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Abstract

Currently, there are enormous Risk Factors (RFs) threating the safety of Oil and Gas Pipelines (OGPs) at all stages of projects. However, there is a lack of information about the root causes of pipeline failures and an absence of trusted data about the "probability and severity" levels of the RFs; this hinders the risk management in such projects. To improve the safety level of OGPs, this paper aims to explore stakeholders' perceptions about pipeline failures issues to analyze the RFs and recommend effective Risk Mitigation Methods (RMMs). Due to the lack of trusted data about the RFs and RMMs, this paper started with extensive investigations to identify the critical RFs and the applied RMMs in OGP projects in different circumstances. The findings of these investigations were used to design a questionnaire survey, which was distributed to analyze the "probability and severity" levels of the RFs and evaluate the "usability and effectiveness" degrees of the suggested RMMs. The survey results revealed that RFs related to Third-Party Disruption (TPD) including sabotage and terrorism, corruption and insecure areas are the most severe RFs. Additionally, based on the survey some RMMs such as anti-corrosion efforts, laying the pipelines underground and using technologically advanced risk-monitoring systems were found to be effective RMMs. These results were found to be varied based on the stakeholders' occupation in the projects; for example, the overall survey results indicated that terrorism and sabotage is the most critical RF, while the planners and the researchers identified corruption as the most critical one. It was also observed that using anti-corrosion measures such as isolation and cathodic protection would be the most effective RMM, while the other stakeholders have different perceptions like moving the pipelines underground an advanced risk-monitoring system are the most effective RMMs as indicated by the consultant, planner or designer and researches respectively.

Keywords

Oil and Gas Pipelines (OGPs), risk analysis, stakeholders' perceptions, Risk Mitigation Methods (RMMs)

1 Introduction

Oil and Gas Pipeline (OGP) projects must be planned, designed, installed and operated in ways that comply with the safety requirements. However, several risks are hindering the safety of these projects such as external sabotage, corrosion (Miesner and Leffler, 2006), design and construction defects, natural hazards, operational errors and others (Focke, 2009; Wan and Mita, 2010; Williamson and Daniels, 2008). Knowing how to mitigate OGP RFs is valuable because it minimizes the economic losses from disturbing the business of oil exporting; additionally, it ensures the safety of the projects' staff and the people that live near the pipelines.

Efforts to mitigate OGP RFs actively require verified historical records about the reasons for the pipelines' accidents and failure (Srivastava and Gupta, 2010). Moreover, the probability of RFs must be accurately analyzed and ranked because dealing with each RF as the most severe risk results in a waste of resources. However, the existing risk analysis methods are not accurate enough to analyze the external sabotage of the pipelines when there is no database of "historical records" about such risk (Ge et al., 2015; Khakzad et al., 2011; Peng et al., 2016). Additionally, an accurate evaluation of the Risk Mitigation Methods (RMMs) regarding their degrees of effectiveness of mitigating the RFs helps the decision makers while they are deciding their strategies to mitigate OGP RFs. Accordingly, the inaccurate analyses of OGP RFs and inaccurate evaluation of the RMMs are hindering any risk mitigation efforts in these projects. This is particularly the case in troubled and developing countries because these highlighted problems are strongly associated

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with OGP projects in these countries. Hence, there is a vital need to help the stakeholders to improve safety for these projects by providing the required data for OGP risk management such as the "probability and severity" levels of the RFs and the "usability and effectiveness" of the RMMs.

This paper aims to explore stakeholders' perceptions about pipeline failures issues to analyze the RFs and evaluate the RMMs in OGP projects more holistically and effectively. Moreover, having up-to-date data about the RFs and RMMs can help the stakeholders to improve the safety of OGPs continuously.

Iraq is selected as the case study in this paper because its oil reserves are the fifth largest in the world (Energy Information Administration, 2015). Furthermore, it is estimated that Iraq's gas reserves are amongst the 10^{th} to 13^{th} largest reserves globally, in addition to the possibility that there is a vast number of reserves that are yet undiscovered (International Energy Agency, 2012). At the present time, a vast range of RFs threatens OGP projects in Iraq and the inadequacy of mitigating the RFs hinders the business of oil exporting, which has been in high demand since 2003. Moving forward in this paper, Section 2 consists of a review about identifying pipeline RFs and RMMs. Section 3 explains the research methodology. The results of analyzing the RFS and evaluating the RMMs are interpreted in Section 4. Section 5 discusses this paper's findings. Finally, Section 6 provides the conclusions.

