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Risk Management in The Oil Sector / Oil Exploration Company as A Case Study

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Abstract

This paper aims to propose a decision tool that helps estimate the risk probability in the petroleum sector in Iraq, which has many benefits for identifying the most important factor. This model was developed by using the relative importance index (RII) method incorporated into fuzzy Logic. An extensive literature review was conducted, and a questionnaire was distributed to the private and government sectors to scan all possible risks in the petroleum sector. As a result, forty–eight risks in the petroleum sector were identified and categorized into four groups: operational risks, financial and administrative risks, economic and political risks, and potential risks. Over 170 questionnaire forms have been distributed to engineers, managers, experts, and technicians, and 153 forms have been adopted for the analysis. The SPSS software was used to execute the statistical analysis concerning statical mean and relative important index. Also, the questionnaire results were analyzed using the relative importance index. The ranking of the groups and factors was demonstrated according to their level of effect on risk. Finally, a fuzzy assessment model was constructed and tested being appropriate to identify the probability of risk in the Iraqi petroleum sector to assess and estimate risk. Oil exploration company, one of the associations of the ministry of oil in Iraq, has been taken as a case study of this research to determine the risks and validate the model. This paper will seek the best solution to eliminate or minimized risks in the Iraqi patrolmen sector, especially at the Iraq oil exploration company as it has been taken as a case study. Three types of risk solutions were tested and optimized and those solutions are the avoid, the mitigate, and the transfer of the risks. The ANP mothed was used to determine the priority or the effectiveness of each type of solution to find the best alternative option for each risk factor. The result shows that the best way to deal with oil and gas risks in the Iraq petroleum sector is to avoid these risks. Because the solutions belonging to this group have an effective value of 65.4 %. The other two groups of mitigation and transfer have less effectiveness of 19.8 % and 14.8 % respectively. Moreover, the local and global priorities of the most important risk factor are also determined to validate and optimized the result. Finally, a list of alternative solutions recommended by the experts has been illustrated.

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Keywords: Operational risks, financial and administrative risks**,** economic and political risks, potential risks, Fuzzy Logic, Analytical Network Process, Alternative, Solutions.

إدارة المخاطر في القطاع النفطي/ شركة الاستكشافات النفطية كحالة دراسية

الخلاصة:

تعتبر إدارة المخاطر من المواضيع المهمة جدًا لنجاح المشاريع حيث يجب تقليل المخاطر في المشاريع البترولية لتحقيق أهداف الإنتاج. تتكون إدارة المخاطر من التخطيط ، والتحديد ، والتحليل والاستجابة وهي اهم مرحلة. عن طريق التحكم في المخاطر تكون للمشاريع القدرة على التغلب على المخاطر وبالتالي إنتاج الكميات المستهدفة بشكل فعال. في هذه الدراسة، تم فحص أربعة أنواع من المخاطر في قطاع النفط والغاز خاصة في شركة الاستكشافات النفطية العراقية والتي تم أخذها كدراسة حالة. هذه الأنواع الأربعة من المخاطر هي المخاطر التشغيلية و المخاطر المالية والإدارية والمخاطر الاقتصادية والسياسية واخيرا المخاطر الكامنة. تم فحص تأثير هذه الأنواع الاربعة من المخاطر باستخدام نموذج استبيان مغلق. استند نموذج الاستبيان على مقياس ليكرت الخماسي ويحتوي الاستبيان المغلق على 114 عامل من عوامل الخطر الموزعة في أربع مجموعات تمثل الأنواع الأربعة للمخاطر التي تم فحصها. تم توزيع أكثر من 170 نموذج استبيان على المهندسين والعاملين والخبراء والفنيين، وتم اعتماد 153 نموذجًا للتحليل. تم استخدام برنامج SPSS لتنفيذ التحليل الإحصائي المتعلق بالمتوسط الإحصائي والاهمية النسبية. وتم التوصل الى أهم العوامل او المخاطر الموثرة على قطاع النفط والغاز في العراق ومن ثم التحقق من صحتها باستخدام قائمة مراجعة التقييم.وجدت الدراسة أن أكثر العوامل التي تؤثر على المخاطر التشغيلية هي: وجود ألغام ومتفجرات من مخلفات الحروب الماضية في مناطق سيتم استكشافها اضافة الى التخزين غير الصحيح للمواد القابلة للاشتعال. اما بالنسبة للمخاطر المالية والإدارية، تبين أن وجود الفساد المالي والإداري في شركات النفط وسوء الإدارة من قبل المديرين أو مساعديهم لهما الأثر الأكبر على هذا النوع من المخاطر.

