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INTRODUCTION

The oil and gas projects (OGPs), just like any other projects, have a determinable lifecycle that must be gone through fully in order to consider the project completion as successful (Merrie & Andrew, 2009). The project manager alongside a selected number of individuals make a project team who are determined to achieve a single objective entailing the completion of various tasks related to the project lifecycle and meet objectives of the project at hand (Merrie & Andrew, 2009). With regards to the lifecycle, it is arguable that every oil and gas project has its beginning or initiation stage (Planning and Construction), its middle phase (Operation) as well its final and ending stage (decommissioning phase) of the lifecycle (Darnall & Preston, 2012). Worth noting is the fact that a project may come to its end with two outcomes; either successful or unsuccessful. Although, projects are unique and highly unpredictable their standard framework consists of same generic lifecycle structure, consisting of the following phases (PMI, 2001): Initiation phase: starting of the project, Planning Phase: planning and preparation of resources, implementing phase: carrying out the project, Closure phase: closing the project. The construction phase of oil and gas projects (OGPs) is a risky process and project managers face numerous challenges in during that particular period. It is going to be classified within the framework of initiation and planning phases during project life cycle. A proper risk analysis and management during the construction phase of the OGPs not only will affect the timely and successful operation of the project as a whole, it can also affect occurrence of risks in subsequent phases and overall economic viability of the project. As a result, this study tries to use extensive literature review for answering the question of what are main risks involved in construction phase of OGPs and which methods can be used in identifying them? The outcome of this research would likely be a valuable source for construction professionals to improve project performance while managing existing risks.

METHODOLOGY

This research is using extensive and critical literature review in the body of knowledge available on risk management in OGPs in general and OGPs construction phase in particular to define exiting risks during the construction phase of OGPs.

RESULTS

Risk management forms a crucial process in the entire project management cycle by identification and mitigation of potential risks which may jeopardize the realization of project objectives (Badiru & Osisanya, 2016). It is regarded as an avenue through which systematic methods of response to unfamiliar risk events in organizations will be addressed to safeguard respective assets and strategic objectives from any possible negative impacts associated with the external or internal influences (Badiru & Osisanya, 2016; Alavi and Khamichonak, 2015). As a process, risk management in the oil and gas industry requires employing systematic techniques by highly skilled and experienced management team in the OGPs projects (Shibani, 2016). It is necessary that the professionals and experts in this field possess a sense of balance regarding the utility of risk contingency for the purpose of linking engineering and organizational management (Shibani, 2016). Therefore, it deems necessary for OGP managers to enjoy an interdisciplinary knowledge of applicable technology in the project together with respective management and organizational knowhow.

Methods of Risk Analysis construction phase of OGPs

Within the framework of risk analysis in the construction phase of OGPs, risks are identified, analysed and mitigated or responded in the most proper manner. Raftery (2003) notes that, a thorough risk assessment should be taken to make sure about identification of all possible risks. Such a process needs an overall evaluation as risks relevant to other phases of project can be identified and mitigated during the construction phase as well. The generic methods of risk analysis in the construction phase in majority of industries are; the Delphic technique, expert evaluations, brainstorming, periodic document reviews, internal audit in the company, etc.

Brainstorming:

Studies show that it is the most applied technique which essentially entails idea generation (Raftery, 2003). All relevant people involved in the project meet at one place. During this meeting, there is one facilitator who gives a brief on diverse aspects of the project and then together with the participants, they note down risk factors. The factors and risks are identified and then the group decides which are relevant to the given project (Raftery, 2003)

Delphi Technique:

This technique is similar to brainstorming. However, the participants in risk identification and analysis do not know each other as they are not in the same place (Haughey, 2018). Thus, they identify the risks without consulting each other. During the process, the facilitator in group sums up the identified risks. This method is effective because it enables the facilitator to collect as much as possible information from all the participants (Haughey, 2018).

Interview/Expert Opinion:

The oil and gas industry is rich with construction experts who can be reached out for providing opinions on the risk factors and method to mitigate them (Nabil, 2014). Given that the experts have vast knowledge about overall risk management in oil and gas projects, they are at a better position to offer objective views on potential risks and risk factors (Nabil, 2014).

