Analysing the Critical Risk Factors of Oil and Gas Pipeline Projects in Iraq

***Kraidi, L.,* [1, 2] *Shah, R.,* [1] *Matipa, W.* [1] *and Borthwick, F.* [1]**

1 Department of the Built Environment, Faculty of Engineering and Technology, Liverpool John Moores University, Byrom Street Campus, Liverpool, L3 3AF

l.a.kraidi@2016.ljmu.ac.uk

2 Layth Ahmed Kahdm Kraidi, College of Engineering, Almuthanna University, Almuthanna, Iraq.

ABSTRACT

Purpose- Oil and Gas Pipelines (OGPs) are the safest mode of transportation for petroleum products. Yet, OGPs are facing a massive range of safety, design and operational risks such as sabotage, design defects, corrosion, material ageing, poor quality, misuse and geological disasters. These risks have resulted in OGP project management becoming more challenging and complex, particularly in developing countries with poor security systems. Additionally, there are two significant problems associated with OGP projects in these countries. The first is the different characteristics of risk factors, and the second is the real shortage of historical data required for any risk evaluation study. These problems mean that the currently accessible risk evolution methods cannot evaluate OGPs risk factors accurately. This paper aims to provide a proper understanding of the characteristics of OGPs risk factors in these countries. It also aims to identify the critical risk factors and their degree of probability and severity in pipeline projects, to avoid the loss of life and increased costs that result from risks to safety.

Methodology- A quantitative research approach is adopted in this paper. Additionally, an industry survey was conducted by using a semi-structured questionnaire. The questionnaire was distributed online amongst the people who are associated with OGP projects in Iraq. SPSS 23 was used to analyse a total of 180 successful questionnaire responses. The survey findings in terms of critical risk factors and their ranking in order of risk index of severity and probability are presented in tables and graphs.

Findings- A total of 30 risk factors associated with OGP projects have been identified as critical risk factors and ranked them into a scale of probability and severity index. Third-party disruption (such as terrorism, theft and sabotage) was found to be the most critical safety risk factor whereas the failure form pipe corrosion was ranked the top most operational risk.

Implications- The list of OPG critical safety and operational risk factors provides the first-stage findings. These findings will be implemented to develop a conceptual framework and a computer-based model for OGPs risk management system at the next stage of the research.

Keywords: *Oil and gas pipelines; risk factors; probability; severity; risk management; safety risk; operational risks and terrorism and sabotage.*

1. Introduction

Oil and gas pipelines (OGPs) are some of the most important and significant critical infrastructures for any country because they are the safest and most economical mode of transportation for petroleum products. However, the number of accidents and the vast range of problems associated with them have severe consequences for the pipelines (Cunha, 2016). Compared to safe countries, pipeline disruption is a cause for concern in developing countries with low levels of security because of internal wars and terrorist organisations. This hazardous environment often results in malicious terrorist attacks on OGPs and makes their risk management more challenging and complex. The main risk factors for a long-distance OGPs include the following four factors: third-party disruption (TPD), misuse, corrosion damage and design flaws (Guo *et al*., 2016). The term 'third-party role' refers to pipelines being accidentally damaged by employees, natural phenomena such as soil movement (landslides, mudslides, foundation collapse and floods), and surface load (caused by blasting construction, illegal buildings compressing pipelines and ground live loads) (Peng *et al*., 2016). Similarly, Muhlbauer (2004) has defined TPD as any direct or indirect action against the infrastructure that is taken individually or by a group in order to obstruct the functionality of the infrastructures system. In this study, TPD refers to all individuals, organisations and mechanical tools that cause expected and/or accidental damage to the pipelines during different project stages. Consequently, proper attention needs to be given to pipeline disruption problems, because neglecting this critical issue has resulted in the disruption of business activity, grave casualties, the expenditure of time and efforts, and economic losses in the oil and gas industry.

Preventing or preparing for something unexpected is almost impossible since nobody knows when or how a crisis will occur, or what will be affected by it (Labaka *et al.*, 2016). Pipeline failures cannot be entirely avoided. Nevertheless, an appropriate and accurate risk evaluation method can contribute in providing reasonable and effectual risk management measures to reduce the overall risk of failure (Guo *et al.*, 2016). For that reason, adequate facilities like 'risk registration' and 'risk assessment' are essential for the risk factor analysis procedure (Whipple and Pitblado, 2009). Evidently, historical records are a valuable information source for risk management studies (Ruijsscher, 2016). Unfortunately, the above-mentioned necessary facilities and databases are not available in developing countries, especially troubled ones, which is making it more challenging and demanding to obtain accurate risk evaluation methods for OGPs risk evaluation.