بالإضافة إلى ذلك، هدفت هذه الدراسة إلى اقتراح أداة قرار تساعد على تقدير احتمالية المخاطر في قطاع البترول في العراق. لهذا السبب، تم تطوير برنامج حاسوبي باستخدام طريقة مؤشر الأهمية النسبية (RII) المدمجة في المنطق الضبابي. تم إنشاء نموذج تقييم ضبابي واختباره ليكون مناسبًا لتحديد احتمالية المخاطر في قطاع النفط العراقي لتقييم وتقدير المخاطر.تم اختبار وتحسين ثلاثة أنواع من حلول المخاطر وهذه الحلول هي تجنب المخاطر اوتخفيفها اونقلها. تم استخدام نهج الشبكة التحليلية (ANP) الذي يعد أحد أكثر طرق اتخاذ القرار متعددة المعايير تقدمًا وتعقيدًا في التحليل. تم محاكاة متغيرات التبعيات والتعليقات بين عناصر الشبكة باستخدام نهج ANP لتحديد الأولوية أو فعالية كل نوع من الحلول للعثور على أفضل خيار. تظهر النتائج أن أفضل طريقة للتعامل مع مخاطر النفط والغاز في قطاع النفط العراقي هو تجنب هذه المخاطر. لأن الحلول التي تنتمي لهذه المجموعة لها قيمة فاعلية تساوي 65.4٪. المجموعتان الأخريان من التخفيف او النقل لديهما فعالية بنسبة 19.8٪ و 14.8٪ على التوالي، علاوة على ذلك، تم تحديد الاوزان للمخاطر العالمية و المحلية وذلك للتحقق من صحة النتيجة وتحسينها. أخيرًا ، تم اعداد قائمة من الحلول البديلة التي أوصى الخبراء بتطبيقها للتعامل مع المخاطر في القطاع النفطي.

1. Introduction:

Risks and their management are important for the success of the projects, as the risks in petroleum projects must be minimized to achieve production goals. Risk management comprises planning, identification, analysis, and response, which has an important risk response phase that should not be undermined. Because its success gains the projects the capability to overcome the uncertainty and thus effectively produce the targeted quantities. The oil and gas industry has a wide array of risks that spread across all business areas. These can be economic risks such as oil

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price collapse, loss of demand, or high operating costs. Political risks can vary depending on the country in which the organization is doing business. Environmental risks can include pollution or damage to the surrounding environment, or perhaps damage the environment causes to equipment or personnel. A large area is also an operational risk, which could include a major oil spill or an expired license to operate. This case has been really seen with the speared of Coronaviruses, at which significant drops in the global economy take place, especially in the petrolatum sector. One of the most apparent effects of Covid-19 is the decrement in oil prices which causes a lot of damages on projects, contracts, and oil refining and productions. Risk management and planning take a big role within an organization to prevent many risks or mitigate the impact of some of the more uncontrollable circumstances. Dedicating the time and resources required to address all requirements and industry best practices is investing in the company's future success. A decision tool using the relative importance index (RII) method and constructed probability of risk management model using fuzzy Logic was proposed to enable the concerned government agencies and contractors to identify the most important factor in the petroleum sector.

Burhan [1] described some of the techniques used in risk assessment, complaining that most Iraqi engineers have little knowledge in the construction risk management field. Risk is defined as the possibility of losses, injuries, damages, or delays arising during the execution of a project causing adverse effects on the success of works. A visual basic program is developed to aid as a tool for calculating the contract contingencies in order to avoid conflicts. The oil industry is like no other industry in the world and demands a different set of skills and technical, political, and financial capacities [2]. This industry is of strategic importance to the global economy. Every country is actively affected by the oil and gas industry in one way or another [3]. Many scholars argue that the industry will remain the most important energy source for decades to come, even as various alternatives emerge [2,4].

It is estimated that hydrocarbons will still be responsible fornearly 80% of total energy sources in 2035, with the MENA region as the main supplier [4]. The oil and gas sector directly or indirectly supports numerous industries across the globe, such as engineering, hospitality, construction, and finance. These industries are so dependent on the oil and gas sector that any changes in the business environment for oil and gas production or exploration directly affect these related industries' outlook [5]. Oil and gas operations are typically divided into three distinct activities – upstream, midstream, and downstream [2,6]. Details of each activity will be

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provided below. The upstream sector refers to activities that happen before the refinery of hydrocarbons and is therefore mainly related to exploration and production phases (E&P) as well as prior conceptual development [2,7]. This sector requires the highest investment for new product development because ofthe large uncertainty involved, especially during exploration [8].

2. Fuzzy Logic Applications in The Petroleum Sector

Sánchez [9] presented a fuzzy set-based approach for representing and synthesizing information about the different kinds of variables involved in evaluating a project's value. A design was given to a fuzzy system for evaluating a project's value in the context of construction in civil engineering. Liang [10] developed an interactive fuzzy linear programming to aid in project management decision-making aiming to minimize total costs concerning specified project completion time and total allocated budget. Plebankiewicz [11] developed a model for contractor prequalification based on fuzzy Logic in which the owner can express his opinion about the weights of criteria and objectives. Satisfying the requirements by contractors were also included using linguistic variables. San Cristobal [12] proposed using the promethea method under fuzzy environments to determine the critical path of a network, considering not only time but also cost, quality, and safety criteria. Gunduz [13] developed a fuzzy model incorporated with relative importance index (RII), where (83) delay causes were identified and categorized into (9) major groups. The model was developed as a support tool for contractors to quantify the probability of delay in construction projects before the bidding stage in Turkey.

