinto, "Polycentric Organizing and Performance: A Contingency Model and Evidence from Megaproject Planning in the UK," Research Policy, vol. 47, no. 4, pp. 717-734, 2018.

[14] M. Siemiatycki, "The Making and Impacts of a Classic Text in Megaproject Management: The Case of Cost Overrun Research," International Journal of Project Management, vol. 36, no. 2, pp. 362-371, 2018.

[15] Trading Economics. (2018.03.01). South Africa GDP From Construction [Online]. Available. https://tradingeconomics.com/south-africa/gdp-from-construction.

[16] A. Pitsis, S. Clegg, D. Freeder, S. Sankaran and S. Burdon, "Megaprojects Redefined–Complexity vs Cost and Social Imperatives," International Journal of Managing Projects in Business, vol. 11, no. 1, pp. 7-34, 2018.

[17] C. Procter and M. Kozak-Holland, "The Giza Pyramid: Learning from This Megaproject," Journal of Management History, vol. 25, no. 3, pp. 364-383, 2019.

[18] C. Kalebuka, E. Mwanaumo and W. D. Thwala, "Causes of Delays in Mega Projects - Case of the Zambian Transmission Power Projects," In Proceedings of the 21st International Symposium on Advancement of Construction Management and Real Estate, Singapore, pp. 435-449, 2018.

[19] G. Locatelli, M. Mikic, N. Brookes, M. Kovačević and N. Ivanisevic, "The Successful Delivery of Megaprojects: A Novel Research Method," Project Management Journal," vol. 48, no. 5, pp. 78–94, 2017.

[20] S. Schindler, S. Fadaee and D. Brockington, "Contemporary Megaprojects: An Introduction," Environment and Society, vol. 10, no.1, pp. 1-8, 2019.

[21] G. M. Gutierrez, S. Kelly, J. J. Cousins and C. Sneddon, "What Makes a Megaproject: A Review of Global Hydropower Assemblages," Environment and Society, vol.10, no. 1, pp. 101-121, 2019.

[22] X. Li, R. Quan, M. C. Stoian and G. Azar, "Do MNES From Developed and Emerging Economies Differ in their Location Choice of FDI? A 36-Year Review," International Business Review, vol. 27, no. 5, pp.1089-1103, 2018.

[23] S. Mišić and M. Radujković, "Critical drivers of megaprojects success and failure," Procedia Engineering, vol.122, pp. 71 – 80, 2015.

[24] J. Pollack, C. Biesenthal, S. Sankaran and S. Clegg, "Classics in Megaproject Management: A Structured Analysis of Three Major Works," International Journal of Project Management, vol.36, no. 2, pp. 372-384, 2018.

[25] Y. J. T. Zidane, A. Johansen and A. Ekambaram, "Megaprojects - Challenges and Lessons Learned," Procedia - Social and Behavioral Sciences, vol.74, pp. 349 – 357, 2013.

[26] A. Haida and R. D. Ellis, "Analysis and Improvement of Mega infrastructure projects Performance," in Engineering Project Organizations Conference. South Lake Tahoe, California, United States, pp. 1-21, 2010.

[27] I. Fischhendler, G. Cohen-Blankshtain and Y. Shuali, “Communicating mega-projects in the face of uncertainties: Israeli mass media treatment of the Dead Sea Water Canal,” Public Understanding of Science, vol. 24, no.7, pp. 794–810, 2015.

[28] M. Grubbauer and N. Čamprag, “Urban Megaprojects, Nation-State Politics and Regulatory Capitalism in Central and Eastern Europe: The Belgrade Waterfront Project,” Urban Studies, vol. 56, no. 4, pp. 649-671, 2019.

[29] E. B. Aurre and A. C. Jaén, “Mozambique’s Megaproject-Based Economic Model: Still Struggling with Uneven Development,” In Value Chains in Sub-Saharan Africa, pp. 95-113, 2019.

[30] A. Kinyondo, “Is China Recolonizing Africa? Some Views from Tanzania,” World Affairs, vol. 182, no. 2, pp. 128-164, 2019.

[31] B. Ndzendze and D. Monyae, “China’s belt and road initiative: linkages with the African Union’s Agenda 2063 in historical perspective,” Transnational Corporations Review, vol. 11, no. 1, pp. 38-49, 2019.

[32] S. Narayanan, A. M. Kure and S. Palaniappan, “Study on Time and Cost Overruns in Mega Infrastructure Projects in India,” Journal of The Institution of Engineers (India): Series A, vol. 100, no. 1, pp.139-145, 2019.

[33] J. Bakhshi, V. Ireland and A. Gorod, “Clarifying the Project Complexity Construct: Past, Present and Future,” International Journal of Project Management, vol. 34, pp.1199-1213, 2016.

