Assessment of Risk Factors of a Completed Oil and Gas Project, with the Use of a Hybrid EVM-SAW Method

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Manuscript received December 17, 2017; Revised February 02, 2018, accepted April 22, 2018. Paper no. JEMT-1712-1052

The motivation of current research study is the way of diagnosing and ranking risk factors of a completed real-world gas injection project. A Nominal Group Technique is used to establish a Risk Matrix Structure, and to identify risk factors. Next, a hybrid group Eigen Vector Method and Simple Additive Weighting is applied to assign the weighs to risk factors. In this procedure, it is assumed that risk factors influence on the project constraints which are scope, quality, cost and time. Moreover, at the whole assessment stages, the opinions of twelve experts are utilized through several expertise meetings. The results indicate that the top-ten risk factors are: Poor or nonexistent project management system in the project; Bad estimation of Scope of Work; Lack of frozen requirements; Lack of cooperation among consultants, suppliers or subcontractors; Overemphasis of technical specifications in design; Conduct planning without a view on the project priorities; Inadequate/Invalid project assumptions; Failure to receive requirements from the client; Lack of people skills in the project leadership; and Absence of precise/accurate information.

keywords: *Risk assessment, Oil and Gas projects, EVM, SAW, NGT.*

http://dx.doi.org/10.22109/jemt.2018.111011.1052

1. INTRODUCTION

Risk, a natural phenomenon in all aspects of projects, could be defined as an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one of the project objectives. On the subject of risk management process, several contributors have developed systematic risk models in the-state-of the art [1]. Table 1 portrays the most famous models. Almost all of these approaches have a similar framework with minor differences. All the models include a fundamental phase namely "Risk identification" [2], "Identify risks" [3], "Identify the issues" [4], or "Identification" [5]. According to relevant investigators, the objective of risk identification is to identify all possible risks, as well as all risk factors. Risk factor is an event or situation that increases the probability of occurrence of a risk event; e.g. "smoking cigarettes" is a risk factor to the risk event of "a heart attack". Of course, a risk factor may refer to an "issue". The term issue sometimes refers to matters of concern that are insufficiently defined or characterized to be treated as risks. In this case, an issue may describe an area (e.g. requirement volatility, resource availability, or weather conditions) from which specific risks might arise [5].

Definitely, a risk factor may cause a few minor risks, while another one may be the source of several major risks. Thereby, ranking risk factors is an important activity in risk management. On the other hand, oil and gas projects are composed of high levels of risk because of intensive investment, numerous stockholders, complex technology, and unique nature [38]. This article includes the assessment of risk factors of a completed oil project. Indeed, the paper diagnoses risk factors, and then ranks them. The choice project is a gas injection project, a real case taken from the oil and gas industry. Naturally, since the pressure of oil filed dropped by dint of long run oil extraction, gas injection project is carried out to increase pressure of wells, as a result, increase oil production rate. Such a project is one of the most important EOR (Enhanced Oil Recovery) strategies which typically contains determining source of gas, developing and installation gas-compression station, transferring gas to the station, and drilling injections wells.

In view of the case project, after launching, it was specified a considerable deviation of project constraints (i.e. scope, quality, cost, and time) from the approved targets. The project upshot on time was not meet; the ultimate state of specifications of the project product has a considerable gap to the desirable scope and quality; moreover, overrun cost was occurred that is the excess of the approved budgeted amounts. Therefore, this study looks for the causes of these deviations.

Table 1. The most famous risk management models

Model	Full name	Main theme	References
SCERT	Synergistic Contingency Evaluation and Response Techniques	Investment projects	[6]
CRMS	Construction Risk Management System	construction projects	[7]
MoD	Ministry of Defense	Engineering projects	[8]
RISKMAN	Risk Management	General	[9]
IETC	International Electro Technical Commission	Engineering projects	[10]
ROMPIT	Risk and Opportunity Management Process Improvement Team	General	[11]
ADAS	Australian Department of Administrative Services	Procurement projects	[12]
SAFE	Safe Activities For Enhancement	Software projects	[13]
TRAM	Technical Risk Assessment Methodology	Engineering systems	[14]
CII	Construction Industry Institute	Construction projects	[15]
ICAEW	Institute of Chartered Accountants in England and Wales	Enterprise	[16]
CRM	Continuous Risk Management	Project management	[17]
WHO	World Trade Organization (WTO)	Safety	[18]
DoT	United States Department of Transport	Enterprise	[19]
CCPS	Center for Chemical Process Safety	Engineering projects	[20]
CMMI	Capability Maturity Model Integration	Software projects	[21]
RISKIT	Risk Kit	Software projects	[2]
RAM	Risk Assessment and Management	Engineering systems	[22]
DoD	United States Department of Defense	Engineering projects	[23]
PUMA	Project Uncertainty Management	Construction projects	[24]
CAN/CSA-Q850-97	Canadian Standard Association	General	[25]
RFRM	Risk Filtering, Ranking and Management	Engineering systems	[26]
AIRMIC/ALARM/IRM	Association of Insurance and Risk Managers / Association of Local Authority Risk Managers / Institute of Risk Management	General	[27]
CDEM	Civil Defense and Emergency Management	Construction projects	[28]
SHAMPU	Shape, Harness And Management Project Uncertainty	Project management	[4]
PRAM	Project Risk Analysis and Management	Project management	[29]
MRMP	Multi-party Risk Management Process	Construction projects	[30]
RISKAID	Risk Aid	Project management	[31]
AS/NZS 4360	Australian Standards/ New Zealand Standard	General	[32]
ATOM	Active Threat and Opportunity Management	Project management	[5]
TPRM	Two-Pillar Risk Management	Project management	[33]
ISO 31000:2009	International Organization for Standardization	General	[34]
M_{OR}	Management of Risks	Enterprise	[35]
BSI	British Standards Institute	General	[36]
PMBoK, Ch11	Project Management Body of Knowledge	Project management	[37]
RAMP	Risk Analysis and Management for Projects	Investment projects	[3]