3. Questionnaire Form

A closed questionnaire form was designed to identify the local causes of risk petroleum sector based on previous domestic and international studies and new issues generated through the dialogue with the respondents. The forty-eight leading causes of risk are classified into four groups: Operational risks, Financial and Administrative risks**,** Economic and Political risks, and Potential risks. These groups were listed in a questionnaire form to obtain local expert opinions about their applicability in the case study. A total of (153) out of (170) distributed questionnaire forms were collected, forming a response rate of (98.88%). The respondents consist of 80 engineers, 50 technicians, 13 consultants, and 12 contractors. The questionnaire form was designed using the 5-point Likert scale to answer each question. The relative importance of various risk causes is calculated according to Khaled [14], who used the relative importance

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index (RII) for such purpose? The five-point Likert scale ranged from (0 = not important) to (4 = very highly important) is adopted and transformed to relative importance indices (RII) for each factor in the questionnaire using Equation (1).

$$RII = \left(\frac{\sum W}{A * N} \right) \quad .... (1)$$

Where:

W: is the weight given by the respondents and ranges from (0 - 5), A: the highest weight given by the respondents (for each factor), and N: the total number of respondents, which is equal to (155).

3.1 Preparations for Risk Management Model

To build fuzzy model that will be used in estimating the risk, the following steps were followed:

1) Utilizing the risks obtained in Table (1) as input data using the same four classification groups.
2) The linguistic variables and fuzzy membership functions were determined.
3) The construction of Fuzzy rules (if-then-rules) using the relative importance index of the factors and groups of factors given in Table (1) were assigned as the weights of the fuzzy rules.
4) Employing aggregation and defuzzification methods were determined to construct the fuzzy model to estimate the probability of risks.
5) The fuzzy model was developed using the fuzzy logic tool in the MATLAB program.
6) Testing the constructed fuzzy model in a real-life case study.

3.2 Construction of Fuzzy Rules and Risk Management Model

The interrelationships of inputs (causes of risk) to outputs (probability of risk) were firstly established in a natural language format. This format makes this assessment method so attractive since it allows decision-makers to express all causes of risk in natural language while not binding them to definite, exact values. Decision-makers must have enough experience or consult experts to define the interrelationships and memberships of causes risk they encounter. If not, they can use the model constructed in this research by adding new rules, including causes of risk, interrelationships, and memberships, or by manipulating or eliminating present irrelevant rules.

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To perform fuzzy inference, rules which connect input variables to output variables in 'IF...THEN' forms were used to describe the desired model regarding linguistic variables (words) rather than mathematical formulae.

As a result, the fuzzy rules were constructed using the acronyms previously listed in Table (1) in addition to the following acronyms: (Nil), (L) for low, (M) for medium, (H) for high, and (VH) for very high. Below are examples of the rules used. On the other hand, the max method is usually used as an aggregation method in the literature. Defuzzification is a mathematical process used to obtain clear sets with fuzzy results. This process is necessary because all fuzzy sets that are derived by Fuzzy inference must be added in fuzzy rules to produce a single number as output from the fuzzy model. The most common form of defuzzification is the center of gravity method because it is based on the idea of finding the center of gravity of a flat figure. A sample of the fuzzy rules with assigned weights constructed for the fuzzy model is shown in Table (1).

1) Rule 1: If the probability of factor inaccurate scope definition (POMEW) is Nil, then ORF causes (ORF) will have a nil probability of risk management having rule weight of 0.901.
2) Rule 97: If the probability of risk management factor approval of changes (WTC) is low, then FArF (FARF) will have a low probability of risk management with the rule weight of 0.805.
3) Rule 133: If the probability of risk management factor inaccurate scope definition (OODPS) is Nil, then OrF causes (EPRF) will have a nil probability of risk management having rule weight of 0.902
4) Rule 164: If the probability of the risk management factor inaccurate scope definition (FCLG) is Nil, then OrF causes (ORF) will have a Nil probability of risk management having rule weight of 0.850
5) Rule 240: If the probability of risk management factor in group potential risk-related causes (TIECS) is high, then the project's probability of risk management (PRF) will be high with the rule weight of 0.835. In this study, The risk management fuzzy model was tested in a real-life in Majnoon oil field in Basrah city. This field is managed by an oil exploration company, one of the associations of the ministry of oil in Iraq, and has significant experience for 15 years in oil and gas projects. The company was invited to join the survey of the probabilities

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of occurrence of the risk management causes. It was found that the model can estimate risks probability better and faster than the existed risk assessment matrix.

4. Risk Analysis

Risk response is seen as a crucial stage in risk management because it is the discovery of projects that lead to the creation of opportunities and the reduction of threats that indicates how well the managers are doing [7]. To be specific, the plan of risk response can make the conditions that are considered to be essential for optimal identification of risk and evaluation, hence, the action of risk response should be designed, classified, and justified on systematic principles [8]. The most important stage of risk management is risk response, yet it's an area that hasn't been studied, where project managers should make risk decisions at this point. Even though the manager has not sacrificed much time or money in reacting to risks, risk response planning is an overlooked aspect of project risk management [9]. Finally, three types of risks response were tested in this study and illustrated as follows.