2 Identifying the Risk Factors (RFs) and Risk Mitigation Methods (RMMs) in OGP Projects

Qualitative document analysis was carried out to identify the RFs in OGP projects in different circumstances, especially in insecure countries. Thirty RFs were identified based on the findings of the literature review, as follows:

- public's legal and moral awareness about OGP projects, vehicle accidents and lawlessness (Peng et al., 2016)
- thieves, terrorism and sabotage, people's poverty and education levels in OGP areas, improper inspection & maintenance, limited warning signs, corruption, little research about this topic, lack of proper training, operational errors, stakeholders are not paying proper attention, lack of risk registration, weather conditions and natural disasters, inadequate risk management approaches, weak ability to identify & monitor the threats, corrosion and lack of anti-corrosive action, and shortage of IT services & modern equipment (Nnadi et al., 2014)
- leakage of sensitive information (Wu et al., 2015), threats to staff and the opportunity to sabotage exposed pipelines – "aboveground pipelines" (Rowland, 2010)
- insecure areas, hacker attacks on the operating or control systems and the pipeline is easy to access (Srivastava and Gupta, 2010)
- conflict over land ownership (Macdonald and Cosham, 2005) and animal accidents (Mubin and Mubin, 2008)
- geological risks, improper safety regulations and design, construction and material defects (Guo et al., 2016).

Accordingly, a number of RMMs were suggested to mitigate RFs like anti-corrosion and cathodic protection; laying the pipelines underground rather than aboveground; modern equipment to monitor the RFs; proper inspection and maintenance; proper training for the staff about mitigating the RFs in their projects; avoiding insecure areas; anti-terrorism planning and design; learn from the past and avoid the RFs that have been registered as causes of pipeline failure; protective barriers; government-public cooperation; and warning signs near the pipelines and marker tape above the pipelines.

This analysis helped to overcome the problem of data scarcity about the RFs and RMMs in OGP projects in Iraq. However, more information is needed about the "probability and severity" of the RFs and the "usability and effectiveness" degrees of the suggested RMMs in OGP projects. In the meanwhile, no available database provides such data. The stakeholders must be aware of the RFs that can damage OGPs. Therefore, their perceptions are a valuable source for this study as they are based on experiences from the field. In addition, they must also have a risk mitigation system that can keep the RFs at the lowest level, as far as possible. Moreover, collecting such perceptions could reduce the time and cost of investigations into the RFs and RMMs by meeting those who are responsible for risk management. Therefore, field investigations were required to analyze the situation of OGP safety in Iraq by distributing a questionnaire survey. The survey was distributed online and it targeted the owners and clients, researchers and students, consultants, planners and designers, construction team members, and operators in Iraq's OGP projects. There are many studies about assessing RFs in OGPs by conducting questionnaire surveys, interviews and ascertaining experts' judgements, like (Guo et al., 2016;

Rowland, 2010; Wu et al., 2015), yet such studies have not analyzed the RFs based on the stakeholders' roles in the projects. However, understanding the stakeholders' perceptions based on their experience is more important than just gaining their perception of OGPs because different groups of stakeholders might have different views about pipeline failure, which reflects their roles in the projects. Different perceptions provide a better understanding about the RFs and RMMs in different stages of the projects from the staff who are working at these stages. Furthermore, they provide a chance to explore the perceptions of everyone concerned with OGPs even if they do not work directly in such projects, such as the researchers. Therefore, correct sampling and representing all of the stakeholder categories enhances the results of this paper.

3 Methodology

An industry-wide questionnaire survey was designed based on the findings of the literature review to collect the perceptions of the stakeholders about OGPs in Iraq. The respondents were promised that the data would be analyzed in a way that protected their anonymity.