2. ITERATURE REVIEW

Risk analysis related to oil and gas projects has not been thoroughly studied [38–40]. There are just a few studies that have focused on risk analysis in this sector of projects. Thus, there is a need for identifying the most important risks and related risk factors [38]. Kalayjian [41] focused on hidden risk which frequently encountered in third world construction projects. He introduced 4 groups of risks that are common in global construction projects: political, financial, weather and design. Shen et.al [42] diagnosed 58 risk factors of construction joint ventures in China and classified them into 6 main clusters: legal, policy and political, legal, financial, management and technical. Chapman [43] recognized and categorized 58 risks into 4 groups: project, environment, industry and client. In a research by [44], it was found that large oil and gas project cost overruns and losses on labor productivity in Canada were due to management deficiency in managing scope, time, cost, quality, productivity, tools, scaffold, equipment, materials, and lack of leadership. Baloi and Price [45] sought to develop a fuzzy decision framework for contractors to handle global risk factors affecting construction cost performance. According to [46], there are 12 reasons that might lead to poor project results, schedule and cost overruns for oil and gas and projects. Zou et.al [47] identified 85 risk factors for construction in China that were prioritized according to their effects on distinctive project objectives in terms of time, quality, environment, cost and safety. In their study "tight project schedule" was recognized to influence all project objectives maximally. Van Thuyet et al [48] assessed 59 major risk factors related to oil and gas projects in Vietnam. Ten of these risks factors are identified as the most critical factors. Lam et.al [49] showed 16 risk factors related to construction projects in terms of contractor capability, contractual and legal, political and societal, economic and physical. Mubin and Mubin [50] diagnosed and analyzed most appropriate risks in Pakistan oil and gas pipeline projects. They identified 40 risk factors categorized in political, socio-economical, organizational, technological, security, natural, and environmental areas. Karim et.al [51] classified 25 risks in Malaysia in five categories such as construction, political, design, financial and environment. Kou and Lou [52] investigated the relative impact of 20 risk factors on the performance of metropolitan construction projects. These risks were divided into 5 categories: design, construction management, social and economy, safety and natural hazard. Aydogan and Kokosal [53] ranked the risks of international construction projects using Analytic Network Processes (ANP). The ANP was selected because they recognized it was the most appropriate tool in constructing the framework of international construction risk factors. In other research by [54], they investigated the risk factors related to engineering, procurement and construction (EPC) contracts for oil and gas projects. They identified 168 risk factors and classified them into 7 groups: financial, human, quality, procurement and contractual, project management, and proposal and engineering. Taylan et.al [55] evaluated a construction project in Saudi Arabia and its overall risk for an uncertain and incomplete situation. They evaluated 30 risk factors and categorized them into 5 key categories: cost, time, quality, environment sustainability and safety. Sixteen risk factors were introduced and recognized as critical risk factors. El-Shehaby et al. [56] evaluated the risk factors related to construction of off-shore oil and gas projects. Fifty-nine risk factors were identified in this research and the top-nine risks were recognized as critical risks. El-karim et.al [57] used Analytical Hierarchy Process (AHP) to assess the risk factors that affect time and cost contingency in construction projects in Egypt. They divided 70 risk factors into 4 criteria (i.e. site condition, resources, project parties, and project features) and 13 sub criteria. Suda et.al [40] reviewed risks and projects risk management for oil and gas industry. They concluded that project risk management yet to be studied extensively, and not much study has been conducted in the oil & gas sector. They also implicated that the oil & gas industry had identified few sources of risks and actually, those risk can be divided into controllable vs. non-controllable risk or hard risk vs. soft risk. Tipili and Ibrahim [58] have jointly determined and analyzed 27 key risk factors affecting public construction project from project stakeholder perspectives (clients, contractors and consultants). This study reveals that these risk factors spread through the whole project life cycle and many risks occur at more than one phase, with the construction stage with risky phase. In a recent research, Khadem et.al [39] studied the recognition, application and quantification of the risks associated in managing oil and gas projects in Oman. They used Monte Carlo simulation as a tool to conduct numerical analysis. In their work, 16 risk factors were identified and analyzed. Mohan [59] used a structured questionnaire to discuss the risk factors affecting the offshore construction projects. In this work, 38 risk factors were identified and combined into 8 major groups relating to their sources. With respect to risk analysis of oil and gas industry in Iran, there are also few studies. Fazlali et.al [60] conducted a survey to analyze major challenges of oil, gas, and petrochemical projects in Iran. They showed that lack of substructures such as strategic risk assessment, documentation, risk evaluation preliminary plan for preferred alternative, and final project risk assessment are the most common issues in all job sites. Moreover, failure in documentation, risk mismanagement, and procurement mismanagement have been indicated as three major challenges which Iranian oil industry faces during the implementation of projects. Dehdasht et.al [38] applied the Decision Making Trial and Evaluation Laboratory (DEMATEL) and ANP, called the DEMATEL-ANP approach, to investigate risk assessment in oil and gas construction projects in Iran. They developed a hierarchical structure of risk factors including 29 factors classified in technical, financial, environmental, design and construction, contractual, and political contexts.

From the literature review, it is revealed that quantification of risk factors is not widely used [39]. This research gap is explored within the scope of the current paper, wherein identification, analysis, and quantification of identified factors are highlighted.

3. METHODOLOGY

The assessment of risk factors is conducted through two main phases, (I) Diagnosing risk factors, and (II) Ranking risk factors; including five stages. In continuation, phases and stages are explained.

Phase I: Diagnosing risk factors: In this phase, risk factors are diagnosed and ranked.

Phase I – Stage I: Establish RMS (Risk Matrix Structure): A good solution to the risk structuring problem would be to adopt a full hierarchical tree. Such a hierarchical structure of risk factors is known as a RBS (Risk Breakdown Structure). RBS is a source-oriented grouping of project risks that organizes and defines the total risk exposure of the project [61]. Following the idea of RBS, a RMS could be structured as a dimensional portray of the risk factors. In this stage, a RMS is made with the use of expertise meetings on the basis of Nominal Group Technique

(NGT).

Phase I – Stage II: Identify risk factors: The experts take part in the NGT meetings to identify risk factors as the sources of risks. The RMS, output of previous stage, would be a good guideline to identify the factors. All meetings participate co-operatively to ensure a complete list of items with common definitions. In this stage, "Documentation review" is applied as a tool to extract risk factors. Some of the documentation and materials that could be used in risk identification as they become available include these [37, 62, 63]:

- Stakeholder strategies; and project goals to achieve these strategies,
- SOW (State Of Work) and WBS (Work Breakdown Structure),
- Project justification and cost-effectiveness (project benefits, present worth, rate of return, etc.),
- Project performance specifications and technical specifications,
- Project plans (financing, cost, time, procurement, execution, etc.),
- Project environmental impact statement,
- Regulations and congressional reports that may affect the project,
- Documents about how the project is viewed by regulators, politicians, and the public sector,
- Historical safety/security performance.

Phase II: Ranking risk factors: The model, to get the initial rank of the identified factors, is shown in Fig. 1. The notion of this model originates in two well-known concepts in project management. The first is Iron Triangle. Graphically, it is a triangle, in which quality, cost, and time are the sides and scope is the area [64]. Subsequently, it has become a method to define and measure project success [1, 65, 66]. This triangle demonstrates that scope, quality, cost and time are interrelated; focusing or fixing one impacts the others. The second idea is based on definition of risk, which declares that risk has a positive or negative effect on at least one of the project objectives [37]. The project objectives are classified as financial, performance, and environmental [67]. According to the model as in Fig. 1, risk factors influence on the project constraints which are scope, quality, cost and time. Next, limitations around the project constraints cause occurring risks and deviation of the project objectives from the target points. For instance, let's consider "Lack of frozen requirements" as a risk factor. Because the needs of the client change, the requirements change. Consequently, the deliverables will never be moved into production because none of the requirements are ever completed. Alternatively, freezing a subset of the functionality and delivering allows of the completion of the deliverables [68]. According to the model, "Lack of frozen requirements" maybe results in the risk of "Scope creep" by a subcontractor. Note that the product scope is the features and functions that characterize the product/service/result of the project. Anyway, scope creep may cause degradation in the operability of the product.

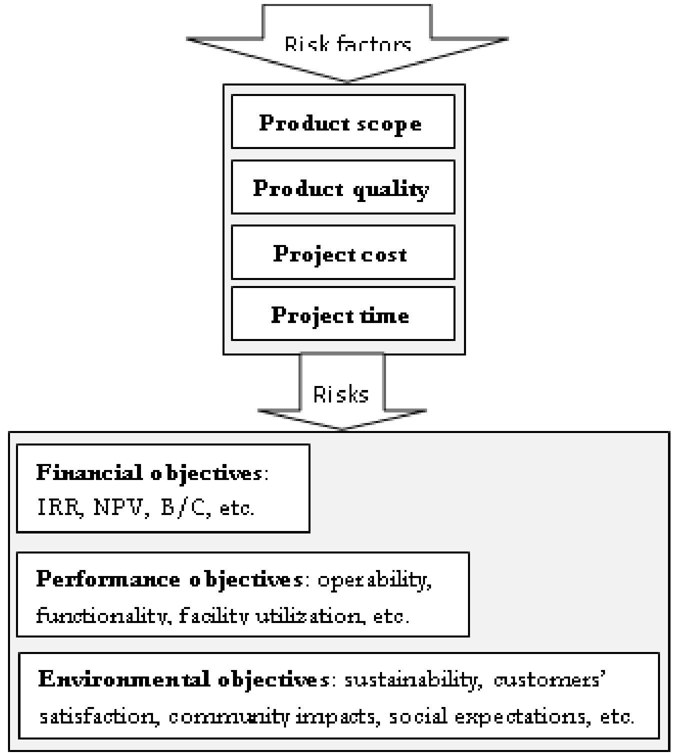

Fig. 1. The model of relations among risk factors, project constraints, and project objectives

Phase II – Stage I – Act I: Assign scores to risk factors: In consideration of the above model, a basis for ranking is a questionnaire to classify risk factors according to their impact size on scope, quality, cost, and time. The scale is Very Low (VL), Low (L), Medium (M), High (H), and Very High (VH). In addition, this questionnaire considers both direct and indirect impacts. Each expert assigns scores to risk factors, taking four project constraints into account: scope, quality, cost, and time.

