QATAR UNIVERSITY

COLLEGE OF ENGINEERING

REOLACTION OF DUKHAN FIELD CIVIL FACILITIES USING ANALYTICAL HIERARCHY PROCESS

BY

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ABSTRACT

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Title: Reolaction of Dukhan Field Civil Facilities Using Analytical Hierarchy Process

Supervisor of Project: Dr. Mohamed, Haouari.

Dukhan field is the only onshore oil field in Qatar. It is in the southwest of the state. The field's size is around 80 km x 8 km. the field contains many civil facilities such as an accommodation compound, Qatar Petroleum office building, Dukhan Beach Club, and Dukhan markets area. This project aims to relocate these buildings to ensure safety for the employees (Dukhan residents), reduce drilling costs, and facilitate future operations. Analytical hierarchy process (AHP) is one of the multi-criteria decision making (MCDM) techniques where criteria and alternatives are prioritized based on a specific judgment which builds on a pairwise comparison matrix to specify the weight of each criterion and rank them. Nine criteria and 22 sub-criteria had been identified through an extensive literature review to select an optimum location to transfer the facilities. A questionnaire survey was distrusted over professional academia and engineers, which helped build the matrices by using the relative importance index technique (RII). The areas that had been selected for the study are, Zekreet, Ras Brouq island, Umm Bab, Alnafayid, and Alshehaniya. After applying the AHP method, the results showed that safety is the most crucial criterion, and the sub-criteria were ranked individually in each category. Also, Zekreet got the highest weight, and Umm Bab received the least criteria weight.

DEDICATION

I dedicate this project to my parents who were always supporting and encouraging me, and to my family and friends for their continues support. Also, special dedication to my son Saoud and I wish this project would motivate him in his future study and career.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 Background

The source of income of the state of Qatar is mainly from oil and gas resources. It owns 70% of the North Field, which has the biggest gas reserves in the world. Besides, many offshore fields locally and internationally. Dukhan field is the only onshore field in the state of Qatar. It is in the west coast of the country. The size of the field approximately 80 Km X 8 Km (Qatar Petroleum Annual Report 2015). The field started production in 1939, followed by multiple stages of development through these years. With more than 1000 wells drilled in four different reservoirs through four other sectors in the field. Khatiya sector is the most important sector, which is around 40% of Dukhan production. The development plan of the field to recover oil and gas production is estimated for many decades. The plan requires drilling more wells in the area. However, some obstacles related to the facilities could affect the development of the plan.

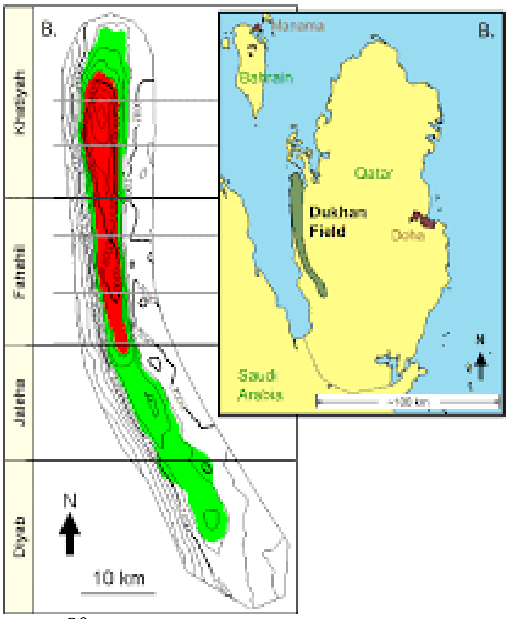

Figure 1. Dukhan Field Map[20]

Oil and gas companies always consider safety as a priority. Before any drilling campaign or start, any project must ensure that the upcoming process will not harm the environment in reducing flare or polluting water aquifers. Also, workers received safety training for their health and the environment. Nevertheless, if the area is already occupied, it will be an issue in ensuring the safe distance of the operation to avoid gas leaking or wells explosions. Onshore fields could always face this kind of matter except in deserts, which are empty of people and life, such as Hasi Messaoud filed in Algeria. Khatiya sector in the Dukhan field is the most important sector where the highest number of wells were drilled in this sector and the highest production percentage. On the other hand, most civil buildings are in this sector, including the accommodation compound, Qatar Petroleum main offices building, Beach club, and shopping center. With the restrictions applied to drilling operations regarding the distance from the buildings and the wells (500-1000m), the distance between the wells makes drilling operations more difficult and costly. Also, these barriers could negatively affect the development plan.

The main objective of this research is relocating civil buildings from the field to a nearby area by applying Analytical Hierarchy Process (AHP) to identify the most important criteria which will affect moving the civil facilities from the field area—also, using the same method to find the optimum location for relocated facilities. Utilizing this method could achieve the ultimate goals, ensuring safety, reducing drilling costs, and facilitating drilling operations.

1.2 Problem statement

Dukhan field has massive of future projects and operations which required to drill more wells. The existence of civil facilities, especially the residential compound, makes people live in danger. H2S gas could be leaked from one of the wells nearby the compound, which might cause disasters for the residents. Also, wells blowout is considered a serious issue in the oil and gas field. If it happened in Khatiya South (where civil facilities are located), it would be a catastrophe. It is required to drill longer wells in Khatiya South from the operational side to keep the drilling rig away from the buildings, which is costly and difficult compared with vertical or slanted wells. Economically, all wells located close to the facilities were abonnements and required to drill a replacement well to produce the remaining oil from that area.

1.3 Project Goals

The project objective is to suggest relocating the civil facilities in Dukhan field based on specific factors based on extensive literature study. Also, apply the same model to find the optimum location based on experts' and engineers' opinions to achieve the project targets. there are three objectives that the project aims to achieve: -

- Study the status of Dukhan facilities
- Use SWOT analysis to establish ideas related to the project regarding strength, weaknesses, threat, and Opportunity
- Apply the AHP model to determine the most important criteria for relocating the buildings
- Use the AHP model to find the best location based on specific factors to ensure safety for people and smoother operations with less economical expenses

1.4 SWOT Analysis

SWOT analysis is a technique that assists in identifying qualitative factors of the status of the organization. It is divided into four main parts, Opportunity, threats, weaknesses, and strength (Bouraima et al., 2020). Figure 2 summarizes the factors in each section of the analysis.

1.4.1 Strength

This part determines things that the organization doing well or overpasses the competitors. Qatar petroleum accommodation is centralized, so the management gathered all employees in one place, have the required information, and facilitate the assembly and evacuation if required. Besides that, all facilities and houses are provided with gas safety detector devices. Since the compound is a QP asset, it reduces the expenses of leasing and housing for employees. (Mindtools .com, 2020)

1.4.2 Weaknesses

Weaknesses reflect parts of the organization that need improvement; it could be in resources, employees, system, or work process. In our project, the location is the main concern since all facilities are located in the center of the field, which makes people's lives endangering regardless of the precautions the safety procedures that the company follows. Also, the facilities are old and not following modern requirements such as the market is too small. The water club and compound required routine maintenance. Employees' families and friends must access through a certain location for a visit, which will put their lives endangering too since they might not be aware of the safety procedures in Dukhan city. (Mindtools .com, 2020)

1.4.3 Opportunity

Opportunities focusing on the requirement that needs to be improved in the future, and things need to bring to the organization for enhancement. Mobilizing the facilities to a new location will help build modern facilities provided with new and developed equipment and technologies and a safer area. Also, the new area might be closer to the capital or shopping malls, which will reduce the distance on employees. Furthermore, removing the current facilities will allow us to drill shorter wells instead of longer ones due to safety restrictions. Also, it will positively affect drilling costs. (Mindtools .com, 2020)

1.4.4 Threat

Threats include anything that negatively affects the project, including resources, financial support, etc. Since Qatar Petroleum is an oil and gas company, a drop in oil prices could negatively affect project progress. Moreover, recommended areas might have a future governmental project that will prevent to move of the facilities. Also, the high budget cost might affect the decision. (Mindtools .com, 2020)

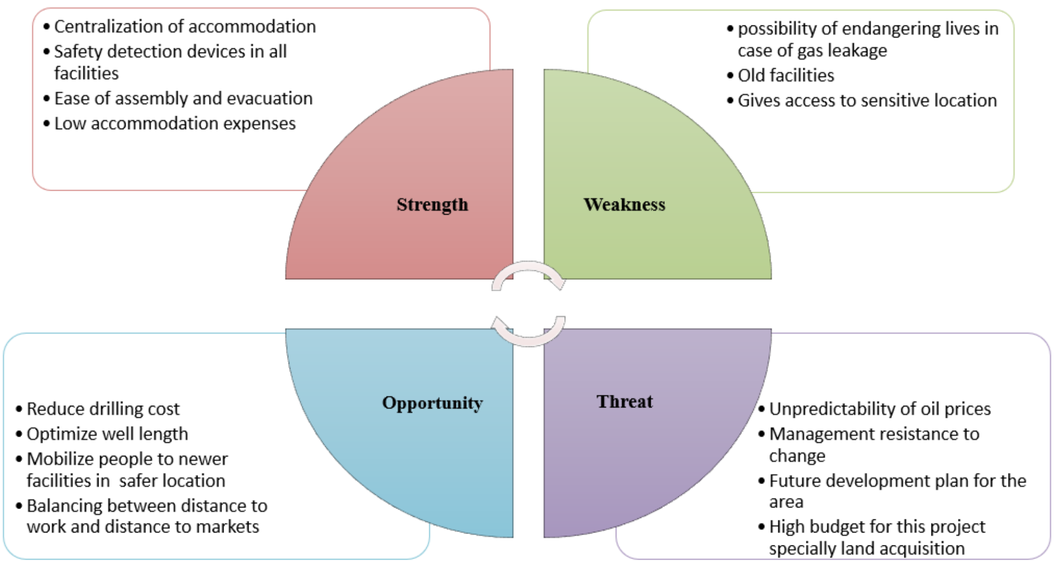

Figure 2. SWOT Analysis

1.5 International Standards of Oil and Gas fields accommodation

International standards of accommodation in oil and gas fields are applied to set policies for companies to ensure good living for their employees during their work period in the field. The standards are established for both onshore and offshore fields in different locations such as an ocean, forest, swamp, or desert. The standards are related to the design, layout, facilities, and services, security, and environment protection. (IOGP, 2015).

Accommodation standards for onshore fields are mainly focusing on the temporary design because it is highly distributed and used around the world. the design of the cabin must endure wind speed not more than 20 m/s (IOGP, 2015). Also, must prevent any kind of mosquitos and bugs to enter through any slot. Also, it should offer private sleeping space for each employee. Electricity, sewage system, and other services must be offered (IOGP, 2015). Moreover, safety systems must ensure minimum danger exposure for workers in case of fire or a natural disaster (IOGP, 2015).

Regarding permanent accommodation type is related to three main aspects, the size of the field, response time, and economics. The main two examples in the region are Dukhan field in Qatar. ARAMCO in Saudi Arabia built an entire city for employees and workers in Ghwar field which consider as the biggest onshore field in terms of reserves and size. Concreted buildings in Hasi Messaoud field in Algeria is allowable for employees only without their families. It includes some facilities such as a gym, swimming pool, and a supermarket. The main standards for permanent facilities are to ensure the safety of employees, proper security system, comfortable hosing includes all appliances, and providing different surrounding facilities such as hospitals, schools, and shops. Offering these requirements will help to create a safe and pleasant community for employees (IFC and EBRD, 2009).

1.6 Report Outline

This section shows the structure of this paper with a short description of each chapter's contents in the project.

- **Chapter 1: Introduction**

This chapter introduces this project's topic besides the problem statement, the goals of the project, status, and an overview of the project contents.

- **Chapter 2: Literature Review**

The literature review chapter reviews the topic from a different perspective and how researchers used the AHP technique in different areas.

- **Chapter 3: Research Methodology**

The part examines the methodology to be followed in the project to solve the problem and the questionnaire design.

- **Chapter 4: Analysis**

This part covers a discussion of the survey responses and the implementation of the solution, and the forming of the AHP method on criteria, sub-criteria, and alternatives.

- **Chapter 5: Results Discussion**

This section will and explain the outcomes of implementing the AHP method on criteria and alternatives.

- **Chapter 6: Conclusion and Recommendation**

The closing chapter in this research contains the conclusion of the project's work, recommendations, and future work for the same topic.

CHAPTER 2: LITERATURE REVIEW

2.1 Decision-making Techniques

Multicriteria Decision Making MCDM) is a mathematical model that assist decision-makers in ranking and evaluating their alternative solution by weighting different criteria to achieve the main objective (Dotoli eta al., 2020). MCDM techniques are considered one of the widely used techniques in research areas (Onden,2018). MCDM methods were used in different fields for solving various problems due to applicability (Veselinovic, 2014).

Methods that are categorized under DMCA application are Analytical Hierarchy Method (AHP), ELECTRE, PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations), which is a method that is used for selecting and ranking alternatives (Sennaroglu, et al., 2018). The Technique for Order Preference by Similarity to Ideal Solution TOPSIS is a distance-based method applied to define the distance from best and worst points (Dotoli et al., 2020). this method was used previously in Turkey to rank renewable energy alternatives (Konstantinos et al., 2019). ANP (Analytical Network Process) is categorized under the pairwise-comparison method, and it is a developed model from AHP. It is used to interact between the criteria from different hierarchy levels, and AHP cannot be used (Ozdagoglu, 2011).

2.2 Analytical Hierarchy Process

AHP is one of the decision-making applications that measure different hierarchy method factors, as Thomas L. Satty established it (Russo et al., 2015). Many researchers widely use the AHP model due to simple mathematical calculations that could solve complex decision problems (Mann, 1995). According to (Dalalah et al., 2010), AHP helps find and weighing criteria besides analyzing data. Moreover, it assists in evaluating and providing objective, reducing bias in the decision making process. The method is based on weights and scores achieved by pairwise comparison between all alternatives (Knickel et al., 2004). Based on (Vaidya et al., 2006), around 150 applications provide a reference in AHP from different fields, as shown in figure 3 below.

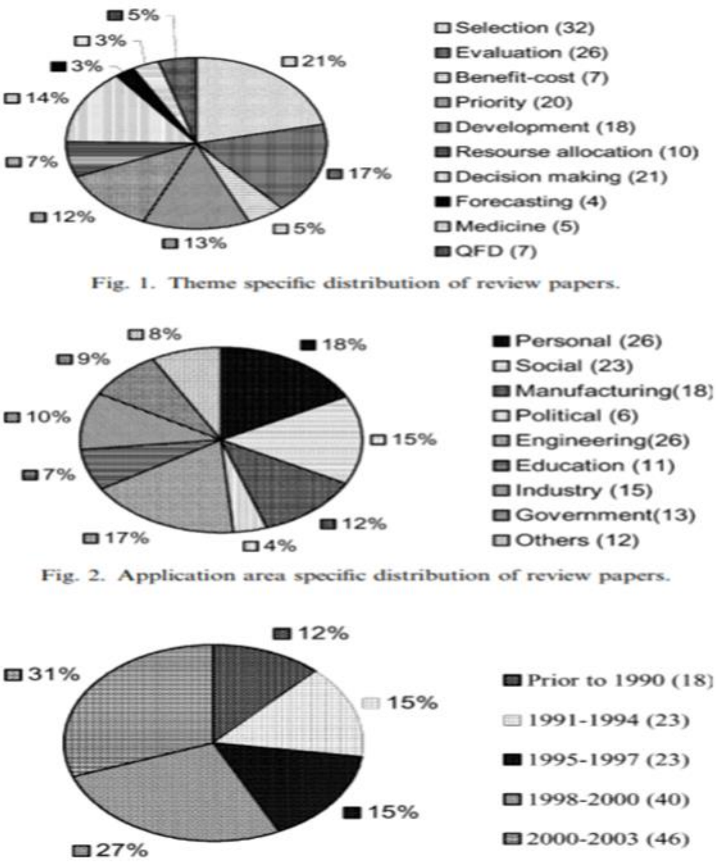

Figure 3. Distribution of reviewed Paper, Applications and Years[46]

The first step of the AHP model is to set a goal or objective of the decision-making problem. Second, provides criteria and sub-criteria where the weights depend on and are based on experience or research (Lobo et al., 2016). The lowest level of the hierarchy includes the alternatives, representing the selections (Knickel et al., 2004).

Also, determine the scale of importance for each criterion and alternatives (Mann, 1995), as shown in Table 1 below. Then create a pairwise matrix to determine each criterion's priority to achieve the target by selecting the best alternative (Lobo et al., 2016). Next, the calculating steps as follow: -

a) Sum the columns in the matrix
b) Divided the elements in the matrix by the column total
c) Normalize the matrix
d) Check consistency measurements
    - Used to determine the matrix consistency
    - Consistency ratio (CR) > 0.1 will be considered as inconsistency and will be accepted if it is less than 0.1. (KA, 2011)

Table 1. Scale of Importance (Despodev et al., 2011)

Intensity of Importance	Definition
1	Equal importance
3	Weak importance
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2,4,6,8	Intermediate values between the two adjacent judgments

2.3 Applications of AHP

2.3.1 Renewable Energy

This section will focus on implementing the AHP method in three different types of renewable energy, including solar, wind, and thermal. All cases are concentrating on finding the optimum location to install the plants or systems to reach the highest benefits from these resources besides reducing expenses.