4.1 Risk Avoidance

Risk avoidance entails looking for alternatives, and by doing so, many hazards can be eliminated from the project. To reduce risks, some adjustments in the project are wanted, such as implementing advanced techniques rather than replacing them with new ones, even though the new ones save more money. As a result, the dangers may be avoided, and the project can proceed without issue because the users will be less stressed [9]. Risk avoidance is the polar opposite of risk acceptance, and it is implemented by making a series of changes to the project plan to reduce risks or maintain project goals. These changes are represented by changing or canceling parts of the project that contain risks, increasing resources, implementing new technology, or avoiding activities that lead to risks. For example, canceling a part of the project may have an impact on the project, but the risk has a greater impact [10].

4.2 Risk Mitigation

Risk Mitigation refers to the process of accepting the consequences of a risk. Risks that are difficult to categorize and recur throughout the project can be effectively controlled by recognizing the project owner's responsibility. Risk acceptance can be divided into two categories: passive acceptance and active acceptance [11]. Passive risk acceptance (also known

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as non-insurance) acknowledges that a risk exists but does not respond to it. It manifests itself as overlooking, unawareness, or a lack of decision, for example, the identification of risk has been neglected and the contractor must bear the consequences of these risks. Active acceptance of risk (sometimes mentioned as self-insurance) is a premeditated strategy for management after the risks have been evaluated and potential losses and costs of the substitution method of dealing with risks to assign an essential allowance of contingency strategy of the projects whenever necessary.

4.3 Risk Transfer

Risk transfer is the practice of transferring some or all of the threat's negative impact, as well as response ownership, to a third party. The term "transformation" refers to the risk being transferred to another party who is responsible for its management, but it does not imply that the risk has been eliminated. Transferring risk liabilities is the most efficient approach to dealing with financial risk [12]. The best choice is to transfer the risks to another party, especially if that party has the skill or capability to manage them. The other party is usually the customer, designer, contractor, subcontractor, and so on. Depending on the nature of the risk, that risk is passed to them. This could increase the cost and amount of work required, which is known as a risk premium [13]. The insurance is not recognized in Iraq until the first years of the sixties of the last century and it is conducted in a very limited manner to cover some of the executed projects in Iraq in that period, the insurance was implemented with the rest of the accident insurance in one type while the subscription and the determination of terms and prices are sets by Commission accidents [14].

5. Analytical Network Process

Analytic network process (ANP) can be defined as a general theory of relative measure that is applied to obtain the compound priority ratio of the individual scale reflecting the comparative measure of the interconnected elements within the specified control criteria. ANP is a mathematical theory that permits the methodical treatment of dependence and return; it thus makes it possible to link tangible and intangible factors utilizing the scale of ANP way advanced to improve called ANP or Analytic quantitative, qualitative decision creation when one is confronted with mix of and at times conflicting issues that are taken addicted to consideration. ANP has active in creating complex, often unalterable decisions. "ANP customs matrix algebra for sorting out is-sues to reach at a just optimal answer. The present chapter proposes the application of the ANP technique to support the decision-making process related to the risk factors affecting the petroleum projects that could optimize the alternatives to solve the important risk solution problem in exploration Oil Company in Baghdad. Following are the three related core ANP principles [15]:

1. Decomposition: the ANP framework is the result of a procedure that divides a complex problem into clusters and/or subgroups in the form of a hierarchy or a network. The emergence of the ANP network from the problem is an example of complexity.
2. Comparative provisions - these are used to build binary comparisons. These pairwise comparisons are used to determine the group elements' "local" priority for parents. The ratio is used to make a comparative comparison. It calculates proportion measures by calculating the ratio and provision of each pair of components in the network.
3. Synthesis: the procedure is used to multiply the local priority elements in the parent element's global priority group leading to universal priorities across the network, adding worldwide priorities to the lowest level elements.

5.1 Working Mechanism of Analytical Network Process

- **Step 1**: Model construction and problem structuring: The problem should be clearly stated and decomposed into a rational system such as a network. The framework can be determined based on decision-makers' opinions via brainstorming or other appropriate methods.
- **Step 2**: Pair-wise comparisons matrices and priority vectors: The ANP decision elements at each component are compared pair-wise with respect to their control criteria and the components themselves are also compared pair-wise concerning their contribution to the goal. An eigenvector is used to determine the influence of each element on others. The comparative importance values are specified on a scale ranging from 1 to 9, whereby "1" signifies equal importance between the two elements and "9" denotes the supremacy of one element (row component in the matrix) on the others (column component in the matrix) [16]. The scale shown in Table (1) is developed by it allows for measuring the power of the judgments [17].
- **Step 3**: The concept of supermatrix generation is comparable to that of the Markov chain process [18]. In a system with mutually dependent impacts, the local priority vectors are

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arranged into the proper matrix columns called a super-matrix to achieve global priorities. As a result, a super-matrix is a partitioned matrix in which each matrix segment represents a relationship between two nodes or system components. [14].