Phase II – Stage I – Act II: Assign weights to project constraints: For the sake of extracting the weights of constraints, a group Eigen Vector Method (EVM) is used [69]. It should be noted that during the last years, several methods have been proposed in literature to derive the criteria weights. However, each method has its advantages and disadvantages. A heated discussion has arisen over the "best" method. This dispute seems to be futile because experimental studies show that each method is best in at least one criterion, but neither is optimal by all or even most criteria [70, 71]. Notwithstanding, among other methods, EVM method which was originally proposed by Saaty [72], is one of the most popular subjective methods for calculating weights based on preference information of criteria given by the decision-makers [73, 74]. In addition, according to [70] EVM method is an effective and valid method for deriving the priority weights from a pairwise comparison matrix.

In EVM method, first, an individual pair-wise comparison (among scope, quality, cost, and time) is received from each expert. In fact, each expert was asked to submit 6 comparisons ((4(4-1))/2). Then, the test of Consistency Rate (CR) is done for each individual comparison. According to this test, a pair-wise comparison is consistent if $CR < 0.1$. The CR is calculated by Equation (1) in which $\lambda_{max(r)}$ is the biggest solution of $|D_r - \lambda_{(r)} \times I|$, n is 4 (four items: scope, quality, cost, and time), and RI is a fixed Random Index that is 0.9 for n=4 [75]. In the absolute term mentioned above, $D_r isthepair-wisecomparisonmatrixforexpertr, andIistheunitmatrix.Afterthetest, th$ ... 1111).Theag

$$CR = \frac{\lambda_{\max(r)} - n}{(n-1)\times RI} \qquad r = 1, ..., 12 \tag{1}$$

$$(V_{1r} V_{2r} V_{3r} V_{4r}) = \lim_{p\to\infty} \frac{D_r^p \times e}{e^t \times D_r^p \times e} \qquad r = 1, ..., 12 \tag{2}$$

$$V_j = \left(\prod_{r=1}^{r=12} V_{jr} \right)^{1/12} \qquad j = 1, ..., 4 \tag{3}$$

Phase II – Stage II: Calculate weights of risk factors: On the basis of Simple Additive Weighting (SAW) method [76,77], the weight for a given factor i could be calculated as Equation 4. It should be mentioned that SAW method is the best known and most widely used MADM method [78–80]. In addition, because SAW method has a simple and fast computation process than many other methods, it is suggested that it may be more suitable for applying SAW in many situations, with respect to ease of understanding method, ease of employing method, and ease of applying method [78,81,82].

$$W_i = \sum_{j\in\{Scope,Quality,Cost,Time\})} V_j \times \sum_{k\in\{Vl,L,M,H,VH\}} U_k \times N_{ijk} \tag{4}$$

where:
W_j Weight of factor i
V_j Weight of constraint j (jScope,Quality,Cost,Time)
U_k Weight of scale point k (kVl,L,M,H,VH)
N_{ik} The number of responses concerned with factor i, constraint j, and scale point k
Following previous researches, herein, the weights of scale points are considered as 1, 3, 5, 7, and 9 for VL, L, M, H, and VH respectively.

Phase II – Stage III: Rank risk factors: The index to rank risk factors is the calculated weights at the previous stage. A Pareto analysis also could be done to screen the factors and select the top-ten ones.

As abstract, the course of action is shown is Fig. 2.

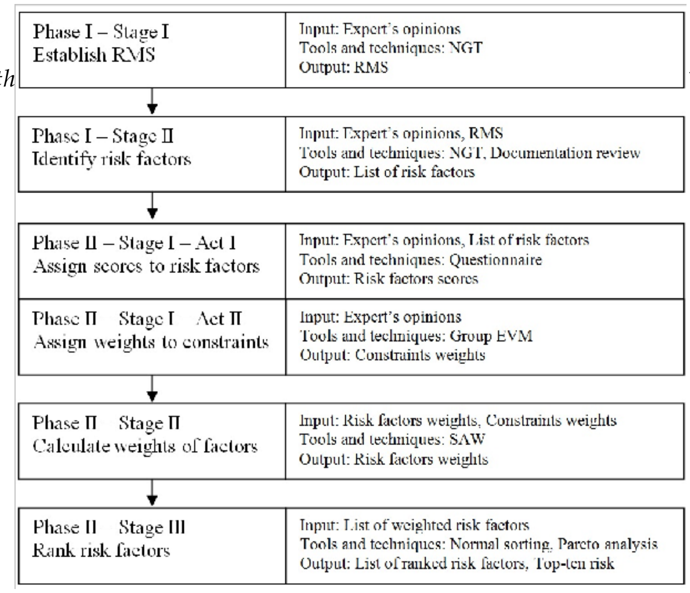

Fig. 2. Description of the process used in this study

4. RESULTS AND DISCUSSION

It should be noted that this research belongs to "Decision-making" environment, not "Statistical" one. According to respective references (e.g., [83–85]) a group of between 5 to 14 experts with different backgrounds has been usually suggested. With regard to the current research, both the above-mentioned phases utilize the opinions of 12 experts. The experts have experiences in industrial engineering, oil engineering, hydrocarbon reservoir engineering, project management, and industrial management. The min/max age of the experts is 27/66 years old. The min/max years' experiences are 8/28. The positions of the professionals in the course of their professional careers are varied; ranging from project engineer to chief executive officer, including program manager and operations manager.

A. Diagnosing risk factors

In the current study, the analysts proposed the risk matrix with two dimensions. The first dimension categorizes risk factors into three branches:

- Project: The internal factors in project; subjects such as team, software, tools, methodologies, etc.
- Company: The first environment around the project. It is the executive project-based organization who undertakes to handle the project, successfully.
- Stakeholders: All parties such as client, consultant, subcontractors, and suppliers.

The items of the second axis are: (1) project foundations, (2) project management/planning, (3) scope/requirements, (4) time/cost/Quality, (5) peoples, (6) communication, and (7) information. Several risk identification NGT meetings have been held to work through the various cells of the RMS, encouraging participants to define issues under each of the cells. Following, the identified risk factors are listed with a numerator as F, and a two-part code. The former part is P, C or S that stands for Project, Company, or Stakeholders respectively. The latter is a number indicating the above mentioned items on the second dimension. For instance, P5 is concerned the people factors related to inside of the project.

- F1:P1: The project not based on a sound business case.
- F2:P1: Strategy volatility of the project.
- F3:P2: Poor or nonexistent project management system in the project.
- F4:P2: Lack of effective project management skills.
- F5:P2: Conduct planning without a view on the project priorities.
- F6:P2: Inadequate/Invalid project assumptions.
- F7:P2: No sign-offs or project tracking methodology.
- F8:P2: Monitoring without quantitative measures.
- F9:P2: No aware system to monitor the overall project status.
- F10:P2: Failure to report/record critical issues.