Rest of the paper is organised as follows. Problem statement, objective of the paper, literature review, methodology with questionnaire survey, results, discussion of survey results followed by conclusion and discussion.

2. PROBLEM STATEMENT

Dealing with OGPs risk factors as the most severe risks is resulting in a great deal of wasteful expenditure and effort (Srivastava and Gupta, 2010). In addition, risk analysis requires a proper knowledge-base and database (Prochazkova, 2010) and real-time data (Balfe *et al.*, 2014) which can provide a verified level of input in the successful development of a risk registry. Risk registers should contain all analysed risks in order to prioritise the areas that require managerial attention and present the risk management profile (Filippina and Dreherb, 2004; Whipple and Pitblado, 2009). Although accurate failure probability and severity values are required, these values are still imprecise, deficient and vague (Khakzad *et al.*, 2011). The probability of TPD risk factors and the similar failure model cannot be calculated by using currently available analytical methods because the historical failure data have not been established yet (Peng *et al*., 2016; Ge *et al*., 2015). Unfortunately, authentic OGPs risk evaluation studies are unachievable as long as the (1) knowledge, (2) essential data, (3) real-time inputs, (4) factor identification facilities and (5) factor probabilities evaluation are not at the required level. These five critical problems are associated with OGP projects in developing and troubled countries and are obstructing risk analysis efforts. Therefore, there is a vital and urgent need for beneficial OGPs risk analytical studies and risk management tools that can identify and rank the OGPs risk factors and contribute to solving these five diagnosed problems.

3. OBJECTIVE OF THE PAPER

This article aims to identify OGPs critical risk factors in countries where pipeline projects are suffering severe consequences from terrorism and sabotage attacks in addition to other risk factors. It also aims to provide a good understating about the characteristics of risk in these countries, and to rank the factors in order of their probability and the severity of their effect on the pipeline. Furthermore, the intention is to provide real input data and to overcome the problem of the shortage of available data. This paper will prepare a table that shows the risk factors and their probability, severity, index and ranking. A risk table that identifies the risk factors and deals with the individual impact of each risk is the first and most fundamental step for any risk evaluation and assessment procedure. This table could help decision-makers, policy-makers and researchers to understand the nature of OGPs risk management in hazardous environments and circumstances. A proper understanding of risk factors can contribute to the adoption of a sustainable risk management strategy during the different stages of OGP projects. Most importantly, accurate results of numerical risk analysis will provide a basis for designing a computer-based model that could be implemented to reduce OGPs risk management challenges and complexity. Iraq is one of a number of troubled, developing countries, and it is the case study in this paper. As this is the first study in the country, it will strongly contribute to the OGP project risk management field in Iraq and in other countries that are in a similar situation.

4. Literature Review

Data about pipeline failures during the project's planning, design, construction, operation and maintenance stages have been examined from different countries around the world in order to identify the critical risk factors associated with OGP projects. This comprehensive data review has been carried out to ensure that the risk factors involved in this research will provide valuable knowledge about OGPs risks in various environments and circumstances. It will also make the research's results suitable for and applicable to many countries and will overcome the crucial problem of the shortage of available data and historical records in developing countries like Iraq. As a summary, Table 1 addresses the most common OGPs risk factors worldwide. This table will be used later on in the research to analyse the risk factors' probability and severity through a quantitative research approach and a questionnaire.

Table 1: Critical risk factors from reviewed articles

Risk Factors	**Author**
Public's low legal and moral awareness	Li *et al.* (2016) and Peng *et al.* (2016).
Socio-political factors such as poverty and education level	Nnadi *et al.* (2014), Mubin and Mubin, (2008), Guo *et al.* (2016), Anifowose *et al.* (2012) and Onuoha, (2008).
Thieves	Nnadi *et al.* (2014) and Onuoha, (2008).
Terrorism and sabotage	Nnadi *et al.* (2014), Mubin and Mubin, (2008), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.* (2015), Anifowose *et al.* (2012) and Onuoha, (2008).
Threats to staff (kidnap and/or murder)	Rowland (2011).
Leakage of sensitive information	Srivastava and Gupta (2010) and Wu *et al.* (2015).
Geographical location like 'Hot-Zones'	Srivastava and Gupta (2010).
Conflicts over land ownership	Mather *et al.* (2001) and Macdonald and Cosham (2005).
Accessibility of pipelines	Srivastava and Gupta (2010).
Geological risks like erosion, soil movement and landslides	Mubin and Mubin (2008), Guo *et al.* (2016) and Riegert (2011).