In the last decades, many countries worldwide focused on converting their source of energy to more sustainable sources to reduce the negative environmental effect (Konstantinos et al., 2019). Many governments consider the development of technologies and change policies to get the highest advantage of renewable energy resources (Ozdemir et al.,2018). Due to the increase in the level of knowledge in environmental problems like climate change, pollution, and Green House Gas (GHG) emission, which could be caused by current energy sources, such as hydrocarbons and coal. For these reasons, countries focused on finding substantial resources that are environmentally friendly (Konstantinos et al., 2019). Based on the European Union, European countries' renewable energy consumption must reach to 32% by 2030. Also, the number could be higher (Energy Union,2018). However, the European Union's enhancement in this sector is pessimistic, based on (European Environmental Agency, 2017) report about the slow achievements in renewable energy.

- Wind Energy

This study aims to determine the best location for installing wind farms by using Analytical Hierarchy Process (AHP) combining with Geographic Information System (GIS) (Konstantinos et al., 2019). In China, wind energy considers the third-largest power supply, with production energy reached 13.5 TWh (Angelopoulos et al. 2017). Also, the market forecast showed Europe by 2021 could improve wind production’s performance to become second place after Asia in this sector (GWEC, 2016). AHP will play the primary role in determining the weight of criteria besides comparing the alternatives (Konstantinos et al., 2019) and using GIS with AHP to determine the most applicable location for the installation. Five different criteria had been chosen for this study, distance from the substations, land uses, slope, wind speed, and road network with several parameters for each criterion (Konstantinos et al., 2019). The result showed wind speed is considered the most important criterion for location installation with a weight of 0.478 following by land uses. The least criteria weight was for road network 0.043 (Konstantinos et al., 2019).

- Thermal Energy

The main purpose of applying AHP in this study is to classify the most important criteria related to selecting the location of the thermal power plant (TPP) in India (Choudhary et al., 2012). The criticality of location selection is related to the power plant's cost and power transmitting (Choudhary et al., 2012). Six criteria had been selected to identify the optimum location based on the literature review and an expert's opinion. "These criteria are accessibility, cost, resource availability, Biological environment, physical environment, and socio-economic development" (Choudhary et al., 2012). Five different areas consider as alternatives locations like Bansagar, Shahpura, Sasan, Umred, and Wani. After running sensitivity analysis, resource availability has the highest weight, and Sasan considers as the most favorable location (Choudhary et al., 2012).

- Solar Energy

According to (Ozdemir et al., 2018), the aim of applying AHP to evaluate three different locations to install a solar PV power plant in Turkey. These locations are Igdir University, Melekli, and Kulluk areas. Furthermore, this test had been tested previously in Saudi Arabia by determining the weight of electricity production. Then select the location based on the criteria (Garni et al., 2017).according to (Ozdemir et al., 2018) study, Five different criteria were chosen, potential energy production, environmental factor, safety, distance from the transmission line, and topographical properties. The result showed that Kulluk is the optimum location to install a solar plant Several uncertainties could affect the outcome regarding the decision maker's judgment and lack of information.

2.3.2 Transportation

According to (Bouruama et al., 2020), AHP had been applied in West Africa to study the railway system's development. AHP method was used to evaluate and prioritize SWOT factors that were selected in the strategy development. The transportation network plays an important factor in West Africa since it is considered one of the efficient trading delivery methods between African countries (Eric, 2011) #4. Implementing SWOT analysis in this study to understand the condition of the railway system, AHP will help to measure the weight of each factor (criteria) and their alternatives (Bouruama et al., 2020). The result showed weakness consider as the most important criteria, and Opportunity is the least. For the alternatives (priorities), "the competition from road and intermittent state intervention" is the most threat. The major weakness is the "non-functionality of infrastructure. The strength in large-capacity rail haulage over a long distance, and the "market growth as an opportunity (Bouruama et al., 2020). Based on PIDA, up to 2040, the estimated cost of infrastructure in West Africa could reach US$ 360 billion, which consider as 9.1% of the capital cost (Bank 2018) # 42. This number proves the theory of AHP, which found the weakness in infrastructure is undeveloped in these countries and required severe investment to improve it.

Furthermore, AHP was executed to evaluate different transportation systems in the lead in zinc mines. The passageway's length is 1,800 m within an area of 11 m square (Dospodov et al., 2011). The ore quantity is estimated at around 750,000 tonnes. The transportation systems that need to be studied are trolley locomotives, battery locomotives, conveyor systems with multiple belts (2-3), and underground mining trucks (Dospodov et al., 2011). The criteria used to find the optimum method are cost, investment, required workforce, health and safety, underground pollution, reliability, and automation. Based on the AHP model, the conveyor system with two belts got the highest value, and based on this; it is the optimum method (Dospodov et al., 2011). Also, the transportation cost had the greatest score of the criteria, which means that it has

It has the highest effect on the result.

2.3.3 Agriculture

In Iran, AHP had been applied to estimate maize farming properties such as climate, topography data, and soil properties (Tashayo et al., 2019). Also, GIS was engaged in this study to generate a map for land suitability in farming. These kinds of studies' importance are to understand the factors that could force on crop quality and productivity (Tashayo et al., 2019). The criteria selected for this study classified into high suitable, moderately suitable, and marginally suitable. All these factors had a range of alternatives for decision-making, including the climate range in terms of temperature and rain periods. Also, the soil factors related to PH value evaluate soil saturation, soil texture, CCE (calcium carbonate equivalent), ESP for sodium cation content, and EC. The topography factors that analyze the slope percentage, which in general low slope, will give an advantage for farming. Finally, the elevation in which many factors could be changed directly with elevation change such as precipitation, temperature, and water content (Tashayo et al., 2019). The result showed that the high suitable category is the best, elevating less than 1700 M, slope less than 2%, and sandy clay texture (Tashayo et al., 2019). By combing GIS, it was found that southwest Iran has the most suitable region for maize farms.

2.3.4 Industry

The multi-criteria design-making tool AHP was also used to select the most applicable crane for the construction process. The model is designed to distinguish between three different crane categories, which are Derrick cranes, Mobile cranes, and tower cranes. Each type has its characteristics and abilities that make it more suitable than others for specific construction work (Dalalah et al., 2010). Cranes selection consider as confusing and a time-consuming process due to lack of information, data inconsistency, and not following standard formats, which AHP does (Dalalah et al., 2010). Five main factors for selecting the best crane used in this model are:

Building design: related to the building high and project duration

Capability: considering the power supply, lifting frequency, and operation visibility

Economy: cost of moving, rent, and setup

Safety-related to the initial planning

Site condition related to ground condition, road accessibility, and operation clearance

The criterion is different between different types; for example, in the economy, the mobile crane is not expensive if the project duration is less than four months. Tower crane is expensive in the setup stage. Derrick crane is cheaper than both, even in renting and buying (Dalalah et al., 2010). The AHP modeling result showed that safety is considered the most important criterion (0.476), and the cost is the least priority. The Tower crane got the highest score, and the mobile crane was last by comparing the criteria and properties for each crane design (Dalalah et al., 2010).

Additionally, the AHP model is used in the industrial maintenance sector to find which component of a specific machine will fail easily (Lima et al., 2010). This study aims to guarantee good maintenance and connected it directly to the equipment to reduce failure. AHP model could decide which machine should provide an advantage between the four different alternatives, comp1, comp2, comp3, and comp4 for maintenance (Lima et al., 2010). The criteria used for this case is the mean value (in 24 hours) for pressure, rotation, vibration, and voltage. The result found comp two will be failed faster than the others, which comp3 is the lowest (Lima et al., 2010.

2.3.5 Technology

Since smartphone selection considers a complicated process due to different types in the market with many features that could give an advantage from one type to another, utilizing AHP could help clarify the best selection. In this case study, the choice of smartphones is based on five criteria like the camera (MP), memory size (GB), battery life (hours), style, and cost (thousand Rs) (Lobo et al., 2016). For confidentiality purposes, the smartphone names were not mentioned and were called ph1, ph2, ph3, and ph4. By applying the AHP model, the most important criteria were the cost, and the top-ranking phone was ph3, followed by ph4, ph2, and then ph1 (Lobo et al., 2016). In case of a close result between the alternative, the decision making will be more critical.

2.3.6 Location Allocation

- Airport Location Selection

In Turkey, the AHP model was applied to identify the best location for military airports. 4 different locations were suggested and named A, B, C, and D for confidentiality (sennaroglu et al., 2018). Nine different criteria with thirty-three sub-criteria were used to evaluate the options by determining the weight (sennaroglu et al., 2018).

PROMETHEE and VIKOR methods are used to rank and select alternatives. Criteria are: -

1- Military criteria

2-Expansion potential

3-cost

4-Environmental and Social Effect

5-Climate Condition

6-Infrastructure Facility

7-Land

8- Geographical Features and

9-Needs

After comparison, normalizing matrix, and weighs, the AHP model sets the ranking as follows, C, A, D, then B. the main criteria were military criteria, which were allocated as a security risk, nearest military airport, transportation to military units. Also. Climate conditions and geographical features had high rates compared with other criteria. On the other hand, the cost was the least important criterion, which focuses on land and construction costs. The environmental and social effects had low weight with infrastructure facilities (sennaroglu et al., 2018). These weights reflect the robust economic level in terms of giving low priority for cost and a good indication of the area's quality of infrastructure.

- Port Location Selection

Referring to (KA, 2011), the importance of dry port is to create an area for customer services includes the declaration, inspection, and insurance. It will facilitate the logistics between the east and west in terms of time. For this reason, establishing an AHP model will assist in selecting the optimal location of a dry port in china based on six main criteria, which are transportation, economic level, infrastructure, trade level, political, environmental, and cost (KA, 2011). The plan is to select between seven different locations. First, utilize the AHP hierarchy structure from the top, which is the objective, middle, which represents the bottom criteria and alternatives (KA, 2011). After checking the consistency index and creating normalize and weight values, the result showed. The result showed that transportation and trading levels have the highest weight, representing distance, complementary resources, and import& export trade (KA, 2011). Also, the result showed Zhengzhou and Xi and are the best locations; on the other hand, Kaifeng is the worst site (KA, 2011)

2.3.7 Oil and Gas Industry

oil and gas production rates are declining continuously with time. For this reason, companies must estimate the economic limit by using Decline Curve Analysis (DCA) or simulation model in a way to move to the second stage or applying sufficient method to enhance the oil recovery (Lestari et al., 2018). Enhancing oil recovery could be done in multi-stages to produce the trapped oil even by secondary stage (water or gas injection) or tertiary recovery like (CO_2 injection, Nitrogen injection) (NETL, 2010). THE fuzzy AHP model was applied in this study to design sufficient and adequate scenarios to support petroleum experts with the information to design decision-making scenarios to estimate the future production results (Lestari et al., 2018). The objective is to build a section support system for oil field development. The criteria are periodized stage and include technical support, geographical location, and management, which refers to expenses before production. The second criteria are the analysis stage, where the sub-criteria are oil production result, contract field, product quality, and management. The third stage is the injection stage and injection process, which refers to adding new wells and maintenance wells. The second part is the secondary process, which relates to injection methods by injecting water or gas and finally, tertiary recovery by injecting chemicals (Lestari, et al., 2018). Three different scenarios represent the alternatives, scenarios A, B, and C. After creating the matrix, determining CR, and performing the criteria and sub-criteria. The result showed the best scenario B is the best at the injection stage that could provide sufficient information for decision making (Lestari, et al., 2018).

2.4 Literature Review Summary

Multi-criteria decision making (MCDM) is considering a powerful tool used in evaluating, weighing, and scientifically ranking different alternatives or criteria. There are different methods of MCDM, such as TOPSIS, ELECTRE, PROMETHEE, ANP, and AHP. Each method has it is own characteristics and advantages to be applied in specific cases and studies. Analytical Hierarchy Process (AHP) is a technique that quantifies a measurement scale based on the decision-maker's judgment. This tool is widely used in different sectors such as agriculture, renewable energy, transportation, and the oil & gas industry. AHP facilitates the ranking of the criteria from most important to the least by identifying criteria weight. Which will help to clarify which criteria need to take into consideration and which require low observation. Also, selecting alternatives if all options are at the same level will prevent the owner from making decisions based on cost and ignore other factors.

CHAPTER 3: METHODOLOGY

3.1 Current Status

It is essential to study the current situation of Dukhan field civil facilities from different ways to improve future facilities. The idea is to study the present accommodation compound from the number of units, such as the number of villas and apartments beside the size of each type, to satisfy all requirements. Also, the facilities inside the compound like the gym, mosque, and soccer field enhance these buildings and add more facilities to the new compound. The same study will be applied to markets, offices building, and beach club to find what these facilities lack and try to meet people's requirements and expectations.

3.2 Factor Identification

This part is significant and essential for the whole research project since the analysis and results are based on these factors. An extensive literature study was done to evaluate and gather information about criteria selection in the AHP model in different areas and how these factors added value to the research. As explained previously in chapter 2, nine other criteria were selected to be applicable for this project, besides twenty-two sub-criteria.

Once selecting the factors, the analysis, ranking of criteria, and sub-criteria will be based on survey design.

3.3 Survey Design

A questionnaire was distributed to professionals and Qatar university students to rank the identified criteria. This study's survey was created by using Google forms services due to the flexibility of this application besides the easy designing process without any complication or restriction.

The survey targets professionals in Qatar's state due to their information about the country's geography. Besides that, it is divided into two sections. The first part concentrates on the respondent's background, such as the field of work and work location, since the project is focusing on relocating facilities from oil and gas field. Also, to understand the answers from different respondents based on their experience and perspective.

The second part is most important in that the responses to the questions are considered input for the AHP model, and the answers will be converted into a pair-wise comparison of the model. For rating factors, the Likert importance scale was used with an important range from (Not at all important to Extremely important), as shown in the table2 below. Scale numbers were excluded from making it easier for respondents. The importance scale will be translated into saaty's scale (1-9), which will be applied in the pair-wise comparison of AHP model, as shown in Table 3 below.

Table 2. Likert importance scaling

Importance	Not at all important	Slightly important	Moderately important	Very Important	Extremely Important

Table 3. (1-9) Scaling used in AHP pair-wise comparison

Scale	Degree of importance	Reciprocal (decimal)
1	Equally important	1/1 (1.000)
2	Equally to moderately important	1/2 (0.500)
3	Moderately important	1/3 (0.333)
4	Moderately to strongly important	1/4 (0.250)
5	Strongly important	1/5 (0.200)
6	Strongly to very strongly important	1/6 (0.167)
7	Very strongly important	1/7 (0.143)
8	Very strongly to extremely important	1/8 (0.125)
9	Extremely important	1/9 (0.111)

3.4 Data Collection

The survey questionnaire (as shown in Appendix 1) was distrusted by local employees and students of the state of Qatar. Also, the survey is targeting different stakeholders, such as clients and contractors. It was shared using the Google forms platform, which is considered an easy communication application that could be provided on different channels such as email and WhatsApp, and these platforms were used for this survey. A total of 72 people had participated in various disciplines in the survey.

3.5 Sample Demography

this section covers the first section of the questionnaires related to the participant's background, and it will summarize this section.

3.5.1 The Current Field of Work

This question focuses on the response's background regarding his/her field of work and the type of the organization. Figure 4 and figure 5 shows the result of the survey.