- F11:P2: Failure to assess the project risks and uncertainties.
- F12:P2: Risk handling options are missing.
- F13:P2: Not managing change properly.
- F14:P3: Bad estimation of SOW.
- F15:P3: Unclear or misunderstood scope by the project team.
- F16:P3: Too changing in scope through the project.
- F17:P3: Lack of frozen requirements.
- F18:P4: Overemphasis of technical specifications in design.
- F19:P4: Designers ignore the requirements of the client.
- F20:P4: Setting the budget, without regard to the scope.
- F21:P4: Unrealistic cost estimation.
- F22:P4: Presence of unrealistic deadlines.
- F23:P4: Conflicting schedule items.
- F24:P5: Presence of inappropriate/wrong skills assigned to the project.
- F25:P5: Lack of sharp and expert peoples in the project leadership.
- F26:P5: Lack of "people skills" in the project leadership.
- F27:P5: Losing the key project team members during the project.
- F28:P5: Improper definition of roles and responsibilities in the project team.
- F29:P6: Lack of communication between project departments.
- F30:P6: Poor team communication.
- F31:P7: Absence of precise/accurate information.
- F32:P7: Lack of management in processing information.
- F33:P7: Misinterpretation of input data to the procurement phase.
- F34:C1: A climate of instability in the company.
- F35:C1: Too changes in the project ownerships or senior management of the company.
- F36:C1: Mismatch between the company culture and required conditions for the project.
- F37:C1: The project is not supported by the company managers.
- F38:C2: Lack of Project Management Office (PMO) in the company.
- F39:C5: Lack of required knowledge/skills in the company.
- F40:C5: Unrecorded human performance in the company.

	Code:	P	C	S
Code:	Areas	Project	Company	Stakeholders
1	Project foundations	●●	●●●●	●●
2	Project management/Planning	●●●●●●●●●●●	●	●●●
3	Scope/Requirements	●●●●		●●
4	Time/Cost/Quality	●●●●●●		
5	Peoples	●●●●●	●●	●●
6	Communication	●●		●●●
7	Information	●●●		

Fig. 3. A RMS plots for the identified risk factors

- F41:S1: Conflict between stakeholder's departments on project the goals.
- F42:S1: The composition of stakeholders changes during the project.
- F43:S2: Failure to identify all influencing stakeholders.
- F44:S2: Lack of stakeholder's commitment to the project.
- F45:S2: Lack of control over consultants, suppliers, or subcontractors.
- F46:S3: Failure to manage client expectations.
- F47:S3: Complexity of client expectations.
- F48:S5: The project stakeholders are unclear as to their roles and responsibilities.
- F49:S5: Lack of appropriate experience of the stakeholders.
- F50:S6: Lack of a common language among stakeholders.
- F51:S6: Lack of cooperation among consultants, suppliers, or subcontractors.
- F52:S6: Failure to receive requirements from the client.

Fig. 3 presents a plot of identified items in the RMS. The preliminary view to this plot shows that the main accumulation area of factors is the column of "Project" and cell P2, specially.

B. Ranking risk factors

As to the above-mentioned process as in Fig. 2, the calculations as in Phase II-Stage II-Act II result in weights: 0.41, 0.25, 0.18, and 0.16 respectively for scope, quality, cost, and time. Details of pairwise comparisons and CR tests as well are presented in Table 2. As shown in this table, due to $CR < 0.1$ in all comparisons; all of comparisons are consistent.

Additionally, according to Phase II-Stage II-Act II, all 12 respondents filled the questioners and gave back them. The results are presented in Table 3. In this table, each cell (in columns scope, quality, cost, and time) indicates the numbers of respondents who select VL, L, M, H, and VH respectively; as the impact of the respective factor on the related column. For example, at row F1 and column Time, "5, 2, 2, 1, 2" shows that 5 experts believe in very low impact of F1 on the project time, and 2 experts believe in low impact of F1 on the project time, and so on.

Last column in Table 3 illustrates the results of Phase II-stage II to derive the factor weights. The final stage is decreasingly sorting the factors according to the last column of Table 3. Top-ten risk factors are as follows, with more than 23 % of the total weights; correspondingly. This is aligned with the famous Pareto principle.

Table 2. Data on EVM method

r	D_r	$\lambda_{max(r)}$	CR	V_{jr}
1	$\begin{vmatrix} 1 & 3 & 4 & 4 \\ 0.33 & 1 & 2 & 2 \\ 0.25 & 0.5 & 1 & 1 \\ 0.25 & 0.5 & 1 & 1 \end{vmatrix}$	4.020	0.007	$\begin{pmatrix} 0.538 \\ 0.220 \\ 0.121 \\ 0.121 \end{pmatrix}$
2	$\begin{vmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{vmatrix}$	4.000	0.000	$\begin{pmatrix} 0.250 \\ 0.250 \\ 0.250 \\ 0.250 \end{pmatrix}$
3	$\begin{bmatrix} 1 & 2.5 & 4 & 2 \\ 0.4 & 1 & 2 & 3 \\ 0.25 & 0.5 & 1 & 1 \\ 0.5 & 0.33 & 1 & 1 \end{bmatrix}$	4.156	0.058	$\begin{pmatrix} 0.462 \\ 0.272 \\ 0.124 \\ 0.142 \end{pmatrix}$
4	$\begin{bmatrix} 1 & 2 & 2 & 1.2 \\ 0.5 & 1 & 0.5 & 1 \\ 0.5 & 2 & 1 & 1 \\ 0.83 & 1 & 1 & 1 \end{bmatrix}$	4.039	0.034	$\begin{pmatrix} 0.357 \\ 0.171 \\ 0.242 \\ 0.230 \end{pmatrix}$
5	$\begin{bmatrix} 1 & 4.3 & 6 & 0.33 \\ 0.24 & 1 & 1 & 2 \\ 0.16 & 1 & 1 & 2.5 \\ 0.30 & 0.5 & 0.4 & 1 \end{bmatrix}$	4.216	0.080	$\begin{pmatrix} 0.592 \\ 0.153 \\ 0.155 \\ 0.100 \end{pmatrix}$
6	$\begin{bmatrix} 1 & 2 & 6 & 2 \\ 0.5 & 1 & 3 & 1 \\ 0.16 & 0.33 & 1 & 0.5 \\ 0.5 & 1 & 1 & 1 \end{bmatrix}$	4.020	0.007	$\begin{pmatrix} 0.467 \\ 0.234 \\ 0.086 \\ 0.213 \end{pmatrix}$
7	$\begin{bmatrix} 1 & 6 & 3 & 2 \\ 0.16 & 1 & 2 & 0.5 \\ 0.33 & 0.5 & 1 & 0.5 \\ 0.5 & 2 & 2 & 1 \end{bmatrix}$	4.170	0.063	$\begin{pmatrix} 0.514 \\ 0.135 \\ 0.113 \\ 0.238 \end{pmatrix}$
8	$\begin{bmatrix} 1 & 1 & 2 & 2 \\ 1 & 1 & 2 & 2 \\ 0.5 & 0.5 & 1 & 1 \\ 0.5 & 0.5 & 1 & 1 \end{bmatrix}$	4.000	0.000	$\begin{pmatrix} 0.333 \\ 0.333 \\ 0.167 \\ 0.167 \end{pmatrix}$
9	$\begin{bmatrix} 1 & 1 & 3 & 3 \\ 1 & 1 & 3 & 2 \\ 0.33 & 0.33 & 1 & 3 \\ 0.33 & 0.5 & 0.33 & 1 \end{bmatrix}$	4.235	0.087	$\begin{pmatrix} 0.370 \\ 0.345 \\ 0.175 \\ 0.110 \end{pmatrix}$
10	$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 3 \\ 1 & 1 & 1 & 3 \\ 1 & 0.33 & 0.33 & 1 \end{bmatrix}$	4.154	0.057	$\begin{pmatrix} 0.241 \\ 0.309 \\ 0.309 \\ 0.141 \end{pmatrix}$
11	$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 2 \\ 1 & 1 & 1 & 1 \\ 1 & 0.5 & 1 & 1 \end{bmatrix}$	4.060	0.022	$\begin{pmatrix} 0.246 \\ 0.298 \\ 0.246 \\ 0.210 \end{pmatrix}$
12	$\begin{bmatrix} 1 & 2 & 3.5 & 8.5 \\ 0.5 & 1 & 2 & 4 \\ 0.28 & 0.5 & 1 & 3 \\ 0.11 & 0.25 & 0.33 & 1 \end{bmatrix}$	4.014	0.005	$\begin{pmatrix} 0.521 \\ 0.267 \\ 0.153 \\ 0.059 \end{pmatrix}$