Vehicle accidents	Peng et al. (2016)
Animal accidents	Rowland (2011) and Mubin and Mubin (2008).
Lack of compliance with the safety regulations	Nnadi *et al.* (2014) and Guo *et al.* (2016).
Non-availability of warning signs	Guo *et al.* (2016) and Kabir *et al.* (2015).
Sabotage opportunities arising due to the exposed pipeline, e.g. above-ground pipeline	Rowland (2011).
Lack of regular inspection and proper maintenance	Balfe *et al.* (2014), Nnadi *et al.* (2014), Guo *et al.* (2016), Lu *et al.* (2015), Wu *et al.* (2015) and Anifowose *et al.* (2012).
Inadequate risk management methods	Balfe *et al.* (2014) and Nnadi *et al.* (2014).
Natural disasters and weather conditions	Nnadi *et al.* (2014), Mubin and Mubin (2008), Anifowose *et al.* (2012) and Onuoha (2008).
Shortage of high-quality IT services and modern equipment	Nnadi *et al.* (2014) and Mubin and Mubin (2008).
Weak ability to identify and monitor the threats	Nnadi *et al.* (2014)
Corrosion: lack of cathodic protection and anticorrosive coating	Nnadi *et al.* (2014), Guo *et al.* (2016), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.(* 2015), Wu *et al.* (2015), Riegert, (2011) and Sulaiman and Tan (2014).
Design, construction, material and manufacturing defects	Guo *et al.* (2016), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.* (2015), Wu *et al.* (2015), Riegert (2011) and Sulaiman and Tan (2014).
Operational errors like human errors and equipment failure	Balfe *et al.* (2014), Nnadi *et al.* (2014), Mubin and Mubi, (2008), Guo *et al.* (2016), Dawotola *et al.* (2010), Dawotola *et al.* (2009), Lu *et al.* (2015) and Wu *et al.* (2015).
Hacker attacks on the operating or control system	Srivastava and Gupta (2010).
The law does not apply to saboteurs	Peng *et al.* (2016) and Mubin and Mubin (2008).

Stakeholders are not paying proper attention	Nnadi *et al.*, (2014).
Few researchers are dealing with this problem	Nnadi *et al.* (2014).
Lack of historical records about accidents and lack of risk registration	Balfe *et al.* (2014) and Nnadi *et al.* (2014).
Lack of proper training schemes	Balfe *et al.* (2014) and Nnadi *et al.* (2014).
Corruption	Nnadi *et al.* (2014).

5. METHODOLOGY

5.1. Questionnaire Survey Development

Because risk factors are characteristically uncertain, vague and random, risk models can accommodate a more personal style of thinking, cognition and processing capability (Guo *et al.*, 2016). This research is engaged with people who are in touch with the OGPs problem and, most importantly, it wants to obtain a consensus view and perception that reflects the reality of OGPs risk factors as far as possible (Sa'idi *et al.*, 2014). A questionnaire survey is utilised because it is one of the most widely used methods for additional data collecting. A semi-structured questionnaire survey was designed and distributed online to OGPs stakeholders in Iraq. The questionnaire has been designed based on the findings of the risk factors' data review (Table 1). The questionnaire's purpose is to evaluate the risk factors' probability and severity based on the real knowledge and expertise of the OGPs stakeholders.

The survey was conducted using the 'SoGoSurvey' website. A snowball sampling technique was used for recruiting respondents from government and private agencies who have relevant experience with OGP projects, for example, consultants, planners, designers, construction workers, operators, maintenance workers, administrators, owners, clients and researchers. An online or Internet questionnaire survey has been adopted in this research because it is easy to manage, inexpensive and a quick data collection method (Dolnicar *et al.*, 2009). However, online surveys have some limitations or disadvantages, such as Internet accessibility might not be available for the targeted sample, web security issues regarding anonymity and knowledge about the website, and computer literacy. These disadvantages could result in a low response rate (Czaja and Blair, 2005). On other side, researchers like Czaja and Blair (2005) and Bertot (2009) have concluded from different international samples that the online survey is the easiest form of data collection and real cooperation is provided via open-ended questions.

