Analyzing the Critical Risk Factors Associated with Oil and Gas Pipeline Projects in Iraq

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ABSTRACT

Although Oil and Gas Pipelines (OGPs) are a safe and economical mode of transportation of petroleum products around the world, they face challenges caused by risk factors including safety, security, design, construction and operational risks due to Third Party Disruption (TPD) and acts of terrorism, particularly in developing and unstable countries like Iraq. A lack of knowledge about managing such risks and the scarcity of past data about pipeline failures, are hindering OGP risk management systems. This paper, therefore, focuses on identifying and analyzing the risks caused by TDP in order to develop a holistic Risk Management Model (RMM). A semi-structured questionnaire was designed, using 30 risk factors identified through a comprehensive literature review, distributed to OGP stakeholders in Iraq, via an online survey tool, to collect the research data. SPSS was used to analyze the data and evaluate risk factors which were ranked in order of probability and severity level using a risk index method. A conceptual framework for the RMM is presented, based on the literature review and survey findings. The results reveal that terrorism, sabotage and theft are the most critical safety risks, official corruption and lawlessness the most influential factors for regulatory risks. Pipeline location “Hot-Zones” also have a serious impact on the failure of pipelines. A computer-based risk management model will be developed at the next stage of the study using the RMM and the results of the numerical risk analysis.

Keywords- *Pipelines; risk evaluation; risk management model; safety risk and third-party disruption.*

1. Introduction

Oil and gas pipelines (OGPs) are considered a safe and economical mode of petroleum product transportation, however they are subject to a range of hazards and accidental damage that have severe consequences on projects and people's lives. Long-distance pipelines mainly suffer from mechanical, operational and natural hazards [1], design flaws, misuse, corrosion damage and third-party disruption (TPD) [2]. Muhlbauer [3] defines TPD as any individual or group action that obstructs the functionality of the infrastructures' systems in any direct or indirect manner. Peng *et al*. [4] add any action that accidentally damages OGPs, such as human error, natural phenomena, soil movement (e.g. foundation collapse, landslides, floods and mudslides), and surface loads as a result of illegal building, blast construction and live ground loads that compress pipelines. In this paper, TPD refers to all individual and group actions that result in expected or unexpected pipeline damage, at any stage of the pipeline project. At the present time, globally insecure situations are adding more cause for concern and potentially serious consequences to OGP projects. This is especially the case in countries with low levels of security where OGPs often suffer malicious terrorist attacks. Such hazardous environments make OGP risk management challenging and complex.

OGP projects are complex and risky but crucial. Consequently, the risk management challenges and difficulties facing OGPs are increasing day by day due to the vast range of problems that are facing pipeline projects because of an unstable global environment. Proper attention needs to be given to OGP risk factors because neglecting these will result in casualties in terms of disturbance to business activities and economic losses. In the OGP risk management field, problems related to proper understanding, data availability and risk evaluation facilities have been noticed, particularly in developing and unstable countries like Iraq. This implies that risk management studies must be conducted and translated into formats that can be reviewed, understood and analyzed in order to maintain safe and secure construction and operational environments [5].

Even though risks to OGPs cannot be entirely avoided, dealing with each risk as severe is resulting in losses in expenditure [6] and time. Reasonable and accurate risk evaluation measures can contribute to a reduction in the overall risk of pipeline failure [2]. Risk management works to control risk factors and minimize risk impact, this process including four steps: (i) risk identification; (ii) risk analysis; (iii) risk response and mitigation, and (iv) risk monitoring and control [7]. Step 1, risk identification, is carried out to identify the factors that affect OGP project success, both positively and negatively. This step is fundamental because risk management is based on the premise that risk factors are identifiable as defending a system from unknown risk is almost impossible [8]. Step 2, risk analysis, is about evaluating the influence of identified risk factors on the project in terms of the chances of it happening, frequency or likelihood, severity and the degree of impact. Both risk identification and analysis depend on an appropriate and accurate knowledge base and real data as these provide the required level of input for a successful risk evaluation [9]. In order to prioritize hazards that need managerial attention, risk registers should contain all analyzed risks [10,11]. Because of this, the current trend in risk management is to take a holistic and comprehensive approach to projects [12], ensuring that adequate 'risk registration' and 'risk assessment' facilities are available for effective risk evaluation. Step 3, risk response and mitigation, are about how to respond to risk and choose actions that will reduce hazards and minimize consequences. Step 4, risk monitoring and control, are continuous processes carried out to identify and analyze new risk factors, re-evaluate current risk factors and improve existing risk responses to ensure adequate risk management.

Existing OGP risk management studies (for details see Table 1) do not focus on all types of risk factors at a time, despite the fact that there are many different types of risks which can affect the OGP. This is especially the case in countries where OGPs face unique risks due to TPD, sabotage, acts of terrorism, civil war and rules and regulations. These risk factors have not been effectively studied to date. While accurate risk factor probability and severity values are required to manage OGP risks, these values are still imprecise, deficient and vague [13] meaning that current analytical methods cannot calculate the probability and severity of TPD and other similar factors.