The first question asked about their occupation in OGP projects. The survey had two questions to analyze the RFs, as follows. The first question aimed to analyze the probability of occurrence of the 30 RFs on a five-point Likert scale: "rare", "unlikely", "possible", "likely" and "almost certain". The second question aimed to evaluate the severity of the RFs on a scale of "negligible", "minor", "moderate", "major" and "catastrophic". Similarly, the survey had two questions to evaluate the RMMs, as follows. The first question asked about evaluating the usability of the RMMs on a scale of "rare", "unlikely", "possible", "likely" and "almost certain". The second question was about evaluating the effectiveness of the RMMs on a scale of "ineffective", "slightly effective", "moderately effective", "very effective" and "extremely effective".

The descriptive statistical analysis in Statistical Package for the Social Sciences (SPSS) software was used to determine the values of Risk Probability (RP) and Risk Severity (RS) for each RF by calculating the mean of the five-point Likert scales. The degree of impact for each RF was found by using a Risk Index (RI) method as explained in Eq. (1) (Yazdani-Chamzini, 2014). The RFs were ranked regarding their RI values. In the same way, the usability and the effectiveness of the RMMs were found.

$$\mathrm{RI} = \left(\mathrm{RP} \times \mathrm{RS}\right)/5 \quad (1)$$

4 Results

Before analyzing the results, the Cronbach's alpha correlation coefficient factor was calculated to measure the reliability level of the survey (Cronbach, 1951; Webb et al., 2006). Commonly, 0.7 indicates a minimum level of reliability (Pallant, 2005). Table 1 shows the Cronbach's alpha coefficient factor case processing summary. The reliability test is not applicable for question 1 because it asked about the participants' occupation in OGP projects.

One hundred and ninety-eight stakeholders answered the survey's questions. It is worth noting that all the targeted groups are represented in the results, which means the results reflect the issues faced by OGPs during all stages of a project as explained at the end of Section 0. The majority of the participants were construction team members (71), followed by the operators (41), owners or clients (39), researchers or students (33), and, finally, the consultants, planners and designers (14).

In order to link the stakeholders' perceptions and the RFs and RMMs, the RFs and RMMs were analyzed based on stakeholders' occupations in OGP projects in Iraq. Table 2 shows the results of calculating the RP and RS of each RF. Table 3 shows the ranking of the RFs based on their RI values. The usability and effectiveness of the RMMs are shown in Table 4. Note, in these tables Total means all the participants; (I) means the consultants, planners and designers; (II) means the construction workers; (III) means the operators; (IV) means the owners and clients; and (V) means the researchers. The discussion section focuses on stakeholders, the reasons for the variances and similarities in the results, and the lessons that can be learned from them.

Table 1 Cronbach's alpha coefficient factor case processing summary for the survey overall and by participants' occupation.

Case Processing Summary	Valid %	Items	α
All the questionnaire's questions	100	95	0.910
The question about RP (survey overall)	100	30	0.919
The question about RS (survey overall)	100	30	0.863
The question about the usability of RMMs (survey overall)	100	12	0.867
The question about the effectiveness of RMMs (survey overall)	100	12	0.867
A consultant, planner or designer	100	95	0.863
A member of a construction team	100	95	0.892
An operator	100	95	0.927
An owner or client	100	95	0.917
A researcher or student	100	95	0.899

Table 2 The probability and severity of the risk factors by participants' occupation.