The final data collection instrument consisted of 12 questions divided into three sections with 95 items in total. Before carrying out the main survey, a pilot survey was conducted, and all ambiguous questions were revised or discarded to improve clarity. The study utilised different response formats, including drop-down, multiple-choice and open-ended questions. This article discusses question numbers 1, 2, 3, 4 and 5. Questions 1, 2 and 3 ask about each participant's occupation, experience and degree of education respectively. Six choices are listed in the first question for participants to select their occupation in relation to OGP projects. Likewise, four choices are listed in the second and third questions to describe the participants' experience and degree of education. Questions 4 and 5 were included to understand the stakeholders' perception about the risk factors' probability and severity. The 30 risk factors listed in these two questions have been identified previously in Table 1. These questions were designed as multi-choice questions by using a five-point Likert scale from 5 to 1. Question number 4 was about ranking the risk factors in order of probability of occurrence, where 5 means almost certain, 4 means likely, 3 means possible, 2 means unlikely, and finally 1 means rare; whereas question number 5 was about ranking the risk factors in order of severity on the OGPs, where 5 means catastrophic, 4 means major, 3 means moderate, 2 means minor and lastly 1 means negligible. Figure 1 and Table 3 represent the statistical analysis results for these questions.

5.2. Survey Sampling and Data Collection

There is a need in any survey to select the right sample from the targeted population. This is because, in general, questionnaire surveys create many non-respondents, therefore getting the right people to participate is extremely important. As mentioned previously, the snowball sampling technique is utilised in this research to ensure widespread distribution of the survey (Dragan and Maniu, 2013; Ameen and Mourshed, 2016) among OGPs Iraqi stockholders. This technique works as follows: the survey is initially distributed by the authors to a number of previously identified participants, who forward it to others, and so forth until the required number of responses is reached (Ameen and Mourshed, 2016). This technique can help to collect data from a large number of participants. The survey was started on 26th of February 2017 by sending the online link to potential participants via social networks. The survey closed on the 16th of March 2017 with a total of 180 responses.

5.3. Data Analysis

The Statistical Package for the Social Sciences 23 (SPSS 23) is used to calculate the Cronbach's alpha coefficient factor (α) to assess the questionnaire's reliability. The α measures the reliability and the internal consistency or average correlation of the survey items (Cronbach, 1951; Webb *et al.*, 2006; Ameen and Mourshed, 2016). Depending on the scale's nature and purpose, different levels of reliability are required; Pallant (2005) recommends 0.7 as a minimum reliability level. Table 2 shows the α of the questionnaire and the paper's related items.

SPSS 23 is used to analyse the questionnaire statistically. The statistical frequency analysis for each item in questions 1 to 3 has been performed as shown in Figure 1. As stated previously in this paper, a scale from 5 to 1 was assumed for questions 4 and 5 to score each risk factor's probability and degree of impact, where 5 means the most 'extreme' risk probability or severity and 1 the 'lowest'. In order to determine each factor's probability and severity, the chosen items are analysed by using the descriptive statistics analysis method to calculate the factors' frequencies summation and means. Then, the total score of RI for each factor is mathematically calculated by using equation 1 (Hill, 1993; Chamzini, 2014; Sa'idi *et al.*, 2014).

$$RI = (RP \times RS)/5 \qquad \ldots (1)$$

Where: RI is risk index, RP is risk probability, and RS is risk severity. The risk factors' probability, severity and index have been ranked depending on their value. Table 3 presents the probability, severity, index and ranking for each risk factor.

6. Results

6.1. Reliability and Validity

As mentioned earlier, SPSS 23 has been used to examine the questionnaire's reliability and calculate the Cronbach's alpha. The results are presented in Table 2.