Table 3. The number of responses concerning VL, L, M, H, and VH, for the impact size of factors

Factor	Scope	Quality	Cost	Time	Weight
F1	4,3,2,3,0	1,2,3,0,6	1,3,2,2,4	5,2,2,1,2	0.5278
F2	0,3,1,2,6	0,3,3,3,3	0,2,6,4,0	1,0,4,0,7	0.7091
F3	0,1,1,5,5	0,1,1,2,8	0,0,1,3,8	0,0,0,3,9	0.8661
F4	0,0,2,5,5	0,6,5,1,0	1,1,3,4,3	0,0,3,4,5	0.7111
F5	1,0,1,4,6	2,2,1,0,7	1,3,0,6,2	1,2,1,1,7	0.7481
F6	1,1,1,3,6	1,3,3,1,4	1,2,0,4,5	1,1,1,0,9	0.7430
F7	4,1,1,4,2	0,2,8,1,1	3,1,0,7,1	3,2,1,0,6	0.5711
F8	3,3,0,3,3	0,2,2,7,1	3,4,1,2,2	4,0,3,3,2	0.5717
F9	6,2,2,1,1	0,0,5,1,6	8,1,1,2,0	7,1,0,0,4	0.4615
F10	1,5,3,3,0	1,3,1,6,1	2,0,5,5,0	6,3,2,0,1	0.5039
F11	3,0,4,2,3	3,7,1,1,0	2,0,0,7,3	1,1,1,4,5	0.5778
F12	3,2,2,1,4	3,7,0,2,0	2,0,2,7,1	1,0,2,3,6	0.5674
F13	1,4,2,0,5	0,2,1,4,5	3,0,7,0,2	8,0,0,1,3	0.6081
F14	0,0,2,1,9	0,0,0,7,5	0,3,4,1,4	0,0,9,0,3	0.8163
F15	0,2,2,5,3	0,1,2,7,2	5,1,6,0,0	0,0,2,4,6	0.6809
F16	0,2,5,4,1	0,0,3,3,6	0,3,4,5,0	0,8,0,2,2	0.6561
F17	0,1,1,1,9	0,1,1,2,8	3,2,3,2,2	0,6,2,0,4	0.7702
F18	0,3,2,2,5	0,0,0,3,9	1,1,1,4,5	5,1,0,4,2	0.7489
F19	0,3,3,5,1	0,0,4,2,6	0,0,9,3,0	3,3,2,0,4	0.6578
F20	1,2,5,3,1	4,6,2,0,0	0,0,6,1,5	0,0,4,0,8	0.5824
F21	3,2,2,1,4	3,3,3,1,2	0,2,0,2,8	3,2,2,4,1	0.5920
F22	8,3,0,0,1	1,5,1,3,2	1,5,2,3,1	0,0,0,9,3	0.4643
F23	3,2,4,2,1	0,0,3,8,1	3,3,3,2,1	0,2,2,2,6	0.5904
F24	2,4,2,0,4	1,1,2,3,5	1,2,5,1,3	0,0,8,2,2	0.6296
F25	3,2,4,0,3	0,5,1,6,0	3,0,3,3,3	2,1,7,1,1	0.5491
F26	1,2,1,6,2	0,2,1,3,6	2,0,3,4,3	0,0,2,6,4	0.7228
F27	4,2,2,2,2	0,0,5,3,4	1,0,9,2,0	0,0,0,9,3	0.6206
F28	5,1,3,3,0	0,0,9,3,0	2,3,1,2,4	0,0,3,8,1	0.5483
F29	6,1,3,2,0	1,2,1,2,6	0,0,7,4,1	2,2,2,2,4	0.5502
F30	0,2,2,7,1	5,5,2,0,0	0,4,7,0,1	2,8,1,0,1	0.5030
F31	1,1,4,4,2	0,0,2,4,6	2,1,1,3,5	2,1,1,4,4	0.7150
F32	2,3,3,0,4	1,0,2,6,3	4,4,2,2,0	5,0,3,2,2	0.5643
F33	6,4,2,0,0	5,2,3,2,0	0,8,0,3,1	8,0,2,2,0	0.3363
F34	1,6,2,2,1	0,0,6,0,6	0,0,0,9,3	3,6,0,1,2	0.6100
F35	4,4,4,0,0	3,1,3,0,5	1,1,3,1,6	0,0,5,6,1	0.5354
F36	2,4,4,2,0	0,0,3,5,4	1,6,0,1,4	0,0,9,0,3	0.5913
F37	4,0,5,2,1	1,0,5,5,1	2,2,3,2,3	0,0,7,0,5	0.5846
F38	3,2,0,7,0	1,1,3,7,0	3,3,3,3,0	3,1,4,0,4	0.5494
F39	1,5,1,5,0	5,3,2,2,0	4,4,1,1,2	0,0,2,3,7	0.5165
F40	3,2,6,1,0	2,0,2,1,7	1,5,6,0,0	0,7,0,0,5	0.5389

Factor	Scope	Quality	Cost	Time	Weight
F41	0,5,3,3,1	1,2,2,0,7	0,2,2,0,8	2,4,3,1,2	0.6396
F42	1,6,0,2,3	0,1,2,9,0	1,1,8,1,1	4,1,2,2,3	0.5896
F43	0,7,5,0,0	2,2,1,3,4	1,1,0,8,2	0,0,8,2,2	0.5733
F44	3,1,3,1,4	5,4,0,3,0	2,2,2,0,6	4,3,0,0,5	0.5369
F45	1,2,5,2,2	3,2,6,1,0	7,2,2,1,0	8,0,0,0,4	0.4646
F46	0,1,1,9,1	0,2,2,3,5	0,4,6,0,2	1,6,4,0,1	0.6646
F47	0,1,1,5,5	1,4,4,3,0	0,0,2,6,4	2,0,7,3,0	0.6917
F48	2,5,3,2,0	2,3,3,3,1	0,0,0,8,4	2,3,0,5,2	0.5524
F49	2,4,2,4,0	0,4,3,3,2	0,1,9,1,1	0,0,6,6,0	0.5635
F50	0,3,1,7,1	2,2,1,6,1	1,5,1,2,3	3,0,1,3,5	0.6344
F51	0,0,2,7,3	0,3,3,3,3	2,0,1,1,8	0,0,0,9,3	0.7698
F52	0,0,1,4,7	0,0,2,3,7	4,2,2,2,2	4,4,2,2,0	0.7280

- Poor or nonexistent project management system in the project.
- Bad estimation of SOW.
- Lack of frozen requirements.
- Lack of cooperation among consultants, suppliers, or subcontractors.
- Overemphasis of technical specifications in design.
- Conduct planning without a view on the project priorities.
- Inadequate/Invalid project assumptions.
- Failure to receive requirements from the client.
- Lack of “people skills” in the project leadership.
- Absence of precise/accurate information.

5. CONCLUSIONS

The current work underlined a research study of how risk factors can be assessed using a group decision-making procedure. The study was conducted by two phases, (I) Diagnosing risk factors, and (II) Ranking risk factors. The core data were obtained through expert’s elicitation in several NGT meetings, and also by means of a questionnaire. The techniques of EVM and SAW were also used to determine the relevant weights. The used process appeared to be the good performance. Fifty two risk factors were identified and categorized in a two-dimensional matrix. The matrix showed internal area (i.e. project) is most important than external areas (i.e. company and stakeholders). Evaluation of risk factors leaded to a list of top-ten factors. Table 4 compares the results of the current research with the outcomes of other similar cases.