- **Step 4**: By producing the supermatrix as indicated in Step 3 that covers the whole network, the priority weights of alternatives can be computed in the column of alternatives in the normalized supermatrix. If a supermatrix is made up entirely of interconnected elements. The overall priority of the alternatives, on the other hand, necessitates additional calculations. The choice should be made based on whatever option has the highest overall priority.

5.2 Geometric Mean

For this study, a mechanism that allows group decision-makers to include a specific situation is required. It involves a variety of persons with varying levels of power and skill, as well as distinct perspectives, to impact production. The geometric mean, a mathematical theorem, is one of the strategies used for merging group assessments. Because it is possible to misjudgment, reciprocating synthesized judgments must be equivalent to synthesizing their reciprocals. [18].

$$GM = \sqrt[\sum_{i=1}^{i=n} f]{(x1^{f1})(x2^{f2})(x3^{f3})(xn^{fn})} \quad (1)$$

where: GM is the Geometric Mean, f is the frequency, i is the iteration order, n is the last iteration, and x is the risk factor.

5.3 Distribution ANP Questionnaire Form

In the ANP search approach, a questionnaire form is created is based on the pairwise comparisons derived from the network structure. The form is given to the decision-makers or experts who make decisions or have preferences. The importance of the effect is determined for each factor using the ANP technique's pairwise comparison [19]. The questionnaire survey to assess the relative relevance between paired clusters and nodes is required to collect exact information from experts to measure all interrelations inside the ANP model quantitatively [20]. Ten experts' knowledge and information on each specific topic are collected and consolidated into an ANP, according to the questionnaire survey. As a result, the ANP model can be used as a decision-making support tool based on knowledge reuse and set up alone by the researcher; the model will be further enhanced based on a questionnaire survey. Pair-wise comparison of paired clusters and nodes in terms of the ANP model's interdependences and relative relevance based on their characteristics and experts' expertise. The questionnaires were created using a research network design and pairwise comparisons to determine the weights of the main criteria, sub-criteria, and alternatives. Analytical Hierarchy Design Process was used to distribute 20 questionnaire forms (ANP). Only 15 of the20 variants have been found. The replies of the sample were gathered from a group of oil industry specialists and a group of academic experts [21] . Fill out a pairwise comparison form for the priority of main and sub-risk criteria, and choose the best choices; then extract the response averages for each form. Pairwise comparisons are made between primary criteria, sub-criteria, and alternative options for each main criteria. A pairwise comparison questionnaire, reflecting the relative influence of affecting clusters and nodes on the affected node for all feasible pairs, was created once the network model was constructed. To discover the geometric means of all paired comparison judgments for each question, researchers computed the geometric means of all paired comparison judgments for each question. The researcher subsequently organized these group judgments in paired comparison matrices using the assess/compare module of the Super Decisions software. Using the software Su-per Decisions, the priorities are obtained from the paired comparison matrices. After highlighting the influence linkages inside the criterion, the components and their underlying criteria in the software were developed to achieve those weights. Finally, the pairwise comparison matrices' information was introduced. The priority weight was calculated automatically by the software. The consistency ratio was less than 0.1 in all paired comparison matrices [22].

6. Research Outcomes

According to the ranking of the groups, the three factors of each group that contribute most to risks are analyzed below:

1) Operational risk: The presence of mines and explosives left over from past wars in areas to be explored (RII= 0.9006. Incorrect storage of flammable materials (RII=0.8692). Lack of fire protection system and sensors (RII=0.8679).
2) Financial and Administrative risks: Existence of financial and administrative corruption in oil companies (RII=0.8892): Mismanagement by managers or their assistants (RII=

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0.81749), Top managers are not interested in risks (RII=0.932), Lack of plans to control or reduce risks (RII 0.8119).

3) Economic and Political risks the entry of some companies into the blacklist of major economic countries (RII= 0.953) Decreased global market demand for oil (RII=1.0963) Sit-ins or blocking of roads leading to the oil projects (RII=1.0295) The occurrence of clan conflicts near the workplaces of oil companies (RII=1.0737).
4) Potential risks (RII= 0.6985): The control of terrorist groups over the oil fields. The economic consequences for countries in which terrorist groups control vast areas (RII=0.8346). They have subjected oil companies to rules of terrorist groups (RII=0.8681). Tables (2) to (5) summarize all the details of the most important risks.
5) The most important results obtained from the ANP are the priorities or, in other words, the effectiveness of each solution. So that the best solution was found to be within the avoid group of solutions with an effective value of 65.4 %. This is mainly because it's always better to avoid the risk before it happens by implementing the correct procedure. This will ensure that the risk will not take place and thus a lot of effort will be saved. Most experts in the Iraq petroleum sector also found that this group of solution are the best choice to deal with risks.
6) Some of the recommended solutions by the expert are shown in Table (3). The group of mitigation was found to be the second choice with an effectiveness of 19.8 % The reason for this is obvious as lowering the effect of risk will not solve it and it may happen again in the future. Anyway, some experts will not always recommend this option if another solution within the group of avoiding is available. Also, some opinions regarding the mitigation group are shown in Table (6).
7) The last and the most ineffective solution are found to be the transfer solution with an effective value of 14.8 %. However, it's a fact that transferring the risk to another association or department is not a solution as this risk will be subjected to a treatment to eliminate, avoid, and mitigate its effect of it. So, the transfer solution is not a final solution to deal with the risks. Table (3) also shows some of the recommended solutions suggested by the expert for the transfer group.
8) Moreover, in this study, the local and global priority for each risk factor has been also calculated. The determination of the model's ordering of outcomes and the analysis of all parts' priorities were used to balance the alternatives about those components, criteria, and

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sub-criteria as shown in Table (4) and Table (8). Using the calculations, priorities command in computation, component values in the criteria, and sub-criteria columns will be found.