RFs	Risk Probability (RP)						Risk Severity (RS)					
	Total	I	II	III	IV	V	Total	I	II	III	IV	V
Terrorism & sabotage	3.995	3.357	3.958	4.195	4.000	4.091	4.490	3.571	3.732	3.829	3.718	3.939
Corruption	3.980	4.000	3.986	3.878	3.846	4.242	4.192	3.286	3.732	3.512	3.769	3.939
Insecure areas	3.717	3.286	3.634	3.805	3.769	3.909	4.106	3.286	3.634	3.659	4.000	3.606
Low public legal & moral awareness	3.712	4.000	3.761	3.561	3.513	3.909	3.859	3.357	3.535	3.244	3.590	3.727
Thieves	3.692	3.214	3.845	3.659	3.564	3.758	4.081	3.000	3.662	3.585	3.846	3.818
Corrosion & lack of protection against it	3.687	3.429	3.648	3.390	3.795	4.121	3.990	3.357	3.676	3.683	3.641	3.697
Improper safety regulations	3.687	3.643	3.662	3.561	3.872	3.697	3.949	3.214	3.592	3.488	3.872	3.667
Exposed pipelines	3.667	3.429	3.437	3.854	3.897	3.758	3.682	2.500	3.042	2.951	3.000	3.000
Shortage of IT services & modern equipment	3.667	3.643	3.592	3.585	3.615	4.000	3.652	1.714	2.155	1.951	2.000	1.970
Improper inspection & maintenance	3.657	3.571	3.606	3.537	3.769	3.818	3.924	3.357	3.746	3.610	3.641	3.394
Lack of proper training	3.646	3.571	3.761	3.439	3.462	3.909	3.773	3.500	3.408	3.098	3.410	3.697
Weak ability to identify & monitor the threats	3.631	3.571	3.577	3.561	3.692	3.788	3.899	3.000	3.690	3.488	3.487	3.758
The pipeline is easy to access	3.631	3.571	3.563	3.732	3.538	3.788	3.646	3.571	3.732	3.829	3.718	3.939
Limited warning signs	3.626	3.429	3.648	3.341	3.974	3.606	3.571	3.286	3.634	3.659	4.000	3.606
Little research on this topic	3.621	3.429	3.789	3.366	3.359	3.970	3.697	2.857	3.042	2.854	3.077	3.455
Lawlessness	3.606	3.786	3.676	3.268	3.795	3.576	3.682	2.500	3.042	2.951	3.000	3.000
Lack of risk registration	3.566	3.214	3.606	3.390	3.615	3.788	3.697	2.857	3.042	2.854	3.077	3.455
Stakeholders are not paying proper attention	3.530	3.286	3.676	3.439	3.462	3.960	3.143	3.577	3.829	3.692	3.727	3.960
Conflicts over land ownership	3.495	3.571	3.451	3.659	3.667	3.152	3.611	3.286	3.732	3.512	3.769	3.939
Public's poverty & education level	3.449	3.357	3.521	3.439	3.256	3.576	3.409	3.357	3.676	3.683	3.641	3.697
Design, construction & material defects	3.333	2.429	3.254	3.293	3.385	3.879	3.848	3.571	3.549	3.390	3.179	3.333
Threats to staff	3.323	2.714	3.394	3.268	3.410	3.394	3.399	3.143	3.577	3.829	3.692	3.727
Inadequate risk management	3.227	2.929	3.183	2.976	3.436	3.515	3.505	3.000	3.662	3.585	3.846	3.818
Operational errors	3.101	2.857	3.042	2.878	3.205	3.485	3.611	3.500	3.958	3.537	3.692	3.636
Leakage of sensitive information	2.980	2.643	3.070	2.707	2.949	3.303	3.505	3.000	3.662	3.585	3.846	3.818
Geological risks	2.747	2.714	2.662	2.537	2.795	3.152	3.182	3.214	3.592	3.488	3.872	3.667
Natural disasters & weather conditions	2.652	2.429	2.606	2.537	2.692	2.939	3.066	3.357	3.746	3.610	3.641	3.394
Vehicle accidents	2.465	2.357	2.380	2.293	2.333	3.061	2.712	3.357	3.535	3.244	3.590	3.727
Hacker attacks on the operating or control system	2.237	1.929	2.268	2.024	2.179	2.636	2.970	3.000	3.690	3.488	3.487	3.758
Animal accidents	1.894	1.929	1.986	1.561	1.821	2.182	2.020	3.571	3.549	3.390	3.179	3.333

5 Discussion

By using the RI to rank the RFs, the overall results of the survey show that terrorism and sabotage, corruption, insecure areas, lawlessness and thefts are the most critical RFs in OGP projects in Iraq. Nevertheless, the ranking of the RFs is quite varied, depending on the occupations of the stakeholders. If we look to the ranking per the stakeholder groups, for example, three groups (construction workers, operators, and owners and clients) ranked terrorism and sabotage actions first, whilst the consultants, planners and designers group ranked it third and the academic group ranked it second, with both of these groups ranking corruption first. If we look at Table 3 by RF, for example, three groups (construction workers, operators, and owners and clients) ranked terrorism and sabotage actions first, while the consultants, planners and designers group ranked it third and the academic group ranked it second, with both of these groups ranking corruption first. The construction workers and owners and clients ranked corruption second; while the operators ranked it third. The consultants, planners and designers, construction workers and owners and clients ranked the insecure areas seventh; while it was ranked second and fourth from the operators' and researchers' point of view respectively. Lawlessness was

Table 3 The index and ranking of the risk factors by participants' occupation.