One of the reasons why it is difficult to manage risk more effectively is because a historical database has not yet been established [4,14]. This implies that current OGP risk evaluation studies and tools are inadequate due to the lack of an acceptable knowledge base and a lack of data. This situation is causing significant challenges for developing and unstable countries like Iraq, as well as general issues around less effective OGP risk management systems. There is, therefore, a vital and urgent need for an effective risk analysis study that can help to identify and analyze OGP risk factors in a more effective way.

This study, therefore, aims to provide a thorough review about the risk factors applicable to OGPs in countries where these projects are suffering severe consequences from terrorist attacks and sabotage in addition to other risk factors. The main objective is to identify and analyze the risk factors specific to Iraq. In doing so, it will address the current shortage of data and provide relevant information for OGP risk management studies, such as a list of risk factors and the degree to which they influence pipelines. This paper will actively contribute to the field of OGP risk management in Iraq and other countries that are suffering the same kinds of risks, through the provision of real data about pipeline failure based on OGPs stakeholders' perceptions that reflect the reality of the problem. Moreover, the evaluation of the impact of each risk is a fundamental step for any risk management study.

Moving forwards, this paper has been organized as follows. The methodology, risk factors identification, data collection and questionnaire development are described in section 2. Section 3 presents the results, section 4 the discussion and section 5 the conclusion moreover, the evaluation of the impact of each on and suggestions for future research.

2. Methodology

A pragmatist paradigm is adopted to obtain meaningful results from both the qualitative and quantitative approaches used in this research. The methodology that has been followed in this research is based on a holistic framework of a Risk Management Model (RMM), which has three phases as illustrated in Fig. 1. Phase I is about identifying OGP risk factors through an available database or through a review of the previous literature, if there is no database available. This phase could help researchers overcome the problems caused by the shortage of available data. The findings from Phase I will be presented in Table 1. Phase II is about risk analysis and data gathering. In this phase, a questionnaire survey will be designed and distributed amongst OGPs stakeholders in Iraq to collect their perceptions about the probability and severity levels of OGPs risk factors. To determine the numerical values of Risk Probability (RP) and Risk Seventy (RS) descriptive statistical analyses are applied to the survey. Phase II results will be presented in Table 3. Finally, phase III is about simulating risk factors using a mathematical algorithm and computer-based model based on the findings from phases I and II. The developed RMM will allow a comprehensive and systematic approach to OGP risk identification and evaluation, specifically for governments or organizations at the beginning of their management efforts in terms of risk factor identification, data registration and systematic risk management. In this research, moreover, a new database will be created to store the findings and recommendations from this research to be used for future research.

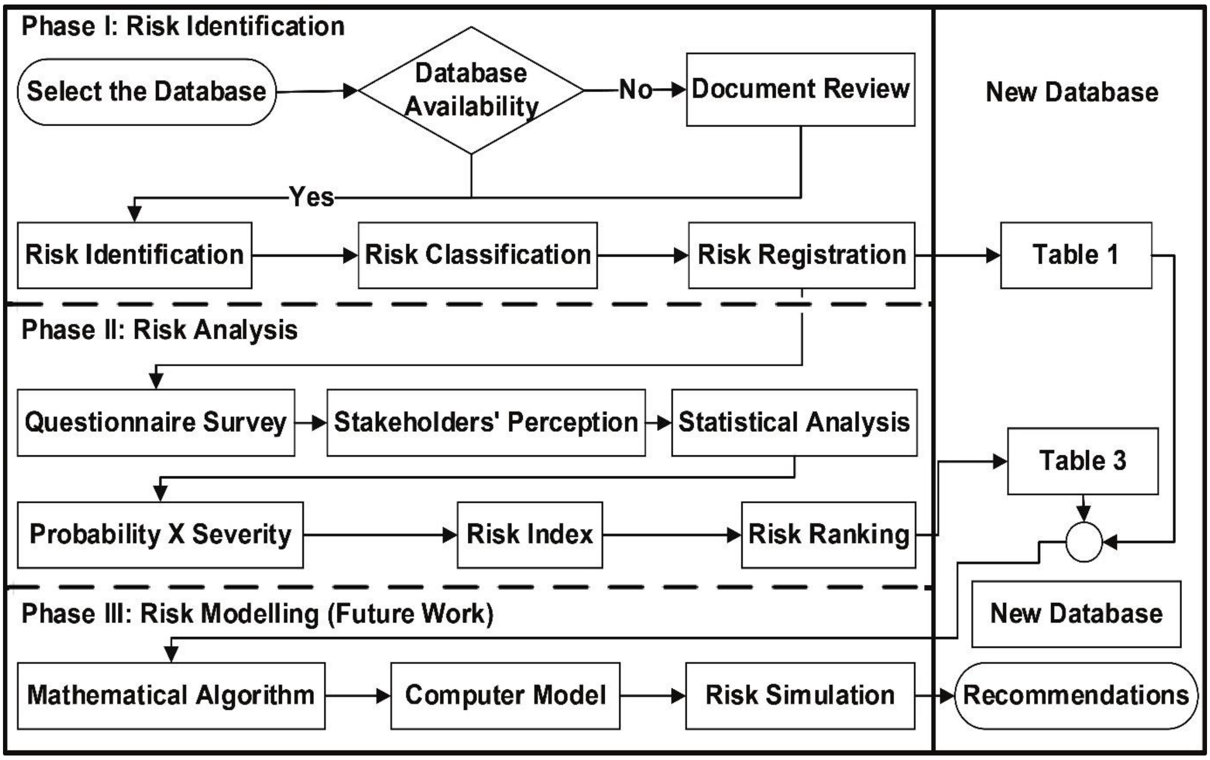

Figure 1: The Framework of the RMM.