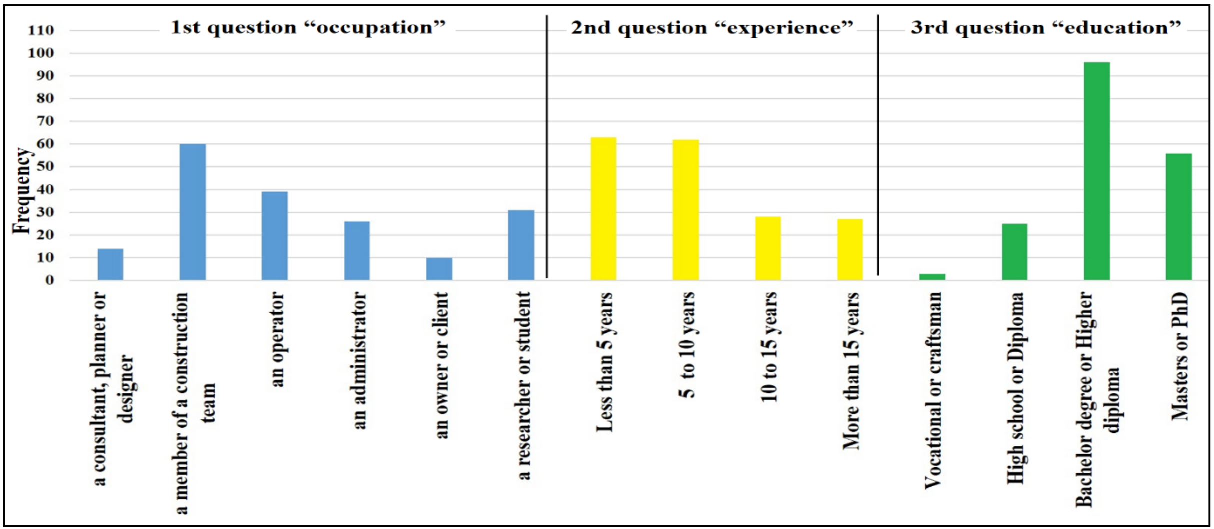
Table 2: Cronbach's alpha case processing summary (SPSS 23)

Case Processing Summary	Valid		Excluded a		Total		Number of items	Cronbach's alpha
	N	%	N	%	N	%		
All of the questionnaire items	180	100	0	0	100	0	95	0.909
Questions No. 4 and 5	180	100	0	0	100	0	60	0.926
Question No. 4	180	100	0	0	100	0	30	0.918
Question No. 5	180	100	0	0	100	0	30	0.863

a Listwise deletion based on all variables in the procedure (SPSS 23).

6.2. Participants' Demographic Data

One hundred and eighty responders successfully answered the questionnaire's questions. Figure 1 provides their demographic information such as occupation, experience and educational degree level.



The question 1 frequency analysis results indicate that the biggest group of participants is the construction workers group, with 60 responders and 33.3% of the total 180 responders. This is followed by the other groups, in this order: the operators group, with 39 responders and 21.7%; the researchers group, with 31 responders and 17.2%; the administrators group, with 26 responders and 14.4 %; the consultants, planners and designers group, with 14 responders and 7.8%; and, lastly, the owners and clients group, with 10 responders and 5.6%. Similarly, question 2 results indicate that most of the participants have less than five years of experience, with a total of 63 responders and 35% in this category. The participants with 5-10, 10-15, and more than 15 years of experience follow, with 62 responders and 34.4%; 28 responders and 15.6%; and 27 responders and 15% respectively. In question 3, the Bachelor's or Higher Diploma degree holders form the majority of the participants, with 96 responders and 53.3%. The Master's and PhD degree holders are next, with 56 responders and 31.1%, followed by the High School or Diploma degree holders, with 25 responders and 13.9%; and last is Vocational, with three responders and 1.7%.

6.3. Risk Probability, Severity, Index and Ranking

The values of RP, RS and RI and the risk ranking have been found using SPSS 23 statistical analysis facilities, as shown in Table 3.

Table 3 Risks' probability, severity, index and ranking

Risk Factors	RP			RS			RI	
	Sum [a]	Mean [b]	Ranking	Sum [a]	Mean [b]	Ranking	Index [c]	Ranking
Terrorism and sabotage	728	4.044	1	814	4.522	1	3.658	1
Corruption	720	4	2	778	4.322	2	3.458	2
Thieves	674	3.744	3	739	4.106	4	3.074	3
Geographical location like 'Hot-Zones'	673	3.739	4	739	4.106	5	3.070	4
The law does not apply to saboteurs	653	3.628	12	751	4.172	3	3.027	5