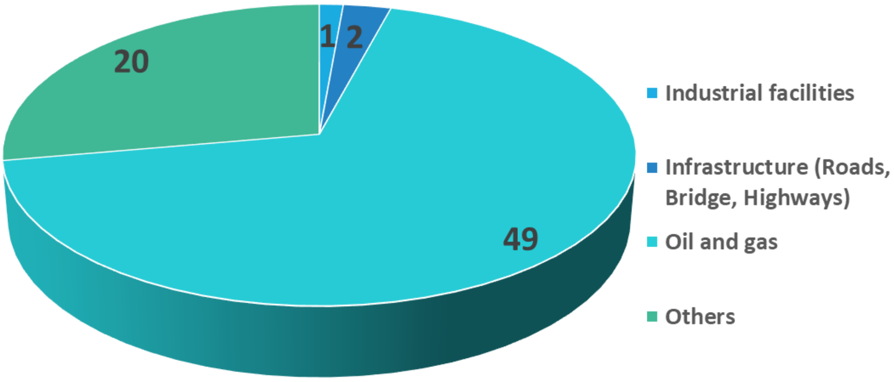

Figure 4. Questionnaire distribution by field of work

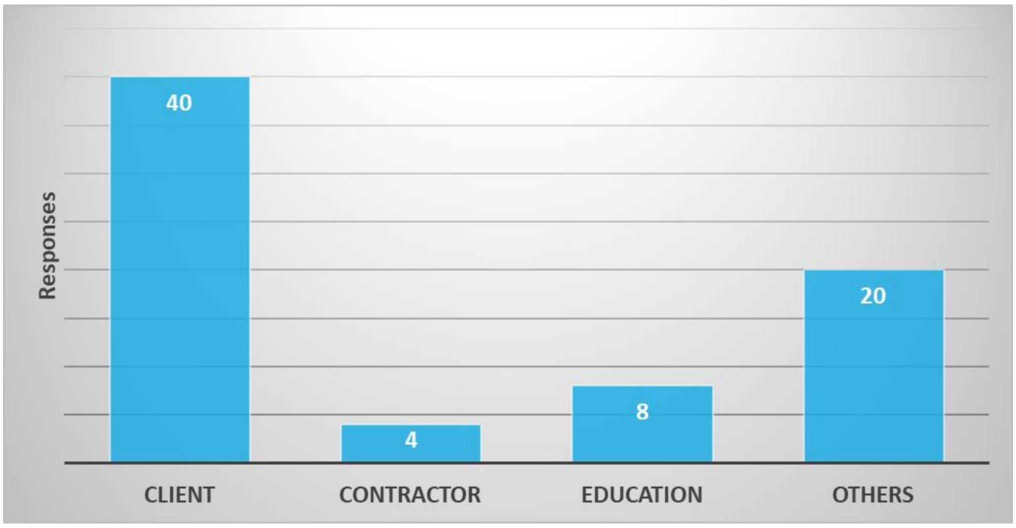

Figure 5. Questionnaire distribution by organizational type

3.5.2 Job designation, years of experience, and work location

This part shows the work designation of the responses besides the years of experience. The summary of the results is shown in Figure 6, Figure 7, and figure 8 which provides clear ideas related to the respondent.

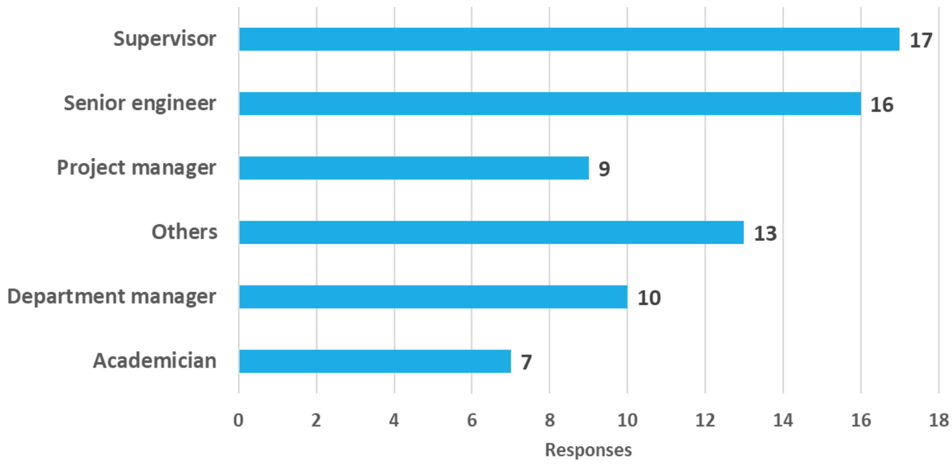

Figure 6. Questionnaire distribution by work designation

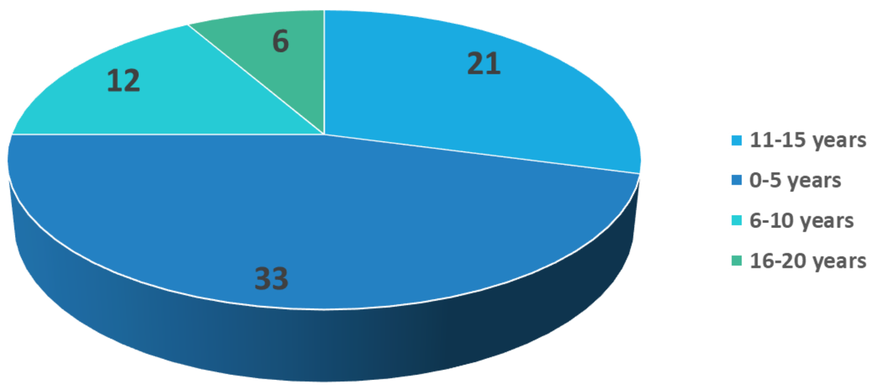

Figure 7. Questionnaire distribution by Work years of experience

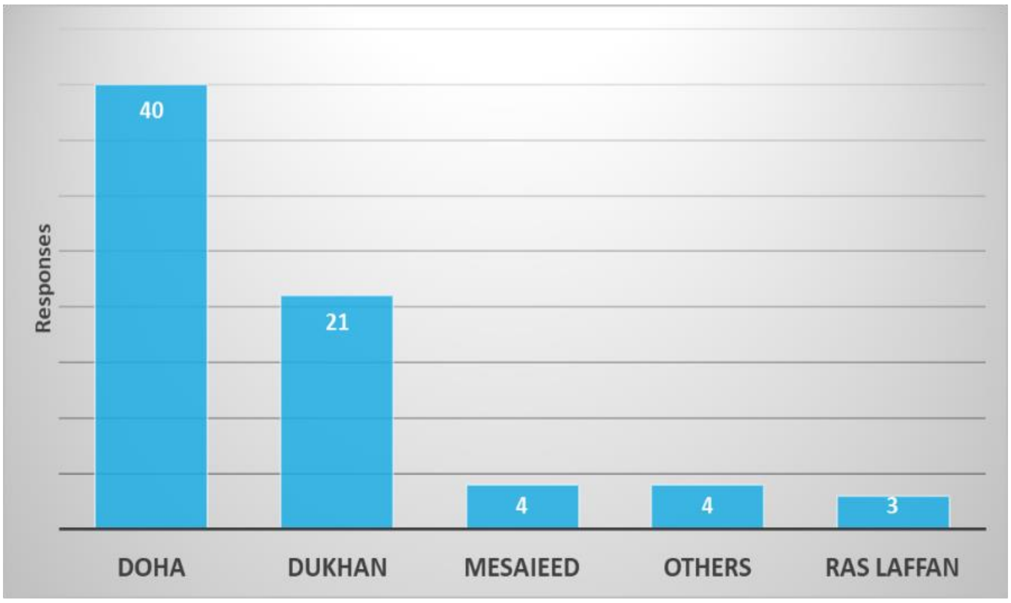

Figure 8. Questionnaire distribution by Work location

In order to evaluate and understand the priorities of stakeholder, the results of criteria ranking were filtered and sorted by stakeholder. It is noticeable that there is a variation between the responses of each stakeholder group, however they most of them believe that safety is the most important factor except for educators who believe that cost is more important than safety where they received an average score of 4.5 and 4.375 respectively.

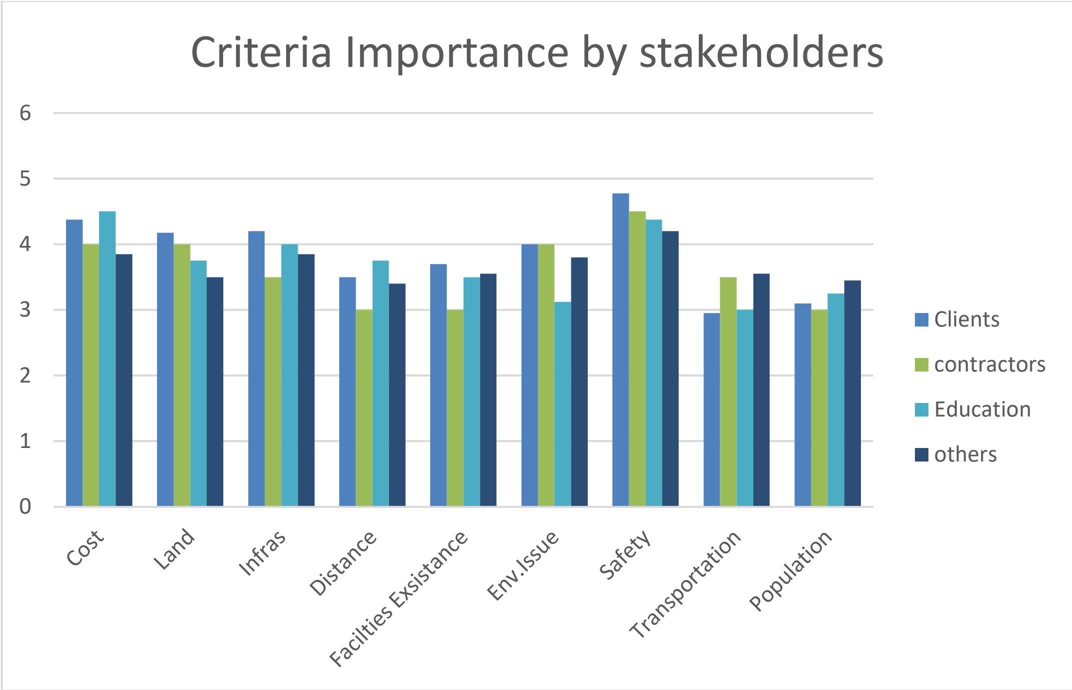

Figure 9. Importance of study criteria by stakeholders.

CHAPTER 4: DATA ANALYSIS

4.1 Overview

This chapter will discuss the second part of the survey by analyzing the questions to create an AHP model to identify the most important criteria and most applicable location.

In the beginning, the ranking will be build based on the relative importance index (RII), then these data will be used to create pair-wise comparison matrices.

The second part is related to build AHP model for criteria, sub-criteria, which will be utilized to find the optimum location.

4.2 Recommended Facilities

This section describes the recommended facilities for relocation, besides the ways to develop it.

4.2.1 Qatar Petroleum Compound (Dukhan)

As shown in figure 10 below, Dukhan accommodation compound is the only residential facility in the city. The compound is only allowable for Qatar Petroleum employees and their families since it is considered a company's asset. The compound's size is approximately 2.5 km (east to west) and 2.8 km (North to south). The compound consists of hundreds of accommodation units, which distrusted the different sizes of villas to fit the family members and the job position. Also, it has many condominiums with other options. Also, the facility consists of a gym, restaurant, kindergarten, and sports fields. Even though the compound is very old, it was subjected to routine maintenance and construction to increase the units. However, a strategic plan should be set to estimate the future number of people who will join the company and work to avoid crowding in the future. Also, the maintenance is not enough since the infrastructure is old and needs to be changed, costly.

Figure 10. Dukhan Accommodation Compound[14]

4.2.2 Qatar Petroleum Office Building

This building is considered the main building office in Dukhan, regardless of the small branches distributed around the city, such as the library and safety training center. The structure design, as shown in figure 11, it is four cylindrical linked building; each one has four floors, including the building. The diameter of the building is 600 m. Regarding the offices, it was separated by a cemented wall and, in most cases, multiple employees in one office. The suggestion in the case of a new office building is to construct a smart building office like an open area divided by partition to control the size of the offices easily. Also, to allocate a private office for each employee in terms of privacy.

Figure 11. Qatar Petroleum Offices Building (Dukhan)[37]

4.2.3 Dukhan Beach Club

The beach club is the only entertainment place for kids and families. It is available for all Qatar petroleum employees. It provides many water games, beach access, and food services for parties and feasts. The club is 170 m along the Dukhan beach. It has the same problem as the rest of the facilities which need to be renewed and add more games. However, Zekreet and Brouq Island are the only options available for beach club due to sea access.

Figure 12. Dukhan Beach Club[14]

4.2.4 Dukhan Shopping Center

Dukhan shopping center consists of a supermarket, food court, three restaurants, a barbershop, and a laundry. If the residents need more services, they need to go to Doha. Due to limited options in the current shopping center, it is recommended to propose tendering and business deals for investors and companies to develop the shopping center in suggested locations. Barwa city in the industrial area and Alwakra is a good example of an integrated market that meets people's needs.

Figure 13. Dukhan Shopping Center[15]

4.3 Possible Alternative Locations

The locations that had been selected based on specific factors are to fulfill the objective of this project. Applying AHP method will identify the best location between these five alternatives.

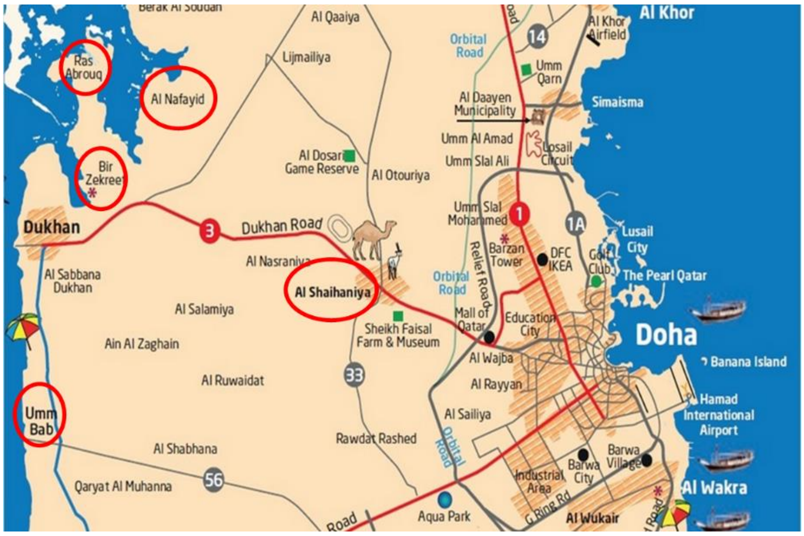

Figure 14. Alternative Locations[44]

4.3.1 Zekreet City

Zekreet village is located northwest of the state of Qatar, around 80 km from the capital Doha. The city was built in 1940 after discovering oil in Dukhan field in 1939 (Qatar Petroleum Annual report, 2-15). The area is divided into three parts. The first part is the tourism section, which contains heritage houses, old Masjid. Besides, geologists do some tours for students and interested groups due to different types of rocks beside geological features in the area, as shown in figure 15. The second part consists of a residential area with several houses and farms for different Qatari families, and the population number does not exceed 1000 people. The third part is the peach, which is vast and considers a tourism destination for those who like water games. Furthermore, the project focuses on this area of zekreet since the beach is wide and could be split between recommended facilities and visitors to ensure privacy for all groups. The other side of the site includes small markets (electrician, supermarket, small restaurant, etc.); however, new shops are highly recommended if this area will be selected.

Figure 15. Zekreet geological natural rock formation marking[36]

4.3.2 Ras Brouq Island

The island considers as an extension of zekreet city; it is in the northmost- west of the state. The island contains cliffs and carvings, which might attract visitors and tourists (Qatar museums, 2020). Besides that, the discoveries showed ancient people lived in this city based on the tools and equipment discovered in the area (Qatar museums,2020). Also, the island includes oryx preserves besides a high concentration of ostriches. These preserves are obstacles in selecting the island, which the ministry of municipality and environment needs to protect these unique animal types from extinction. Rather than that, the area is perfect since it is vast, unpopulated, and close to the field. However, the issue is related to environmental issues besides the lack of infrastructure foundations.

Figure 16. Oryx natural preserves in Ras Brouq[36]

4.3.3 Alnafayid

The city considers as an extension of Ras Brouq. It is an unpopulated and non-industrial city. The ground is rocky and rugged; besides, it does not have a beach even though the city is not suitable for camping or tourism—no life in this city.

4.3.4 Umm Bab

The area of the city is around 130 km^. Also, it is located 25 km from Dukhan city. The town was under exploration in the 1960s. From an industrial perspective, the city contains huge silica sand used for cement and construction. The government decided to build a cement factory around 8 km from the village. Also, flowlines to transport productions from Dukhan to Mesaieed (export port location) are established through Umm Bab with various stations in the way. The area has small accommodation compounds for the workers in the cement company. In addition, it has a beach which considers as an adequate distention for people to visit.

4.3.5 Alshehaniya

Alshehaniya considers as the main city of the west of the state of Qatar. The municipality of Alshehaniya is controlling all cities and villages in the west, such as Dukhan, Zekreet, and Umm Bab. The town area is around 3500 km^2, and the population based on 2015 statistics reached 190,000, which makes it higher than Alwakra at that time (Planning and Statistics authority annual report 2015). the city has the country's main camel race beside many farms for camels, cows, and cattle. Also, Al-Dosari preserves are in the town. The infrastructure is developed extensively due to a huge number of movements to the city besides the construction and development in nearby areas such as Qatar mall and Education city. Also, many government lands are distributed for the citizens in the region and contributed to increasing the city's investments.

4.4 Criteria and sub-criteria classification

criteria are the components that the project's success would be built on. The selection of criteria and evaluation is a critical part that requires to be studied very well. For this project, the choice of criteria and sub-criteria is based on an extensive literature review study of academic papers and research in different fields and countries. Figure 17 classifies the criteria and sub-criteria that are going to be used for this project.