Following the design of the RMM, section 2.1 details the process for phase I, sections 2.2 to 3.3 the process for phase II, and section 5 explains future work (phase III).

2.1. Risk factor identification

In Iraq, and other developing countries under similar situations, OGP risk management is hampered by a shortage of data. To overcome this problem, a comprehensive document analysis has been carried out here to identify the common causes of pipeline failure in different countries, and under different circumstances, around the world. Pipeline risk factors at the planning, design, construction, operation and maintenance stages have been identified, classified by type and listed in Table 1.

Table 1: Critical OGP risk factors from the reviewed literature.

Risk Factors	Author	Risk Type
Socio-political factors such as education level and poverty	[2,9,15-17]	Security and societal (S&S)
Low levels of the general publics' legal and moral awareness	[4,18]	S&S
Thieves	[16,17]	S&S
Terrorism and sabotage	[9,15-17,18-20]	S&S
Threats to staff (kidnap and/or murder)	[21]	S&S
Leakage of sensitive information	[6,22]	S&S
Geographical location like 'Hot-Zones'	[6]	Pipeline location (PL)
Conflict over land ownership	[23,24]	PL
Accessibility of pipelines	[6]	PL
Geological risks like soil movement and landslides	[2,15,25]	PL
Vehicle accidents	[4]	PL
Animal accidents	[15,21]	PL
Lack of compliance with the safety regulations	[2, 16]	Health & safety and environment (HSE)
Non-availability of warning signs	[2,26]	HSE
Lack of proper maintenance and regular inspection	[2,9,5,11,16,20]	HSE
The opportunity to sabotage exposed pipelines	[21]	HSE
Inadequate risk management methods	[5,16]	HSE
Natural disasters and weather conditions	[9,15-17]	HSE
Weak ability to identify and monitor the risk factors	[16]	Operational constraints (OC)
Shortage of high-quality and modern IT services	[15,16]	OC
Corrosion and lack of anti-corrosive action	[2,6,11,16,19, 20,25]	OC
Design, construction, material and manufacturing defects	[2,11,19,20,25,27]	OC
Operational errors e.g. human error and equipment failure	[2,5,11,15,16,19,20]	OC
Hacker attacks on the operating or control systems	[6]	OC

The law not applying to saboteurs (lawlessness)	[4,15]	Rules and regulations (R&R)
Stakeholders are not paying proper attention	[16]	R&R
Few researchers are dealing with this problem	[16]	R&R
Lack of historical records about accidents and risk registration	[5,16]	R&R
Lack of proper training schemes	[5,16]	R&R
Corruption	[16]	R&R

30 risk factors have been identified and classified into five types as follows: (i) Security and societal. This type of risk includes terrorism and sabotage; thieves; public, legal and moral awareness; socio-political dimensions such as education level and poverty; threats to staff, and leakage of sensitive information about risks. (ii) Pipeline location. This includes risk factors like "Hot-Zones"; easy access to pipelines; conflict over land ownership; geological risks such as groundwater and landslides, and vehicle and animal accidents. (iii) Health & Safety and Environment (HSE). This incorporates improper safety regulations; improper inspection and maintenance; sabotage opportunities due to pipelines that are exposed as laid above ground; limited warning signs; inadequate risk management, and natural disasters and weather conditions, and (iv) Operational constraints. This includes corrosion and a lack of protection against it; the weakened ability to identify and monitor threats; a shortage of IT services and modern equipment; design, construction and material defects; operational errors, and hacker attacks on the operating or control systems. (v) Rules and regulations covering corruption; laws which do not apply to saboteurs and thieves; a lack of attention paid to circumstances by stakeholders; a lack of proper training; a lack of historical and risk registration, and a paucity of research addressing these problems.

2.2. Data collection and questionnaire development

Risk factors are characteristically vague, random and uncertain often accommodating a more personal style of thinking, processing capability and cognition [2]. For these reasons, stakeholders' perceptions and observations are both valuable and vital when identifying the problems associated with OGPs and to evaluate risk factors. Stakeholders' perceptions are based on their actual experience and knowledge about OGPs, making them well qualified to monitor existing pipeline risks. Therefore, a quantitative industrial survey has been carried out with stakeholders to analyze the probability and severity of risk factors in Iraq.