Corrosion and lack of protection against it	668	3.711	6	712	3.956	6	2.936	6
Improper safety regulations	666	3.7	7	707	3.928	8	2.907	7
Public's low legal and moral awareness	669	3.717	5	692	3.844	11	2.858	8
Improper inspection and maintenance	658	3.656	10	703	3.906	9	2.856	9
Weak ability to identify and monitor the threats	658	3.656	11	699	3.883	10	2.839	10
Stakeholders are not paying proper attention	642	3.567	18	712	3.956	7	2.822	11
Lack of proper training	650	3.611	16	675	3.750	13	2.708	12
Sabotage opportunities arising due to the exposed pipeline, e.g. above-ground pipeline	661	3.672	8	662	3.678	16	2.701	13
Limited warning signs	651	3.617	15	660	3.667	17	2.652	14
Shortage of IT services and modern equipment	661	3.672	9	650	3.611	19	2.652	15
Lack of historical records about accidents and lack of risk registration	644	3.578	17	667	3.706	15	2.652	16
The pipeline is easy to access	651	3.617	14	659	3.661	18	2.648	17

Few researchers are dealing with this problem	652	3.622	13	645	3.583	20	2.596	18
Design, construction and material defects	598	3.322	22	687	3.817	12	2.536	19
Conflicts over land ownership	627	3.483	19	644	3.578	21	2.492	20
Threats to staff	598	3.322	21	668	3.711	14	2.466	21
Socio-political factors such as poverty and education level	621	3.45	20	612	3.400	24	2.346	22
Operational errors	554	3.078	24	642	3.567	22	2.196	23
Inadequate risk management	579	3.217	23	604	3.356	25	2.159	24
Leakage of sensitive information	535	2.972	25	628	3.489	23	2.074	25
Geological risks such as groundwater and landslides	492	2.733	26	574	3.189	26	1.743	26
Natural disasters and weather conditions	473	2.628	27	546	3.033	27	1.594	27
Vehicle accidents	437	2.428	28	486	2.700	29	1.311	28
Hacker attacks on the operating or control system	401	2.228	29	524	2.911	28	1.297	29
Animal accidents	337	1.872	30	365	2.028	30	0.759	30

a $Sum = \sum(5 - Frequency \times 5 + 4 - Frequency \times 4 + 3 - Frequency \times 3 + 2 - Frequency \times 2 + 1 - Frequency \times 1)$

b $Mean = {Sum}/{N} = {Sum}/{N}$ Where N= number of participants = 180 and c Equation 1.

7. Discussion and Conclusion

7.1. Discussion

Along with a comprehensive and in-depth literature review, the stakeholders' perceptions are vital and valuable in identifying the OGPs problems. This is because stakeholders' perceptions are based on their real experience in the OGPs context, which makes them qualified to monitor the existing problems of TPD. For that reason, it is expected that the questionnaire survey results will provide a kind of database for OGPs risk factors in the country of study, Iraq.

The questionnaire data are reliable because all α values are above 0.7, as shown in Table 2. The demographic information about the 180 responders reflects the diversity of the successfully collected sample, as shown in Figure 1. This decent level of diversity means the questionnaire has definitely reached the targeted population because all the categories are represented in the survey. Proper sampling reflects the identification of more realistic risk factors, and enhances the final results. In other words, it provides the verified and valuable data required for the risk factor evaluation process.

In this paper, 30 risk factors have been investigated and ranked on a five-point Likert scale from 5-1. Overall, the probability analysis of these factors indicates that the most frequent factors were terrorism and sabotage (mean= 4.044), corruption (mean= 4.000), thieves (mean= 3.744), hot-zones (mean= 3.739) and the public's low awareness (mean= 3.717). Geological (mean= 2.733), natural disasters (mean= 2.628), vehicle accidents (mean= 2.428), hackers (mean= 2.228) and animal accidents (mean= 1.872) were the less frequent factors. In the same way, the risk factors were ranked regarding the severity degree. The factors' severity ranking shows that the most severe risks were terrorism and sabotage (mean= 4.522), corruption (mean= 4.322), the law does not apply to saboteurs (mean= 4.172), thieves (mean= 4.106) and hot-zones (mean= 4.106). On the other side, the geological risks (mean= 3.189), natural disasters (mean= 3.033), hackers (mean= 2.911), vehicle accidents (mean= 2.700) and animal accidents (mean= 2.028) were the less severe factors. The RI values highlight the hazardous risk factors. The factors with the highest impact on the pipeline projects were terrorism and sabotage (RI= 3.658), corruption (RI= 3.458), thieves (RI= 3.074), hot-zones (RI= 3.070) and the law does not apply to saboteurs (RI= 3.027). Geological risks (RI= 1.743), natural disasters and weather conditions (RI= 1.594), vehicle accidents (RI= 1.311), hacker attacks (RI= 1.297) and animal accidents (RI= 0.759) were the factors that had less impact. Table 3 has shown the risk factors' probability, severity, index and ranking.