RFs	Risk Index (RI)						Ranking the RFs					
	Total	I	II	III	IV	V	Total	I	II	III	IV	V
Terrorism & sabotage	3.587*	3.021	3.579	3.909	3.405	3.669	1	3	1	1	1	2
Corruption	3.441	3.314	3.537	3.254	3.314	3.677	2	1	2	3	2	1
Insecure areas	3.053	2.722	2.928	3.267	3.035	3.222	3	7	7	2	7	4
Lawlessness	3.023	2.812	3.210	2.583	3.211	3.056	4	4	3	16	3	9
Thieves	3.013	2.388	3.206	2.998	2.906	3.029	5	15	4	4	10	11
Corrosion & lack of protection against it	2.942	2.498	2.918	2.696	3.172	3.222	6	11	8	10	4	3
Improper safety regulations	2.912	2.810	2.899	2.797	2.958	3.070	7	5	9	9	9	8
Improper inspection & maintenance	2.870	2.755	2.742	2.829	3.015	3.078	8	6	13	7	8	7
Public's legal and moral awareness	2.865	3.086	2.934	2.588	2.738	3.127	9	2	6	14	13	5
Weak ability to identify & monitor the threats	2.832	2.551	2.802	2.831	2.878	2.961	10	10	11	6	11	14
Stakeholders are not paying proper attention	2.796	2.629	2.972	2.583	2.716	2.855	11	8	5	15	15	16
Lack of proper training	2.751	2.551	2.807	2.634	2.574	3.080	12	9	10	13	19	6
Exposed pipelines	2.700	2.253	2.498	2.820	3.118	2.710	13	16	21	8	5	19
Shortage of IT services & modern equipment	2.678	2.446	2.641	2.641	2.633	2.958	14	12	17	12	17	15
Limited warning signs	2.656	2.057	2.672	2.396	3.057	2.754	15	20	16	18	6	18
The pipeline is easy to access	2.648	2.245	2.550	2.858	2.613	2.824	16	17	19	5	18	17
Lack of risk registration	2.636	2.112	2.692	2.381	2.725	2.984	17	18	14	19	14	12
Little research on this topic	2.586	2.057	2.796	2.348	2.343	2.983	18	19	12	20	23	13
Design, construction & material defects	2.566	1.839	2.410	2.538	2.760	3.033	19	23	22	17	12	10
Conflicts over land ownership	2.524	2.398	2.586	2.641	2.670	2.139	20	14	18	11	16	26
Threats to staff	2.481	1.900	2.687	2.312	2.518	2.468	21	22	15	22	20	22
The education and poverty levels in OGP areas	2.352	2.398	2.500	2.332	2.071	2.384	22	13	20	21	25	24
Operational errors	2.240	1.837	2.185	2.008	2.482	2.556	23	24	23	23	21	21
Inadequate risk management	2.194	2.050	2.170	1.843	2.343	2.599	24	21	25	24	22	20
Leakage of sensitive information	2.089	1.774	2.171	1.756	2.117	2.462	25	25	24	25	24	23
Geological risks	1.748	1.551	1.605	1.670	1.749	2.273	26	26	26	26	26	25
Natural disasters & weather conditions	1.626	1.388	1.585	1.448	1.657	2.031	27	27	27	27	27	27
Vehicle accidents	1.337	1.010	1.274	1.275	1.328	1.707	28	28	29	28	28	28
Hacker attacks on the operating or control system	1.329	0.964	1.380	1.195	1.308	1.582	29	29	28	29	29	29
Animal accidents	0.765	0.661	0.856	0.609	0.728	0.860	30	30	30	30	30	30