An online questionnaire survey was used in this research because it is one of the most widely-used methods of additional data collection, are easy to manage, quick and inexpensive [28]. The survey targets participants who have relevant experience with OGP projects such as consultants, planners and designers; construction, operating and maintenance workers; administrators; owners and clients, and researchers. There are however, some disadvantages/limitations associated with online services that could result in a low response rate such as a lack of accessibility to the internet, issues regarding computer literacy, web security and anonymity and knowledge about the website [29]. That said, authors like Bertot [30] and Czaja and Blair [29] have concluded that this kind of survey is the easiest form of data collection as real cooperation is provided via open-ended questions.

Before carrying out the main survey, a pilot survey was conducted to assess the clarity of the survey and all questions which were found to be vague were revised or discarded. The revised survey was distributed via an online survey tool to OGP stakeholders in Iraq. To ensure a widespread distribution of the survey, the snowball sampling technique was applied [31,32] whereby the survey was initially distributed to a number of previously identified participants who were also asked to forward it to others until the required number of responses is reached [31]. This technique can help to collect data from a large number of participants. Participants were promised that their answers will be analyzed with confidentiality and anonymity.

The survey includes 12 questions comprising 95 items in total. Questions 1 to 6 are discussed in this paper. Questions 7 to 12 are related to the future risk modelling work and simulation therefore, they are not included here. Questions 1, 2 and 3 concern the participant's occupation, experience and level of education in relation to OGP projects. Questions 4 and 5 are multi-choice, five-point Likert rating scales. Question 4 asks respondents to evaluate risk factors in order of probability of occurrence on a scale of 1 to 5 where (1) = rare, (2) = unlikely, (3) = possible, (4) = likely and (5) = almost certain. Question 5 asks participants to evaluate risk factors in order of severity on a similar scale where (1) = negligible, (2) = minor, (3) = moderate, (4) = major and (5) = catastrophic. Question 6 is a drop-down question to compare the five types of risk factors by ranking these types from 1 to 5 regarding their impact and consequences on OGPs.

3. Results

3.1. Reliability and Validity

To assess the questionnaire's reliability, Cronbach's alpha correlation coefficient (α) has been calculated to measure the reliability and average correlation, or internal consistency, of survey items [31, 33, and 34]. Different levels of reliability are required depending on the purpose and nature of the study. Pallant [35] recommends an alpha value of 0.7 as a minimum level of reliability.

The α values are shown in Table 2 where it can be seen that all α values are well above the acceptable value of 0,7. In this paper, reliability testing was carried out for questions 4 and 5 as these were rated on a Likert rating scale. Regarding individual questions, reliability testing is not applicable, as question 1, 2 and 3 are asking about demographic information and question 6 is asking about participants' personal opinions about ranking risk factors types where no scale is applicable.

Table 2: α case processing summary.

Case Processing Summary	Total (N)	Number of items	Valid		Excluded *		α
			N	%	N	%	
Question No. 4	194	30	194	100	194	0	0,918
Question No. 5	194	30	194	100	194	0	0,863

* List wise deletion based on all variables in the procedure [36].

3.2. Sample demographics

194 responders completed the questionnaire. As shown in Fig. 2, a wide range of OGP stakeholders are represented in the sample.