[34] P. A. Daniel and C. Daniel, “Complexity, Uncertainty and Mental Models: From a Paradigm of Regulation to a Paradigm of Emergence in Project Management,” International Journal of Project Management, vol. 36, no. 1, pp.184-197, 2018.

[35] L. B. De Rezende, P. Blackwell and M.D. Pessanha Goncalves, “Research Focuses, Trends, and Major Findings on Project Complexity: A Bibliometric Network Analysis of 50 Years of Project Complexity Research,” Project Management Journal, vol. 49, no. 1, pp. 42-56, 2018.

[36] L. D. Nguyen, L. Le-Hoai, D. Q. Tran, C. N. Dang and C. V. Nguyen, “Effect of project complexity on cost and schedule performance in transportation projects,” Construction Management and Economics, vol.37, no. 7, pp. 384-399, 2019.

[37] Y. Qiu, H. Chen, Z. Sheng and S. Cheng, “Governance of Institutional Complexity in Megaproject Organizations,” International Journal of Project Management, vol. 37, no. 3, pp. 425-443, 2019.

[38] J. Bizimungu. (2018.11.12). Africa50 to spend $400m on Kigali Innovation City [Online]. Available: https://www.newtimes.co.rw/news/africa-kigali-innovation-city.

[39] B. Clark, “Undersea cables and the future of submarine competition,” Bulletin of the Atomic Scientists, vol. 72, no. 4, pp. 234-237, 2016.

[40] N. Czernich, O. Falck, T. Kretschmer and L. Wöesmann, “Broadband Infrastructure and Economic Growth,” The Economic Journal, vol. 121, no. 552, pp. 505–532, 2011.

[41] J. Hecht, “Undersea Data Monster,” IEEE Spectrum, vol. 55, no. 1, pp. 36-39, 2018.

[42] Y. Hu, Y. Le, X. Gao, Y. Li and M. Liu, “Grasping Institutional Complexity in Infrastructure Mega-Projects Through the Multi-Level Governance System: A Case Study of The Hong Kong–Zhuhai–Macao Bridge Construction,” Frontiers of Engineering Management, vol. 5, no. 1, pp. 52-63, 2018.

[43] V. Nagpal. (2017.07.26). Subsea Fiber Cables are Making Their Way to Virginia [Online]. Available. https://www.digitalrealty.com/blog/subsea-fiber-cables-are-making-their-way-to-virginia.

[48] F. Van Noorloos, D. Avianto and R.O. Opiyo, “New Master-Planned Cities and Local Land Rights: The Case of Konza Techno City, Kenya,” Built Environment, vol. 44, no. 4, pp. 420-437, 2019.

[49] P. T. Gbahabo and O. S. Ajuwon, "Mobile Broadband and Economic Growth in Nigeria," Oradea Journal of Business and Economics, vol. 4, no. 1, pp. 65-78, 2019.

[50] N. Eagle, "Turning the Rift Valley into Silicon Valley: Mobile Phones and African Entrepreneurship," Interactions, vol. 14, no. 5, pp. 14-15, 2007.

[51] A. A. Akaev and V. A. Sadovnichii, "The Mathematical Dimension of the One Belt One Road Megaproject," Herald of the Russian Academy of Sciences, vol. 88, no. 4, pp. 243-253, 2018.

[52] P. Bond, "BRICS Banking and the Demise of Alternatives to the IMF and World Bank," In International Development Assistance and the BRICS, pp. 189-218, 2019.

[53] D. Wang, H. Fu and S. Fang, "The Relationship Between Relational Quality and Megaproject Success: The Moderating Role of Incentives," Engineering Management Journal, vol. 31, no. 4, pp.1-13, 2019.

[54] R. E. Hoskisson, M. Wright, I. Filatotcher. and M. W. Peng, "Emerging Multinationals from Mid-Range Economies: The Influence of Institutions and Factor Markets," Journal of Management Studies, vol. 50, no. 7, pp. 1295-1321, 2013.

[55] R. W. Damayanti, A. R. Wijaya and B. Hartono, "Seven Management and Planning Tools in Megaproject Management: A Literature Review," Materials Science and Engineering vol. 598, no. 1, pp. 1-8, 2019.

[56] A. Abdurraheem and A. M. Naim, "Sub-Sahara Africa's Infrastructure Funding Gap: Potentials from Sukuk Financing," Indian-Pacific Journal of Accounting and Finance, vol. 2, no. 4, pp. 26-34, 2018.

[57] J. Y. Park and W. J. Yang, "A Study on the Effectiveness of Overseas Construction Projects Using Official Development Assistance (ODA)," The Journal of the Korea Contents Association, vol. 18, no. 6, pp. 144-154, 2018.