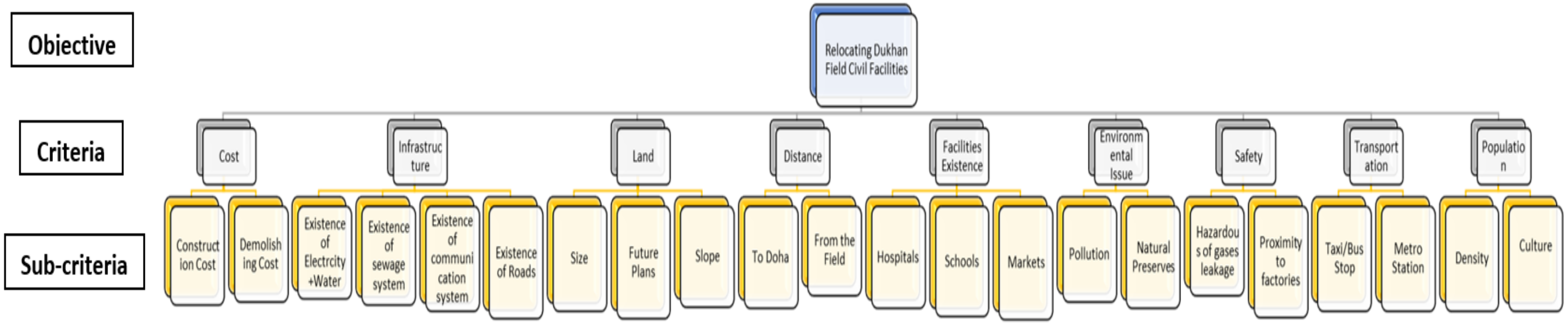

Figure 17. Hierarchy of Criteria and Sub-criteria

4.4.1 Cost

The first criteria are related to the main factor which could stop any project or continue. This project focused on construction cost, which is related to build a compound with an estimated size as the original compound in the Dukhan field. To determine the cost, some real estate websites such as "property finder" estimate the cost of a compound slightly like Dukhan (in our case, assumed Ezdan Alwukair). Furthermore, the land cost will not be an issue for Qatar Petroleum if the selected location between Zekreet and Ras Brouq is under QP custody based on the Amiry decree in 1995. As per ASHGHAL engineer, the demolishing price is different from one site to another regarding demolishing costs. For example, in Zekreet, it will be easier since the area is empty. However, in Doha, it will be higher due to more advanced techniques and more equipment besides more manpower to ensure safety in the area.

4.4.2 Land

Land emptiness will impact determining the size of the compound. In the case of the unavailability of building nearby, it will be easier to enlarge the compound for around 500 extra in an increasing number of employees due to future operational development in the field. Besides that, if the area doesn't have any future projects such as lands distribution for citizens, malls, and stadiums, then will not have any issue in the area .in a way to identify future projects, need to revise with different ministries and organizations to have a clear vision regarding the future of the area. However, this project will estimate the plan for the next three to five years. Also, the slope will be ignored due to the unavailability of sufficient data regarding this part.

4.4.3 Distance

It is important to select an optimized location that balances the distance to Doha and the field. However, prioritization is based on the survey. Also, it is not an issue since the distance from Dukhan field to the farthest city is less than 80 km. It is important to locate the buildings in an area that close to the field for a fast response. On the other hand, not far away from the capital for people's needs that are not available in nearby areas, plus for the family's entertainment purposes.

4.4.4 Facilities Existence

The existence of services facilities is important to simplify employee's lives, in terms of schools' availability in different levels to avoid long time transportation, which will be counted from their time or money in case of providing drivers. Also, hospitals, health centers, emergency, and dentists are critical in case of an urgent situation and to reduce response time even for the ambulance. Furthermore, supermarkets and hypermarkets for grocery in the neighborhood compound itself to supply residents and avoid long-way travel. Even though respondents will evaluate the weight of these types from the survey.

4.4.5 Transportation

Public transportation availability is important for the proposed location if the employee cannot drive or relax. Nevertheless, public transportation companies like Karwa provided customer service to call for a cab if needed, but they don't have a Dukhan driver base due to low demand. Similar issues with Alrail company, in a way, it will be costly to extend the railroad to an unpopulated area. For this reason, the selected site needs to focus on optimizing the public transportation system in the area.

4.4.6 Population

Population criteria are divided into two main sections. The first section is the density. If the recommended city is already crowded, it will reduce the opportunity to select this area. The number of Dukhan population is around 8000 (MONGABAY), and transfer a huge number could cause problems in adding more pressure on the infrastructure, services, and the community. On the other side, diversity considers as an advantage, and it is an indication of civilization. Qatar Petroleum is an excellent example of diversity, where employees are from different countries, religions, and cultures. In this project, we will assume a high number of diversities as an advantage.

4.4.7 Environmental Issue

All types of pollution will be counted for this criterion, including noise, air, and water. In any region that is facing these issues, the weight might be positively affected. Also, livestock is important epically for rare animals such as oryx. Qatar is trying to save this type form extinction. So the construction and moving people into the preserves area could negatively affect these types. In this project, the focus is to keep the new location away from current and future preserves.

4.4.8 Safety

Safety is a priority for Qatar Petroleum. To optimize the current location, facilities must be away from factories to prevent the spread of gases and be away from factories' operation. Also, not to be affected in case of any emergency. Hazardous gas leakage is directly connected to the proximity of factories. Since most of the recommended cities are clear from factories will have an advantage from a city with an existing or future factory.

4.4.9 Infrastructure

Areas with existing infrastructure and roads will be more favorable than others. Otherwise, the quality of infrastructure is varied from one city to another. All towns have water and electricity facilities, though, the sewage system is still not developed in all recommended areas. Also, telecommunication network quality is moderate to strong in most cities except isolated lands and deserts. Roads are not an issue since it is the easiest part of operation and cost if it is compared with other infrastructure parts compared with others. This part will be evaluated based on interviewing ASHGHAL engineers.

4.5 Relative Importance Index

This method had been implemented in other researches which related construction project (Gundus et al., 2013), also in "construction project safety management performance" (Gunduz et al., 2020). RII is calculated as follow: -

$$\text{RII} = \frac{\Sigma P}{N\ X\ H}$$

Where

N: total number of responses (72)

H: Highest number used in scale (5)

P: Product some of the responses with their respective count

Table 4. Factor (cost) count response

A1 (Cost)						
Rate	**1**	**2**	**3**	**4**	**5**	**Total**
Count	0	4	11	22	35	37

$$RII = \frac{(1X0) + (2X4) + (3X11) + (4X22) + (5X35)}{5\text{ X }72} = 0.844$$

Variables in the equation, are depending on the survey data explained in chapter 3. After distributing responses (72) N. Also, the highest number of scale which is (5) is counted as (H). Each criterion based on the Linkert scale (1-5) will help to identify the value of (P) besides the votes counted for each scale. Similar procedures were used to calculate RII for all criteria and sub-criteria. After that, factors will be rearranged based on the RII value (from highest to lowest), as shown in the. Furthermore, codes had been assigned for all sub-criteria to differentiate and categorize them based on each criterion. The rest of the criteria will be discussed in chapter 5

4.6 AHP as Ranking Tool

AHP is considered a powerful decision-making tool in combining data and judgments to rank options effectively and analyze the outcomes. Also, the linear additive weights could be applied to rank the alternatives (Lobo et al., 2016). Besides, Saaty, when developed AHP in 1970, the model was a hierarchal base where criteria are not influenced by each other such as (cost and quality). Otherwise, ANP was developed by Saaty later to link between criteria and effect on each other. The purpose of applying AHP due to variation between criteria and the need to show how each criterion will influence alternatives separately.

4.7 Steps of creating AHP matrix

AHP considers a multi-criteria decision-making technique done by creating a decision matrix consisting of criteria and alternatives. Each alternative has it is own weight of criteria associated with it. Building AHP model can be done as follows: -

1. Identify the main objective as a top-level of the hierarchy.
2. Connect all criteria (in the second level) to the main objective
3. Link each sub-criterion to the criteria related to it.
4. For creating a matrix, use the RII ranking table as shown in table 4 above by using highest and lowest rank (1,9)
5. Use Satty scale (1-9) to determine the importance of criteria to the goal
6. Identify linear equation by using Max and Min ranking between RII and Satty scale as a coordinates
7. Find Max Rank, Min rank for criteria. Max rank =9 and Min rank =1

8. Calculate the rating equation for the points (1,9) from the ranking and (2,8) from Saaty scale as follow

straight line standard form→$y=mx+c$

by Calculating the slope $(m)= (y_2-y_1)/ (x_2-x_1) =1$, so $Y=X+1$.

9. After that, for comparison, substitute the difference between the criteria to build the matrix.

Table 5. Criteria Matrix

	Safety	Cost	Infrastructure	Land Size	Environmental Issue	New Facilities	Distance	Population	Transportation
Safety	1	2	3	4	5	6	7	8	9
Cost	0.5	1	2	3	4	5	6	7	8
Infrastructure	0.33	0.5	1	2	3	4	5	6	7
Land Size	0.25	0.33	0.5	1	2	3	4	5	6
Environmental Issue	0.2	0.25	0.33	0.5	1	2	3	4	5
New Facilities	0.160	0.2	0.25	0.33	0.5	1	2	3	4
Distance	0.14	0.16	0.2	0.25	0.33	0.5	1	2	3
Population	0.125	0.142857143	10.16	0.2	0.25	0.33	0.5	1	2
Transportation	0.11	0.125	0.14	0.16	0.2	0.25	0.33	0.5	1

10. For sub-criteria, repeat step 6 by ranking them based on RII value, as shown in the matrix above.

11. After finding the Max rank and Min rank for all sub-criteria to create the equation, the same as step 7. Min rank=1 and Max rank=22.

12. By repeating the same steps as number 7, the equation is $Y=0.35X +1.65$

13. This step will be repeated for all sub-criteria by using the same equation.

4.8 AHP Analysis

A few steps need to be determined in the pair-wise comparison to rank the criteria from the highest to the lowest. The procedure as follows: -

1. After creating the matrix, some need to be calculated for each column as shown below in table 6 in the criteria comparison matrix

Table 6. Criteria matrix (sum)

	Safety	Cost	Infrastructure	Land Size	Environmental Issue	New Facilities	Distance	Population	Transportation
Safety	1	2	3	4	5	6	7	8	9
Cost	0.5	1	2	3	4	5	6	7	8
Infrastructure	0.33	0.5	1	2	3	4	5	6	7
Land Size	0.25	0.33	0.5	1	2	3	4	5	6
Environmental Issue	0.2	0.25	0.33	0.5	1	2	3	4	5
New Facilities	0.160	0.2	0.25	0.33	0.5	1	2	3	4
Distance	0.14	0.16	0.2	0.25	0.33	0.5	1	2	3
Population	0.125	0.142857143	10.16	0.2	0.25	0.33	0.5	1	2
Transportation	0.11	0.125	0.14	0.16	0.2	0.25	0.33	0.5	1
Sum	2.82	4.71	17.58	11.44	16.28	22.08	28.83	36.50	45.00

2. Normalize pair-wise matrix by dividing the sum of each column by the element they belong to it as shown in table 7

Table 7. Normalization

	Safety	Cost	Infrastructure	Land Size	Environmental Issue	New Facilities	Distance	Population	Transportation
Safety	0.35	0.42	0.17	0.35	0.31	0.27	0.24	0.22	0.20
Cost	0.18	0.21	0.11	0.26	0.25	0.23	0.21	0.19	0.18
Infrastructure	0.12	0.11	0.06	0.17	0.18	0.18	0.17	0.16	0.16
Land Size	0.09	0.07	0.03	0.09	0.12	0.14	0.14	0.14	0.13
Environmental Issue	0.07	0.05	0.02	0.04	0.06	0.09	0.10	0.11	0.11
New Facilities	0.06	0.04	0.01	0.03	0.03	0.05	0.07	0.08	0.09
Distance	0.05	0.03	0.01	0.02	0.02	0.02	0.03	0.05	0.07
Population	0.04	0.03	0.58	0.02	0.02	0.01	0.02	0.03	0.04
Transportation	0.04	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.02

3. Calculate the criteria weight by averaging all elements in the raw

Table 8. Criteria Weight

	Safety	Cost	Infrastructure	Land Size	Environmental Issue	New Facilities	Distance	Population	Transportation
Safety	0.35	0.42	0.17	0.35	0.31	0.27	0.24	0.22	0.20
Cost	0.18	0.21	0.11	0.26	0.25	0.23	0.21	0.19	0.18
Infrastructure	0.12	0.11	0.06	0.17	0.18	0.18	0.17	0.16	0.16
Land Size	0.09	0.07	0.03	0.09	0.12	0.14	0.14	0.14	0.13
Environmental Issue	0.07	0.05	0.02	0.04	0.06	0.09	0.10	0.11	0.11
New Facilities	0.06	0.04	0.01	0.03	0.03	0.05	0.07	0.08	0.09
Distance	0.05	0.03	0.01	0.02	0.02	0.02	0.03	0.05	0.07
Population	0.04	0.03	0.58	0.02	0.02	0.01	0.02	0.03	0.04
Transportation	0.04	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.02

4. Calculate the consistency to check the calculated values are correct or not by multiplying the non-normalized matrix by criteria weight

Table 9. Consistency Ratio

	Safety	Cost	Infrastructure	Land Size	Environmental Issue	New Facilities	Distance	Population	Transportation
Criteria Weight	0.31	0.22	0.15	0.11	0.08	0.05	0.04	0.03	0.02
Safety	1	2	3	4	5	6	7	8	9
Cost	0.5	1	2	3	4	5	6	7	8
Infrastructure	0.33	0.5	1	2	3	4	5	6	7
Land Size	0.25	0.33	0.5	1	2	3	4	5	6
Environmental Issue	0.2	0.25	0.33	0.5	1	2	3	4	5
New Facilities	0.16	0.2	0.25	0.33	0.5	1	2	3	4
Distance	0.14	0.16	0.2	0.25	0.33	0.5	1	2	3
Population	0.13	0.14	0.16	0.2	0.25	0.33	0.5	1	2
Transportation	0.11	0.12	0.14	0.16	0.2	0.25	0.33	0.5	1

5. Then, weighted some value had been calculated by adding each raw in the consistency matrix

6. Next, calculate the ration of the calculated sum ratio over the criteria weight for each raw

Table 10. The ratio

	Safety	Cost	Infrastructure	Land Size	Environmental Issue	New Facilities	Distance	Population	Transportation	Weighted Sum Value	Criteria weight	WSV/CW
Safety	0.31	0.44	0.46	0.44	0.38	0.32	0.26	0.21	0.17	2.98	0.31	9.71
Cost	0.15	0.22	0.31	0.33	0.31	0.27	0.22	0.18	0.15	2.13	0.22	9.78
Infrastructure	0.10	0.11	0.15	0.22	0.23	0.21	0.19	0.16	0.13	1.50	0.15	9.72
Land Size	0.08	0.07	0.08	0.11	0.15	0.16	0.15	0.13	0.11	1.04	0.11	9.55
Environmental Issue	0.06	0.05	0.05	0.05	0.08	0.11	0.11	0.10	0.09	0.71	0.08	9.34
New Facilities	0.05	0.04	0.04	0.04	0.04	0.05	0.07	0.08	0.08	0.49	0.05	9.12
Distance	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.06	0.33	0.04	9.03
Population	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.23	0.03	9.03
Transportation	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.17	0.02	9.10

7. calculate ʎ max by averaging the ratio (weight sum value/ criteria weight)

8. After that, calculate the consistency index (C.I.) by using the equation

$$C.I = \frac{ʎ\,\max - \mathrm{n}}{-1}$$

Where n is the number of compared element

For the criteria, n=9

and ʎ max=9,36

$$C.I = \frac{9.36-9}{9-1} = 0.04$$

9. Calculate the consistency ratio (C.R.), which equal consistency index over random index (C.R. = C.I. / R.I.), where R.I. values are constantly based on randomly generated pair-wise matrix from 1 up to 10 criteria, wherein this example, the value at 9. The table is attached below with the values

Table 11. Random consistency index value (R.I.)

S. No.	Size of the Matrix	Random Consistency Index (RI)
1	1	0
2	2	0
3	3	0.52
4	4	0.89
5	5	1.11
6	6	1.25
7	7	1.35
8	8	1.4
9	9	1.45
10	10	1.49

4.8.1 Alternatives Selection Analysis

AHP will be done in this section in the same way as in criteria and sub-criteria parts. However, RII is not applied in this section since this section was not part of the questionnaire. A building matrix for sub-criteria will be created based on expert's judgments or general information and confidential reports by governments and organizations.

Table 12. Cost Pairwise Comparison Matrix for Alternative Locations

	Zekreet	Brouq Island	Umm Bab	Alshaihanya	Alnafayid
Zekreet	1	2	5	8	4
Brouq Island	0.50	1	4	7	3
Umm Bab	0.2	0.25	1	5	2
Alshaihanya	0.12	0.14	0.2	1	0.14
Alnafayid	0.2	0.33	0.5	7	1

The final stage to determine the optimum location is to multiple the criteria weight with the sub-criteria weight of the same category, then multiply the result by the vector of the locations to find the weights for each area as shown in figure 18. The whole tables and results of each location could be found in appendix 3.