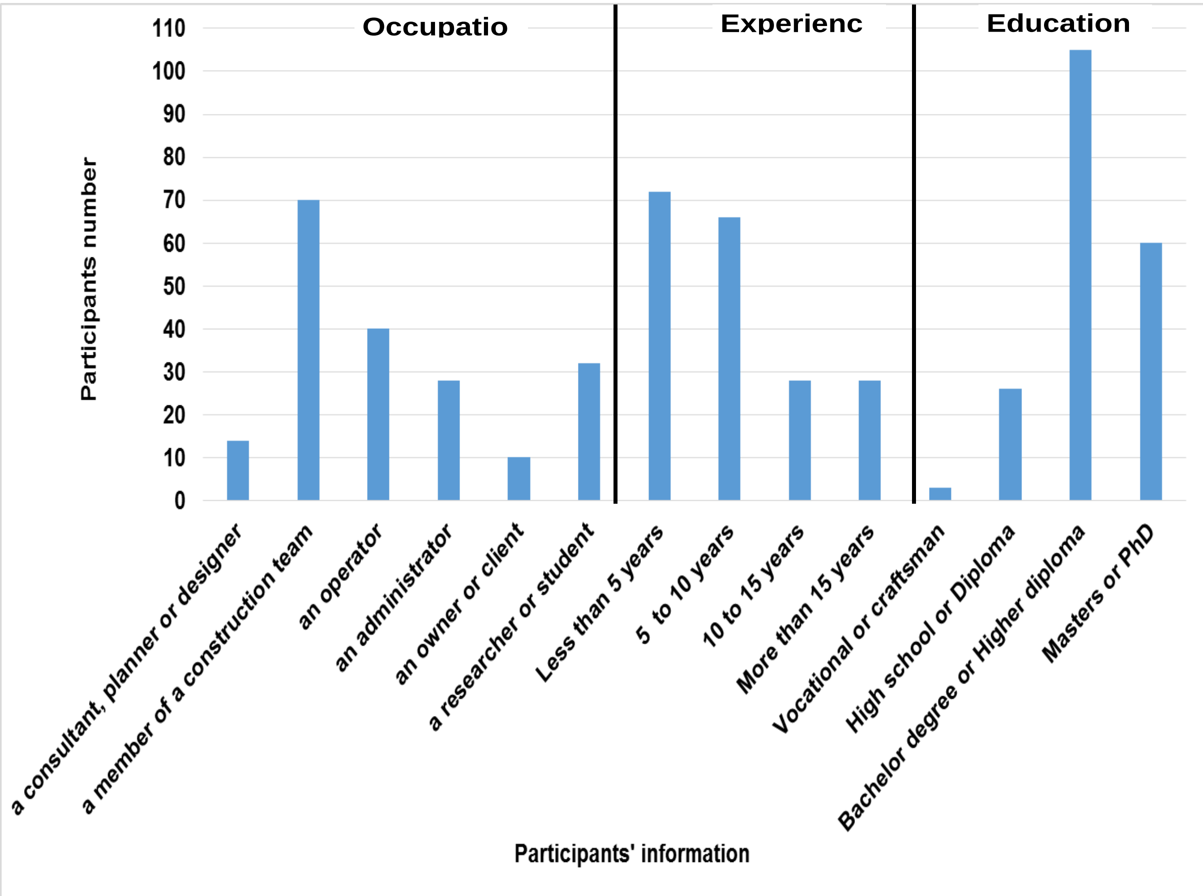

Figure 2: Participants' demographic information

Where * means occupation, ** means experience and *** means level of education.

RP and RS values have been calculated by determining the mean of the 5-point Likert rating scales. The RI value for each risk factor has been calculated using Eq. (1) [37-39].

$$RI = (RP \times RS)/5 \quad \dots (1)$$

Based on the statistical analysis of survey, the risk factors have been ranked according to their values of RI as presented in Table 3.

In Table 3, column 2 shows the probability of the risk factors and column 3 ranks the factors by their degree of probability. Column 4 shows the severity of the risk factors and column 5 ranks the factors by their degree of severity. Column 6 shows the RI values for each risk factors. Regarding the rank of the risk factors, there are two columns of risk ranking, column 7 shows the overall ranking of risk factors and column 8 shows per type risk factors ranking. The ranking for each of the five types of risk factors is as follows: (I) Regarding S & S risk factors, the survey results revealed that terrorism and sabotage actions are the most critical risk factors.

This is followed by theft; reduced legal and moral awareness by the public; threats to staff, socio-political factors such as education level and poverty, and leakage of sensitive information. (II) Regarding pipeline location risk factors, hot-zones are the riskiest, while animal accidents factor the lowest. The 2nd, 3rd, 4th and 5th factors are pipeline is easy to access, conflict over land ownership, geological risk and vehicle accidents, respectively. (III) HSE risk factors are ranked as follows: improper safety regulations; inadequate maintenance and inspection; pipelines above the ground and exposed; limited warning signs; the weak nature of risk management, and natural disaster and weather conditions. (IV) Corrosion is the major operational issue facing pipelines. This is followed by an inadequate ability to identify and monitor risk factors; limited availability of IT; design, construction and material defects, and operational constraints. Problems caused by hacker attacks on operating or control systems have the least impact on pipeline systems in Iraq. (V) From R & R risks, corruption has the highest impact, the remaining rules and regulations factors ranked as the law does not apply to saboteurs and thieves; stakeholders are not paying proper attention; a lack of proper training; the lack of an accident database and historical records, and little research on this subject.

Table 3: Risks factor probability, severity, index and ranking.

Risk Factors	RP	R1 *	RS	R2 *	RI	R3 *	R4 *
Terrorism and sabotage	3,985	1	4,485	1	3,574	1	S&S 1
Corruption	3,959	2	4,309	2	3,412	2	R&R 1
Geographical location e.g. "Hot-Zones"	3,696	4	4,093	4	3,025	3	PL 1
The law does not apply on the saboteurs and thieves	3,593	16	4,191	3	3,011	4	R&R 2
Thieves	3,680	6	4,067	5	2,994	5	S&S 2
Corrosion and lack of protection against it	3,691	5	3,979	6	2,937	6	OC 1
Improper safety regulations	3,675	7	3,938	8	2,895	7	HSE 1
Improper inspection and maintenance	3,649	10	3,923	9	2,863	8	HSE 2
Low public legal and moral awareness	3,711	3	3,840	11	2,850	9	S&S 3
Weak ability to identify and monitor the threats	3,624	12	3,876	10	2,809	10	OC 2