Checklists:

Is another method of risk analysis used in construction phase of the Oil and gas industry. The use of checklist is simple but can be useful in risk identification. Usually, it consists of a list of the risks identified in the project undertaken in the past. Within the oil and gas industry, there are dozens of checklists from previous projects which can be used in the current and future projects (Raftery, 2003).

Once the risks have been identified, and a risk matrix will be prepared accordingly. The matrix will classify the potential risks based on the probability of their occurrence and their impact on the project. The identified risks in matrix can be demonstrated in qualitative or quantitative manner (Raftery, 2003).

Types of risks Associated with the Oil and Gas Industry

Like all other types of construction projects, oil and gas construction projects are dealing with numerous types of risk. Raftety (2003) categorizes them into 7 main groups of technical, physical, construction, organizational, financial, socio political and environmental risks. However, he further subdivides any category into different types. Due to fluid nature of risk types in oil and gas construction projects, it would not be proper to consider the above mentioned risk categorization as solid. A comprehensive review of literature in this field by authors is summarized in the table 1 as most significant risks existing in the oil and gas construction phase.

According to Table 1, associated risks in construction phase of oil and gas projects fall into different groups namely: Political factors, Design, Financial related i.e. poor estimation, overrun, or losses, Environmental factors i.e. natural disasters, Human resource, Raw materials, Management and Leadership.

Table 1 Identified risks in construction projects by risk management researchers

Author	Result of Research
Mustafa et al., (1991)	Inflation, Country Economic, Condition and rules and regulation, unavailability of funds, Financial failure.
Kumar P(2002)	Scope and design changes, Technology, Weather and climatic Conditions, Statutory clearance and approvals.
Ghosh et al., (2004)	Scope and design changes, Inflation, Country Economic Condition and rules and regulation, unavailability of funds, Financial failure, Construction Delays
Elliot (2005)	project cost overruns and losses on labour productivity in Canada were due to management deficiency in managing scope, time, cost, quality, productivity, tools, scaffold, equipment, materials, and lack of leadership by project managers.
Laryea, (2007)	Scope and design changes, Technology Implementation, Site conditions and Unknown Geological Condition, Inflation, Country Economic Condition and rules and regulation, unavailability of funds, Financial failure, Lack of availability of resources
Enhassi and Mosa, (2008)	Scope and design changes, Technology Implementation, Site conditions and Unknown Geological Condition, Inflation, Country Economic Condition and rules and regulation, unavailability of funds, Financial failure, Weather and climatic Conditions, Poor Safety procedures, Construction Delays.
Sun & meng, (2009)	Site conditions and Unknown Geological Condition, Inflation, Country Economic Condition and rules and regulation, unavailability of funds, Financial failure, Inadequate managerial skills, improper coordination between teams, Lack of availability of resources
Wang et al., (2010)	Inflation, Country Economic Condition, Statutory clearance and approvals, construction delays.
Eybpoosh, (2011)	Scope and design changes, Technology Implementation, Site conditions and Unknown Geological Condition, Inflation, Country Economic Condition and rules and regulation, Lack of availability of resources.
Rezakhani, (2012)	Scope and design changes, Technology, Unavailability of funds, Financial, Weather and climatic Conditions, Poor Safety procedures.
Badiru and Osisanya (2013)	possible sources of uncertainty for oil and gas industry might be due to, several sources as listed below: Poor estimates of time and cost. Lack of a clear specification of project requirements, Ambiguous guidelines about managerial processes. Lack of knowledge of the number and types of factors influencing the project, Lack of knowledge about the interdependencies among activities in the project, Unknown events within the project environment. Variability in project design and logistics, Project scope changes, Varying direction of objectives and priorities.
Goh et al., (2013)	Scope and design changes, Technology Implementation, Site conditions and Unknown Geological Condition, Inadequate managerial skills, improper coordination between teams, Lack of availability of resources, Construction Delays.