9) For the first sub-criteria, the globe priorities were found to be 9.9627. This value has been found by multiplying the local priority of the sub-criteria by the main criteria of the group (0.4966 * 0.20062) * 100 %.

10) These priorities were used to optimize and determine the best alternative solutions. Table (8) shows the values of local and global priorities for each risk factor.

Table (2) Details of operational risk factors.

No	Type of risk	Acronyms	RII	Rank	Weight	Probability (%)
	Operational risks factors	ORF				
1	The presence of mines and explosives left over from past wars in areas to be explored	POMEW	0.90	9	4.50	60.70
2	Incorrect storage of flammable materials	ISFM	0.87	12	4.35	60.18
3	Lack of fire protection system and sensors	LFPS	0.87	14	4.34	68.25
4	Employees do not comply with safety regulations and procedures	EDWSP	0.86	18	4.29	67.19
5	Neglecting equipment maintenance	NEM	0.84	26	4.20	63.68
6	Lack of training and risk awareness	LTRA	0.83	31	4.16	61.40
7	Lack of automatic alarm device	LAAD	0.83	33	4.14	67.02
8	Neglecting fire equipment maintenance	NFEM	0.83	33	4.14	65.44
9	Neglect training the staff working on equipment	TSWEN	0.83	36	4.13	60.88
10	No safety equipment	NSE	0.82	37	4.10	64.04
11	Lack of professional medical staff	LPMS	0.81	40	4.03	64.74
12	No emergency exit	NEE	0.80	44	3.99	61.05

Table (3) Details of financial and administrative risks factors.

No	Type of risk	Acronyms	RII	Rank	Weight	Probability (%)
	Financial and administrative risks factors	FARF				
1	Existence of financial and administrative corruption in oil companies	FCO	0.90	6	4.52	72.81
2	Mismanagement by managers or their assistants	MMA	0.87	15	4.33	70.00
3	referring projects to companies with poor CV and don't have similar businesses	RPCP	0.86	19	4.28	68.60
4	Top managers are not interested in risks	TMIR	0.83	32	4.15	67.37
5	Lack of plans to control or reduce risks	LPCR	0.81	39	4.05	67.72

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6	Failure to check the financial background of the contracting companies	CFBC	0.81	40	4.03	67.19
7	Unclarity on the requirements of top management	URTM	0.81	42	4.03	65.79
8	Weakness of technical control	WTC	0.81	42	4.03	70.00
9	Contracting companies defraud legal controls and exploit weak contract clauses	CCDLCW	0.80	44	3.99	68.42
10	Delayed payment of labor dues	DPLD	0.79	46	3.96	63.33
11	referring projects with no insufficient financial allocations	ARPIF	0.79	47	3.95	60.70
12	Unclarity of contract terms	UOCT	0.79	48	3.95	63.16

Table (4) Details of economic and political risks factors.

No	Type of risk	Acronyms	RII	Rank	Weight	Probability (%)
	Economic and political risks factors	EPRF				
1	The entry of some companies into the blacklist of major economic countries	ESCBME	0.91	3	4.56	71.40
2	Decreased global market demand for oil	GMDD	0.91	4	4.54	74.74
3	Sit-ins or blocking of roads leading to the oil projects	PSBRLO	0.90	8	4.51	76.49
4	The occurrence of clan conflicts near the workplaces of oil companies	TOCWOC	0.87	11	4.35	67.54
5	Presence of terrorism or armed conflicts near the workplaces of oil companies	WISCOC	0.87	12	4.35	74.56
6	The inability of the state to completely impose security at work sites c	WISCIS	0.85	21	4.27	72.63
7	Excessive local and international debts on the governments of oil countries	ELIDG	0.85	23	4.24	60.70
8	Occurrence of demonstrations or political sat ins near to oil and gas projects	OODPS	0.85	24	4.23	64.04
9	Foreign companies are not complying to the laws stipulated by governments	FCLG	0.83	29	4.17	62.81
10	spread of financial corruption among officials in the oil sector oil and gas	SSFAOG	0.83	30	4.16	63.33
11	Effect of moving international companies away from politically turbulent countries on oil sector of these countries	EMICAF	0.83	33	4.14	65.79
12	Delayed payment of companies' dues by governments	DPCGM	0.82	38	4.09	61.75

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Table (5) Details of potential risks factors.