It could be concluded that outcomes of various studies are different, depends on country, extent of industry cluster, group of involved experts, or even time period. Thereby, for application of the results of the current study, the user should pay attention to the facts of the current study that are: data were collected in 2017 in Iran, and in a gas injection project.

As the future researches, the recommendations are: (I) Application of other tools to extract risk factors. Among others Pondering method, Assumption analysis, Summary risk register, Prompt list, and so on; (II) Conducting a post analysis to evaluate interactions among top-ten risk factors, with the use of techniques such as ISM, DEMATEL, Cognitive-map and so on; and (III) Providing comprehensive responses to handle the identified risk factors in future projects.

Table 4. Comparing the results of this research with other respective investigations

Reference	Methods	Country	Diagnosed key risk factors
The current study ;	EVM-SAW, Documentation review, NGT meetings, Questionnaire	Iran	Poor or nonexistent project management system in the project; Bad estimation of SOW Lack of frozen requirements; Lack of cooperation among consultants, suppliers, or subcontractors; Overemphasis of technical specifications in design; Conduct planning without a view on the project priorities; Inadequate/Invalid project assumptions; Failure to receive requirements from the client; Lack of "people skills" in the project leadership; & Absence of precise/accurate information.
[38]	DEMATEL-ANP, Interview	Iran	Lack of financial allocation for the project; Errors in design drawings; Delay in auditing and payment of contractor's provisional monthly statements; &Poor quality of procured materials or materials shortage.
[59]	Questionnaire, Risk allocation matrix, Pareto analysis.	Global	Size of the project; Climatic nature of the area; Insufficient data collection for design; Use of management and planning tools; Inefficient training of human resources; Lack of leadership quality and monitoring; Chances of project manager quitting the project; Selection of faulty materials; Equipment breakdown; Labour shortage /strike; No formal training; Unfavorable economic fluctuations; Unfavorable political environment; &Time limitations.
[39]	Interview , Monte Carlo simulation	Oman	Unauthorized deviation from vendor; Late provision of vendor data; Late placement of the purchase orders; Late arrival of materials on site due to poor vendor performance or quality failures; &Complex interfaces within package vendors.
[58]	Literature review, Questionnaire.	Nigeria	Quality problems; Problems of licenses; Inadequate cash flow; Insufficient detailing; Inadequate program schedule; Incorrect contract time estimates; War and civil disorders; Underestimation of direct cost; &Environmental impact of the project.
[57]	Literature review, Consulting experts, Questionnaire, AHP	Egypt	Delay in permits and licenses; Differing site conditions; Drop in labor productivity; Equipment malfunctions; Material theft & damage; Design error: Defective work; Rework; Fluctuation in price; Invoices delay; Change in currency rate; Wars and revolutions; Changes in laws and regulations; Earthquake; Precipitation/Flood; Unpredicted weather conditions; &Pollution.
[56]	Documentation reviews, Checklist analysis, Assumptions analysis, Risk register	Global	Weather effect on the project; Increase in material price; Currency fluctuation (foreign exchange rate); Delay of tender offer evaluation and purchase order cycle; Project duration (schedule is too short for the required activities; Client delay in making decision or delay in approval of contractor's submittals; Delay in performing inspection &testing by the consultant; Conflict between the contractor and the consultant; &Commitment to the schedule delay due to contactor.
[55]	Consultant experts, Interview, Questionnaire, Relative Importance Index (RII), Fuzzy AHP, Fuzzy Topsis.	Saudi Arabia	Delay due to excessive approval procedures; Lack of professional pre-planning studies for project by other participants; Too tight project schedule due to loose planning practices; Schedule delays due to delays payments; Delays due to lack of coordination between project participants; Excessive delays due to late decision making by project participants; High cost due to unfair or unprofessional bidding practices; Delays due to solving legal disputes between participants; Appointment frequency of an unqualified project part icipant; &Poor information flow between project participants.
[86]	Literature review, Assumption analysis .	Global	Poor estimates of time and cost; Lack of a clear specification of project requirements; Ambiguous guidelines about managerial processes; &Lack of knowledge of the number and types of factors influencing the project.
[53]	Literature review, Consulting experts, Interview, Questionnaire, ANP	Global	Problems relevant to: Political stability; Socio-economic stability; Force majeure; Inflation; Government policy to construction sector and the strength of the legal system.
[54]	Questionnaire	Pakistan	Issues related to: Cost; Time; Average of critical time and cost risk value; Engineering; Proposal; Project management; Procurement and contractual; Quality, health & safety; Human recourse; &Finance and audit.
[51]	Literature review, Questionnaire	Malaysia	Shortage of material; Late deliveries of material: Insufficient technology; Poor quality of workmanship; &Cash flow difficulties.
[60]	Literature review, Interview, Questionnaire,	Iran	Weakness of the project scope definitions; Poor cost estimation; Absence of an educational system; &Lack of contractual knowledge.
[50]	Information collection, Documentation review, Assumption analysis, Checklist analysis	Pakistan	Change in economic parameters; Unexpended weather condition; Precipitation wind storms; Financial delays; Strains in contractual relationships; Flood ; Request for increase in project budget; Insufficient specialist and engineers; Slow communication between team members; &Loss of human life.
[47]	Literature review, onsulting experts, Interview, Questionnaire	China	Tight project schedule; Design variations; Excessive approval procedures in administrative government departments; High performance/quality expectation; Inadequate program scheduling; Unsuitable construction program planning; Variations of construction programs; Low management competency of subcontractors; Variations by the client; &Incomplete approval and other documents.
[49]	Literature review, Consulting experts, Interview, Questionnaire	Global	Change in law; Unstable government; Project approval and permit; Improper design; Insolvency of subcontractors; Quality issues; Site safety; Availability of Labour/materials; Ground conditions; Site availability; Construction/design changes; Labour disputes and strikes; Excessive contract variation; Third party tort liability; Inflation; & Weather conditions.
[48]	Checklist analysis, Interview, Questionnaire	Vietnam	Bureaucratic government system and long; Project approval procedure; Poor design; Incompetence of project team; Inadequate tendering; Late internal approval process from the owner; Inadequate project organization structure; Improper project feasibility study; Inefficient and poor performance of constructors; Improper project planning and budgeting; &Design changes.
[46]	Literature review, Questionnaire	Canada	Lack of experienced owner and contractor sources; Overall quality of owner and contractor management capabilities; &Ineffective organizational and alliance structures for mega projects.
[87]	Literature review	Palestine	Employer or government delay; Lack of information from the employer; Difficulty of instructions; Conflict of interest &Variation to changes.
[44]	Literature review, Consulting experts.	Canada	Deficiencies in managing in Scope; Time; Cost; Quality; Productivity; Tools; Scaffold; Equipment; Materials; &Lack of leadership.
[42]	Past experience, Interview, Questionnaire.	China	Cost increase due to changes of policies; Improper project feasibility study; Project delay; Inadequate forecast about market demand; Improper selection of project location; Increase of resettlement costs; Inadequate choice of project partner; Loss due to bureaucracy of late approvals; &Design changes.
[41]	Interview	the Third World	Issues respective to: Site safety; on-site cash reserves; Coding of labor costs and activities; Procurement of materials and equipment; Modes of communication; Travel; Medical and health issues; Site security; &Language and cultural barriers.

REFERENCES

1. Seyedhoseini S.M., Noori S., and Hatefi M.A., (2009), An integrated methodology for assessment and selection of the project risk response actions, Risk Analysis: an International Journal, 29(5): 752-763.

2. Kontio, J., (2001), Software Engineering Risk Management: A Method, Improvement Framework and Empirical Evaluation, Ph.D. Dissertation, Helsinki University of Technology, Helsinki, Finland.

3. ICE (Institution of Civil Engineers), FOA (Faculty of Actuaries), and IOA (Institute of Actuaries), (2014), Risk Analysis and Management for Projects (RAMP), 3rd edition, Thomas Telford, London, UK.