Challenges in Risk Analysis and Management construction phase of OGP

The existing literature identify numerous challenges affecting risk analysis and management process in the construction phase of the oil and gas industry. For example, existence of diversified tools for risk analysis does not mean that all of them are suitable for identification and management of complex risks in construction phase of the oil and gas industry (Nabil, 2014) additionally, Raftery (2003) notes that while many companies today recognise the need to use the available tools for risk analysis, they are not capable of utilizing them due to lack

of relevant knowledge at organizational level. As noted by the proponents of the knowledge-based approach to risk management, knowledge management is a critical tool for risk management (Paiva et al., 2007). The knowledge management in an organisation intends to ensure continuity and improvement of overall performance in the key areas of the organisations via combining knowledge in synergistic ways, gaining the relevant knowledge and developing new knowledge (Paiva et al., 2007). The latter will be achieved through a learning process to be built on external knowledge and internal experiences (Paiva et al., 2007). It is important to apply the knowledge-based model to risk assessment in the construction projects in oil and gas industry as lack of continuity in most of the companies makes it quite difficult for them to effectively manage the risks (Paiva et al., 2007).

According to Hillson (2002), there are four main strategies to risk management including: risk response, risk mitigation, risk acceptance and risk transfer. He also notes that risk response and mitigation are weakest parts of the entire risk management process. Thus, the proper management of risks needs them to be identified well ahead of time and allocated in a manner that is in a crystal clear manner. This can be achieved if parties to the contract understand their responsibilities, risk handling capabilities and events which might result risky conditions.

On the other hand, the type of tendered contract can be a challenge for effective risk analysis and management. Subsequently, Zaghoul and Hartman (2003) note that there is no possibility of eliminating all types of risk in any given construction project. they propose to regulate the risk and allocate it to different agents in the risk management process. Chapman and Ward (2003) point out that decisions relevant to contract type are important for stakeholder management as well as the management of uncertainty in risks. In most contracts, the aim of the contractors is to gain an acceptable range of profit margin. However, reduction of profit margins in recent years calls for decision makers on either party to understand and allocate risks properly in order to avoid erosions in expected profit.

According to Chapman et al (2003) risk management can be considered amongst most difficult tasks in construction projects. This leads us to systematic approach to risk management in the construction phase of the oil and gas projects.

Systematic Risk Analysis Models

An extensive literature review shows that construction projects in any industry face with numerous risks of different nature. These risks can impose far-reaching effects on the success of the project. Nevertheless, the complexity of the construction projects (the multiplicity of risks and their possible impacts, as well as the stakeholders) makes their risk assessment and management extremely difficult (Walewski & Gibson, 2003). In order to overcome such challenges in project risk management, scholars offer using models like

Stochastic Multi-agent simulation for Construction Project (SMACC), Risk Breakdown Structure and The Knowledge Based Approach.

SMACC – Stochastic Multi-agent simulation for Construction Project

SMACC is an agent paradigm used for simulating construction projects (Taillandier, 2014). The agent paradigm comprises of a set of autonomous agents. According to Taillandier et al. (2015), each agent possesses unique behavioral characteristics and interacts with other agents in order to be evolved in a dynamic and complex environment. An agent has her own vision, action capabilities and decision-making ability. The model also recognizes that the interests and objectives of each agent can differ from one to the other and there is no global control over that. The complexity arises from the interactions.

The SMACC suggests the use of agent-based simulations and a stochastic approach for risk assessment is useful in evaluating the consequences of classical hazards like time, project quality and cost (Mehdizadeh et al 2011). In fact, SMACC is a dynamic model taking into account methods of risk evolution in the course of a project. Additionally, it permits the project manager to choose the task most relevant to risk control strategy.