No	Type of risk Potential risks factors	Acronyms PRF	RII	Rank	Weight	Probability (%)
1	The control of terrorist groups over the oil areas	CTG	0.93	1	4.65	63.16
2	The control of terrorist groups over the oil fields	TCG	0.93	1	4.52	60.18
3	The economic consequences for the countries in which terrorist groups control vast areas	TECCW	0.90	5	4.52	62.63
4	Subjected oil companies to the rules of terrorist groups	SOCR	0.90	6	4.46	57.54
5	The migration of international oil companies in the areas where terrorist groups appear	TMOBG	0.89	10	4.32	70.70
6	Selling the oil on the black market by terrorist groups	SOBT	0.86	16	4.31	60.35
7	Impact of epidemics on global oil prices	IEGP	0.86	17	4.28	72.46
8	The outbreak of sudden wars between countries	TOSW	0.86	19	4.25	67.37
9	The spread of the Corona virus in oil fields	TSCV	0.85	22	4.22	68.60
10	The sudden spread of epidemics such as the Corona virus	TSSESC	0.84	25	4.20	68.25
11	Closing the oil field due to the spread of epidemics such as Corona virus	ACOFEC	0.84	26	4.18	61.93
12	The impact of economic collapse or stagnation in countries whose economies are completely dependent on oil because of the drop in global oil prices due to the outbreak of the Corona epidemic	TIECS	0.84	28	4.65	74.74

As a result of applying the fuzzy model developed in this research, it was found that group of risk petroleum management is the most influential group of the following most influential causes:

1) Funding problems operational risks with a probability of risk petroleum management (61%).
2) Financial and Administrative risks a probability of risk management (64.5%).
3) Economic and Political risks a probability of risk management (66.4%).
4) Potential risks a probability of risk management (63.6%).

Table (6) Saaty's Fundamental Scale. [17]

ANP Scale of Importance for contrast	Numeric Rating	Reciprocal (decimal)
Extreme Importance	9	1/9 (0.111)
Very strong to extremely	8	1/8 (0.125)
Very strong Importance	7	1/7 (0.143)
Strongly to very strong	6	1/6(0.167)
Strong Importance	5	1/5(0.200)
Moderately to Strong	4	1/4(0.250)
Moderate Importance	3	1/3(0.333)
Equally to Temperately	2	1/2(0.500)
Equal Importance	1	1 (1.000)

Table (7) The Ranking of the Main Criteria

Risks Group	Main Criteria Ranking
Operational risks	0.20062
Financial and Administrative risks	0.36874
Economic and Political risks	0.17323
Potential risks are equal	0.25741

Table (8) The Priorities of Each Sub-Criteria

Criteria	Sub-criteria	Local Priorities	Global Priorities
Operational risks Operational risks	The presence of mines and explosives left over from past wars in areas to be explored	0.50	9.96
	Incorrect storage of flammable materials	0.16	3.14
	Lack of fire protection system and sensors	0.12	2.33
	Employees do not comply with safety regulations and procedures	0.23	4.63
Financial and Administrative risks Factors	Existence of financial and administrative corruption in oil companies	0.47	17.31
	Mismanagement by managers or their assistants	0.19	7.17
	Referring projects to companies with poor CVs and don't have similar businesses	0.10	3.59
	Existence of financial and administrative corruption in oil companies	0.47	17.31
Economic and Political risks	The entry of some companies into the blacklist of major economic countries	0.47	8.08
	Decreased global market demand for oil	0.20	3.45
	Sit-ins or blocking of roads leading to the oil projects	0.14	2.38
	The occurrence of clan conflicts near the workplaces of oil companies	0.20	3.41
Potential risks	The control of terrorist groups over the oil areas	0.51	13.00
	The economic consequences for the countries in which terrorist groups control vast areas	0.16	4.11

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	Subjected oil companies to the rules of terrorist groups	0.19	4.85

7. Conclusions

The most important results that concluded in this study can be summarized as follows:

1. The presence of mines, neglecting safety and security procedures, and the incorrect store of flammable material, were found to have the most effect on operational risks.
2. It was found that corruption is the main risk that the Iraqi petroleum sector is facing in terms of financial and administrative risks.
3. Regarding, economic and political risks, it was found that if working companies entered the blacklist of the major economic countries, and if the global oil demand has been reduced, the production rate will be significantly affected. Also, the Sit-ins or blocking of roads due to po-litical reasons will affect the production rate.
4. The control of terrorist groups in the oil area has the most danger to the oil and gas sector in the country in which case happed. This risk was found to be the most important risk especially in unstable countries.
5. It was found that the speared of COIVD-19 and other epidemics should always be treated as a potential risk since it has a huge effect on the global and local oil and gas industries.
6. Potential risks such as the sudden war between countries and the out-break of pandemics come in the second rank in effect after economic and political risks as it is less to happen.
7. It was found that financial and administrative risks have the most im-pact on the oil and gas sector in Iraq with a priority of 0.36 followed by the Potential risks with a priority of 0.25. less priority was found to be for operational risks and economic and political risks with priorities of 0.2 and 0.17 respectively.

From The analytical network process, the best choice for dealing with risk in the petroleum sector in Iraq was found to be the avoid option with an effectiveness of 65.4 %, followed by the second alternative, which is the mitigation, with an effectiveness of 19.8 %, and the third alternative is the transfer with 14.8 %. effectiveness on risk solutions.