*For example: RI for Terrorism & sabotage = (RP) 3.995 × (RS) 4.490 = (RI) 3.587

ranked third based on construction workers' and owners and clients' perceptions. It ranked fourth, ninth and 16th regarding consultants, planners and designers', researchers' and operators' perceptions respectively. Thefts were ranked fourth by both the construction workers and operators, 10th by owners and clients, 11th by researchers and 15th by consultants, planners and designers. Regarding the less influential RFs, researchers ranked the leakage of sensitive information 23rd; construction workers and owners and clients ranked it 24th; and the consultants, planners and designers and operators ranked it 25th. All the stakeholders ranked the geological risk 26th, apart from researchers, who ranked it 25th. All the stakeholders ranked natural disasters and weather conditions 27th and vehicle accidents 28th, apart from construction workers, who ranked vehicle accidents 29th. The ranking of RFs indicated that the hacker attack on the operating or control system and animal accidents were ranked 29th and 30th respectively. Only the construction worker group ranked hacker attack on the operating system differently, at 28th.

At the same time, to highlight the top five RFs by each group of stakeholders, it is worth noting that the public's legal and moral awareness was second-highest and RF from the consultants, planners and designers' point of view. Corrosion & lack of protection against it was the fourth RF according to owners and clients. Other RFs

Table 4 The usability and effectiveness degree of each RMM by participants' occupation.

RMMs	Usability						Effectiveness					
	Total	I	II	III	IV	V	Total	I	II	III	IV	V
Avoid "Insecure Zones"	3.652	2.929	3.789	3.829	3.385	3.758	3.778	3.214	4.014	3.659	3.744	3.697
Anti-terrorism design	3.475	2.643	3.676	3.268	3.564	3.545	3.778	3.143	3.986	3.341	4.179	3.667
Avoid the registered risks and threats	3.616	3.357	3.662	3.634	3.513	3.727	3.773	3.500	3.817	3.683	4.000	3.636
Proper training	3.768	3.643	3.634	3.854	3.769	4.000	3.793	3.857	3.662	3.780	3.897	3.939
Move to an underground pipeline	4.051	3.857	4.085	4.390	3.846	3.879	4.066	3.929	4.000	4.220	4.333	3.758
Anti-corrosion measures such as isolation and cathodic protection	4.247	4.000	4.282	4.512	4.103	4.121	4.232	3.857	4.113	4.415	4.513	4.091
Protective barriers and perimeter fencing	3.783	3.214	3.732	3.878	3.872	3.909	3.773	3.500	3.817	3.683	4.000	3.636
Warning signs and marker tape above the pipeline	3.727	3.143	3.732	3.683	3.846	3.879	3.571	2.929	3.577	3.439	3.923	3.576
Foot and vehicle patrols	3.606	3.143	3.648	3.683	3.590	3.636	3.530	3.429	3.563	3.634	3.615	3.273
High technology and professional remote monitoring	3.480	2.643	3.606	3.415	3.359	3.788	3.995	3.643	4.070	3.878	4.000	4.121
Government-public cooperation	3.278	3.000	3.183	3.463	3.205	3.455	3.545	3.214	3.563	3.561	3.564	3.606
Proper inspection, tests and maintenance	3.677	3.429	3.549	3.805	3.769	3.788	3.828	3.429	3.887	3.829	3.872	3.818

like improper safety regulations, stakeholders are not paying proper attention, exposed pipelines and public's legal and moral awareness were the fifth RFs according to consultants, planners and designers, construction workers, owners and clients and researchers.

Form the previous discussion it is obvious that the ranking of the RFs is significantly influenced by the occupations of the stakeholders in OGP projects. The staff who are working on-site considered terrorism and sabotage as the most severe RF. This consideration might be because they are the people who are suffering from these threats directly; while this kind of risk is only threatening other staff like consultants, planners and designers, and researchers in an indirect way, as these people are office-based workers and might not work at the site. Thus, the staff who are working on-site see that terrorism and sabotage is the RF that has the most effect. However, office-based staff (i.e. consultants, planners and designers, and researchers) considered corruption to be the most severe RF, as these people are usually checking the work procedures (e.g. welding) and the quality of the final work. This might give them a chance to compare the designs and work procedures on paper with the real work being carried out at the project site. If they identify a difference between the project on paper and on-site, they may conclude that the final check and acceptance of the work has been affected by some kind of corruption; so they are the ones who perceive that corruption is the RF that has the most effect.