Although, first version of SMACC found to be effective in assessing risks, some flaws occurred in practice: (1) the model only took into consideration the operational tasks, leaving out payment or management issues (2) the approach was purely quantitative (3) the management of human resource and material was rather poor. In order to overcome above mentioned problems, SMACC2 was developed. SMACC2 allows integration of inheriting links between the diverse concepts. In SMACC2, there are nine agents which have been defined so as to cope with the vision:

- **Stakeholder:** Refers to an organisation (either the local authority, company, association) or individual which is either impacted on by the construction project or influences it (Honzírková, 2016).
- **Activity:** it is construction process which aims at developing the project. (Taillandier et al., 2016). There are four main activities to be considered for the purpose of risk analysis and assessment including: managerial (e.g. supervising the task the subcontractor), contractual (coming up with the contract and assigning each stakeholder an activity to accomplish within a specified time), operational (such as structural works, study), financial (payment of purchasing activity or stakeholder by another) (Taillandier et al., 2016).
- **Product:** Refers to the result of an activity. The result can be an architectural plan, a concrete structure or just information or decision. The type of product that one gets depends on the type of activity (Taillandier et al., 2016).
- **Contractor:** physical element that has a legal value and that specifies the link between stakeholders and activities and the particular conditions in

which the activity has to be completed (duration or budget allowed, aimed performance, etc.).

- **Resource:** Refers to the element that owned by the stakeholder enabling them to carry out a given activity. There are two types of resources to be considered in the risk assessment: material resources and human resource (e.g. the workers and designers). When considered as human resource, it is viewed as the working force (Altoryman, 2014 as cited in Honzírková,2016).
- **Skill:** Skill entails expertise, knowledge and know-how to carry out an activity (Altoryman, 2014 as cited in Honzírková,2016).
- **Exterior environment:** Entails all the elements exterior to the project which have an impact on the construction project (e.g. economical context, third parties or weather) (Altoryman, 2014).
- **Risk factor:** In the context of risk assessment model, a risk factor is the condition or state of the world which has an impact on occurrence of the risk. For example, extreme cold temperature will increase the likelihood and probability of a risk occurring (Taillandier et al., 2016). The initial version of the SMACC1 model was purely quantitative. However, improvement have been made to the SMACC 2 model to cater for the needs of qualitative risk assessment due to extreme difficulties in justification of numerical data.
- **Risk event:** even the occurrence of which is uncertain and that can impact the objective of the project. We distinguish the activity risk events that impact the proceeding of the activities and the actualization risk events that impact the agents (creation or destruction of an agent, modification of an agent attribute, etc.).

Risk Breakdown Structure

Risk identification often leads to development of a long list. In order to assess the impact of identified risks on the project, they should be prioritized. The hierarchical classification and organization of risks is a practical tool which makes them easier to be managed the can be achieved via the Risk Breakdown Structure (RBS) model. RBS categorizes the risks identified into diverse levels in a bottom-up approach. According to Holzmann & Spiegler (2010), RBS hierarchically organizes the projects risks by both category and sub-category. In addition, it identifies areas and causes of the potential risks. In fact, RBS is a reflection of the overall project and organizational risk factors and events, organized by category or event. It also attempts to provide the structure of the diverse risks which can affect the project.

According to Hillson (2002), the RBS model is an important tool for identifying, assessing and reporting risks in an organisation.

In terms of risk classification, different classes have been developed in the course of time. Tah and Carr (2001) classified the risks in relation to their origin; either internal or external. Other ways of classifying risks use multiple criteria for

this purpose. Cooper and Chapman (1987) categorise risks according to their magnitude and nature, differentiating between primary and secondary risks. Zou, Zhang and Wang (2007) suggest the classification of risks according to the different phases of the project, and risks associated with the different partners in the project. Tam, Shen, Tam and Pang's (2007), provide three main classifications of risk in accordance with their importance and magnitude including upper, middle- and lower-class risks.

Knowledge-Based Approach

The knowledge-based approach is one of the important models for risk analysis used in construction phase of oil and gas projects. Studies on failure of risk management strategies underscore three main causes of such failures: ineffective controls, dysfunctional culture and unmanaged organizational knowledge (Rodríguez and Edwards, 2009). The third cause (unmanaged organizational knowledge) indicates that in majority of occasions, failure is not due to lack of information about the positional risk. In fact, it is result of improper knowledge management (Rodríguez and Edwards, 2009). In the context of risk management, knowledge has a critical role. It enables working skills and improves the capacity of project teams (Rodríguez and Edwards, 2009). Knowledge is also tied to the people's commitments and beliefs, particularly concerned with human action in a manner that adds value to the entire project (Paiva et al., 2007). Hsu and Shen (2007) argue that knowledge management is an organised and systematic approach to improve the ability of the organisation and mobilise knowledge to improve decision making and develop actions to deliver results.