[58] M. Tan-Mullins, G. Mohan and M. Power, "Redefining 'Aid' in The China–Africa Context," Development and Change, vol. 41, no. 5, pp. 857-881, 2010.

[59] Hernandez and M. F. Guillén, "What's Theoretically Novel about Emerging-Market Multinationals?" Journal of International Business Studies, vol. 49, no. 1, pp. 24-33, 2018.

[60] C. Chakamera and P. Alagidede, "The nexus between infrastructure (quantity and quality) and economic growth in Sub Saharan Africa," International Review of Applied Economics, vol. 32, no. 5, pp. 641-672, 2018.

[61] S. Estrin, Z. Liang, D. Shapiro and M. Carney, "State capitalism, economic systems and the performance of state-owned firms," Acta Oeconomica, vol. 69, no. 1, pp. 175-193, 2019.

[62] A. U. Aydinoglu, "Complex Adaptive Systems Theory Applied to Virtual Scientific Collaborations: The Case of DataONE," PhD. dissertation, University of Tennessee, Knoxville, United States, 2011.

[63] M. Peres, W. Ameer and H. Xu, "The Impact of Institutional Quality on Foreign Direct Investment Inflows: Evidence for Developed and Developing Countries," Economic Research-Ekonomska Istraživanja, 31(1), pp. 626-644, 2018.

[64] L. Castello, "The Conversable Scale of Cities," Focus, vol. 14, no. 1, p. 31-36, 2018.

[65] K. U. Ehigiamusoe and H. H. Lean, "Finance–Growth Nexus: New Insights from The West African Region," Emerging Markets Finance and Trade, vol. 54, no. 11, pp. 2596-2613, 2018.

[66] J. Valsiner, "Human psyche between the mundane and the aesthetic: The sublime as the arena for semiosis," In Cultural Psychology as Basic Science, pp. 43-55, 2018.

[67] E. Hewitt, "Romanticism of Numbers: Hamilton, Jefferson, and the Sublime," American Literary History, vol, 31, no. 4, pp. 619-638, 2019.

[68] D. Lester and J. Torero, “Using Megaproject Performance Outcomes to Enhance Decision-Making Behaviors in Civil Engineering Graduates,” Construction Economics and Building, vol. 19, no. 1 pp. 96-110, 2019.

[69] A. Kofinas, “Managing the Sublime Aesthetic when Communicating an Assessment Regime: The Burkean Pendulum,” Management Learning, vol. 49, no. 2, pp. 204-221, 2018.

[70] M. Nyarirangwe and O. Babatunde, “Implications of the Fourth Industrial Revolution for Managing Megaprojects: A Literature Review,” In 2018 SACQSP International Research Conference, Johannesburg, South Africa, pp. 371-383, 2018.

[71] C. Callegari, A. Szklo and R. Schaeffer, “Cost overruns and delays in energy megaprojects: How big is big enough?” Energy policy, vol. 114, pp. 211-220, 2018.

[72] M. Giezen, “Keeping It Simple? A Case Study into The Advantages and Disadvantages of Reducing Complexity in Mega Project Planning,” International Journal of Project Management, vol. 30, pp. 781–790, 2012.

[73] F. Almeida and J. Simões, “Moving from Waterfall to Agile: Perspectives from IT Portuguese Companies,” International Journal of Service Science, Management, Engineering, and Technology, vol. 10, no. 1, pp. 30-43, 2019.

[74] The Standish Group. (2017.02.27). CHAOS Summary Report 2016 [Online]. Available: www.standish/reports/reports.php.

[75] J. Johnson and H. Mulder, “Chaos chronicles, focusing on failures and possible improvements in IT projects,” In Proceedings of the 20th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI, Orlando, Florida, United States, pp. 1-5, 2016.

[76] O. Olatunji, “Causations of failure in megaprojects: A case study of the Ajaokuta Steel Plant project,” Frontiers of Engineering Management, vol. 5, no. 3, pp. 334-346, 2018.

[77] P. Kettunen and M. Laanti, “How to Steer an Embedded Software Project: Tactics for Selecting the Software Process Model,” Information and Software Technology, vol. 47, no. 9, pp. 587-608, 2005.

[78] A. P. Siddaway, A. M. Wood and L. V. Hedges, “How to do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses,” Annual Review of Psychology, vol. 70, pp. 747-770, 2019.

[79] J. K. Williams, “A Comprehensive Review of Seven Steps to a Comprehensive Literature Review,” The Qualitative Report, vol. 23, no. 2, pp. 345-349, 2018.

[80] M. J. Grant and A. Booth, “A Typology of Reviews: An Analysis of 14 Review Types and Associated Methodologies,” Health Information and Libraries Journal, vol. 26, pp. 91–108, 2009.