Stakeholders are not paying proper attention	3,521	18	3,943	7	2,777	11	R&R 3
Lack of proper training	3,629	11	3,753	13	2,724	12	R&R 4
The opportunity to sabotage exposed pipelines	3,655	9	3,665	16	2,679	13	HSE 3
Shortage of IT services and modern equipment	3,660	8	3,634	19	2,660	14	OC 3
Limited warning signs	3,624	13	3,665	17	2,656	15	HSE 4
The pipeline is easy to access	3,608	15	3,639	18	2,626	16	PL 2
Lack of historical and risk registration	3,552	17	3,696	15	2,625	17	R&R 5
Little research on this topic	3,624	14	3,577	22	2,593	18	R&R 6
Design, construction and material defects	3,320	21	3,830	12	2,543	19	OC 4
Conflict over land ownership	3,474	19	3,598	20	2,500	20	PL 3
Threats to staff	3,309	22	3,727	14	2,467	21	S&S 4
Socio-political effects such as poverty and level of education	3,428	20	3,397	24	2,329	22	S&S 5
Operational errors	3,072	24	3,588	21	2,204	23	OC 5
Inadequate risk management	3,206	23	3,387	25	2,172	24	HSE 5
Leakage of sensitive information	2,964	25	3,485	23	2,066	25	S&S 6
Geological risks such as groundwater and landslides	2,732	26	3,175	26	1,735	26	PL 4
Natural disasters and weather conditions	2,639	27	3,057	27	1,613	27	HSE 6
Vehicles accidents	2,443	28	2,706	29	1,322	28	PL 5
Hacker attacks on the operating or control systems	2,227	29	2,948	28	1,313	29	OC 6
Animals accidents	1,892	30	2,026	30	0,766	30	PL 6

*Where R1 = RP ranking, R2 = RS ranking, R3 = RI ranking and R4 = ranking per type.

According to the survey results, the five types of risk factors have been ranked as follows. Security and social type is the most critical risk factor, followed by pipe location; HSE; rules and regulations and operational constraints, as presented in Table 4, where rank 1 represents the highest impact and 5 the lowest impact amongst risk factors types.

Table 4: The ranking of risk factors types.

Risk factors type	Mean	Rank
Security and societal factors	2,155	1
Pipe location factors	2,634	2
HSE factors	3,134	3
Rules and regulations factors	3,536	4
Operational constraints	3,541	5

4. Discussion

Iraq has an extensive pipeline network used to transport oil products for local consumption and for exports through ports and neighboring countries. To handle increases in oil production and exports, a substantial number of new pipelines have to be built, both inside and outside of Iraq. As well as, much of the existing pipelines are in need of repair and expansion [40]. At the same time, there is an urgent need for the country to overcome the many formidable challenges and risk factors that work to obstruct pipeline performance and the development of new projects [40, 41]. A risk index that identifies risk factors and evaluates the probability and severity of each risk is fundamental for risk management. Understanding and evaluating OGP risk factors will help stakeholders, decision makers, policymakers and researchers to adopt a sustainable risk management strategy during the different stages of pipeline projects.

The holistic RMM framework developed here aims to support the identification, analyses and ranking of OGP risk factors more comprehensively and systematically. As such, this paper is based on an extensive literature review which serves as its foundation providing a comprehensive overview about OGP risk factors especially those in insecure environments. OGPs risk factors have been analyzed and ranked based on the real observations of the stakeholders. The RMM developed here provides a holistic and systematic approach to risk management. It also provides a new database that supplies the data essential for risk management processes, such as a potential list of risk factors and the probability and severity of these factors. This paper’s findings and recommendations are suitable and applicable for OGPs in Iraq and many other countries under similar situations. OGP stakeholders could use this paper's findings, specifically Tables 1 and 3 and Fig. 1, to improve risk management during the pipeline projects' stages.

The questionnaire results were found to be reliable as all α values are above 0,7, as shown in Table 2. The demographic information about the 194 responders reflects the diversity of the sample, as shown in Fig. 2. This level of diversity means the questionnaire has reached the target population as all categories of stakeholder are represented. Correct sampling facilitates more realistic risk identification and enhances the results of the evaluation. The top risk factors in Table 3 indicate that terrorism and acts of theft are the first and fifth most pressing factors. Corruption is the second top risk factor, followed by geographical location e.g. "Hot-Zones" and law as not applicable to saboteurs and thieves, all of which are obstructing pipeline projects. Table 4 reveals that Iraqi OGP stakeholders are most concerned with security and societal risk factors, the geographical location of pipelines and HSE factors. To establish an effective OGP risk management approach in Iraq, stakeholders' perceptions are crucial to help identify and analyze OGP problems because they are based on real experience of pipeline projects and existing problems in the field. For these reasons, both the literature findings and survey results will provide a clearer understanding of OGP risk factors.

5. Conclusion

Risk management is a continuous process of risk identification, analysis, evaluation and risk response actions. Based on an extensive literature review, a list of thirty risk factors relevant to OGPs, were identified and used to design a questionnaire and conduct an industry-wide survey. A total of 194 participants were recruited using a snowball approach, the risk factors ranked based on RP, RS and RI values. The results indicated that the risk factors with the highest impact are terrorism and sabotage, corruption, "Hot-Zones", lawlessness regarding saboteurs, and thieves. Geological risks, natural disasters and weather conditions, hacker attacks on operating and/or control systems, and vehicle and animal accidents are the risk factors with the least impact. The results of the statistical analysis show that the TPD is mostly responsible for OGP failure in Iraq. It is concluded that TPD should be given priority in order to mitigate and limit damage to OGPs in Iraq.