In the construction phase of OGPs, most of the knowledge is project specific and obtained in process of implementing the project. Therefore, in absence of methods suitable for storing, distributing and sharing knowledge generated in a project, it will not be possible to keep it in organizational framework and critical resources will be lost. As a result, business performance would suffer substantial loss.

Within the knowledge-based approach, different models are used for the purpose of risk assessment and management. Amongst them a useful model is the Quality Improvement Paradigm (QIP) (Basili, 1989). The QIP is seen as an approach in different cyclic phases (Characterize, Choose Process, Execute, Analyze and Package). This approach can be used in the construction phase of the OGPs to perform and optimise the process of collecting knowledge, packaging and transferring it at the organizational level (Basili, 1989).

DISCUSSION

Kumar (2007) by conducting a survey on project managers in Petro Vietnam categorized main risks in construction phase of OGPs as following: Bureaucratic government system and long project approval procedures, poor design, incompetence of project team, inadequate tendering practices, and late internal

approval processes from the owner were identified as major risks. The executives suggested various strategies to mitigate the identified risks. Reforming the government system, effective partnership with foreign collaborators, training project executives, implementing contractor evaluation using multiple criteria decision-making technique, and enhancing authorities of project people were suggested as viable risk management approaches.

El-Shehaby, Nosair, El Sanad (2014) indicated that most of the top-9 risk factors affecting the companies working in the construction of oil & gas projects are: weather effect on the project, Increase in material price ,currency fluctuation (foreign exchange rate), delay of tender offer evaluation and purchase order cycle ,project duration (schedule is too short for the required activities ,client delay in making decision or delay in approval of contractor's submittals ,delay in performing inspection & testing by the consultant, the conflict between the contractor and the consultant, commitment to the schedule delay due to contractor.

Nabil (2014) concluded that the main risk factors affecting the Projects of construction oil & gas in Egypt are: Weather effect, increase in material price, currency fluctuation (foreign exchange rate), delay of tender offer evaluation and purchase order cycle, project duration (schedule is too short for the required activities), client delay in making decision or delay in approval of contractor's submittals, delay in performing inspection & testing by the consultant ,the conflict between the contractor and the consultant , delay due to contractor.

The result of analysing questionnaires received from contractors in Ghana by Alhassan (2016) conclude the most important risk factors that affect construction projects as: Inflation, Delayed payments on contract, Difference in actual quantities and the executed quantities, Defective design and Poor safety procedures.

Study of Honzirková (2016) indicates main risks in construction phase of OGPs as: Change in the project, Staff turnover, mismatch between ordination plans and cost plan, absence of cost control mechanism, unexpected expenses occurring during the construction phase, a sudden shortage of construction materials.

Kraidia and Borthwick (2018) study conclude main risks as: Improper safety regulations, improper inspection & maintenance, weak ability to identify & monitor the threats, low public legal & moral awareness, design, construction & material defects lack of proper training, threats to staff, lack of risk registration, exposed pipelines ,limited warning signs, shortage of the IT services & modern equipment, the pipeline is easy to access, operational errors, conflicts over land ownership, lack of sufficient research on subject matter.

Table 2 The related researches regarding the construction risks involved in phase of oil and gas projects