The RMMs were evaluated by their degree of usability, which means which of the RMMs has the highest chance of being used to mitigate the RFs in OGP projects in Iraq based on the stakeholders' perceptions. The overall results of the survey indicate anti-corrosion measures such as isolation and cathodic protection, moving to an underground pipeline, and protective barriers and perimeter fencing are the RMMs with the highest chance of being used in OGP projects in Iraq. The stakeholders have a similar point of view, which is that anti-corrosion measures such as isolation and cathodic protection is the RMM with the highest chance of usability. The second highest RMM, according to the planners, consultants and designers, construction members and operators, is moving the pipelines underground. However, this method was only third highest for owners and clients. Protective barriers and perimeter fencing was the method with the second-highest chance of usability according to owners and clients, and third highest according to operators and researchers. Proper training was second highest for researchers, and third for consultants, planners and designers; while avoiding "Insecure Zones" was third highest according to construction members.

The result of evaluating the effectiveness of the RMMs shows that anti-corrosion measures such as isolation and cathodic protection, moving to an underground pipeline, and the use of high technology and professional remote monitoring are the most effective RMMs. The RMM anti-corrosion measures such as isolation and cathodic protection is the most effective RMM based on the perceptions from construction team members, operators, and owners and clients; while this method is the second most effective according to consultants, planners and designers and researchers. Laying the pipelines underground is the most effective RMM for consultants, planners and designers; while this method is the second most effective according to operators and owners and clients. Using high technology and professional remote monitoring is the most effective RMM according to researchers, the second for construction workers and the third for consultants, planners and designers and operators. Proper training to mitigate the RFs is the third most effective RMM according to consultants, planners and designers and researchers. Meanwhile, the third most effective RMMs for construction workers and owners and clients were avoiding insecure areas and anti-terrorism design.

Even though the overall results indicated that anti-corrosion measures and laying the pipelines underground are the RMMs with the highest rate of usability chance and the most effective methods, the stakeholders' jobs in OGP projects might affect their evaluation of the RMMs. This can be seen in some examples: consultants, planners and designers said that training the staff is the RMM with the highest rate of usability to mitigate the RFs. However; the construction teams and operators said avoiding insecure areas and having protective barriers and perimeter fencing are the methods with the highest rate of usability and effectiveness, as they are facing the risk of terrorism and sabotage directly. In addition, using high technology and professional remote monitoring was evaluated as an effective RMM because such methods could cover wide areas in less time (compared to foot and/or vehicle patrols) to identify any threats to the pipelines.

The survey results were found to be reliable as all Cronbach's alpha coefficient factor values were above 0.7, as explained in Table 1. Collecting the required information from various and trusted sources such as research articles and stakeholders provides real information for OGP risk management. However, it depends on the availability of such documents and the willingness of the stakeholders to cooperate with the authors. Analyzing the RFs and evaluating the RMMs based on the perceptions of the stakeholders could reduce the time and the cost of the investigations and increase the stakeholders' awareness about their responsibilities regarding OGP risk management. Additionally, it helps to analyze OGP RFs more realistically and to identify the positive and negative recommendations about RMMs in a way that ensures the continuity of pipeline security. This is because the stakeholders' perceptions are based on real experience about OGP issues. Furthermore, correct sampling and representing all the stakeholder categories enhances the results of RF analysis and RMM evaluation.

6 Conclusion

There is a need for an accurate analysis of OGP RFs because the safe RFs have not been accurately analyzed yet. The overall results of the survey showed that the external risk factors like terrorism and sabotage, corruption, insecure areas, lawlessness and thieves were found to be the most critical risks in OGP projects in Iraq. Avoiding "Insecure Zones", having a good anti-terrorism design, and avoiding the registered risks and threats were found to be the most usable risk mitigation methods. Meanwhile, anti-corrosion measures such as isolation and cathodic protection, moving to an underground pipeline, and high technology and professional remote monitoring were the most effective risk mitigation methods. However, OGP stakeholders had different perceptions about this ranking, based on their occupation. This is because, as the OGPs are subject to different RFs during a project's stages, the views of the staff who are working on these stages could reflect this fact. Collecting and understanding these perceptions helped to provide the essential data for OGP risk management, along with a comprehensive and accurate analysis of the RFs and effective analysis of RMMs.

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