The findings support OGP risk management systems specifically in developing and unstable countries like Iraq. OGP stakeholders could use the results provided in Tables 1, 3 and 4, as a database to overcome the problem of data availability, using the research as a risk evaluation tool for monitoring and prioritizing risks during design, re-design, construction, operation, inspection and maintenance activities.

Looking to the future, this paper presents the initial findings of a PhD research which mainly focuses on identifying and analyzing the risks associated with OGPs and to present the initial framework for an RMM. These findings will be used to develop a computer based risk management model in the next stage of study, where the numerical results will be used as key input for the model.

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References

[1] M. El-Abbasy, A. Senouci, T. Zayed, F. Mosleh. A condition assessment model for oil and gas pipelines using integrated simulation and analytic network process. Structure and Infrastructure Engineering. Vol. 11, No. 3, pp. 263–281. 2015

[2] Y. Guo, X. Meng, D. Wang, T. Meng, S. Liu, R. He. Comprehensive risk evaluation of long-distance oil and gas transportation pipelines using a fuzzy Petri net model. Journal of Natural Gas Science and Engineering. Vol. 33, issue Jul 31, pp. 18-29. 2016.

[3] W. Muhlbauer. Pipeline Risk Management Manual: Ideas, Techniques, and Resources. Gulf Professional Publishing: Elsvier Inc. Burlington, MA 01803, USA. ISBN 0-7506-7579-9. 2004.

[4] X. Peng, D. Yao, G. Liang, J. Yu, S. He. Overall reliability analysis on oil/gas pipeline under typical third-party actions based on fragility theory. Journal of Natural Gas Science and Engineering. Vol. 34, issue Aug 31, pp. 993-1003. 2016.

[5] N. Balfe, M. Chiara Leva, B. McAleer, M. Rocke. Safety Risk Registers: Challenges and Guidance. Chemical Engineering Transactions. Vol. 36, pp. 571-576. 2014. DOI: 10.3303/CET1436096.

[6] A. Srivastava, J. Gupta. New methodologies for security risk assessment of oil and gas industry. Process Safety and Environmental Protection. Vol. 88, issue 6, pp. 407-412. 2014.

[7] C. Fang, F. Marle. A simulation-based risk network model for decision support in project risk management. Decision Support Systems. Vol. 52, issue 3, pp. 635-644. 2012.

[8] L. Labaka, J. Hernantes, J. Sarriegi. A holistic framework for building critical infrastructure resilience. Technological Forecasting and Social Change. Vol. 103, issue Feb 29, pp. 21-33. 2016.

[9] B. Anifowose, D. Lawler, D. Horst, L. Chapman. Attacks on oil transport pipelines in Nigeria: A quantitative exploration and possible explanation of observed patterns. Applied Geography. Vol. 32, issue Mar 31, pp. 636-651. 2016.

[10] K. Filippina, L. Dreher. Major Hazard Risk Assessment for Existing and New Facilities. American Institute of Chemical Engineers. Vol. 23, No. 4, pp. 237 - 243. 2004.

[11] T. Whipple, R. Pitblado. Applied risk-based process safety: A consolidated risk register and focus on risk communication. Journal of American Institute for Chemical Engineers, Process Safety Progress, Vol. 29, No. 1, pp. 39-46. 2009.

[12] X. Zhao, N. Singhaputtangkul. Effects of Firm Characteristics on Enterprise Risk Management: Case Study of Chinese Construction Firms Operating in Singapore. Journal of Management in Engineering. Vol. 32, issue 4, pp. 05016008-1 to 9. 2016.

[13] N. Khakzad, F. Khan, P. Amyotte. Safety analysis in process facilities: Comparison of fault tree and Bayesian network approaches. Reliability Engineering & System Safety. Vol. 96, issue 8, pp. 925-932. 2011.

[14] D. Ge, M. Lin, Y. Yang, R. Zhang, Q. Chou. Reliability analysis of complex dynamic fault trees based on an adapted K.D. Heidtmann algorithm. SAGE Journals, Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability. Vol. 229, issue 6 pp. 576-586. 2015.

[15] S. Mubin, G. Mubin. Risk analysis for construction and operation of gas pipeline projects in Pakistan. Pak. J. Engg. & Appl. Sci. Vol. 2, issue Jan, pp. 22-37. 2008.

[16] U. Nnadi, Z. El-Hassan, D. Smyth, J. Mooney. Lack of proper safety management systems in Nigeria oil and gas pipelines. IChemE Institution of Chemical Engineers. Vol. 2, issue 237, pp. 27-34. 2014.

[17] F. Onuoha. Oil pipeline sabotage in Nigeria: Dimensions, actors and implications for national security. African Security Review. Vol. 17, issue 3, pp. 99-115. 2008.

[18] H. Li, R. Sun, W. J. Lee, K. Dong, R. Guo. Assessing Risk in Chinese Shale Gas Investments Abroad: Modelling and Policy Recommendations. Sustainability MDPI. Vol. 8, issue 8, pp. 1-17. 2016.

[19] A. Dawotola, P. Gelder, J. Vrijling. Multi Criteria Decision Analysis framework for risk management of oil and gas pipelines. Reliability, Risk and Safety – Ale, Papazoglou & Zio (eds). Taylor & Francis Group, London, ISBN 978-0-415-60427-7. pp. 307-314. 2010.