Criteria	
Safety	0.31
Cost	0.22
Infrastructure	0.15
Land Size	0.11
Environmental Issue	0.08
New Facilities	0.05
Distance	0.04
Population	0.03
Transportation	0.02
	1.00

	Sub-criteria	Criteria Weight	
Cost	Construction	0.9	0.196
	Demolishing	0.1	0.022
Infrastructure	Existence of Electricity + Water	0.502	0.077
	Existence of sewage system	0.242	0.037
	Existence of communication system	0.172	0.027
	Existence of Roads	0.084	0.013
Land	Land size	0.615	0.067
	future plan	0.308	0.034
	slope	0.077	0.008
Distance	Distance to Doha	0.833	0.031
	Distance to the Field	0.167	0.006
Facilities existence	Hospital and clinics	0.614	0.033
	Schools	0.268	0.014
	Markets	0.117	0.006
Environmental Issues	Pollution	0.8	0.061
	Natural Preserves	0.2	0.015
Safety	Hazardous of gases leakage	0.75	0.230
	Proximity to factories	0.25	0.077
Transportation	Taxi/Bus station	0.875	0.017
	Metro station	0.125	0.002
Population	Density	0.8	0.021

	Counstruction	Demolishing	Exsistence of Elec+Water	Exsistence of sewage system	Exsistence of communcation system	Exsistence of transportation (Roads+signs)	Land size	future plan	slope	Distance to Doha	Distance to the Field	Hospital and clinics	Schools	Markets	Pollution	Natural Preserves	Hazardous gases leakage	Proximity to factories	Taxi/Bus station	Metro station	Density	Culture
Zekreet	0.436	0.485	0.312	0.200	0.332	0.235	0.416	0.439	0.200	0.112	0.402	0.367	0.343	0.334	0.175	0.302	0.243	0.086	0.207	0.200	0.077	0.315

Location		Total
Zekreet	0.293980355	29.4

Figure 18. Multiplication of criteria Weights by alternatives vectors

CHAPTER 5: DISCUSSION OF RESULTS

This section will discuss and explain the result of finding the optimum criteria sub-criteria, align with selecting the best location. The analysis of this chapter goes through three stages. First is RII ranking, AHP ranking for criteria and sub-criteria, and finally, the location selection stage.

5.1 RII results

The ranking of the relative importance index is mainly based on the survey ranking. As the method explains in chapter 4, the highest criteria ranking goes to safety in the criteria section, as shown in the table below. Most oil and gas companies consider it a priority, and it is necessary to live in an area clear from industrial operations. Also, in the survey, the highest voting number believes it is the highest important (scale 5). Otherwise, transportation received the lowest in the ranking. It might be assumed that Qatar's public transportation is not highly popular, and people always have their cars. So, the availability of public transportation is not an issue.

Table 13. RII value for Criteria

Rank	Criteria	RII
1	Safety	0.911
2	Cost	0.844
3	Infrastructure	0.808
4	Land	0.786
5	Environmental Issue	0.769
6	Facilities	0.719
7	Distance	0.694
8	Population	0.642
9	Transportation	0.631

In the sub-criteria part, the highest-ranking goes to one of the safety subs, the hazardous gas leaking problem. Simultaneously, the existence of electricity and water besides construction cost RII value was too close, which the participants gave higher ranking. On the contrary, demolishing cost in the required area is the least important based on value with the metro station, explained in the criteria section. This ranking result reflects how public transportation is neglected in this project. The graph below shows the ranking of sub-criteria based on RII value. If these sub-criteria arrange based on the category, safety is of the highest importance, followed by infrastructures and roads, followed by the land based on the sum of RII for each type. Construction cost was affected due to low ranking for demolishing cost; otherwise, the cost rate might be higher.

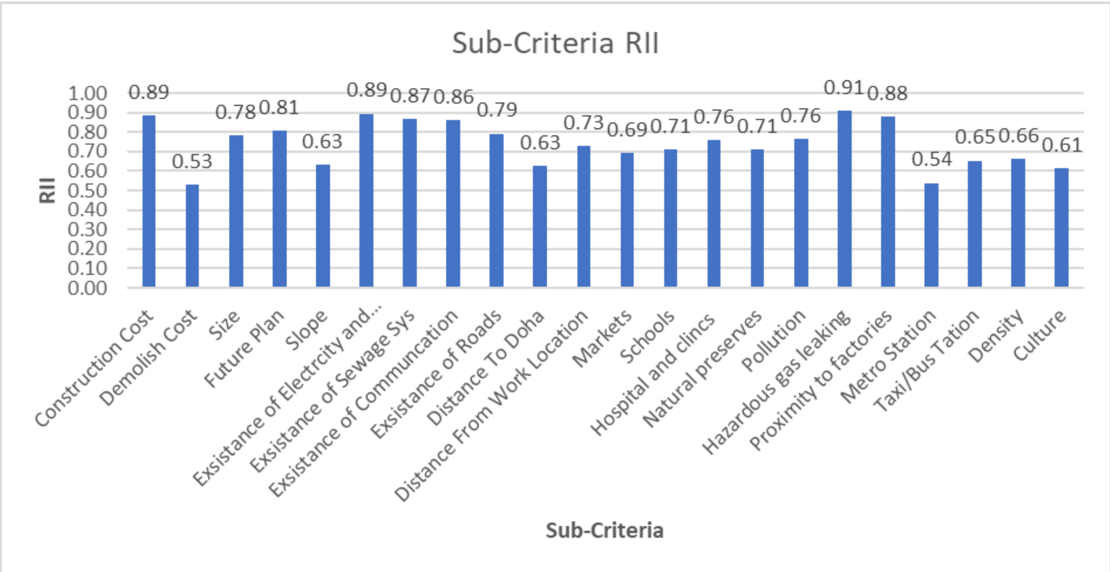

Figure 19. Sub-criteria Vs. RII

5.2 Criteria and Sub-criteria Results

5.2.1 Criteria Results

Criteria weights have a similar ranking as RII. The reason is expected because RII values are higher for the highest number of maximum scales, which is five in this project. Likewise, in AHP method, the highest weight is for the highest scale based on the comparison between factors. The table 14below shows the result and similarity in ranking between two different calculation methods.

Table 14. Criteria weight & RII values

Criteria	RII	Criteria Weight
Safety	0.911	0.31
Cost	0.844	0.22
Infrastructure	0.808	0.15
Land	0.786	0.11
Environmental Issue	0.769	0.08
Facilities	0.719	0.05
Distance	0.694	0.04
Population	0.642	0.03
Transportation	0.631	0.02

Same as RII ranking, safety is a priority for respondents, which for this reason they gave it highest vote numbers, which reflected on criteria weight and has the highest weight (31%). Cost is coming to the second important criterion due to the high budget required to implement this project (22%). Infrastructure and roads help to facilitate the project in terms of duration and expenses received (15%). The land is also critical criteria, but due to the availability of vast empty lands around the country, so this criterion is not a big issue that got (11%). Environmental issues and new facilities are medium-level criteria which are not that highly important. The reason might be due to the low awareness of people regarding the environmental issues and reasonable distribution of facilities around the country. The weights for these criteria are (8%) and (5%). Distance is one of the lowest weights due to country size area, where the distance from north to south of the country is less than 200km. Also, new highways make it easier to travel. The weight is around 4%. Also, the population is the second least criterion which a weight of about 3%. The lowest weight criteria are transportation facilities, which the beneficiaries number is too low, and the existence of these facilities in industrial cities is not an in the future development plan for the transportation network around the country, so for this reason, it is least important with weight around 2%.

5.2.2 Sub-criteria Results

On the contrary, the RII value is in a different ranking from RII value. Implementing the weights of sub-criteria is based on a category such as a cost, land, infrastructure, and other criteria—the difference in ranking between criteria weights and RII values, as shown in table 15.

Table 15. Sub-criteria Vs. RII

Rank	Code	Count	RII	Sub-criteria Weight
3	A11	Construction Cost	0.89	0.9
22	A12	Demolish Cost	0.53	0.1
9	B11	Size	0.78	0.62
7	B12	Future-Plan	0.81	0.31
18	B13	Slope	0.63	0.08
2	C11	Existence of W&E	0.89	0.5
5	C12	Existence of Sewage Sys	0.87	0.24
6	C13	Existence of Comm.	0.86	0.17
8	C14	Existence of Transportation	0.79	0.08
19	D11	Distance to Doha	0.63	0.83
12	D12	Distance to the Field	0.73	0.17
15	E11	Markets	0.69	0.12
13	E12	Schools	0.71	0.27
11	E13	Hospital and clinics	0.76	0.61
14	F11	Natural preserves	0.71	0.2
10	F12	Pollution	0.76	0.8
1	G11	Hazardous gas leaking	0.91	0.75
4	G12	Proximity to factories	0.88	0.25
21	H11	Metro Station	0.54	0.13
17	H12	Taxi/Bus stop	0.65	0.88
16	I11	Density	0.66	0.8
20	I12	Culture	0.61	0.2

The comparison matrix between sub-criteria was done using a robust application(https://bpmsg.com/ahp/ahp-calc.php), which helps accelerate the process of 22 sub-criteria.

The highest priority for the cost is construction cost, which is obvious if it is compared with demolishing cost. The ratio is 90% to 10% between the two factors.

Cat		Priority	Rank	(+)	(-)
1	Construction	90.0%	1	0.0%	0.0%
2	Demolishing	10.0%	2	0.0%	0.0%

Figure 20. Cost Sub-criteria Comparison Matrix

In the infrastructure group, electricity and water's existence got the highest weight with around 50%, followed by sewage system 24%, communication system existence around 17%, and the least important is roads that got 8%. This weight may be due to long time infrastructure needs to work on, which might bother residents and delay other projects; on the other side roads, it is not an issue regarding time and cost.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Existence of W&E	50.2%	1	15.5%	15.5%
2	Existence of Sewage System	24.2%	2	7.0%	7.0%
3	Existence of Communication System	17.2%	3	5.2%	5.2%
4	Existence of Transportation (Roads)	8.4%	4	2.7%	2.7%

Number of comparisons = 6
Consistency Ratio CR = 5.3%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4
1	1	3.00	3.00	4.00
2	0.33	1	2.00	3.00
3	0.33	0.50	1	3.00
4	0.25	0.33	0.33	1

Principal eigen value = 4.144
Eigenvector solution: 5 iterations, delta = 2.4E-8

Figure 21. Infrastructure Sub-criteria Comparison Matrix

For the land category, size is the most critical sub-criteria with a weight of around 60%, the plan was second with a weighted value of 30%, and the slope is the lowest, about 7%. Plans could be modified, but the land size is a very important factor in the success of the project currently and in the future if there is a plan to build extra buildings or villas.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Size	61.5%	1	0.0%	0.0%
2	Future Plans	30.8%	2	0.0%	0.0%
3	Slope	7.7%	3	0.0%	0.0%

Number of comparisons = 3
Consistency Ratio CR = 0.0%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3
1	1	2.00	8.00
2	0.50	1	4.00
3	0.12	0.25	1

Principal eigen value = 3.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Figure 22. Land sub-criteria Comparison Matrix

Distance from the proposed facility location to Doha has a higher weight than the distance to the work location. The weights for these two are around 83% and 16%.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Distance to Doha	83.3%	1	0.0%	0.0%
2	Distance to work location	16.7%	2	0.0%	0.0%

Number of comparisons = 1
Consistency Ratio CR = 0.0%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2
1	1	5.00
2	0.20	1

Principal eigen value = 2.000
Eigenvector solution: 1 iterations, delta = 7.7E-34

Figure 23. Distance sub-criteria Comparison Matrix

Hospitals and clinics are the highest sub-criteria with weight around61%, and the second is schools with 8%, and the market is last, which around 11%.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Hospital and Clincs	61.4%	1	16.5%	16.5%
2	Schools	26.8%	2	7.2%	7.2%
3	Markets	11.7%	3	3.1%	3.1%

Number of comparisons = 3
Consistency Ratio CR = 7.7%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3
1	1	3.00	4.00
2	0.33	1	3.00
3	0.25	0.33	1

Principal eigen value = 3.074
Eigenvector solution: 4 iterations, delta = 5.9E-8

Figure 24. Facilities Existence sub-criteria Comparison Matrix

In the environmental issue, air, noise pollutions are the highest with 80% weight, and the availability of natural reserves is 20% due to the limited number of preserves in Qatar.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Pollution	80.0%	1	0.0%	0.0%
2	Natural Preserves	20.0%	2	0.0%	0.0%

Number of comparisons = 1
Consistency Ratio CR = 0.0%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2
1	1	4.00
2	0.25	1

Principal eigen value = 2.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Figure 25. Environmental Issue sub-criteria Comparison Matrix

Safety, hazardous gas leakage is higher important than proximity to factories. In Dukhan, civil facilities are closer to oil and gas wells, making exposure to leakage higher with weight around 75% and more comparable to factories is 25%.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Hazardous gas leaking	75.0%	1	0.0%	0.0%
2	Proximity to factories	25.0%	2	0.0%	0.0%

Number of comparisons = 1
Consistency Ratio CR = 0.0%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2
1	1	3.00
2	0.33	1

Principal eigen value = 2.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Figure 26. Safety sub-criteria Comparison Matrix

The transportation system, taxi, and bus stops are higher because KARWA cars and buses are well distrusted, especially in main cities. Also, the metro station is still in progress, and recommended areas are out of scope. Weights of these factors are 87% and 13%.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

	Cat	Priority	Rank	(+)	(-)
1	Bus/Taxi Station	87.5%	1	0.0%	0.0%
2	Metro Station	12.5%	2	0.0%	0.0%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2
1	1	7.00
2	0.14	1

Number of comparisons = 1
Consistency Ratio CR = 0.0%

Principal eigen value = 2.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Figure 27. Transportation sub-criteria Comparison Matrix

In terms of population, density is more favorable than culture, in which different nationalities are in the country, and it seems not a problem. The ratio of these two factors is 80 to 20%.

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

	Cat	Priority	Rank	(+)	(-)
1	Density	80.0%	1	0.0%	0.0%
2	Culture	20.0%	2	0.0%	0.0%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2
1	1	4.00
2	0.25	1

Number of comparisons = 1
Consistency Ratio CR = 0.0%

Principal eigen value = 2.000
Eigenvector solution: 1 iterations, delta = 0.0E+0

Figure 28. Population sub-criteria Comparison Matrix

5.3 Alternatives Results

After applying the multiplication factor between locations and sub-criteria, as explained in chapter 4, the result follows. The same procedures were followed to find the alternative pairwise comparison matrix for each sub-criteria Tables 25 to 30 explains the steps to determine the weight of each city. Other alternatives- sub-criteria comparison matrix is in the Appendix section.

Table 16. Alternative Vs. Future Plan Sub-criteria Matrix

	Zekreet	**Brouq Island**	**Umm Bab**	**Alshaihanya**	**Alnafayid**
Zekreet	1	5	4	8	2
Brouq Island	0.2	1	4	5	0.33
Umm Bab	0.25	0.25	1	4	0.33
Alshaihanya	0.12	0.2	0.25	1	0.16
Alnafayid	0.5	3	3	6	1

Table 17. Alternative Vs. Future Plan Sub-criteria Matrix (Sum)

	Zekreet	**Brouq Island**	**Umm Bab**	**Alshaihanya**	**Alnafayid**
Zekreet	1	5	4	8	2
Brouq Island	0.2	1	4	5	0.33
Umm Bab	0.25	0.25	1	4	0.33
Alshaihanya	0.12	0.2	0.25	1	0.16
Alnafayid	0.5	3	3	6	1
SUM	2.07	9.45	12.25	24	3.82

Table 18. Alternative Vs. Future Plan Sub-criteria Matrix (Normalization)

	Zekreet	Brouq Island	Umm Bab	Alshaihanya	Alnafayid
Zekreet	0.48	0.53	0.33	0.33	0.52
Brouq Island	0.1	0.11	0.33	0.21	0.09
Umm Bab	0.12	0.03	0.08	0.17	0.09
Alshaihanya	0.06	0.02	0.02	0.04	0.04
Alnafayid	0.24	0.32	0.24	0.25	0.26

Table 19. Alternative Vs. Future Plan Sub-criteria Matrix (sub-criteria Weight)

	Zekreet	Brouq Island	Umm Bab	Alshaihanya	Alnafayid	Criteria Weight
Zekreet	0.48	0.53	0.33	0.33	0.52	0.44
Brouq Island	0.1	0.11	0.33	0.21	0.09	0.16
Umm Bab	0.12	0.03	0.08	0.17	0.09	0.1
Alshaihanya	0.06	0.02	0.02	0.04	0.04	0.04
Alnafayid	0.24	0.32	0.24	0.25	0.26	0.26

Table 20. Alternative Vs. Future Plan Sub-criteria Matrix (Consistency Ratio)

	Zekreet 0.439	Brouq Island 0.165	Umm Bab 0.096	Alshaihanya 0.037	Alnafayid 0.263
Zekreet	0.439	0.824	0.386	0.293	0.526
Brouq Island	0.088	0.165	0.386	0.183	0.087
Umm Bab	0.11	0.041	0.096	0.146	0.087
Alshaihanya	0.053	0.033	0.024	0.037	0.042
Alnafayid	0.22	0.494	0.289	0.22	0.263

Table 21. Alternative Vs. Future Plan Sub-criteria Matrix (the Ratio)

	Zekreet 0.439	**Brouq Island 0.165**	**Umm Bab 0.096**	**Alshaihanya 0.037**	**Alnafayid 0.263**	**Weighted Sum Value**	**Consistency Ratio**	**WSV/CR**
Zekreet	0.439	0.824	0.386	0.293	0.526	2.47	0.44	5.62
Brouq Island	0.088	0.165	0.386	0.183	0.087	0.91	0.16	5.51
Umm Bab	0.11	0.041	0.096	0.146	0.087	0.48	0.1	4.99
Alshaihanya	0.053	0.033	0.024	0.037	0.042	0.19	0.04	5.15
Alnafayid	0.22	0.494	0.289	0.22	0.263	1.49	0.26	5.65

$$C.I = \frac{\lambda \max - n}{n - 1}$$

Where n is the number of compared element

For the criteria, n=5

and λ max=5.38

$$C.I = \frac{5.38-5}{5-1} = 0.095$$

C.R. = C.I. / R. I= 0.095/1.115=0.085

After determining the weight of alternatives on 22 different sub-criteria as explained in chapter 4, the result shown in table 31 Zekreet got the highest score with 29.3 %, followed by Brouq island, Alshahaniya, Alnafayid, and Umm Bab.