[81] R. J. Torraco, “Writing Integrative Literature Reviews: Guidelines and Examples,” Human Resource Development Review, vol. 4, no. 3, pp. 356-367, 2005.

[82] Y. Xiao and M. Watson, “Guidance on conducting a systematic literature review,” Journal of Planning Education and Research, vol. 39, no. 1, pp. 93-112, 2019.

[83] F. C. Saunders and E. A. Townsend. “Delivering New Nuclear Projects: A Megaprojects Perspective,” International Journal of Managing Projects in Business, vol. 12, no.1, pp. 144-160, 2019.

[84] J. R. Turner and Y. Xue, “On the success of megaprojects,” International Journal of Managing Projects in Business, vol. 11, no. 3, pp. 783-805, 2018.

[85] A. Shenhar, “Meeting Time, Cost, and Moneymaking Goals with Strategic Project Leadership,” In PMI Global Congress, Quality Management, Organizational Project Management, Dallas, Texas, United States, 2011.

[86] R. Turner and R. Zolin, “Forecasting Success on Large Projects: Developing Reliable Scales to Predict Multiple Perspectives by Multiple Stakeholders over Multiple Time Frames,” Project Management Journal, vol. 43, no. 5, pp. 87-99, 2012.

[87] B. Flyvbjerg and A. Budzier, “Why Your IT Project Might Be Riskier Than You Think,” Harvard Business Review, vol. 89, no. 9, pp. 601-603, 2011.

[88] A. R. A Hamid, D. M. C. Botiti and S. R. Mohandes, “Managing the Delayed Completion on Construction Project,” Journal of Advanced Research in Business and Management Studies, vol. 1, no. 1, pp. 14-24, 2015.

[89] G. Wu, X, Zhao, J. Zuo and G. Zillante, “Effects of contractual flexibility on conflict and project success in megaprojects,” International Journal of Conflict Management, vol. 29, no. 2, pp. 253-278, 2018.

[90] Zheng, J., Wu, G., Xie, H. and Li, H. (2019), "Leadership, organizational culture, and innovative behavior in construction projects: The perspective of behavior-value congruence,” International Journal of Managing Projects in Business, Vol. 12 No. 4, pp. 888-918.

[91] P. Crosby, “Shaping complex mega-projects: practical steps for success,” Australian Journal of Civil Engineering, vol. 15, no. 1, pp.1-19, 2017.

[92] M. Holweg and H. Maylor, “Lean Leadership in Major Projects: From “Predict and Provide” to “Predict and Prevent,” International Journal of Operations and Production Management, vol. 38, no. 6, pp.1368-1386, 2018.

[93] A. P. Lukosevicius, C. A. P. Soares and L. A. Joia, “Characterization of complexity in engineering projects. Gestão and Produção, vol. 25, no. 2, pp. 331-342, 2018.

[94] M. Nyarirangwe and O. Babatunde, “Impact of Project Manager’s Leadership Competences on Complex Mega Infrastructure Project Performance: A Literature Review,” In 9th CIDB Postgraduate Conference, Cape Town, South Africa, pp. 249-259, 2016.

[95] J. H. Huh, T. Koh and K. Seo, “Design and Test Bed Experiment of Graph-Based Maintenance Management System for Yokohama Zone Undersea Cable Protection,” International Journal of Multimedia and Ubiquitous Engineering, vol. 11, no. 10, pp. 15-32, 2016.

[96] J. K. Hazy and M. Uhl-Bien, "Towards Operationalizing Complexity Leadership: How Generative, Administrative and Community-Building Leadership Practices Enact Organizational Outcomes," Leadership, vol. 11, no. 1, pp: 79-104, 2015.

[97] M. Nyarirangwe and O. K. Babatunde, “Competences for Managing Mega Infrastructure Projects. A Pilot Study,” Journal of Construction Project Management and Innovation, vol. 8, no. 1, p. 2219 – 2231, 2018.

[98] R. Yang, S. Jayasuriya, C. Gunarathna, M. Arashpour, X. Xue and G. Zhang, "The evolution of stakeholder management practices in Australian mega construction projects," Engineering, Construction and Architectural Management, vol. 25, no. 6, pp. 690-706, 2018.

Biographical notes

Maxwell Nyarirangwe

A postgraduate research student studying towards a PhD in Construction Project Management with the School of Construction Economics and Management, University of Witwatersrand, Johannesburg, South Africa. Currently works as a Project Leader on a public transport megaproject in South Africa. His research interests concern project leadership, complexity management and project management.

Oluwayomi. K. Babatunde

Senior Lecturer in Project and Construction Project Management. Graduated from the National University of Singapore, with MSc and PhD degrees in Project Management. A registered member of the Society of Project Managers in Singapore and a Fellow Member of the American Academy of Project Management. His research interests cohere around total quality management and project management competence.