In this paper, the 30 risk factors have been classified into five groups, namely: security and social factors; pipeline location factors; health, safety and environment (HSE) factors; operational factors; and rules and regulations factors. For the security and social factors, terrorism and sabotage factors are always at the top of the most influencing factors ranking list. They are followed by thefts; public's low legal and moral awareness; threats to staff; socio-political factors such as poverty and education level; and leakage of sensitive information. Amongst the risk factors related to the pipeline's location, it has been found that hot-zones are the most risky and accidents due to animal crossing are the least. Meanwhile, easy access to the pipeline; conflicts over land ownership; geological risk; and vehicle accidents are the 2nd, 3rd, 4th and 5th ranking factors respectively. HSE factors are ranked as follows: improper safety regulations; inadequate inspection and maintenance; the pipelines are exposed and above the ground; limited warning signs; risk management nature character; and, last of all, natural disaster and weather conditions. Corrosion and the lack of protection against it are the major operational issues facing the pipes. This is followed by weak ability to monitor the risk factors; limited availability of IT; design, construction and material defects; and operational error, which are the 2nd, 3rd, 4th and 5th issues respectively. Problems caused by hacker attacks on the operating or control system have the least impact on the pipeline system in Iraq. The group of risk factors related to the rules and regulations have been evaluated as follows: corruption and the law does not apply to saboteurs and thieves are the factors with the highest impact among this type of risk. The rest of the rules and regulations factors are ranked as follows: stakeholders are not paying proper attention; lack of proper training; lack of an accident database and historical records; and, lastly, few researchers looking into this subject.

The top five risk factors in Table 3 indicate that the Iraqi OGPs stakeholders are most increasingly concerned with security and social issues; rules and regulations; and the pipelines' geographical locations, because terrorist and theft acts have become respectively the first and third most pressing factors facing OGPs in Iraq. Additionally, corruption is the second top risk factor, and the law does not apply to saboteurs and thieves is the fourth, both of which are obstructing pipeline projects in Iraq. Hot-zones are fifth in this top five list, and so are also a cause for concern.

7.2. Conclusion

OGP projects are complex and risky; the risk management challenges are increasing day by day due to the vast range of problems facing pipeline projects and the insecure global environment. Balfe *et al.* (2014) stated that, in order to maintain safe and secure construction and operation circumstances, monitoring studies must be continuously conducted, and translated into formats that can be reviewed, understood and analysed. For that reason, this article has been written to represent the final outcomes of this research. Common OGPs risk factors have been identified based on an extensive review of the causes of pipeline failure around the word. A quantitative research approach has been adopted to evaluate the 30 identified factors. The probability and severity of risk factors have been determined based on the statistical analysis results of a questionnaire survey with a total of 180 respondents. The RI for each factor was mathematically calculated to rank the risk factors in relation to their degree of influence on OGPs. Their ranking indicates that terrorism and sabotage acts, corruption, hot-zones and the law is not applied to saboteurs are the risks that have the highest impact on OGPs. On the other side, geological hazards, natural disasters and weather conditions, vehicle accidents, hacker attacks and animal accidents are the factors with the least impact. TPD risks occupied the top positions in the ranked list of OGP risk factors. Furthermore, the prioritised risk factors showed an essential need to understand the profile of TPD in Iraqi OGP projects. TPD should be an important focus for management in order to mitigate and limit damage to pipelines.

The research's findings could support decision-makers, policy-makers and researchers to understand the nature of TPD to OGPs properly in troubled countries like Iraq. A ranked list of risk factors could help to provide more active and suitable risk management methods to avoid or minimise the adverse impact of risks in OGP projects. Precisely, OGPs stakeholders could use the outcomes (presented in tables 1 and 3) as a database and tools for risk evaluation at different stages of a pipeline project. T findings could also be used for monitoring and prioritising risks during design, re-design, construction, operation, inspection and maintenance activities. Respectively, these numerical results will be adopted to develop a new computer-based model for OGPs risk management at the next stage of the research.

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