Table 22. Alternative locations result

Location	Total
Zekreet	29.4
Brouq Island	20.27
Um bab	10.09
Alshaihanya	22.3
Alnafayid	17.94

Zekreet overcomes other locations in different sub-criteria, like in construction cost and demolishing cost. It is considering the best because the land cost is cheap if it is compared with Alshehaniya. Also, there is a plan of distribution lands rather than others, which plans are not done yet. Regarding demolishing costs, Al-shehaniya is crowded, which could require more equipment and technologies with an extra workforce. On the other hand, Alnafayid and Umm Bab lands are rocky and contain plants, which will add cost. Brouq's cost is close to zekreet. Zekreet was also on top of other sub-criteria, such as land size, plans, and distance to the field. The city is empty from any preserves, accommodation, and no plans regarding housing's operational side or land distribution.

Furthermore, it is the closest area to Dukhan field. Additionally, safety has the highest criteria weight, Zekreet received high value equally with other alternatives except for Umm Bab. In general, Zekreet was dominating high criteria weight, which allows this location to be on top. Even if it is not on the top, but the criteria are high, like infrastructure. Brouq island becomes second since the weight that this city received due to similarity of factors with Zekreet, however the weakness due to the existence of animals preserves. Alshehaniya is very good in infrastructure, facilities, and distance to Doha, but since these factors have low weight or values are close to Zekreet and Brouq. Several criteria supported Alnafayid, but due to difficulties in reaching the city, with weaknesses in infrastructure and plans. So all these factors played the primary role to degrade the ranking for Alnafayid. Umm Bab is the least favorable option between all alternatives. In terms of distance, Umm Bab is too far from Doha and also from the field. In terms of infrastructure, it is acceptable due to having a small compound for the workers. For safety, the existence of factories and stations put these options in the tail. Furthermore, the vanishing of markets and other facilities could add additional costs if this option was selected. It has one highway with a single lane for each direction, which will need to plan road developments.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Selecting a location for rebuilding facilities in industrial areas is considered one of the most critical decisions in projects. In most cases, management and project holders look for the closest area to the industry or the lowest bid cost. However, multiple factors could affect the project's progress and might be on its success, which might be delayed or additional cost.

This project was done to define, analyze, and rank the most important criteria and sub-criteria that must be considered in the same type of this project. Also, evaluate different locations to select the most optimum based on the factors that had been examined. This project goes through various stages, including a literature review study via academic paper and publication to identify the most critical factors used. Based on this study, nine criteria had been determined with 22 sub-criteria. Then, a questionnaire had been distrusted in Qatar only to rank criteria and sub-criteria to relocate buildings based on their perspective and experience. The number of Responses reached 72 from different professional backgrounds such as academia and engineers in oil & gas industry and construction. After that, the responses were analyzed using the relative importance index (RII) to rank criteria and sub-criteria to build pairwise comparison matrices. The matrices were used as input for the analytical hierarchy method (AHP). Finally, AHP tool was used to rank criteria and sub-criteria based on the importance scale. After identifying the criteria and the subs, AHP method was applied to alternative locations based on factors that match the criteria. AHP evaluation for locations was based on experts' judgments and general knowledge of government websites and documentations. Five different locations were identified for this study.

The result showed safety criteria received a higher weight, and transportation was the lowest. On the other side, each sub-criteria highest and lowest weights were identified, as explained in section five. After the multiplication of the weights of criteria, and the sub of it is the category with the vector of alternatives, Zekreet is the optimum alternative location for the facilities.

6.2 Recommendations

To ensure the highest level of safety and security in Zekreet, it is recommended to build the facilities in the farthest distance from Dukhan field, where especially in the areas that closer to the Cuban hospital. The main concern is to keep residents away from wells and facilities in case of blowout or explosions. Regarding gas leakage such as H2S, the concentration is too low in Dukan, and by removing facilities this issue will be solved. Also, from a security perspective, will minimize the access to the field from civilian (non-QP employees).

The analytical hierarchy method is a powerful multi-criterion decision-making method MCDM, which could be applied in different areas like selecting construction projects, university ranking, or any other field. This method could be applicable if reliable data are available. Governments and agencies should also apply different MCDM techniques to improve the process of classifying and selecting projects based on scientific bases.

This project had identified different criteria and sub-criteria by using one of MCDM, which is AHP. For suture study, the same standards could be used by applying ANP method, which criteria are connected and to figure out if the result will be different or not, or other fuzzy techniques, since the input are the same.

Regarding the alternatives, the study could be applied to different industrial areas such as Mesaieed and Ras Laffan. Factors might be like this study; however, a comprehensive literature review study and expert analysis could help classify the criteria that might not be relevant to another research. Also, a new study could be applied to a similar project but to rank the buildings based on the necessity to relocate these buildings or not.

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Appendix-1: Questionnaire

What is your current field of work? *

- ◯ Oil and gas
- ◯ Industrial facilities
- ◯ Infrastructure (Roads, Bridge, Highways)
- ◯ Utilities (Water, electricity, sewage system)
- ◯ Others

What is your organization's type? *

- ◯ Consultant
- ◯ Contractor
- ◯ Client
- ◯ Education
- ◯ Others

What is your designation? *

- ◯ Department manager
- ◯ Project manager
- ◯ Supervisor
- ◯ Senior engineer
- ◯ Academician
- ◯ Others

How many years of experience do you have? *

- 0-5
- 6-10
- 11-15
- 16-20
- +20

Your work location ? *

- Doha
- Dukhan
- Ras Laffan
- Mesaieed
- Others

Based on your opinion, rate the following criteria based on their importance to relocate facilities. *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Cost (Rebuildin...					
Land (Size and ...					
Infrastructure q...					
Distance of ne...					
Facilities in new...					
Environmental I...					
Safety					
Existence of pu...					
Population (ove...					

Sub-Criteria

Please rate the following sub-criteria based on their importance, and you think it has effect on selecting new location

Cost *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Demolishing Co...					
Construction C...					

Land (Area) *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Land Size					
Future Land Pla...					
Slope					

Infrastructure *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Existence of Se...	◯	◯	◯	◯	◯
Existence of Co...	◯	◯	◯	◯	◯
Existence water...	◯	◯	◯	◯	◯
Existence of Tra...	◯	◯	◯	◯	◯

Distance *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Distance to Doha	◯	◯	◯	◯	◯
Distance from ...	◯	◯	◯	◯	◯

Preferred Facilities in new area

	Not at all impor...	Slightly Import...	Moderately imp...	Very important	Extremely impo...
Markets	◯	◯	◯	◯	◯
Schools	◯	◯	◯	◯	◯
Hospital and cli...	◯	◯	◯	◯	◯

Existence of Environmental Issues *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Natural preserv...	○	○	○	○	○
Pollution (air, N...	○	○	○	○	○

Safety *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Hazardous gas ...	○	○	○	○	○
Proximity to exi...	○	○	○	○	○

Transportation facilities *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely Impo...
Metro station	○	○	○	○	○
Taxi/Bus Statio...	○	○	○	○	○

Population *

	Not at all impor...	Slightly import...	Moderately imp...	Very important	Extremely impo...
Density	○	○	○	○	○
Culture	○	○	○	○	○

Appendix 2 Alternatives Pair-wise Comparison

a) Demolishing Cost

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	3	7	8	4
Brouq Island	0.33	1	4	7	3
Umm Bab	0.14	0.25	1	5	2
Alshahaniya	0.12	0.14	0.2	1	0.14
Alnafayid	0.2	0.33	0.5	7	1
SUM	1.79	4.72	12.7	28	10.14

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.56	0.64	0.55	0.29	0.39
Brouq Island	0.18	0.21	0.31	0.25	0.30
Umm Bab	0.08	0.05	0.08	0.18	0.20
Alshahaniya	0.07	0.03	0.02	0.04	0.01
Alnafayid	0.11	0.07	0.04	0.25	0.10

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.56	0.64	0.55	0.29	0.39	0.49
Brouq Island	0.18	0.21	0.31	0.25	0.30	0.25
Umm Bab	0.08	0.05	0.08	0.18	0.20	0.12
Alshahaniya	0.07	0.03	0.02	0.04	0.01	0.03
Alnafayid	0.11	0.07	0.04	0.25	0.10	0.11

4

C.W	0.49	0.25	0.12	0.03	0.11
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.49	0.75	0.82	0.26	0.46
Brouq Island	0.16	0.25	0.47	0.23	0.34
Umm Bab	0.07	0.06	0.12	0.16	0.23
Alshahaniya	0.06	0.04	0.02	0.03	0.02
Alnafayid	0.10	0.08	0.06	0.23	0.11

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.49	0.75	0.82	0.26	0.46	2.77	0.49	5.72
Brouq Island	0.16	0.25	0.47	0.23	0.34	1.45	0.25	5.76
Umm Bab	0.07	0.06	0.12	0.16	0.23	0.64	0.12	5.44
Alshahaniya	0.06	0.04	0.02	0.03	0.02	0.17	0.03	5.10
Alnafayid	0.10	0.08	0.06	0.23	0.11	0.58	0.11	5.08

6

N	5	
L. MAX	5.421644	
CI	0.105411	
CR	0.094539	9.453905458

b) Construction Cost

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	2	5	8	4
Brouq Island	0.50	1	4	7	3
Umm Bab	0.2	0.25	1	5	2
Alshahaniya	0.12	0.14	0.2	1	0.14
Alnafayid	0.2	0.33	0.5	7	1
SUM	2.02	3.72	10.7	28	10.14

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.50	0.54	0.47	0.29	0.39
Brouq Island	0.25	0.27	0.37	0.25	0.30
Umm Bab	0.10	0.07	0.09	0.18	0.20
Alshahaniya	0.06	0.04	0.02	0.04	0.01
Alnafayid	0.10	0.09	0.05	0.25	0.10

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.50	0.54	0.47	0.29	0.39	0.44
Brouq Island	0.25	0.27	0.37	0.25	0.30	0.29
Umm Bab	0.10	0.07	0.09	0.18	0.20	0.13
Alshahaniya	0.06	0.04	0.02	0.04	0.01	0.03
Alnafayid	0.10	0.09	0.05	0.25	0.10	0.12

4

C.W	0.44	0.29	0.13	0.03	0.12
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.44	0.57	0.64	0.26	0.47
Brouq Island	0.22	0.29	0.51	0.23	0.35
Umm Bab	0.09	0.07	0.13	0.17	0.23
Alshahaniya	0.05	0.04	0.03	0.03	0.02
Alnafayid	0.09	0.09	0.06	0.23	0.12

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.44	0.57	0.64	0.26	0.47	2.38	0.44	5.45
Brouq Island	0.22	0.29	0.51	0.23	0.35	1.59	0.29	5.55
Umm Bab	0.09	0.07	0.13	0.17	0.23	0.68	0.13	5.39
Alshahaniya	0.05	0.04	0.03	0.03	0.02	0.17	0.03	5.06
Alnafayid	0.09	0.09	0.06	0.23	0.12	0.59	0.12	5.09

6

N	5	
L. MAX	5.308471	
CI	0.077118	
CR	0.069164	6.916392458

c) Proximity to Factories

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	0.33	3	0.2	0.25
Brouq Island	3	1	5	0.25	0.2
Umm Bab	0.33	0.2	1	0.3	0.12
Alshahaniya	5	4	3	1	4
Alnafayid	4	2	6	0.25	1
SUM	13.33	7.53	18	2	5.57

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.08	0.04	0.17	0.10	0.04
Brouq Island	0.23	0.13	0.28	0.13	0.04
Umm Bab	0.02	0.03	0.06	0.15	0.02
Alshahaniya	0.38	0.53	0.17	0.50	0.72
Alnafayid	0.30	0.27	0.33	0.13	0.18

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.08	0.04	0.17	0.10	0.04	0.09
Brouq Island	0.23	0.13	0.28	0.13	0.04	0.16
Umm Bab	0.02	0.03	0.06	0.15	0.02	0.06
Alshahaniya	0.38	0.53	0.17	0.50	0.72	0.46
Alnafayid	0.30	0.27	0.33	0.13	0.18	0.24

4

C.W	0.09	0.16	0.06	0.46	0.24
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.09	0.05	0.17	0.09	0.06
Brouq Island	0.26	0.16	0.28	0.11	0.05
Umm Bab	0.03	0.03	0.06	0.14	0.03
Alshahaniya	0.43	0.64	0.17	0.46	0.96
Alnafayid	0.34	0.32	0.33	0.11	0.24

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.09	0.05	0.17	0.09	0.06	0.46	0.09	5.32
Brouq Island	0.26	0.16	0.28	0.11	0.05	0.86	0.16	5.39
Umm Bab	0.03	0.03	0.06	0.14	0.03	0.28	0.06	5.07
Alshahaniya	0.43	0.64	0.17	0.46	0.96	2.66	0.46	5.80
Alnafayid	0.34	0.32	0.33	0.11	0.24	1.35	0.24	5.62

6

N	5	
L. MAX	5.437714	
CI	0.109428	
CR	0.098142	9.814204438

d) Hazardous of Gas Leaking

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	0.3	3	0.14	0.33
Brouq Island	3	1	2	0.12	1
Umm Bab	0.33	0.5	1	0.2	0.2
Alshahaniya	7	6	5	1	6
Alnafayid	3	1	4	0.12	1
SUM	14.33	8.8	15	1.58	8.53

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.07	0.03	0.20	0.09	0.04
Brouq Island	0.21	0.11	0.13	0.08	0.12
Umm Bab	0.02	0.06	0.07	0.13	0.02
Alshahaniya	0.49	0.68	0.33	0.63	0.70
Alnafayid	0.21	0.11	0.27	0.08	0.12

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.07	0.03	0.20	0.09	0.04	0.09
Brouq Island	0.21	0.11	0.13	0.08	0.12	0.13
Umm Bab	0.02	0.06	0.07	0.13	0.02	0.06
Alshahaniya	0.49	0.68	0.33	0.63	0.70	0.57
Alnafayid	0.21	0.11	0.27	0.08	0.12	0.16

4

C.W	0.09	0.13	0.06	0.57	0.16
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.09	0.04	0.18	0.08	0.05
Brouq Island	0.26	0.13	0.12	0.07	0.16
Umm Bab	0.03	0.06	0.06	0.11	0.03
Alshahaniya	0.60	0.78	0.30	0.57	0.94
Alnafayid	0.26	0.13	0.24	0.07	0.16

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.09	0.04	0.18	0.08	0.05	0.43	0.09	5.04
Brouq Island	0.26	0.13	0.12	0.07	0.16	0.73	0.13	5.63
Umm Bab	0.03	0.06	0.06	0.11	0.03	0.30	0.06	5.02
Alshahaniya	0.60	0.78	0.30	0.57	0.94	3.19	0.57	5.61
Alnafayid	0.26	0.13	0.24	0.07	0.16	0.85	0.16	5.43

6

N	5	
L. MAX	5.346594	
CI	0.086649	
CR	0.077712	7.771174058

e) Pollution

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	0.33	5	4	0.33
Brouq Island	3	1	6	5	3
Umm Bab	0.2	0.16	1	0.5	0.16
Alshahaniya	0.25	0.2	2	1	0.2
Alnafayid	3	0.33	6	5	1
SUM	7.45	2.02	20	15.5	4.69