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References

[1] A. M. Burhan, “Risk management in construction projects”, MSc thesis, University of Baghdad, Baghdad, Iraq, 2003.

[2] L. A. Herkenhoff, “ Profile of the Oil and Gas Industry: resources, market forces, Geopolitics, and Technology”, New York, United States of America: Business Expert Press Industry Profiles Collection, 2014.

[3] K. Schwab, "The global competitiveness report 2018", World Economic Forum, Vol. 671, 2018.

[4] K. Schwab, “The Global Competitiveness Report 2016–2017”, World Economic Forum, September 2016. available at www.weforum.org/gcr

[5] BP Energy Outlook, available at: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2016.pdf

[6] H. Devold, “Oil and gas production handbook: an introduction to oil and gas production”, Lulu. Com, 2013.

[7] K. A. Suda, N. S. A. Rani, H. A. Rahman, & W. Chen, “A review on risks and project risks management: oil and gas industry”, International Journal of Scientific & Engineering Research, Vol. 6, no. 8, pp. 938-943, 2015.

[8] R. M. Razalli, “The Malaysian oil and gas industry: an overview”, Jurutera, the Institution of Engineers, Malaysia, 1, pp. 8-12, 2005.

[9] J. F. F. Barata, O. L. G. Quelhas, H. G. Costa, R. H. Gutierrez, V. de Jesus Lameira, and M. J. Meiriño, “Multi-criteria indicator for sustainability rating in suppliers of the oil and gas industries in Brazil”, Sustainability, vol. 6, no. 3, pp. 1107-1128, 2014. https://doi.org/10.3390/su6031107

[10] M. Sánchez, F. Prats, N. Agell, and G. Ormazabal, “Multiple-criteria evaluation for value management”, Journal of Management in Engineering, vol. 21, no. 3, pp. 131-137, 2012. https://doi.org/10.1061/(ASCE)0742-597X(2005)21:3(131)

[11] T. F. Liang, “Project management decisions using fuzzy linear programming”, International journal of systems science, vol. 37, no. 15, pp. 1141-1152, 2006. https://doi.org/10.1080/00207720601014396

[12] E. Plebankiewicz, “Contractor prequalification model using fuzzy sets”, Journal of Civil Engineering and Management, vol. 15, no. 4, pp. 377-385, 2009.

Open Access
No. 40, September 2023, pp. 183-201

P- ISSN: 2220-5381
E- ISSN: 2710-1096

https://doi.org/10.3846/1392-3730.2009.15.377-385

[13] J. R. San Cristobal, "Critical path definition using multicriteria decision making: PROMETHEE method", Journal of Management in Engineering, vol. 29, no. 2, pp. 158-163, 2013. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000135

[14] M. F. Hasan, and M. S. Mohammed, "Time Overrun Model for Construction Projects in Iraq by Using Fuzzy Logic", Vol. 9, no. 11, pp. 2593–2607, Article ID: IJCIET_09_11_262, 2018.

[15] Z. S. M. Khaled, R. S. A. Ali, and M. F. Hassan, "Predicting the Delivery Time of Public School Building Projects Using Nonlinear Regression", Engineering and Technology Journal, vol. 34, no. 8 Part (A), pp. 1538-1548, 2016. https://doi.org/10.30684/etj.34.8A.6

[16] L. A. Zadeh, "Fuzzy set", Information and Control, vol. 8, no. 3, pp. 338-353, 1965. https://doi.org/10.1016/S0019-9958(65)90241-X

[17] A. S. Tofan, and H. K. Breesam, "Using the Fuzzy-AHP technique for determining the key performance indicators of public construction companies in Iraq", International Journal of Civil Engineering and Technology, vol. 9, no. 13, pp. 1431-1445, 2018.

[18] J. Zeng, M. An, and N. J. Smith, "Application of a fuzzy based decision making methodology to construction project risk assessment", International journal of project management, vol. 25, no. 6, pp. 589-600, 2007. https://doi.org/10.1016/j.ijproman.2007.02.006

[19] J. Shao, M. Taisch, M. A. Ortega Mier, and E. D'Avolio, "Application of the DEMATEL Method to Identi-fy Relations among Barriers between Green Products and Consumers", 17th European Roundtable on Sustainable Consumption and Production - ERSCP 2014, pp. 1029–1040, 2014.

[20] Jihan M. S. Daoud, A thesis submitted to the College of Engineering of the Uni-versity of Baghdad – Iraq Alternative of Affordable Residential Complexes to Solve Slums Areas in Baghdad, 2019.

[21] Meervat R. Wali, A thesis submitted to the College of Engineering of the University of Baghdad – Iraq Optimal Selection of Investment and Traditional Contracts For Infrastruc-ture Projects in Iraq, 2015.

[22] S. Jharkhariaa, and R. Shankarb, "Selection of logistics service provider": An analytic net-work process (ANP) approach, Vol. 35, no. 3, 2007. https://doi.org/10.1016/j.omega.2005.06.005