[20] L. Lu, W. Liang, L. Zhang, H. Zhang, Z. Lu, J. Shan. A comprehensive risk evaluation method for natural gas pipelines by combining a risk matrix with a bow-tie model. Journal of Natural Gas Science and Engineering. Vol. 25, issue Jul 31, pp. 124-133. 2015.

[21] A. Rowland. GIS-based prediction of pipeline third-party interference using hybrid multivariate statistical analysis. PhD thesis. School of Marine Science and Technology. Newcastle University. Newcastle, England, UK. 2011.

[22] W. Wu, C. Yang, J. Chang, P. Château, Y. Chang. Risk assessment by integrating interpretive structural modeling and Bayesian network, case of offshore pipeline project. Reliability Engineering & System Safety. Vol. 142, pp. 515-524. 2015.

[23] K. Macdonald, A. Cosham. Best practice for the assessment of defects in pipelines – gouges and dents. Engineering Failure Analysis. Vol. 12, pp. 720-745. 2005.

[24] J. Mather, C. Blackmore, A. Petrie, C. Treves. An Assessment of Measures in Use for Gas Pipelines to Mitigate Against Damage Caused by Third Party Activity. Contract Research Report 372/2001. WS Atkins Consultants for the Health and Safety Executive, Birchwood, Warrington, WA3 7WA, UK. ISBN 0 7176 2113 8. 2001.

[25] S. Akel, F. Riegert. Third-party interference pipeline survey based on risk assessment. Journal of Pipeline Engineering. Third-party interference pipeline survey based on risk assessment Vol. 10, pp. 231-236. 2011.

[26] G. Kabir, R. Sadiq, S. Tesfamariam. A fuzzy Bayesian belief network for safety assessment of oil and gas pipelines. Structure and Infrastructure Engineering. Vol. 12, No. 8, pp. 874-889. 2015.

[27] N. Sulaiman, H. Tan. Third party damages of offshore pipeline. Journal of Energy Challenges and Mechanics. Vol. 1, issue 1, pp. 14-19. 2014.

[28] S. Dolnicar, C. Laesser, K. Matus. Online versus paper: format effects in tourism surveys. Journal of Travel Research. Vol. 47, issue 3, pp. 295-316. 2009.

[29] J. Blair, R. Czaja. J. Blair. Designing surveys: A guide to decisions and procedures, Pine Forge Press. SAGE. London. ISBN 978-1-4129-9734-8. 2013.

[30] J. C. Bertot. Web-Based Surveys: Not Your Basic Survey Anymore. The University of Chicago Press Journal. Vol. 79, No. 1, pp. 119-124. 2009.

[31] R. Ameen, M. Mourshed. Environmental, Social and Economic Challenges for Urban Development: Stakeholder's Perception in a Developing Economy. Proceedings of the sixteenth of International Conference on Computing in Civil and Building Engineering. Osaka, Japan. 2016.

[32] I. M. Dragan, A. Isaic-Maniu. Snowball sampling completion. Journal of Studies in Social Sciences. Vol. 5, No. 2, pp.160-177. 2013.

[33] L. Cronbach. Coefficient alpha and the internal structure of tests. Psychometrika, Springer Link. Vol. 16, issue, 3, pp. 279-334. 1951.

[34] N. Webb, R. Shavelson, and E. Haertel. Reliability Coefficients and Generalizability Theory. In: Rao, C.R. & Sinharay, S. (eds.) Handbook of Statistics, North Holland: Elsevier. Vol. 26, pp. 81-124. 2006.

[35] J. Pallant. SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS. Allen & Unwin Pty Limited, Crow's Nest, NSW, Australia, 2005.

[36] IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

[37] R. Hill, Pipeline risk analysis. Institution of Chemical Engineers Symposium Series No. 130. Hemisphere Publishing Corporation, Manchester, England. Pp. 657-670. 1993.

[38] E. Sa'idi, B. Anvaripour, F. Jaderi, N. Nabhani. Fuzzy risk modeling of process operations in the oil and gas refineries. Journal of Loss Prevention in the Process Industries. Vol. 30, pp. 63-73. 2014.

[39] A. Yazdani-Chamzini. Proposing a new methodology based on fuzzy logic for tunneling risk assessment. Journal of Civil Engineering and Management. Vol. 20, issue 1, pp. 82-94. 2014.

[40] A. JAFFE and James A. Baker, Institute for Public Policy. Iraq's Oil Sector: Past, Present and Future. Japan Petroleum Energy Center, 2007. Available at http://large.stanford.edu/publications/power/references/baker/studies/noc/docs/NOC_Iraq_Jaffe.pdf

[41] N. Moosa. Director General of State Company for Oil Projects SCOP, Ministry of Oil, Iraq. Blueprint for Iraqi Oil & Gas Infrastructure Development and Plans for Pipeline network and storage in Oil Industry Ministry of Oil. The 31st JCCP International Symposium, January 30-31, 2013. Available online at https://www.jccp.or.jp/english/international/conference/cat290/2013/.