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.13	0.16	0.25	0.26	0.07
Brouq Island	0.40	0.50	0.30	0.32	0.64
Umm Bab	0.03	0.08	0.05	0.03	0.03
Alshahaniya	0.03	0.10	0.10	0.06	0.04
Alnafayid	0.40	0.16	0.30	0.32	0.21

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.13	0.16	0.25	0.26	0.07	0.18
Brouq Island	0.40	0.50	0.30	0.32	0.64	0.43
Umm Bab	0.03	0.08	0.05	0.03	0.03	0.04
Alshahaniya	0.03	0.10	0.10	0.06	0.04	0.07
Alnafayid	0.40	0.16	0.30	0.32	0.21	0.28

4

C.W	0.18	0.43	0.04	0.07	0.28
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.18	0.14	0.22	0.27	0.09
Brouq Island	0.53	0.43	0.27	0.34	0.84
Umm Bab	0.04	0.07	0.04	0.03	0.04
Alshahaniya	0.04	0.09	0.09	0.07	0.06
Alnafayid	0.53	0.14	0.27	0.34	0.28

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.18	0.14	0.22	0.27	0.09	0.90	0.18	5.16
Brouq Island	0.53	0.43	0.27	0.34	0.84	2.41	0.43	5.57
Umm Bab	0.04	0.07	0.04	0.03	0.04	0.23	0.04	5.11
Alshahaniya	0.04	0.09	0.09	0.07	0.06	0.34	0.07	5.05
Alnafayid	0.53	0.14	0.27	0.34	0.28	1.56	0.28	5.55

6

N	5	
L. MAX	5.288383	
CI	0.072096	
CR	0.06466	6.465984291

a) Distance to Doha

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	3	0.33	0.14	3
Brouq Island	0.33	1	0.25	0.12	3
Umm Bab	3	4	1	0.16	4
Alshahaniya	7	8	6	1	8
Alnafayid	0.33	0.33	0.25	0.12	1
SUM	11.66	16.33	7.83	1.54	19

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.09	0.18	0.04	0.09	0.16
Brouq Island	0.03	0.06	0.03	0.08	0.16
Umm Bab	0.26	0.24	0.13	0.10	0.21
Alshahaniya	0.60	0.49	0.77	0.65	0.42
Alnafayid	0.03	0.02	0.03	0.08	0.05

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.09	0.18	0.04	0.09	0.16	0.11
Brouq Island	0.03	0.06	0.03	0.08	0.16	0.07
Umm Bab	0.26	0.24	0.13	0.10	0.21	0.19
Alshahaniya	0.60	0.49	0.77	0.65	0.42	0.59
Alnafayid	0.03	0.02	0.03	0.08	0.05	0.04

4

C.W	0.11	0.07	0.19	0.59	0.04
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.11	0.21	0.06	0.08	0.13
Brouq Island	0.04	0.07	0.05	0.07	0.13
Umm Bab	0.34	0.29	0.19	0.09	0.17
Alshahaniya	0.78	0.57	1.13	0.59	0.34
Alnafayid	0.04	0.02	0.05	0.07	0.04

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.11	0.21	0.06	0.08	0.13	0.60	0.11	5.33
Brouq Island	0.04	0.07	0.05	0.07	0.13	0.35	0.07	4.93
Umm Bab	0.34	0.29	0.19	0.09	0.17	1.07	0.19	5.68
Alshahaniya	0.78	0.57	1.13	0.59	0.34	3.41	0.59	5.83
Alnafayid	0.04	0.02	0.05	0.07	0.04	0.22	0.04	5.22

6

N	5	
L. MAX	5.398803	
CI	0.099701	
CR	0.089418	8.941773918

b) Distance to the field

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	3	0.33	0.14	3
Brouq Island	0.33	1	0.25	0.12	3
Umm Bab	3	4	1	0.16	4
Alshahaniya	7	8	6	1	8
Alnafayid	0.33	0.33	0.25	0.12	1
SUM	2.14	3.62	15.25	30	8.32

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.47	0.55	0.33	0.30	0.36
Brouq Island	0.23	0.28	0.26	0.27	0.48
Umm Bab	0.09	0.07	0.07	0.13	0.02
Alshahaniya	0.05	0.03	0.02	0.03	0.01
Alnafayid	0.15	0.07	0.33	0.27	0.12

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.47	0.55	0.33	0.30	0.36	0.40
Brouq Island	0.23	0.28	0.26	0.27	0.48	0.30
Umm Bab	0.09	0.07	0.07	0.13	0.02	0.08
Alshahaniya	0.05	0.03	0.02	0.03	0.01	0.03
Alnafayid	0.15	0.07	0.33	0.27	0.12	0.19

4

C.W	0.40	0.30	0.08	0.03	0.19
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.40	0.61	0.39	0.27	0.56
Brouq Island	0.20	0.30	0.31	0.24	0.75
Umm Bab	0.08	0.08	0.08	0.12	0.04
Alshahaniya	0.04	0.04	0.02	0.03	0.02
Alnafayid	0.13	0.08	0.39	0.24	0.19

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.40	0.61	0.39	0.27	0.56	2.23	0.40	5.54
Brouq Island	0.20	0.30	0.31	0.24	0.75	1.80	0.30	5.93
Umm Bab	0.08	0.08	0.08	0.12	0.04	0.39	0.08	5.06
Alshahaniya	0.04	0.04	0.02	0.03	0.02	0.15	0.03	5.12
Alnafayid	0.13	0.08	0.39	0.24	0.19	1.02	0.19	5.43

6

N	5	
L. MAX	5.415346	
CI	0.103836	
CR	0.093127	9.312679892

c) Culture

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	9	9	0.2	9
Brouq Island	0.11	1	1	0.11	1
Umm Bab	0.11	1	1	0.11	1
Alshahaniya	5	9	9	1	9
Alnafayid	0.11	1	1	0.11	1
SUM	6.33	21	21	1.53	21

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.16	0.43	0.43	0.13	0.43
Brouq Island	0.02	0.05	0.05	0.07	0.05
Umm Bab	0.02	0.05	0.05	0.07	0.05
Alshahaniya	0.79	0.43	0.43	0.65	0.43
Alnafayid	0.02	0.05	0.05	0.07	0.05

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.16	0.43	0.43	0.13	0.43	0.31
Brouq Island	0.02	0.05	0.05	0.07	0.05	0.05
Umm Bab	0.02	0.05	0.05	0.07	0.05	0.05
Alshahaniya	0.79	0.43	0.43	0.65	0.43	0.55
Alnafayid	0.02	0.05	0.05	0.07	0.05	0.05

4

C.W	0.31	0.05	0.05	0.55	0.05
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.31	0.42	0.42	0.11	0.42
Brouq Island	0.03	0.05	0.05	0.06	0.05
Umm Bab	0.03	0.05	0.05	0.06	0.05
Alshahaniya	1.57	0.42	0.42	0.55	0.42
Alnafayid	0.03	0.05	0.05	0.06	0.05

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.31	0.42	0.42	0.11	0.42	1.68	0.31	5.33
Brouq Island	0.03	0.05	0.05	0.06	0.05	0.23	0.05	5.04
Umm Bab	0.03	0.05	0.05	0.06	0.05	0.23	0.05	5.04
Alshahaniya	1.57	0.42	0.42	0.55	0.42	3.37	0.55	6.18
Alnafayid	0.03	0.05	0.05	0.06	0.05	0.23	0.05	5.04

6

N	5	
L. MAX	5.325298	
CI	0.081324	
CR	0.072937	7.293672683

d) Density

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	0.16	0.25	6	0.14
Brouq Island	6	1	2	9	0.5
Umm Bab	4	0.5	1	8	0.12
Alshahaniya	0.16	0.11	0.12	1	0.11
Alnafayid	7	2	5	9	1
SUM	18.16	3.77	8.37	33	1.87

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.06	0.04	0.03	0.18	0.07
Brouq Island	0.33	0.27	0.24	0.27	0.27
Umm Bab	0.22	0.13	0.12	0.24	0.06
Alshahaniya	0.01	0.03	0.01	0.03	0.06
Alnafayid	0.39	0.53	0.60	0.27	0.53

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.06	0.04	0.03	0.18	0.07	0.08
Brouq Island	0.33	0.27	0.24	0.27	0.27	0.27
Umm Bab	0.22	0.13	0.12	0.24	0.06	0.16
Alshahaniya	0.01	0.03	0.01	0.03	0.06	0.03
Alnafayid	0.39	0.53	0.60	0.27	0.53	0.46

4

C.W	0.08	0.27	0.16	0.03	0.46
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.08	0.04	0.04	0.17	0.06
Brouq Island	0.46	0.27	0.31	0.25	0.23
Umm Bab	0.31	0.14	0.16	0.23	0.06
Alshahaniya	0.01	0.03	0.02	0.03	0.05
Alnafayid	0.54	0.55	0.78	0.25	0.46

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.08	0.04	0.04	0.17	0.06	0.39	0.08	5.14
Brouq Island	0.46	0.27	0.31	0.25	0.23	1.53	0.27	5.58
Umm Bab	0.31	0.14	0.16	0.23	0.06	0.88	0.16	5.66
Alshahaniya	0.01	0.03	0.02	0.03	0.05	0.14	0.03	4.97
Alnafayid	0.54	0.55	0.78	0.25	0.46	2.59	0.46	5.57

6

N	5	
L. MAX	5.383801	
CI	0.09595	
CR	0.086054	8.605410036

e) Metro Station

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	1	1	1	1
Brouq Island	1	1	1	1	1
Umm Bab	1	1	1	1	1
Alshahaniya	1	1	1	1	1
Alnafayid	1	1	1	1	1
SUM	5	5	5	5	5

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.20	0.20	0.20	0.20	0.20
Brouq Island	0.20	0.20	0.20	0.20	0.20
Umm Bab	0.20	0.20	0.20	0.20	0.20
Alshahaniya	0.20	0.20	0.20	0.20	0.20
Alnafayid	0.20	0.20	0.20	0.20	0.20

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.20	0.20	0.20	0.20	0.20	0.20
Brouq Island	0.20	0.20	0.20	0.20	0.20	0.20
Umm Bab	0.20	0.20	0.20	0.20	0.20	0.20
Alshahaniya	0.20	0.20	0.20	0.20	0.20	0.20
Alnafayid	0.20	0.20	0.20	0.20	0.20	0.20

4

C.W	0.20	0.20	0.20	0.20	0.20
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.20	0.20	0.20	0.20	0.20
Brouq Island	0.20	0.20	0.20	0.20	0.20
Umm Bab	0.20	0.20	0.20	0.20	0.20
Alshahaniya	0.20	0.20	0.20	0.20	0.20
Alnafayid	0.20	0.20	0.20	0.20	0.20

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Brouq Island	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Umm Bab	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Alshahaniya	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Alnafayid	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00

6

N	5	
L. MAX	5	
CI	0	
CR	0	0

f) Taxi/Bus Stop

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	3	4	0.2	3
Brouq Island	0.33	1	1	0.16	1
Umm Bab	0.25	1	1	0.14	1
Alshahaniya	5	6	7	1	7
Alnafayid	0.33	1	1	0.14	1
SUM	6.91	12	14	1.64	13

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.14	0.25	0.29	0.12	0.23
Brouq Island	0.05	0.08	0.07	0.10	0.08
Umm Bab	0.04	0.08	0.07	0.09	0.08
Alshahaniya	0.72	0.50	0.50	0.61	0.54
Alnafayid	0.05	0.08	0.07	0.09	0.08

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.14	0.25	0.29	0.12	0.23	0.21
Brouq Island	0.05	0.08	0.07	0.10	0.08	0.08
Umm Bab	0.04	0.08	0.07	0.09	0.08	0.07
Alshahaniya	0.72	0.50	0.50	0.61	0.54	0.57
Alnafayid	0.05	0.08	0.07	0.09	0.08	0.07

4

C.W	0.21	0.08	0.07	0.57	0.07
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.21	0.23	0.28	0.11	0.22
Brouq Island	0.07	0.08	0.07	0.09	0.07
Umm Bab	0.05	0.08	0.07	0.08	0.07
Alshahaniya	1.03	0.45	0.49	0.57	0.51
Alnafayid	0.07	0.08	0.07	0.08	0.07

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.21	0.23	0.28	0.11	0.22	1.05	0.21	5.08
Brouq Island	0.07	0.08	0.07	0.09	0.07	0.38	0.08	5.03
Umm Bab	0.05	0.08	0.07	0.08	0.07	0.35	0.07	4.97
Alshahaniya	1.03	0.45	0.49	0.57	0.51	3.07	0.57	5.34
Alnafayid	0.07	0.08	0.07	0.08	0.07	0.37	0.07	5.04

6

N	5	
L. MAX	5.089961	
CI	0.02249	
CR	0.020171	2.017051694

g) Markets

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	9	9	0.33	9
Brouq Island	0.11	1	4	0.11	2
Umm Bab	0.11	0.25	1	0.11	1
Alshahaniya	3	9	9	1	9
Alnafayid	0.11	0.5	1	0.11	1
SUM	4.33	19.75	24	1.66	22

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.23	0.46	0.38	0.20	0.41
Brouq Island	0.03	0.05	0.17	0.07	0.09
Umm Bab	0.03	0.01	0.04	0.07	0.05
Alshahaniya	0.69	0.46	0.38	0.60	0.41
Alnafayid	0.03	0.03	0.04	0.07	0.05

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.23	0.46	0.38	0.20	0.41	0.33
Brouq Island	0.03	0.05	0.17	0.07	0.09	0.08
Umm Bab	0.03	0.01	0.04	0.07	0.05	0.04
Alshahaniya	0.69	0.46	0.38	0.60	0.41	0.51
Alnafayid	0.03	0.03	0.04	0.07	0.05	0.04

4

C.W	0.33	0.08	0.04	0.51	0.04
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.33	0.72	0.34	0.17	0.37
Brouq Island	0.04	0.08	0.15	0.06	0.08
Umm Bab	0.04	0.02	0.04	0.06	0.04
Alshahaniya	1.00	0.72	0.34	0.51	0.37
Alnafayid	0.04	0.04	0.04	0.06	0.04

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.33	0.72	0.34	0.17	0.37	1.93	0.33	5.79
Brouq Island	0.04	0.08	0.15	0.06	0.08	0.41	0.08	5.09
Umm Bab	0.04	0.02	0.04	0.06	0.04	0.19	0.04	5.00
Alshahaniya	1.00	0.72	0.34	0.51	0.37	2.94	0.51	5.80
Alnafayid	0.04	0.04	0.04	0.06	0.04	0.21	0.04	5.18

6

N	5	
L. MAX	5.373789	
CI	0.093447	
CR	0.083809	8.380917402

h) Schools

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	9	9	0.33	9
Brouq Island	0.11	1	1	0.11	1
Umm Bab	0.11	1	1	0.11	1
Alshahaniya	3	9	9	1	9
Alnafayid	0.11	1	1	0.11	1
SUM	4.33	21	21	1.66	21

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.23	0.43	0.43	0.20	0.43
Brouq Island	0.03	0.05	0.05	0.07	0.05
Umm Bab	0.03	0.05	0.05	0.07	0.05
Alshahaniya	0.69	0.43	0.43	0.60	0.43
Alnafayid	0.03	0.05	0.05	0.07	0.05

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.23	0.43	0.43	0.20	0.43	0.34
Brouq Island	0.03	0.05	0.05	0.07	0.05	0.05
Umm Bab	0.03	0.05	0.05	0.07	0.05	0.05
Alshahaniya	0.69	0.43	0.43	0.60	0.43	0.52
Alnafayid	0.03	0.05	0.05	0.07	0.05	0.05

4

C.W	0.34	0.05	0.05	0.52	0.05
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.34	0.42	0.42	0.17	0.42
Brouq Island	0.04	0.05	0.05	0.06	0.05
Umm Bab	0.04	0.05	0.05	0.06	0.05
Alshahaniya	1.03	0.42	0.42	0.52	0.42
Alnafayid	0.04	0.05	0.05	0.06	0.05

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.34	0.42	0.42	0.17	0.42	1.78	0.34	5.19
Brouq Island	0.04	0.05	0.05	0.06	0.05	0.24	0.05	5.02
Umm Bab	0.04	0.05	0.05	0.06	0.05	0.24	0.05	5.02
Alshahaniya	1.03	0.42	0.42	0.52	0.42	2.81	0.52	5.45
Alnafayid	0.04	0.05	0.05	0.06	0.05	0.24	0.05	5.02

6

N	5	
L. MAX	5.136124	
CI	0.034031	
CR	0.030521	3.052117576

i) Hospitals and Clinics

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	7	9	0.5	9
Brouq Island	0.14	1	6	0.25	4
Umm Bab	0.11	0.16	1	0.11	0.5
Alshahaniya	2	4	9	1	9
Alnafayid	0.11	0.2	2	0.11	1
SUM	3.36	12.36	27	1.97	23.5

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.30	0.57	0.33	0.25	0.38
Brouq Island	0.04	0.08	0.22	0.13	0.17
Umm Bab	0.03	0.01	0.04	0.06	0.02
Alshahaniya	0.60	0.32	0.33	0.51	0.38
Alnafayid	0.03	0.02	0.07	0.06	0.04