4. Chapman, C.B., and Ward, S.C., (2003), Project Risk Management: Processes, Techniques and Insights, 2nd edition, John Wiley, Chichester, UK.

5. Hillson, D., and Simon, P., (2007), Practical Project Risk Management: The ATOM Methodology, Vienna, Virginia, Management Concepts, 2007.

6. Chapman, C.B., (1979), Large Engineering Project Risk Analysis, IEEE Transactions on Engineering Management, 26(3): 78-86.

7. Al-Bahar, J.F., and Crandall, K.C., (1990), CRMS: Systematic Risk Management Approach for Construction Projects, Journal of Construction Engineering and Management, 116(3): 533-546.

8. UK MOD (United Kingdom Ministry of Defense), (1991), Risk Management in Defense Procurement, Document Reference D/DPP (PM)/2/1/12, Directorate of Procurement Policy (Project Management), Whitehall, London, UK.

9. Carter, B., Hanock, T., Morin, J.M., and Robins, N., (1994), Introducing RISKMAN Methodology: The European Project Risk Management Methodology, NCC Blackwell Ltd, Oxford, UK.

10. IETC (International Electro Technical Commission), (1995), Dependability Management, Part 3: Application guide Section 9, Risk analysis of technological systems, Geneva, Italy.

11. HSSSO (Honeywell's Space and Strategic Systems Operation), (1995), Risk and Opportunity Management Process Improvement Team (ROMPIT), Technical report.

12. ADAS (Australian Department of Administrative Services), (1996), Managing Risks in Procurement, Australian Government Publishing Services, Canberra, Australia.

13. Meli, R., (1998), SAFE: A Method To Understand, Reduce, and Accept Project Risk, ECOMENCRESS 98, Project Control for 2000 and Beyond, Rome, Italy.

14. Klein, J.H., and Cork, R.B., (1998), An Approach to Technical Risk Assessment, International Journal of Project Management, 16(6): 345-351.

15. CII (Construction Industry Institute), (1988), Risk Management in Capital Projects, CII Source Document 41, Austin, TX, USA.

16. ICAEW (Institute of Chartered Accountants in England and Wales), (1999), Internal Control: Guidance for Directors on the Combined Code, Turn bill Report, London, UK.

17. Rosenberg, L., Gallo, A., and Parolek, F., (1999), Continuous Risk Management (CRM): Structure of Functions at NASA, American Institute of Aeronautics and Astronautics, NY, USA.

18. WTO (World Trade Organization), (1999), Community Emergency Preparedness: A Manual for Managers and Policy-makers, Malta, Hong Kong.

19. US DOT (United States Department of Transport), (2000), Project Management in the DoT, Retrieved: from http://www.fta.dot.gov.

20. CCPS (Center for Chemical Process Safety), (2000), Guidelines for Chemical Process Quantitative Risk Analysis, 2nd edition, American Institute of Chemical Engineers (AICE), Wiley, NY, USA.

21. SEI (Software Engineering Institute), (2001), CMMI: Capability Maturity Model Integration, Ver. 1.1, Carnegie Mellon University, Pittsburgh, PA, USA.

22. Bea, R., (2001), Human and Organizational Factors: Risk Assessment and Management (RAM) in Engineering Systems, CEE-Berkeley, CA, USA.

23. US DOD (United States Department of Defense), DAU (Defense Acquisition University), and DSMC (Defense Systems Management College), (2001), Risk Management Guide for DoD Acquisition, Virginia, USA.

24. Del Cano, A. and De La Cruz, M.P., (2002), Integrated Methodology for Project Risk Management, Journal of Construction Engineering and Management, 128(6): 473-485.

25. CSA (Canadian Standard Association), (2002), Risk Management: Guidelines for Decision Makers: CAN/CSA-Q850-97, National Standards of Canada, Ontario, Canada.

26. Haimes, Y.Y., Kaplan, S., and Lambert, J.H., (2002), Risk Filtering, Ranking, and Management Framework Using Hierarchical Holographic Modeling, Risk Analysis, 22(2): 383-397.

27. UK AIRMIC (United Kingdom Association of Insurance and Risk Managers), ALARM (Association of Local Authority Risk Managers), and IRM (Institute of Risk Management), (2002), Risk Management Standard: AIRMIC/ALARM/IRM, London, UK.

28. MO-CDEM (Ministry of Civil Defense and Emergency Management), (2002), Working Together: Developing a CDEM Group Plan, New Zealand.

29. Simon, P., Hillson, D., Newland, K., (2004), PRAM Project Risk Analysis and Management Guide, The Association for Project Management, High Wycombe, UK.

30. Pipattanapiwong, J., (2004), Development of Multi-Party Risk and Uncertainty Management Process for an Infrastructure Project, Ph.D. Dissertation, Kochi University of Technology, Kochi, Japan.

31. Swabey, M., (2004), Project Risk Management, An Invaluable Weapon in any Project Manager's Armory, White Paper, Aspen Enterprises Ltd, USA.

32. ANZS (Australia and New Zealand Standards), (2004), AS/NZS 4360:2004: Risk Management, Sydney, NSW.

33. Seyedhoseini, S.M., Hatefi, M.A., (2009), Two-pillar risk management (TPRM): A Generic Project Risk Management Process, Journal of Scientica Iranica, 16(2): 138-148.

34. ISO (International Organization for Standardization), (2009), ISO 31000:2009, Risk management Principles and guidelines.

35. UK OGC (United Kingdom Office of Government Commerce), (2010), Management of Risk (M_{OR}): Guide for Practitioners, 3rd edition, London, UK.

36. BSI (British Standards Institute), (2010), British Standard BS 6079-1:2010, Project management: Principles and guidelines for the management of projects, London, UK.

37. PMI (Project Management Institute), (2013), A Guide to the Project Management Body of Knowledge (PMBoK guide), Newtown Square, PA, USA.

38. Dehdasht, G., Mohamad Zin, R., Ferwati, M.S., Abdullahi, M.M., Keyvanfar, A., and McCaffer, R., (2017), DEMATEL-ANP Risk Assessment in Oil and Gas Construction Projects, Sustainability, 9(1420): 2-24.

39. Khadem, M.M.R.K., Piya, S., and Shamsuzzoha, A., (2017), Quantitative risk management in gas injection project: a case study from Oman oil and gas industry, Journal of Industrial Engineering International, https://doi.org/10.1007/s40092-017-0237-3.

40. Suda, K.A., Abdul-Rani, A.S., Abdul-Rahman, H., Chen, W., (2015), A Review on Risks and Project Risks Management: Oil and Gas Industry, International Journal of Scientific & Engineering Research, 6(8):938-943.

41. Kalayjian, W.H., (2000), Hidden Risks of Construction in the Third World, Proceedings of the Construction Congress VI: Building Together for a Better Tomorrow in an Increasingly Complex World, Orlando, FL, USA, 20–22 February, 1126–1135.

42. Shen, L., Wu, G.W., Ng, C.S., (2001), Risk assessment for construction joint ventures in China, Journal of Construction Engineering and Management, 127: 76–81.

43. Chapman, R.J., (2001), The controlling influences on effective risk identification and assessment for construction design management, International Journal of Project Management, 19: 147–160.

44. McTague, B., and Jergeas, G., (2002), Productivity Improvement on Alberta Major Construction Projects, Calgary, Alberta Economic Development.

45. Baloi, D., and Price, A.D., (2003), Modelling global risk factors affecting construction cost performance, International Journal of Project Management, 21: 261–269.

46. Elliot, B.G., (2005), Project Historical Databases for the Canadian Oil sands, AACE International Transactions, EST.02, Pages: 1-5.

47. Zou, P.X., Zhang, G., and Wang, J., (2007), Understanding the key risks in construction projects in China, International Journal of Project Management, 25: 601–614.

48. Van Thuyet, N., Ogunlana, S.O., and Dey, P.K., (2007), Risk management in oil and gas projects in Vietnam, International Journal of Energy Sector Management, 1: 175–194.