Author	Purpose	Method	Result (Major risks)
Kumar (2007)	to the identify risk factors, which affect oil and gas construction projects in Vietnam and derive risk responses.	The questionnaire survey was conducted with the participation of Petro Vietnam project managers.	<ul style="list-style-type: none"> • Changing Government regulation and Delay government permit. • Poor project design. • Incompetence of project team. • Inadequate tendering practices • Late internal approval processes from the owner.
El-Shehaby, Nosair, El Sanad (2014)	to identify and analyze the associated risks in the construction of Off-Shore Oil & Gas projects.	Field survey was conducted through a structure questionnaire to the companies.	<ul style="list-style-type: none"> • Weather effect on the project. • Increase in material price. • Currency fluctuation (foreign exchange rate). • Delay of tender offer evaluation and purchase order cycle. • Project duration (schedule is too short for the required activities). • Client delay in making decision or delay in approval of contractor's submittals. • Delay in performing inspection & testing by the consultant. • The conflict between the contractor and the consultant. • Commitment to the schedule delay due to contractor.
Nabil 2014	to identify and analyze associated risks in the construction of Off-Shore Oil & Gas projects in Egypt.	Quantitative risk analysis tool "risky project" was used	<ul style="list-style-type: none"> • Weather effect. • Increase in material price. • Currency fluctuation (foreign exchange rate). • Delay of tender offer evaluation and purchase order cycle. • Project duration (schedule is too short for the required activities). • Client delay in making decision or delay in approval of contractor's submittals. • Delay in performing inspection & testing by the consultant. • The conflict between the contractor and the consultant. • Commitment to the schedule delay due to contractor.
Alhassan (2016)	In achieving project and business objectives, Contractors usually experiment many techniques and management practices in addressing construction risk.	questionnaire survey was used for data collection and the SPSS and relative importance index were employed for analysis.	<ul style="list-style-type: none"> • Inflation • Delayed payments on contract • Defective design • Poor safety procedures. • Project duration (schedule is too short for the required activities). • Client delay in making decision or delay in approval of contractor's submittals.
Honzírková (2016)	Risk Analysis in The Construction Industry.	Qualitative and quantitative analysis.	<ul style="list-style-type: none"> • change in the project • Staff turnover • Coordination plans differ from cost plan • Unexpected expenses of materials

			<ul style="list-style-type: none"> • a sudden shortage of construction materials.
Kraidia, Shaha, and Fiona Borthwick (2018)	Analysing the Critical Risk Factors in Oil and Gas Pipelines Projects Regarding the Perceptions of the Stakeholders	a questionnaire survey	<ul style="list-style-type: none"> • Improper safety regulations • Improper inspection & maintenance • Weak ability to identify & monitor the threats • Low public legal & moral awareness • Design, construction & material defects • Lack of proper training • Threats to staff • Lack of risk registration • Exposed pipelines • Limited warning signs • Shortage of the IT services & modern equipment • The pipeline is easy to access • Operational errors • Conflicts over land ownership • Little researches on this topic
Kassem, Khoiry and Hamzah, 2019	To identify and assess the relative importance of the significant risk factors contributing to cost and time overrun in oil and gas construction project in Yemen.	A questionnaire was use to collect the perceptions of construction projects in the oil and gas sectors in Yemen.	<ul style="list-style-type: none"> • Political Instability • War in Country • Economic and Financial Crisis the Threat of Armed Groups • Lack of infrastructure projects Unsafe Transportation Routes Unstable of Government • Country Conditions During Construction • Foreign Currency Fluctuation Corruption accompanying tenders Higher Insurance and Transport prices to Yemen • Health and Safety • Illegal support and nepotism Length of Oil Sector Border • Poor Planning and controlling for Scheduling, and Budgeting

CONCLUSION

In conclusion, current paper presents a review of the existing literature concerning the idea of risk analysis and management in construction phase of the oil and gas projects. In the first section, this paper presents outcome of literature review on what risk analysis and management entails in construction industry. It also gives an overview of project and project lifecycle and the stages of the construction phase of oil and gas project cycle. Finally, it concludes with probing down for identification of most important risks within the construction phase of OGP in existing body of knowledge. The paper also underscores the centrality of knowledge management in risk management in OGP.

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Abstract: The construction phase of oil and gas projects (OGPs) is a risky process and project managers face numerous challenges during this particular period. A proper risk analysis and management during the construction phase of the OGP not only will affect the timely and successful operation of the project as a whole, it can also affect occurrence of risks in subsequent phases and overall economic viability of the project. As a result, via using extensive literature review, this study tries to answer the question of what are main risks involved in construction phase of OGP and which methods are used for identifying them? The outcome of this research would likely be a valuable source for construction professionals to improve project performance while managing existing risks. It is also useful to avoid common problems that befall many project managers and will assist them to have a better understanding of risk management as part of a project plan.

Keywords: project management, Construction projects, risk management, Oil and Gas industry