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.30	0.57	0.33	0.25	0.38	0.37
Brouq Island	0.04	0.08	0.22	0.13	0.17	0.13
Umm Bab	0.03	0.01	0.04	0.06	0.02	0.03
Alshahaniya	0.60	0.32	0.33	0.51	0.38	0.43
Alnafayid	0.03	0.02	0.07	0.06	0.04	0.04

4

C.W	0.37	0.13	0.03	0.43	0.04
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.37	0.90	0.29	0.21	0.40
Brouq Island	0.05	0.13	0.19	0.11	0.18
Umm Bab	0.04	0.02	0.03	0.05	0.02
Alshahaniya	0.73	0.51	0.29	0.43	0.40
Alnafayid	0.04	0.03	0.06	0.05	0.04

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.37	0.90	0.29	0.21	0.40	2.17	0.37	5.90
Brouq Island	0.05	0.13	0.19	0.11	0.18	0.66	0.13	5.11
Umm Bab	0.04	0.02	0.03	0.05	0.02	0.16	0.03	5.07
Alshahaniya	0.73	0.51	0.29	0.43	0.40	2.36	0.43	5.51
Alnafayid	0.04	0.03	0.06	0.05	0.04	0.22	0.04	5.00

6

N	5	
L. MAX	5.31921	
CI	0.079802	
CR	0.071572	7.157169216

j) Land Size

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	3	4	6	3
Brouq Island	0.3	1	0.25	4	0.2
Umm Bab	0.25	4	1	5	0.33
Alshahaniya	0.16	0.24	0.12	1	0.11
Alnafayid	0.33	5	3	9	1
SUM	2.04	13.24	8.37	25	4.64

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.49	0.23	0.48	0.24	0.65
Brouq Island	0.15	0.08	0.03	0.16	0.04
Umm Bab	0.12	0.30	0.12	0.20	0.07
Alshahaniya	0.08	0.02	0.01	0.04	0.02
Alnafayid	0.16	0.38	0.36	0.36	0.22

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.49	0.23	0.48	0.24	0.65	0.42
Brouq Island	0.15	0.08	0.03	0.16	0.04	0.09
Umm Bab	0.12	0.30	0.12	0.20	0.07	0.16
Alshahaniya	0.08	0.02	0.01	0.04	0.02	0.03
Alnafayid	0.16	0.38	0.36	0.36	0.22	0.29

4

C.W	0.42	0.09	0.16	0.03	0.29
	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.42	0.27	0.65	0.21	0.88
Brouq Island	0.12	0.09	0.04	0.14	0.06
Umm Bab	0.10	0.36	0.16	0.17	0.10
Alshahaniya	0.07	0.02	0.02	0.03	0.03
Alnafayid	0.14	0.46	0.49	0.31	0.29

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.42	0.27	0.65	0.21	0.88	2.44	0.42	5.85
Brouq Island	0.12	0.09	0.04	0.14	0.06	0.46	0.09	5.00
Umm Bab	0.10	0.36	0.16	0.17	0.10	0.90	0.16	5.54
Alshahaniya	0.07	0.02	0.02	0.03	0.03	0.18	0.03	5.02
Alnafayid	0.14	0.46	0.49	0.31	0.29	1.69	0.29	5.74

6

N	5	
L. MAX	5.42995	
CI	0.107487	
CR	0.096401	9.640124199

k) Road

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	6	3	0.25	6
Brouq Island	0.16	1	0.33	0.12	2
Umm Bab	0.33	3	1	0.16	5
Alshahaniya	5	8	6	1	9
Alnafayid	0.16	0.5	0.2	0.11	1
SUM	6.65	18.5	10.53	1.64	23

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.15	0.32	0.28	0.15	0.26
Brouq Island	0.02	0.05	0.03	0.07	0.09
Umm Bab	0.05	0.16	0.09	0.10	0.22
Alshahaniya	0.75	0.43	0.57	0.61	0.39
Alnafayid	0.02	0.03	0.02	0.07	0.04

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.15	0.32	0.28	0.15	0.26	0.23
Brouq Island	0.02	0.05	0.03	0.07	0.09	0.05
Umm Bab	0.05	0.16	0.09	0.10	0.22	0.12
Alshahaniya	0.75	0.43	0.57	0.61	0.39	0.55
Alnafayid	0.02	0.03	0.02	0.07	0.04	0.04

4

C.W	0.23	0.05	0.12	0.55	0.04
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.15	0.32	0.28	0.15	0.26
Brouq Island	0.02	0.05	0.03	0.07	0.09
Umm Bab	0.05	0.16	0.09	0.10	0.22
Alshahaniya	0.75	0.43	0.57	0.61	0.39
Alnafayid	0.02	0.03	0.02	0.07	0.04

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.15	0.32	0.28	0.15	0.26	1.29	0.23	5.48
Brouq Island	0.02	0.05	0.03	0.07	0.09	0.27	0.05	5.02
Umm Bab	0.05	0.16	0.09	0.10	0.22	0.63	0.12	5.09
Alshahaniya	0.75	0.43	0.57	0.61	0.39	3.23	0.55	5.86
Alnafayid	0.02	0.03	0.02	0.07	0.04	0.19	0.04	5.15

6

N	5	
L. MAX	5.319198	
CI	0.0798	
CR	0.071569	7.15690765

l) Communication

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	6	6	0.5	8
Brouq Island	0.16	1	0.33	0.16	4
Umm Bab	0.16	3	1	0.16	6
Alshahaniya	2	6	6	1	8
Alnafayid	0.12	0.25	0.16	0.12	1
SUM	3.44	16.25	13.49	1.94	27

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.29	0.37	0.44	0.26	0.30
Brouq Island	0.05	0.06	0.02	0.08	0.15
Umm Bab	0.05	0.18	0.07	0.08	0.22
Alshahaniya	0.58	0.37	0.44	0.52	0.30
Alnafayid	0.03	0.02	0.01	0.06	0.04

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.29	0.37	0.44	0.26	0.30	0.33
Brouq Island	0.05	0.06	0.02	0.08	0.15	0.07
Umm Bab	0.05	0.18	0.07	0.08	0.22	0.12
Alshahaniya	0.58	0.37	0.44	0.52	0.30	0.44
Alnafayid	0.03	0.02	0.01	0.06	0.04	0.03

4

C.W	0.33	0.07	0.12	0.44	0.03
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.33	0.44	0.73	0.22	0.26
Brouq Island	0.05	0.07	0.04	0.07	0.13
Umm Bab	0.05	0.22	0.12	0.07	0.19
Alshahaniya	0.66	0.44	0.73	0.44	0.26
Alnafayid	0.04	0.02	0.02	0.05	0.03

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.33	0.44	0.73	0.22	0.26	1.98	0.33	5.96
Brouq Island	0.05	0.07	0.04	0.07	0.13	0.37	0.07	5.03
Umm Bab	0.05	0.22	0.12	0.07	0.19	0.66	0.12	5.38
Alshahaniya	0.66	0.44	0.73	0.44	0.26	2.53	0.44	5.73
Alnafayid	0.04	0.02	0.02	0.05	0.03	0.16	0.03	5.05

6

N	5	
L. MAX	5.432007	
CI	0.108002	
CR	0.096863	9.686258237

m) Sewage System

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	1	1	1	1
Brouq Island	1	1	1	1	1
Umm Bab	1	1	1	1	1
Alshahaniya	1	1	1	1	1
Alnafayid	1	1	1	1	1
SUM	5	5	5	5	5

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.20	0.20	0.20	0.20	0.20
Brouq Island	0.20	0.20	0.20	0.20	0.20
Umm Bab	0.20	0.20	0.20	0.20	0.20
Alshahaniya	0.20	0.20	0.20	0.20	0.20
Alnafayid	0.20	0.20	0.20	0.20	0.20

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.20	0.20	0.20	0.20	0.20	0.20
Brouq Island	0.20	0.20	0.20	0.20	0.20	0.20
Umm Bab	0.20	0.20	0.20	0.20	0.20	0.20
Alshahaniya	0.20	0.20	0.20	0.20	0.20	0.20
Alnafayid	0.20	0.20	0.20	0.20	0.20	0.20

4

C.W	0.20	0.20	0.20	0.20	0.20
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.20	0.20	0.20	0.20	0.20
Brouq Island	0.20	0.20	0.20	0.20	0.20
Umm Bab	0.20	0.20	0.20	0.20	0.20
Alshahaniya	0.20	0.20	0.20	0.20	0.20
Alnafayid	0.20	0.20	0.20	0.20	0.20

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Brouq Island	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Umm Bab	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Alshahaniya	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00
Alnafayid	0.20	0.20	0.20	0.20	0.20	1.00	0.20	5.00

6

N	5	
L. MAX	5	
CI	0	
CR	0	0

n) Electricity and Water

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	6	3	0.5	9
Brouq Island	0.16	1	0.25	0.16	3
Umm Bab	0.33	4	1	0.33	9
Alshahaniya	2	6	3	1	9
Alnafayid	0.11	0.33	0.11	0.11	1
SUM	3.6	17.33	7.36	2.1	31

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.28	0.35	0.41	0.24	0.29
Brouq Island	0.04	0.06	0.03	0.08	0.10
Umm Bab	0.09	0.23	0.14	0.16	0.29
Alshahaniya	0.56	0.35	0.41	0.48	0.29
Alnafayid	0.03	0.02	0.01	0.05	0.03

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.28	0.35	0.41	0.24	0.29	0.31
Brouq Island	0.04	0.06	0.03	0.08	0.10	0.06
Umm Bab	0.09	0.23	0.14	0.16	0.29	0.18
Alshahaniya	0.56	0.35	0.41	0.48	0.29	0.42
Alnafayid	0.03	0.02	0.01	0.05	0.03	0.03

4

C.W	0.31	0.06	0.18	0.42	0.03
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.31	0.37	0.54	0.21	0.27
Brouq Island	0.05	0.06	0.05	0.07	0.09
Umm Bab	0.10	0.25	0.18	0.14	0.27
Alshahaniya	0.62	0.37	0.54	0.42	0.27
Alnafayid	0.03	0.02	0.02	0.05	0.03

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.31	0.37	0.54	0.21	0.27	1.70	0.31	5.46
Brouq Island	0.05	0.06	0.05	0.07	0.09	0.31	0.06	5.06
Umm Bab	0.10	0.25	0.18	0.14	0.27	0.94	0.18	5.17
Alshahaniya	0.62	0.37	0.54	0.42	0.27	2.22	0.42	5.35
Alnafayid	0.03	0.02	0.02	0.05	0.03	0.15	0.03	5.03

6

N	5	
L. MAX	5.215194	
CI	0.053799	
CR	0.04825	4.824987567

o) Natural Preserves

1

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	1	9	1	9	1
Brouq Island	0.11	1	0.11	0.33	0.11
Umm Bab	1	9	1	9	1
Alshahaniya	0.11	3	0.11	1	0.11
Alnafayid	1	9	1	9	1
SUM	3.22	31	3.22	28.33	3.22

2

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid
Zekreet	0.31	0.29	0.31	0.32	0.31
Brouq Island	0.03	0.03	0.03	0.01	0.03
Umm Bab	0.31	0.29	0.31	0.32	0.31
Alshahaniya	0.03	0.10	0.03	0.04	0.03
Alnafayid	0.31	0.29	0.31	0.32	0.31

3

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	C.W
Zekreet	0.31	0.29	0.31	0.32	0.31	0.31
Brouq Island	0.03	0.03	0.03	0.01	0.03	0.03
Umm Bab	0.31	0.29	0.31	0.32	0.31	0.31
Alshahaniya	0.03	0.10	0.03	0.04	0.03	0.05
Alnafayid	0.31	0.29	0.31	0.32	0.31	0.31

4

C.W	0.31	0.03	0.31	0.05	0.31
	Zekreet	**Brouq Island**	**Umm Bab**	**Alshahaniya**	**Alnafayid**
Zekreet	0.31	0.26	0.31	0.42	0.31
Brouq Island	0.03	0.03	0.03	0.02	0.03
Umm Bab	0.31	0.26	0.31	0.42	0.31
Alshahaniya	0.03	0.09	0.03	0.05	0.03
Alnafayid	0.31	0.26	0.31	0.42	0.31

5

	Zekreet	Brouq Island	Umm Bab	Alshahaniya	Alnafayid	WSV	CW	Ratio
Zekreet	0.31	0.26	0.31	0.42	0.31	1.61	0.31	5.23
Brouq Island	0.03	0.03	0.03	0.02	0.03	0.15	0.03	5.00
Umm Bab	0.31	0.26	0.31	0.42	0.31	1.61	0.31	5.23
Alshahaniya	0.03	0.09	0.03	0.05	0.03	0.24	0.05	5.04
Alnafayid	0.31	0.26	0.31	0.42	0.31	1.61	0.31	5.23

6

N	5	
L. MAX	5.143686	
CI	0.035922	
CR	0.032217	3.221669654

Appendix 3 Calculations

Criteria	
Safety	0.31
Cost	0.22
Infrastructure	0.15
Land Size	0.11
Environmental Issue	0.08
New Facilities	0.05
Distance	0.04
Population	0.03
Transportation	0.02
	1.00

	Sub-criteria	Criteria Weight	
Cost	Construction	0.9	0.196
	Demolishing	0.1	0.022
Infrastructure	Existence of Electricity + Water	0.502	0.077
	Existence of sewage system	0.242	0.037
	Existence of communication system	0.172	0.027
	Existence of Roads	0.084	0.013
Land	Land size	0.615	0.067
	future plan	0.308	0.034
	slope	0.077	0.008
Distance	Distance to Doha	0.833	0.031
	Distance to the Field	0.167	0.006
Facilities existence	Hospital and clinics	0.614	0.033
	Schools	0.268	0.014
	Markets	0.117	0.006
Environmental Issues	Pollution	0.8	0.061
	Natural Preserves	0.2	0.015
Safety	Hazardous of gases leakage	0.75	0.230
	Proximity to factories	0.25	0.077
Transportation	Taxi/Bus station	0.875	0.017
	Metro station	0.125	0.002
Population	Density	0.8	0.021
	Culture	0.2	0.005

	Counstruction	Demolishing	Exsistence of Elec+Water	Exsistence of sewage system	Exsistence of communcation system	Exsistence of transportation (Roads+signs)	Land size	future plan	slope	Distance to Doha	Distance to the Field	Hospital and clinics	Schools	Markets	Pollution	Natural Preserves	Hazardous gases leakage	Proximity to factories	Taxi/Bus station	Metro station	Density	Culture
Zekreet	0.436	0.485	0.312	0.200	0.332	0.235	0.416	0.439	0.200	0.112	0.402	0.367	0.343	0.334	0.175	0.302	0.243	0.086	0.207	0.200	0.077	0.315
Brouq Island	0.287	0.251	0.062	0.200	0.073	0.054	0.091	0.165	0.200	0.071	0.304	0.128	0.047	0.080	0.432	0.058	0.243	0.159	0.075	0.200	0.275	0.046
Um bab	0.127	0.117	0.181	0.200	0.122	0.124	0.163	0.096	0.200	0.189	0.077	0.032	0.047	0.038	0.044	0.302	0.027	0.056	0.071	0.200	0.156	0.046
Alshaihanya	0.033	0.032	0.415	0.200	0.441	0.551	0.035	0.037	0.200	0.585	0.030	0.429	0.516	0.507	0.068	0.035	0.243	0.458	0.574	0.200	0.028	0.546
Alnafayid	0.117	0.114	0.030	0.200	0.032	0.036	0.295	0.263	0.200	0.042	0.188	0.044	0.047	0.041	0.280	0.302	0.243	0.241	0.073	0.200	0.464	0.046

Cost	Counstruction	0.9	0.196383384
	Demolishing	0.1	0.021820376
Infrastructure	Exsistence of Elec+Water	0.502	0.077469933
	Exsistence of sewage system	0.242	0.037346063
	Exsistence of communcation system	0.172	0.026543483
	Exsistence of transportation (Roads+signs)	0.084	0.012963096
Land	Land size	0.615	0.066962197
	future plan	0.308	0.033535539
	slope	0.077	0.008383885
Distance	Distance to Doha	0.833	0.030844597
	Distance to the Field	0.167	0.006183731
Facilties exsistence	Hospital and clinics	0.614	0.03273154
	Schools	0.268	0.014286731
	Markets	0.117	0.006237118
Enviromental Issues	Pollution	0.8	0.06115389
	Natural Preserves	0.2	0.015288473
Safety	Hazardous gases leakage	0.75	0.23021445
	Proximity to factories	0.25	0.07673815
Transportation	Taxi/Bus station	0.875	0.016549827
	Metro station	0.125	0.002364261
Population	Density	0.8	0.020756775
	Culture	0.2	0.005189194

Location		**Total**
Zekreet	0.293980355	29.4
Brouq Island	0.20274116	20.27
Um bab	0.100858264	10.09
Alshaihanya	0.223004458	22.3
Alnafayid	0.179362455	17.94
	0.999946691	100