49. Lam, K.C., Wang, D., Lee, P.T., and Tsang, Y.T., (2007), Modelling risk allocation decision in construction contracts, International Journal of Project Management, 25: 485–493.

50. Mubin, S., and Mubin, G., (2008), Risk Analysis for Construction and Operation of Gas Pipeline Projects in Pakistan, Pakistan Journal of Engineering and Applied Science, 2(1): 22-37.

51. Karim, N.A.A., Rahman, I.A., Memmon, A.H., Jamil, N., and Azis, A.A.A., (2012), Significant risk factors in construction projects: Contractor's perception, Proceedings of the IEEE Colloquium on Humanities, Science and Engineering (CHUSER), Kota Kinabalu, Malaysia, 3–4 December, 347–350.

52. Kuo, Y.C., and Lu, S.T., (2013), Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects, International Journal of Project Management, 31: 602–614.

53. Aydogan, G., and Koksal, A., (2013), An analysis of international construction risk factors on partner selection by applying ANP approach, ICCREM 2013, Construction and Operation in the Context of Sustainability, Proceedings of the International Conference on Construction and Real Estate Management, Karlsruhe, Germany, 10–11 October; American Society of Civil Engineers: Reston, VA, USA, 658–669.

54. Mubin, S., and Mannan, A., (2013), Innovative Approach to Risk Analysis and Management of Oil and Gas Sector EPC Contracts from a Contractor's Perspective, Journal of Business Economics, 5(2): 149-170.

55. Taylan, O., Bafail, A.O., Abdulaal, R.M., and Kabli, M.R., (2014), Construction projects selection and risk assessment by fuzzy AHP and fuzzy TOPSIS methodologies, Applied Soft Computing, 17: 105–116.

56. El-Shehaby, M., Nosair, I., and Sanad, A.E.M., (2014), Risk assessment and analysis for the construction of off shore oil & gas projects, International Journal of Scientific Research and Education, 2(2): 317-333.

57. El-karim, M.S.B.A.A., El-Nawawy, O.A.M., and Abdel-Alim, A.M., (2015), Identification and assessment of risk factors affecting construction projects, Housing and Building National Research Center, 13: 202-216.

58. Tipili, L.G., and Yakubu, I., (2016), Identification and assessment of key risk factors affecting public construction projects in Nigeria: stakeholders' perspectives, International Journal of Engineering and Advanced Technology Studies, 4(2): 20-32.

59. Mohan, A., (2017), Risk Management in Offshore Construction, International Journal of Engineering Technology Science and Research, 4(10): 1163-1171.

60. Fazlali M., Ebrahimi, S., and Hosseini, S.J., (2011), Analysis of Major Challenges to the Implementation of Oil, Gas, and Petrochemical Projects in Iran, International Conference on E-business, Management and Economics, IACSIT Press, Singapore.

61. Hillson D.A., (2002), The Risk Breakdown Structure (RBS) as an aid to Effective Risk Management, Presented at the Fifth European Project Management Conference, PMI Europe, Cannes, France.

62. US DOE (United States Department of Energy), (2005), The Owner's Role in Project Risk Management, National Academy of Sciences, United States of America, NY, USA.

63. Kerzner, H., (2017), Project Management: A Systems Approach to Planning, Scheduling, and Controlling, 12th edition, John Wiley & Sons, Hoboken, New Jersey, USA.

64. Lewis, J.P., (2007), Fundamentals of Project Management, 3rd edition, AMACOM, New York, USA.

65. Schade, C., (2016), Disciples of the Iron Triangle: Other People's Guide to Projects and Project Managers, Book-baby publisher.

66. Atkinson, R., (1999), Project management: cost, time and quality, two best guesses and a phenomenon, it's time to accept other success criteria, international Journal of Project Management, 17(6): 337-342.

67. Jaafari, A., Doloi, H.K., and Gunaratnam, D., (2004), Life cycle project management: a platform for strategic management. Paper presented at PMI® Research Conference: Innovations, London, England. Newtown Square, PA: Project Management Institute.

68. Othman, A.E, Hassan, T.M and Pasquire, C.L., (2005), Analysis of Factors that Drive Brief Development in Construction", Engineering, Construction and Architectural Management, 12(1): 69-87.

69. Groselj, P., Stirn, L.Z., Ayrilmis, N. and Kuzman, M.K. (2015) 'Comparison of some aggregation techniques using group analytic hierarchy process', Expert Systems with Applications, Vol. 42, pp.2198–2204.

70. Zhang, F., Ignatius, J., Lim, C.P., and Zhao, Y. (2014), New method for deriving priority weights by extracting consistent numerical-valued matrices from interval-valued fuzzy judgment matrix, Information Sciences, 279: 280-300.

71. Budescu, D.V., Zwick, R., and Rapoport, A., (1986), A Comparison of the Eigenvalue Method and The Geometric Mean Procedure for Ratio Scaling, Applied Psychological Measurement, 10(1): 69-78.

72. Saaty, T.L., (1977), A scaling method for priorities in hierarchical structures, Journal of Mathematical Psychology, 15(1): 234-281.

73. Pirdavani, A., Brijs, T., and Wets, G., (2010), A multiple criteria decision-making approach for prioritizing accident hotspots in the absence of crash data, Transport Reviews, 30(1): 97-113.

74. Wang, Y.M., Parkan, C., and Luo, Y., (2007), Priority estimation in the AHP through maximization of correlation coefficient, 31: 2711-2718.

75. Saaty, T.L. and Vargas, L.G. (2012) Models, Methods, Concepts & Applications of the Analytic Hierarchy Process (International Series in Operations Research & Management Science), 2nd Ed., Springer Science & Business Media.

76. Churchman, C.W. and R.L. Ackoff, (1954), An approximate measure of value, Operations Research, 2(2): 172-187.

77. Hwang, C.L., and Yoon, K., (1981), Multiple Attribute Decision Making-Methods and Applications, A State of the Art Survey, Springer Verlag, Berlin, Heidelberg, New York.

78. Chen, T.Y., (2012), Comparative analysis of SAW and TOPSIS based on interval-valued fuzzy sets: Discussions on score functions and weight constraints, Expert Systems with Applications, 39: 1848-1861.

79. Alinezhad, A., Sarrafha, K., and Amini, A., (2014), Sensitivity Analysis of SAW Technique: the Impact of Changing the Decision Making Matrix Elements on the Final Ranking of Alternatives, Iranian Journal of Operations Research, 5(1): 82-94.

80. Anupama, K.S.S., Gowri, B.P.R., and Rajesh, P., (2015), Application of MADM algorithms to network selection, International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, 3(6): 64-67.

81. Podvezko, V., (2011), The Comparative Analysis of MCDA Methods SAW and COPRAS, Inzinerine Ekonomika-Engineering Economics, 22(2): 134-146.

82. Karlitasari, L., Suhartini, D., and Benny, A, (2017), Comparison of simple additive weighting (SAW) and composite performance index (CPI) methods in employee remuneration determination, IOP Conf. Series: Materials Science and Engineering, 166-012020.

83. McConnell, S., (2006), Software Estimation: Demystifying the Black Art (Developer Best Practices), Microsoft press

84. Cooke, R.M. and Probst, K.N., (2006), Highlights of the Expert Judgment Policy Symposium and Technical Workshop, Resources for the Future, Washington, DC.

85. Morgan, M.G., (2014), The Use (and Abuse) of Expert Elicitation in Support of Decision Making for Public Policy, Proceedings of the National Academy of Sciences, 111(20): 7176-7184.

86. Badiru, A.B., and Osisanya, S.O., (2013), Project Management for the Oil and Gas Industry: A World System Approach, CRC Press, Taylor & Francis Group, New York.

87. Enshassi, I., Lisk, A., Sawalhi, R., and Radwan, I., (2003), Contributors to construction delays in Palestine, Journal of American Institute of Constructors, 27(2): 45–53.